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Soils and Agricultural Suitability of the Maryborough–Tiaro Area, Queensland

PR Zund and DM Brown

Queensland Government
Natural Resources and Mines

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available on request or on CD with report

Agricultural Land Classes (A0 3322)

Suitability for furrow irrigated:
Curcubit (A0 3288); Navy Bean (A0 3289); Peanut (A0 3290);Potato (A0 3291); Sorghum (A0 3292); Soy Bean (A0 3292); Sugar Cane (A0 3294): Sweet Corn (A0 3295)

Suitability for micro irrigated:
Avocado (A0 3296); Capsicum (A0 3297); Citrus (A0 3298); Cruciferae (A0 3299); Grapes (A0 3300); Macadamia (A0 3301); Lychee (A0 3302); Mango (A0 3303); Stone Fruit (A0 3304); Tomato (A0 3305); Zucchini (A0 3306)

Suitability for spray irrigated:
Asparagus (A0 3308); Beans (A0 3309); Curcubit (A0 3310); Improved Pastures (A0 3311); Lucerne (A0 3312) Maize (A0 3313); Navy Bean (A0 3314); Peanut (A0 3315); Pineapple (A0 3316); Potato (A0 3317); Sorghum (A0 3318); Soya Bean (A0 3319); Sweet Corn (A0 3320); Sweet Potato (A0 3321)

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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. In response to this need, The Maryborough Sugar Factory, Sugar Industry Reference Panel (SIRP), Department of Primary Industries (DPI) and Department of Natural Resources (DNR) funded the first survey of 73 805 ha in the Hervey Bay, Beaver Rock, Susan/Prawle, Churchill Mines, Tuan Forest, and Yerra Pilerwa areas. (Wilson *et al* 1999). Subsequently, this survey of 50 571 ha in the Walkers Point, Tinana, Bidwill, Teddington, Owanyilla, Tiaro, Netherby, Gundiah, Yengarie, Grahams Creek, Pilerwa, Pioneer's Rest and Mungar area has been undertaken.

The survey aims to provide 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 processes and a discussion of limitations to agricultural use.

The complex distribution of 55 soils and 9 phases or variants 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, salinity and soils with low water holding capacity, 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. 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 36 land uses are identified. Five classes of agricultural land suitability are used. The study shows 16 553 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 adequate 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 36 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 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 1860s as a port for exporting agricultural products 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 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.

A total of 7.2% of sugarcane land in the Maryborough district was converted to non-rural uses between 1980–95 (Haywood 1996). The sugarcane industry and other agricultural industries have 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 (Wilson *etal.* 1999).

The Maryborough–Tiaro soil survey and land use study of 50 571 ha (not including rural residential and urbanised area, waterways and water storages, and mountainous areas) on the Maryborough 1:100 000 map sheets (Figure 1) began in 1998. 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 (apart from Wilson 1994, Wilson 1997, Wilson *et al.* 1999) was generally fragmented, done for a specific purpose or in insufficient detail to address today's land use and management issues.

The survey and maps use the same land suitability criteria and soil profile classes where appropriate as has been used in the Childers, Bundaberg and Maryborough–Hervey Bay 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
- 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 Maryborough 1:100 000 map sheet
- 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 suitability. This report should be used in conjunction with the soils and suitability maps.

Information on climate, water resources, vegetation, land disturbance and land use information for this survey area, is outlined by Pointon (1998) and Pointon and Collins (2000).

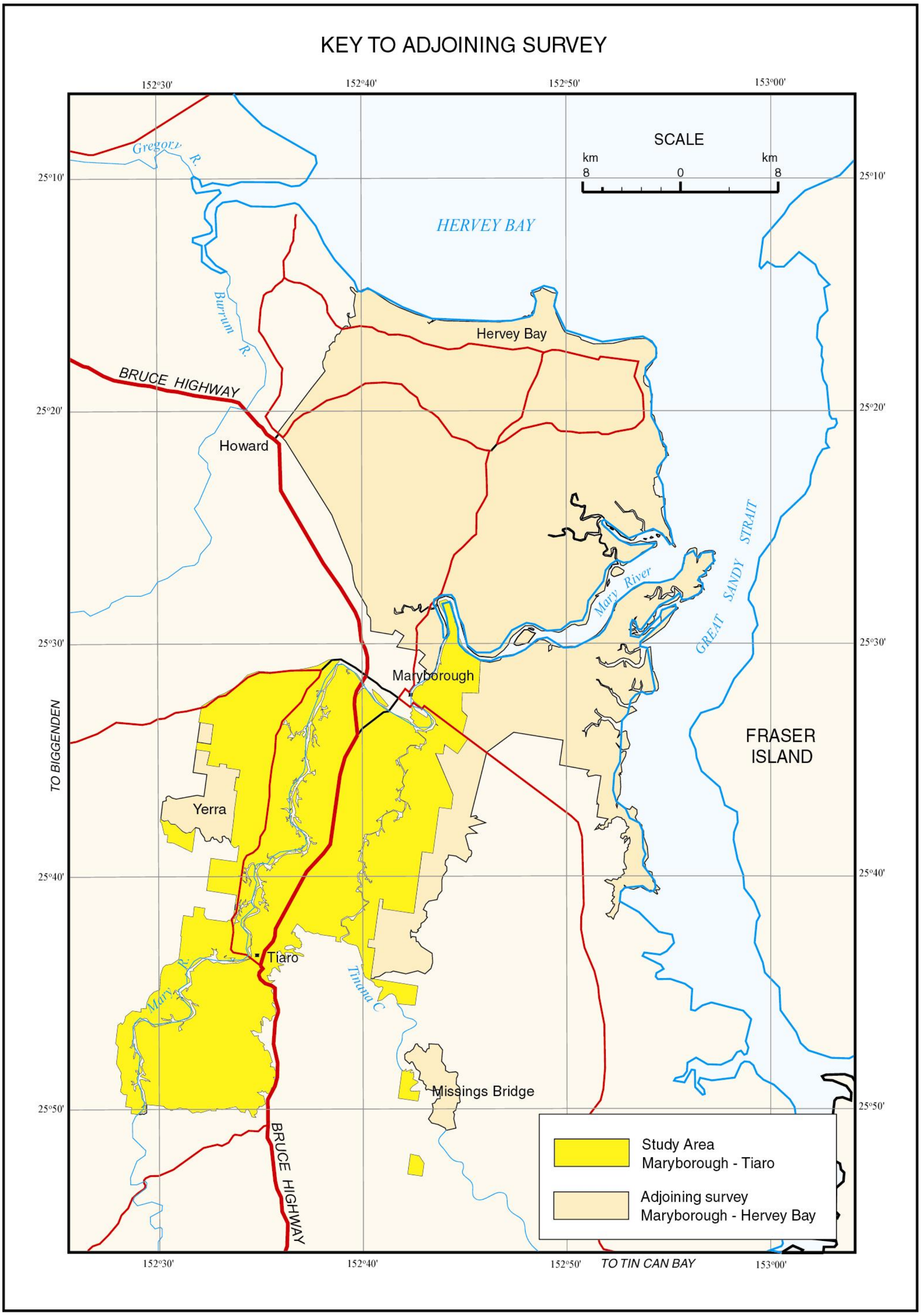


Figure 1. Study area and adjoining survey

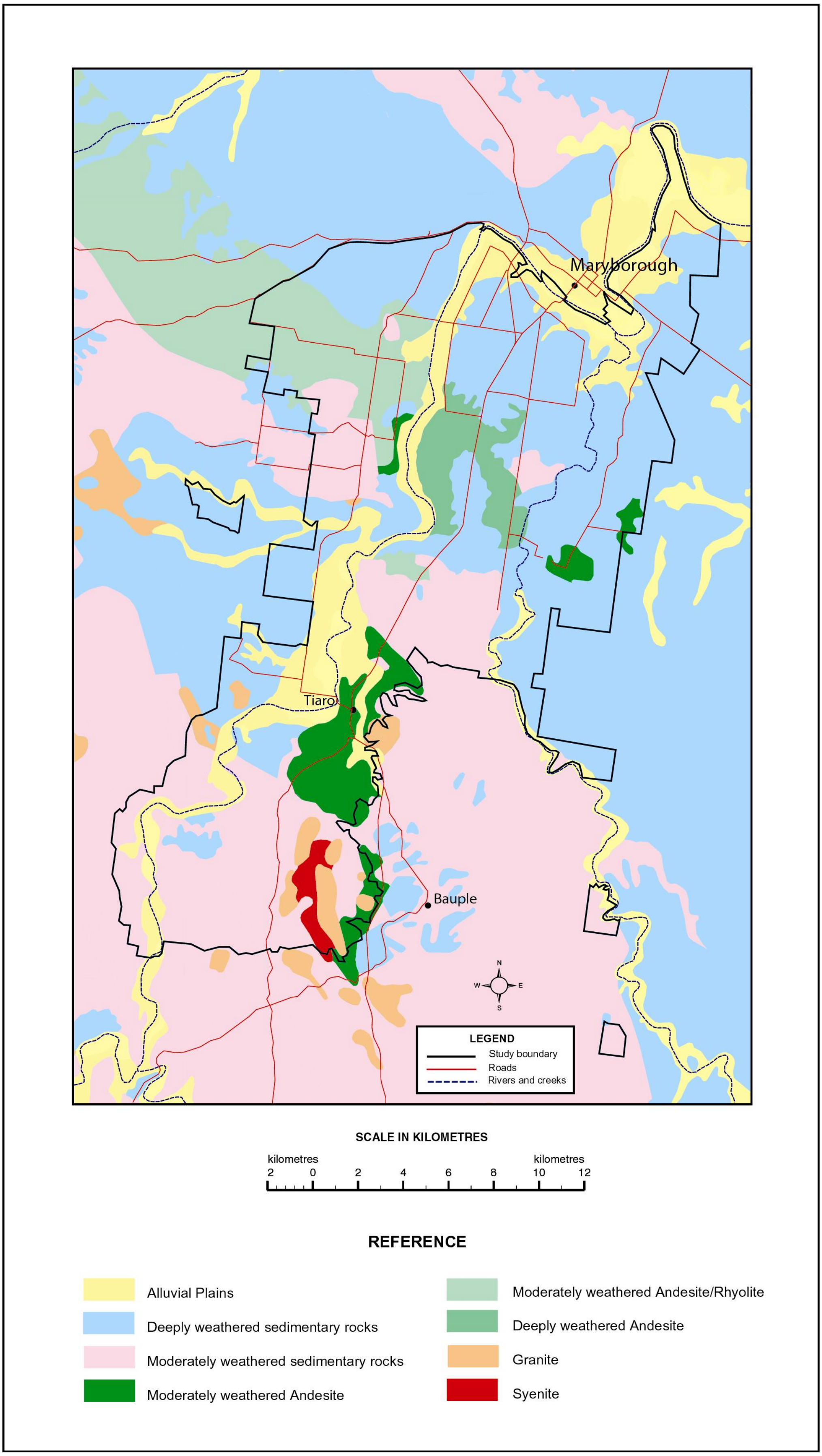


Figure 2 – Geomorphic unit map.
modified after Cranfield 1992.

2. Geology and geomorphology

Information for this section has been gained from geology reports (Cranfield 1993, 1994 and Ellis 1968) and from field observations. The study area is located entirely within the Maryborough Basin. This basin consists of a series of marine and freshwater sediments and volcanic lava flows and pyroclastics. These deposits have been folded and intruded by igneous rocks mainly along the western margin of the basin and study area. During the Tertiary period, fresh water sediments covered the folded landscape of the basin. These sediments underwent a long period of weathering during the mid-Tertiary period. The Tertiary surface has since been tilted and parts of the surface has been removed, reworked and/or deposited in Hervey Bay. In the Pleistocene and Holocene creeks and river have deposited and eroded material forming different levels in the landscape related to Pleistocene sea level changes. The effect of these processes has been to form relict alluvial terraces along major rivers. The Mary River continues to be an actively meandering river with regular flood events with aggradation and erosion of the river channel. Figure 2 shows the geomorphic relationships in the study area.

2.1 Geological history relevant to soil formation in the study area

The study area is located in an area of transition between the depositional landscape of the *Maryborough Basin* and the erosional landscapes of the *Gympie Province* to its west. The boundary of these two landscapes lies along a north-west to south-east direction parallel to the coastline. The southern part of the study area is located within this transition zone and consequently different soils are encountered than in previous studies in the Bundaberg, Childers and Hervey Bay areas.

The oldest rocks in the study area are fluvial and lacustrine sediments of the *Myrtle Creek sandstones* (RJdm) and *Tiaro Coal Measures* (Jdt), which were deposited during the late Triassic to Middle Jurassic period. These rocks were subsequently folded and faulted before being covered in part, by andesite to rhyolite flows and pyroclastics of the *Grahams Creek Formation* (JKg) and locally intruded by sill-like bodies of microdioite composition of unit JKi (see below).

During the middle Jurassic to early Cretaceous the landscape was intruded by *Mount Bauple Syenite* (JKb) south of Tiaro and *Unnamed Hornblende-Phyric Microdioritie* (JKi) throughout the western and southern parts of the study area.

During the early Cretaceous period fine sediments were deposited in a marine environment, over the *Grahams Creek Formation*. These sediments are the *Maryborough Formation* (Km). The upper layer of siltstones and mudstones of the Maryborough Formation were silicified to form the *Silicified Maryborough Formation* (Kms). Following a lowering in sea level, freshwater sediments of the *Burrum Coal Measures* (Kb) were deposited on top of the *Maryborough Formation* and this was followed by folding and faulting of the landscape. The *Burrum Coal Measures* do not outcrop in the study area.

During the Tertiary period alluvial, colluvial and lacustrine sediments were laid down unconformably over all the other formations to form the *Elliott Formation.* The *Elliott Formation* was subsequently subjected to periods of deep weathering and silicification to form duricrusts in parts. The *Elliott Formation* has been tilted and has a gentle dip to the northeast. Since the Tertiary period, the study area has had a relatively benign geomorphic history with only the *Elliott* surfaces being stripped away by rivers and creeks that drained the landscape. Where the *Elliott* surface has been stripped away, underlying older less-weathered rocks have been exposed.

During the Quaternary (Quaternary includes both Pleistocene and Holocene ie the present time), alluvial deposition has occured along the Mary River and its tributaries. Due to sea level change, the river recut down into these depositional layers creating a number of relict alluival terraces (Qpa, Qha1, Qha2). Figure 2 shows a map of the results of geomorphic activity in the area. More detailed information on the geology of the area is available from Cranfield (1994).

2.2 Sedimentary rocks

Because of folding, the oldest formation in the study area, the *Myrtle Creek Sandstone* comprising quartzose sandstones outcrop west of the Mary River opposite Netherby. Sandy surfaced soils have formed on these moderately weathered sandstones. The *Myrtle Creek Sandstones* are overlain by *Tiaro Coal Measures*, which are composed of shale, mudstones, siltstone, fine sandstones, and coal seams. The finer sediments dominate this unit and consequently form soils with loamy surfaces and sodic clay subsoils. The *Grahams Creek Formation*, although mostly andesite and rhyolite flows with pyroclastics within the study area, is interbedded with fine-grained sediments. The *Maryborough Formation*, in the northern part of the study area, overlies the *Grahams Creek Formation*. The *Maryborough Formation* is comprised mainly of mudstones, shale, siltstones, and fine-grained sandstones. The hard and resistant *Silicified Maryborough Formation* outcrops on distinct ridgelines, which form south east to north west trending ridges throughout the Maryborough area. Some of these ridges extend into the northern part of the study area. Soils high in fragmented rocks have formed on the ridges and adjacent slopes (eg Takura beds). The *Elliott Formation* unconformably overlies all the formations. The *Elliott Formation* comprises of sandstones, mudstones, siltstones and conglomerates that were unconformably deposited on an undulating, eroded older land surface.

All of the *Elliott Formation*, and parts of the *Maryborough Formation, Grahams Creek Formation* and *Tiaro Coal Measures* which were exposed to the effects of weathering during and since the Tertiary period have been deeply weathered. The underlying moderately weathered rocks are generally softer than the deeply weathered rocks resulting in undulating rises and low hills, these rocks can be distinguished from the deeply weathered rocks because they retain strata bedding and evidence of primary minerals (eg. feldspars). These features are lost during deep weathering (Wilson 1997). Similar lithology, regardless of the formation, gives rise to similar soils.

A period of deep weathering after the formation of the *Elliott Formation* sediments resulted in extensive silicification forming a duricrust. The duricrust surface forms on elevated level plains and hillcrests. The undulating landscapes on 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 (Wilson 1997).

Where coarse-grained sediments (sandstones) of the *Elliott Formation* occur, sand moves down slope over other formations, predominantly the moderately and deeply weathered sedimentary rocks (Wilson 1997).

2.3 Andesite and Rhyolitic rocks

The Jurassic-Cretaceous *Grahams Creek Formation* is exposed as a belt of moderately weathered to deeply weathered rocks along the western margin of the *Maryborough Formation* in the north of the survey area and as an isolated outcrop south of Tiaro. There are also some deeply weathered andesites of the *Grahams Creek Formation* between Tinana and Owanyilla. Erosion of the deeply weathered Tertiary surface has exposed the fresher moderately weathered rocks of the *Grahams Creek Formation*. The rhyolite and tuffs dominate the north west part of the survey area on which loamy surfaced soils with clay subsoils have formed. Where andesite is dominant, dark, clayey moderately deep soils have formed on fresher rocks while deep red soils have formed on deeply weathered rocks.

2.4 Intrusive rocks

The Jurassic *Mount Bauple Syenite* outcrops in the valleys west of Mount Guyra and is part of a granite intrusion, which forms Mount Guyra and Mount Bauple. Brown or grey sandy surfaced soils with clay subsoils have formed on this fresh rock. The *Unnamed Jurassic Microdiorites* have sporadically intruded the western parts of the survey area. A thin loamy surfaced soil with clay subsoils has developed on these rocks.

2.5 Alluvium

The alluvial plains along the Mary River are the largest continuous area of alluvium in the study area. The remaining alluvia are generally restricted to narrow areas along creeks (Qa), which drain the local landscapes and alluvial fans off Mt. Guyra and Mt. Bauple.

The alluvium of the Mary River comprises channel benches, scrolls, flood plains, terraces, alluvial plains and swamps. The channel benches, scrolls and flood plains (Qha1 and Qha2) occur low in the landscape adjacent to the Mary River. Regular flooding and associated silt deposition or occasionally scouring and bank slumping are a feature. Mineral composition of the alluvium reflects the geology of the Mary River catchment.

The terraces and alluvial plains (Qpa) 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 poorly-drained clays occur on backplains and swamps.

The alluvium associated with creeks draining the local geology (Qa) 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 narrow 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.

The alluvium of the fans west of Mt. Guyra and Mt. Bauple comprises of gently sloping fans with prior streams. Coarse, deep, sandy soils are associated with prior streams, which run in an irregular pattern over the fans. The upper parts of the fans are dominated by coarse, sandy soils grading to finer, clayey soils on the lower parts of the fans.

3. Soils

3.1 Background

Within the survey area a number of reconnaissance soil surveys have been undertaken since the 1960's. These include, an unpublished report on the soil associations in the Maryborough – Tinana area (Smith 1981), unpublished soils map (Smith and Nevell 1981), a soil study of steep lands of the Hervey Bay, Bauple and Yerra–Pilerwa areas (Smith 1983), 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), the Land Management Manual Maryborough District (DPI Staff 1992), and the Wide Bay–Burnett Resources Investigation, Volume 2–Land Resources (Queensland Co-ordinator-Generals Department 1979).

Since these studies, soil surveys of adjoining areas have been undertaken by the Department of Natural Resources and the Department of Primary Industries, including soils of Maryborough, Hervey Bay (Wilson *et al.* 1999) and the Beaver Rock area east of Maryborough (Wilson 1994).

A number of land evaluation studies have also been undertaken in the survey area. These include a sugarcane land suitability survey of vacant crown land surrounding Maryborough (Turner and Hughes 1983), a study of irrigated sugar cane land suitability for the Maryborough Sugar Factory by Leverington (1986 and 1993) and Macnish and Leverington (1984), and a planning study for the Maryborough Sugar Factory area (DPI 1988) which assessed the suitability of cane assigned areas.

Other relevant studies include, an assessment of the ecosystems of the coastal lowlands (Coaldrake 1961), and the geology of the Maryborough map sheet, (Ellis 1968) and (Cranfield 1992, 1993, 1994).

Mapping for this study was done at medium to low intensity (1:50 000 to 1:100 000) by free survey method (Reid 1988). Soil landscape boundaries were drawn using a combination of ground observations and aerial photo interpretations. A total of 600 sites have been described in detail and entered on computer file, along with 438 observations with soil name only.

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 site per 52 ha. A greater density of sites were recorded in more productive land types. The mapping information becomes more reliable at a larger (more detailed) scale.

A total of 55 soil profile classes (SPCs) have been identified (Appendix I) in the Maryborough–Tiaro study area. The soil distribution is shown on the accompanying soils map. Classification of the soils is based on the Australian Soil Classification system, Isbell (1996). A key to the soils (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, or <20% clay); loamy (fine sandy loam, loam, sandy clay loam, clay loam, or 20–35% clay); and clayey (light clay to heavy clay, or >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 Soil Classification Order (Isbell 1996) as for example, Podosols. Subdivision of the grouped mapping units is based on geology and geomorphology. The boundary between two distinct 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 modify all surface horizons, with the result that the ploughed layer is often a mixture of the original surface and subsurface horizons.

A total of 14 analysed sites (Appendix III) from the study area and 380 analysed sites from other projects in the area provides information on soil chemistry. 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 and Maryborough soil surveys (Wilson 1997, Wilson *et al.*1999).

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.

The present landscape in the Maryborough–Tiaro 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.

3.2 Podosols

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

Two Podosols have been identified on the deeply weathered sandstones of the *Elliott Formation*. Major attributes, the classification and areas of the Podosol soils can be found in Table 1. The Podosols represent a very minor order of soils in the study area (83 ha or 0.2%)

Landscape

The Podosols on the deeply weathered sandstones of the *Elliott Formation* have formed on level plains or hillslopes up to 6% slope. The 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 (McDonald *et al.* 1990) or black coffee rock pan (0.45 to 1.0 m) over grey sand.	Semiaquic Podosol; Aquic Podosol	18
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	65

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

Vegetation

The *Kinkuna* and *Theodolite* soils typically have wallum vegetation, usually *Banksia aemula* with an understory of heath. *Eucalyptus umbra* usually occurs as emergent species and may be locally dominant.

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 or Theodolite* soils on the *Elliott Formation* typically have an ortstein layer due to the accumulation of iron and organic compounds at approximately 1.0 m. Below the orstein layer, a bleached sandy layer occurs which overlies a structured sodic clay in the *Theodolite* soil.

Soil chemistry

Soil pH. All Podosols have an acid laboratory pH (pH 4.6–6.3) throughout the profile with surface field pH ranging from 4.5 to 6.2 and subsoil field pH ranging from 4.6 to 6.3. 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 <0.03 dS/m, Cl <0.002%).

Sodicity. Effective Cation Exchange Capacity (ECEC) is extremely low (<2 meq/100 g soil). Subsoils are sodic (ESP 5–19), however, sodicity in association with low ECEC, low clay activity (<2 meq ECEC/100 g clay) and low dispersion ratio (<0.02) indicates that sodicity is not expressed. Higher exchangeable sodium percentage (ESP >15) levels exist in the clay subsoil of the *Theodolite* soil and this sodicity can express itself through dispersion.

Soil nutrients. All Podosols are low in all nutrients with a surface accumulation due to organic matter (Table 2). Calcium /magnesium ratio (Ca/Mg) for *Kinkuna* soil ranges between 0.6–1.0 in the surface and 1.5–1.7 in the subsoil. For *Theodolite* soil, Ca/Mg ratio is between 0.36 and 0.44, apart from the sodic subsoil which has a Ca/Mg ratio of 0.03 which is magnesic and could restrict root growth.

Table 2. Mean profile soil nutrients 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	0.07 (VL)	0.51 (VL)	6 (VL)	4 (VL)	2.5 (M)	0.05 (L)	0.1 (L)	0.3 (L)
	0.2-0.3	0.04 (VL)	0.20 (VL)						
	0.5-0.6	0.03 (VL)	0.09 (VL)						
	0.8-0.9	0.03 (VL)	0.16 (VL)						
	1.1-1.2	0.03 (VL)	0.20 (VL)						
Theodolite	0-0.1	0.03 (VL)	0.06 (VL)	--	--	0.66 (L)	0.03(VL)	--	--
	0.2-0.3	0.04 (VL)	0.04 (VL)						
	0.5-0.6	0.01(VL)	0.04 (VL)						
	0.8-0.9	0.01 (VL)	0.05 (VL)						
	1.1-1.2	0.02 (VL)	0.04 (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 >1.0 m. Coffee rock or ortstein pans are generally thin and discontinuous on the deeply weathered *Elliott Formation* and are not expected to restrict rooting depth. 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. Using the model of Littleboy (1997), one *Theodolite* soil site has an estimated PAWC of 58 mm due to the clay subsoil occurring above one metre.

3.3 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). It is a wet grey clay developed on alluvial sediments derived from andesite rocks of the *Grahams Creek Formation*.

This is a very minor order of soils, occupying 422 ha or 0.8% of the survey area.

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

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
ALLUVIAL PLAINS AND SWAMPS			
Pelion	Root mat (in undisturbed areas) overlying a black or grey light medium clay to medium clay surface (0.12 to 0.23m) over a neutral to alkaline, black, brown or grey, light medium clay to medium clay subsoil (0.5 to 1.15m) over a alkaline, mottled, brown or grey light medium clay to medium clay.	Aquic Vertosol Brown Vertosol Grey Vertosol	422

Landscape

The *Pelion* soil occurs on the level to very gently sloping (0–2%) plains and swamps draining the hillslopes to the south of Tiaro. These hillslopes are occupied by soils derived from andesite rocks of the *Grahams Creek Formation*.

Vegetation

The vegetation has predominantly been cleared. Isolated stands of river blue gum (*Eucalyptus tereticornis*) and swamp oak (*Casuarina glauca*) occur along the margins of streams with sedges and native grass species dominating the swamps and plains.

Soil profile

All vertosols have clay textures throughout the profile. The soils occurring in swamps (or drained swamps) have a thin (<0.04 m) root mat on the surface. The surface soil has root channel mottling indicating that the soil is wet in the surface horizon for prolonged periods of time. The soil is self-mulching and will crack occasionally. The surface has normal gilgai, which are 0.1 to 0.5 m deep and 1.5 to 3.0 m wide. Subsoil horizons become paler, more mottled and alkaline with depth. Very few manganiferous and/or calcareous nodules occur throughout the subsoil.

Soil chemistry

Soil pH. *Pelion* soil has a alkaline trend, mean field measured pH is 7.7 in the surface increasing to 9.3 (Laboratory pH 8.1–9.0) at 1.5 m depth.

Salinity. Generally, electrical conductivity (EC) increases gradually with depth. Some profiles have salt bulges at about 0.6 m reflecting a shallow watertable. Mean field measured EC ranges from 0.05 dS/m (very low) in the surface to 0.70 dS/m (medium) at 1.5 m. Laboratory measurements ranged from zero to 1.3 dS/m (high); with a range from 0.25dS/m in the surface to 0.92 dS/m at 0.5 m.

Sodicity. Subsoils are strongly sodic throughout reflecting their very slow permeability and low position in the landscape and thus these soils accumulate salts from the surrounding landscape. The soil has high dispersion and clay activity ratio's which indicate that the soil would be prone to gully erosion in stream channels.

Soil nutrients. The soil has moderate to high amounts of nutrients, apart from exchangeable potassium, which is low throughout the profile (Table 4**)**.

Table 4. Profile soil nutrients for *Pelion* soil of the Vertosols

	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**
*Pelion**	0-0.1	0.19 (L)	14 (H)	10 (L)	22 (M)	4.75 (H)	0.28 (H)	1.2 (M)	1.8 (M)
	0.2-0.3	0.08 (VL)	13 (H)						
	0.5-0.6	0.08 (VL)	11 (H)						
	0.8-0.9	0.06 (VL)	13 (H)						
	1.1-1.2	0.02 (VL)	11 (H)						

VL – very low; L – low; M – medium: H – high;
• Results derived from one analysed site

Plant Available Water Capacity (PAWC). *Pelion* soil has a low PAWC (<60 mm) because of restrictions to rooting depth from stiff strongly sodic clayey subsoils.

3.4 Hydrosols

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

Saturation by a watertable may not necessarily be caused by low soil permeability. Site drainage is particularly important. In artificially drained soils, drainage has merely lowered the watertable. The appraisal of hydrosols is based on: site drainage, topographic position, climate and soil profile attributes such as colour, mottles, segregations 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 (Wilson 1997). It should be recognised that soil colours, mottles and segregations can be relict and may not be indicative of a saturated condition.

Eight Hydrosols have been recognised (Table 5) with a diverse range of soil profile attributes. Hydrosols occupy 5324 ha or 11% of the area.

Minor hydrosols may be associated with other dominant soil orders such as the Sodosols (*Turpin, Avondale*). Other minor soils from the soil orders Kandosols, Dermosols and Sodosols may be associated with the dominant Hydrosols. These associated soils orders usually reflect slight changes in site drainage due to topographic position.

Table 5. 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	103
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	434
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	56
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	430

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
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	148
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	9
ALLUVIAL PLAINS OF LOCAL CREEKS AND RIVERS			
Woober	Black or 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	3293
Timbrell	Black or grey silty clay loam, silty clay to light medium clay surface over a bleached A2 horizon (0.2 to 0.4 m) over a neutral to alkaline, mottled, grey or brown light medium clay to medium heavy clay.	Redoxic Hydrosol Oxyaquic Hydrosol	851

Landscape

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

Vegetation

All the Hydrosols support isolated areas of native vegetation. Tea trees (*Melaleuca quinquenervia, M. viridiflora*) are conspicuous tree species usually mixed with scattered eucalypt species (*Eucalyptus siderophloia, E. tereticornis, E. exserta, E. acmenoides, E. fibrosa, Corymbia trachyphloia, C. intermedia, Lophostemon suaveolens*). *Robur* soil frequently has an understory of *Banksia oblongifolia* and /or *B. robur*. *Beaver* soil is dominated by *Melaleuca quinquenervia.*

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 five 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. For example, *Quart* (Kandosol) grades into *Kinkuna* (Podosol), *Winfield* or *Robur* soil.

Isis (Chromosols) grades into *Alloway* or *Robur* soil. *Kepnock* (Dermosol) on level plains grades into *Clayton* which grades into *Kalah* while *Kepnock* (Dermosol) on hillslopes grades into *Tirroan* or *Owanyilla* (Sodosols), *Kolan* (Kurosol), Dermosols and *Avondole or Woco* (Hydrosols) on lower slopes.

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

Subsoils range from massive loamy sands to sandy loams (*Winfield*) to non sodic structured clays (*Alloway, Clayton*) to sodic structured clays (*Robur, Kalah*). All soils frequently have ferruginous nodules in the profile indicating fluctuating watertables.

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

Soil chemistry

Soil pH. Most Hydrosols are typically acid (pH <6.5) throughout the profiles. The texture contrast Hydrosols (*Robor and Kalah*) are more variable and may have neutral pH (pH 7–8) in the subsoil. The *Woober* soil, which is developed on alluvium derived from weathered sediments, has a field pH of 5.5-6.0 in the surface and subsoil field pH from 4.5 to 7. *Timbrell* soils, which are developed on alluivum derived from country dominated by andesite, have a alkaline trend with pH ranging from 5.5 to 7.0 (laboratory pH 6.0) in the surface to 7.0 to 9.5 (laboratory pH 8.5-9.5) in the subsoil.

Salinity. The Hydrosols developed on sandstones (*Alloway, 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 watertables.

The impermeable *Kalah* soils frequently have moderate to high salt levels (range EC 0.12–1.4 dS/m, Cl 0.007–0.2%) at depth and surface salt levels (range EC 0.02–1.5 dS/m, Cl 0.001–0.3). 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%; *Timbrell,* subsoil EC 0.77 dS/m, Cl 0.07%) Salt levels are strongly related with to 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 landscape position and lithology. The *Alloway* and *Clayton* soils which occupy level plains and lower slopes of rises have mean ESP values between 1 and 10 (non sodic to sodic respectively) whereas *Robur* and *Kalah* soils which occupy lower slopes and drainage depressions have mean ESP values between 9 and 36 throughout the profile. The *Alloway* and *Robur* soils developed on deeply weathered sandstones have deep sandy A horizons with corresponding lower ESP (mean ESP 10 to 13) in the upper 0.2 m of the B horizon compared to the other Hydrosols (*Kalah*) developed on fine grained sedimentary rocks (mean ESP >29). The *Clayton* soil is non sodic throughout.

The abrupt change in ESP of the *Robur* (mean ESP 11 lower A to 23 upper B horizon) and *Kalah* soils (mean ESP 13 lower A to 29 upper B) reflects the abrupt change in texture from the A to B horizons. The higher ESP levels generally correspond to greater EC levels.

Valley flats and local creeks occupy the lowest positions in the landscape and have very little fall (relative relief) down the creek or valley. Because of this, soils in these zones have accumulated salts from the surrounding rises. Hydrosols (*Woober* and *Timbrell*) developed on this alluvium have very high ESP values (mean ESP 24 to 40).

Soil nutrients. All Hydrosols developed on deeply weathered sedimentary rocks *(Alloway, Clayton, Kalah, Robur*) are low to very low in all nutrients (Table 6) reflecting the high leaching environment. The *Woober* soil occurring on alluvium draining the local geology (mainly sedimentary rocks) is typically low to very low in all nutrients. The *Timbrell* soil occurring on alluvium draining rises of andesitic rocks has moderate levels of nutrients throughout and this is reflected in the alkaline soil reaction**.** No information is available for *Beaver* and *Winfield* soils.

Table 6. Mean profile soil nutrients for soils of the Hydrosols

	Depth (m)	K meq/100g	Ca meq/100g	Acid P mg/kg	Bicarb P mg/kg	Organic C %	Total N %	Cu mg/kg	Zn mg/kg
Alloway	0-0.1	0.09 (VL)	0.3 (VL)	<5(VL)	4 (VL)	0.8 (L)	0.04 (VL)	0.36(M)	0.26(L)
	0.2-0.3	0.04 (VL)	0.12 (VL)						
	0.5-0.6	0.03 (VL)	0.18 (VL)						
	0.8-0.9	0.03 (VL)	0.26 (VL)						
	1.1-1.2	0.02 (VL)	0.19 (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)
	0.2-0.3	0.07 (VL)	0.20 (VL)						
	0.5-0.6	0.02 (VL)	0.9 (VL)						
	0.8-0.9	0.02 (VL)	1.10 (L)						
	1.1-1.2	0.02 (VL)	0.70 (VL)						
Kalah	0-0.1	0.16 (L)	0.54 (VL)	1.4 (VL)	1.3 (VL)	1.2 (L)	0.07 (L)	0.07 (VL)	0.8 (M)
	0.2-0.3	0.02 (VL)	0.19 (VL)						
	0.5-0.6	0.06 (VL)	0.35 (VL)						
	0.8-0.9	0.07(VL)	0.32 (VL)						
	1.1-1.2	0.07 (VL)	0.20 (VL)						
Robur	0-0.1	0.03(VL)	0.49 (VL)	12(L)	2 (VL)	0.86 (L)	0.10 (L)	0.09 (VL)	0.19 (VL)
	0.2-0.3	0.02(VL)	0.19 (VL)						
	0.5-0.6	0.02 (VL)	0.18 (VL)						
	0.8-0.9	0.05 (VL)	0.25 (VL)						
	1.1-1.2	0.07 (VL)	0.31 (VL)						
*Timbrell**	0-0.1	0.23 (M)	2.7 (M)	3 (VL)	19 (L)	2.8 (H)	0.2 (M)	1.2 (M)	1.1 (M)
	0.2-0.3	0.38 (M)	3.5 (M)						
	0.5-0.6	0.11 (L)	5.2 (M)						
	0.8-0.9	0.26 (M)	7.3 (M)						
	1.1-1.2	0.09 (VL)	4.8 (M)						
*Woober**	0-0.1	0.06 (VL)	0.46 (VL)	3 (VL)	4 (VL)	1.6 (M)	0.06 (L)	0.07 (VL)	0.21 (L)
	0.2-0.3	0.05 (VL)	0.25 (VL)						
	0.5-0.6	0.06 (VL)	0.14 (VL)						
	0.8-0.9	0.07 (VL)	0.24 (VL)						
	1.1-1.2	0.10 (L)	0.43 (VL)						

VL – very low; L – low; M – medium: H – high
* Results derived from one analysed site

Plant available water capacity (PAWC). PAWC (Table 7) is mainly related to texture and rooting depth. Any physical restriction on the effective rooting depth in the Hydrosols is dependent on the sodicity of the subsoils and consequently soil density. 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, contributes 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 7. Estimated PAWC (mm) and rooting depth (m) for soils of the Hydrosols

Soil	Rooting depth (m)	PAWC (mm)
Alloway	>1.0	63–65
Clayton	>1.0	60–80
Kalah	0.4–0.6	45–49
Robur	0.5–0.9	47–66
*Winfield**	>1.0	<50
Woober	0.4–0.8	45–70
Timbrell	0.5	86

* - This is an estimate of PAWC based on soils which are similar in morphology.

3.5 Kurosols

Kurosols are soils with a strong texture contrast between A horizons and a strongly acid (pH <5.5) B horizon. Only the *Kolan* soil type and its *red variant* and *rocky phase* consistently fall into this soil order. The soil has formed on moderately weathered mudstones and siltstones of the *Elliott Formation, Maryborough Formation, Tiaro Coal Measures* and rhyolite of the *Graham's Creek Formation*. The *Kolan* soil occupies 9096 ha or 18% of the total study area. The Sodosol soils, *Bauple*, *Owanyilla, Tirroan*, *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 8.

Table 8. 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	8745
Kolan rocky phase	As above with >20% coarse fragments on the surface.	Grey Kurosol Brown Kurosol	197
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	155

Landscape

The *Kolan* soil occurs on hillslopes of rises and low hills with slopes of 1 to 15%, with an average of 3 to 8 %.

Vegetation

Tall (18–25 m) lemon scented gum/spotted gum (*Corymbia citrodora*), ironbarks (*Eucalyptus siderophloia, E. fibrosa),* brush box *(Lophostemon confertus*) 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 clayey surfaced Dermosol (*Bucca*), loamy surfaced Sodosols (*Owanyilla*, *Givelda* or *Avondale* soils) or sandy surfaced Sodosols (*Tirroan or Doongul*) adjacent to sedimentary rocks or granite.

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 results 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 *Avondale* from *Kolan*.

The *Kolan red variant* soil has a grey mottled red subsoil, generally occurring on better drained areas.

Soil chemistry

Soil pH. pH in the surface ranges from 5.3 to 6.2 (field pH 5.3 to 5.8) with subsoil pH ranging from 4.8 to 5.8 (Field pH 4.5 to 5.5).

Salinity and Sodicity. *Kolan* soils have low salt levels and are strongly sodic in their upper B horizons. They have a salt bulge at 0.5 to 0.9 m (mean EC 0.08 dS/m at 0.2–0.3 m, 0.36 dS/m at 0.5–0.6 m, and 0.42 dS/m at 0.8–0.9m) which corresponds to the soil becoming strongly sodic in the upper B horizon (mean ESP 7 at 0.2–0.3 m, 28 at 0.5–0.6 m, 41 at 0.8–0.9m).

Soil nutrients. The medium levels of nutrients in the surface correspond 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 9. Mean profile soil nutrients for the Kolan soil of the Kurosols

	Depth (m)	K meq/100g	Ca meq/100g	Acid P mg/kg	Bicarb P mg/kg	Organic C %	Total N %	Cu mg/kg	Zn mg/kg
Kolan	0-0.1	0.41 (M)	2.8 (M)	9 (VL)	4 (VL)	2.3 (M)	0.14 (L)	0.23 (L)	1.1 (M)
	0.2-0.3	0.28 (M)	0.41 (VL)						
	0.5-0.6	0.20 (M)	0.47 (VL)						
	0.8-0.9	0.23 (M)	0.42 (VL)						
	1.1-1.2	0.29 (M)	0.38 (VL)						

VL – very low; L – low; M – medium

Plant available water capacity (PAWC). The shallow rooting depth due to the strongly sodic, magnesic and saline upper B Horizon results in a low PAWC. A predicted rooting depth of 0.3–0.6 m corresponds to a PAWC of 45–75 mm. The low nutrient status, particularly very low calcium, below the surface may further reduce rooting depth and PAWC.

3.6 Sodosols

Sodosols are soils with a clear or abrupt textured B horizon which are 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 and/or dispersion of the clay fraction.

Eleven Sodosols have been recognised (Table 10), with soils developed on granite (*Gigoon*, *Doongul*), syenite (*Bauple*), andesite (*Owanyilla*), deeply weathered sedimentary rocks (*Turpin, Avondale*), moderately weathered sedimentary rocks (*Tirroan and Givelda*), alluvial fans (*Springs*) and alluvial plains (*Peep, Butcher*). They occur extensively throughout the study area, occupying 10 867ha or 22% of the survey area.

Table 10. Major attributes, classification and areas for soils of the Sodosols

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
HILLSLOPES ON GRANITES			
Gigoon	Black or grey loamy sand to sandy loam surface over a conspicuously bleached A2 horizon (0.2 to 0.6 m) over an acid to alkaline, mottled, brown or grey sandy clay to sandy medium heavy clay (0.5 to 1.2 m) over weathered granite.	Brown Sodosol Grey Sodosol	Not mapped
Doongul	Black or grey light sandy clay loam to clay loam sandy surface over a conspicuously bleached A2 horizon (0.1 to 0.25 m) over a frequently mottled, grey or brown medium clay (0.2 to 0.85 m) over weathered granite.	Grey Sodosol Brown Sodosol	1290
HILLSLOPES ON SYENITE			
Bauple	Black or grey sand to sandy loam surface over a conspicuously bleached A2 horizon (0.2 to 0.35 m) over an acid, mottled, grey or brown sandy light medium clay to sandy medium heavy clay (1.1 to 1.6 m) over weathered syenite.	Brown Sodosol Grey Kurosol	227
HILLSLOPES ON MODERATELY WEATHERED ANDESITE			
Owanyilla	Black or grey fine sandy loam to clay loam surface surface over a conspicuously or sporadically bleached A2 horizon (0.03 to 0.35 m) over an acid to neutral mottled, brown or grey light medium clay to heavy clay (0.35 to 0.95 m) with ferromanganiferous nodules frequently over a mottled, neutral to alkaline, brown, grey or yellow medium clay to heavy clay with andesite fragments.	Brown Sodosol Grey Sodosol	1471

Table 10 (continued)

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	2283
Givelda	Black or grey loam fine sandy to clay loam fine sandy surface over a conspicuously bleached A2 horizon (0.15 to 0.3m) over an acid to neutral, mottled, brown or yellow medium clay to heavy clay (0.45 to 1.3m) over weathered rock.	Brown Sodosol Yellow Sodosol	Not mapped
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	1427
Avondale rocky phase	As above with >20% rock fragments throughout the profile or rock within 0.3 m of the surface.	Grey Sodosol	221
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	1355
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	1777
Butcher sandy variant	Black or grey sandy loam to fine sandy loam 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	85
ALLUVIAL PLAINS OF LOCAL CREEKS			
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	793

Table 10 (continued)

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
ALLUVIAL FANS			
Springs	Black or grey sandy loam to sandy clay loam surface over a conspicuously bleached A2 horizon (0.2 to 0.35 m) over a neutral, grey or brown coarse sandy light medium clay to sandy medium clay (0.45 to 1.45m) with manganiferous nodules and grit over layered sands and sandy clays.	Grey Sodosol Brown Sodosol	159

Landscape

The *Gigoon, Doongul, Bauple, Owanyilla, Turpin, Avondale, Tirroan* and *Givelda* soils occur on hillslopes (slopes 5 to15%) of rises and low hills. *Bauple* soil occurs on the western lower slopes of Mt Guyra and Mt. Bauple and on rises in the valley between Penny Hill and Mt. Guyra. Slopes range between 2 and 10%. 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 3%. The *Peep* soil occurs on narrow alluvial plains of streams draining the local geology and the *Springs* soil occurs on lower to middle part of gently sloping (1 to 3%) alluvial fans on the western side of Mount Guyra.

Vegetation

Dominant tree vegetation is related to soil type. The *Gigoon* on granite has narrow leaf ironbark (*Eucalyptus crebra*) and lemon scented gum (*Corymbia citrodora*) while *Doongul* is dominated by lemon scented gum and grey ironbark (*E. siderophloia)* often with gum topped box (*E. moluccana*).

Bauple soil is dominated by forest red gum (*E. tereticornis*), narrow leaf ironbark, Moreton Bay ash (*C. tessellaris*), pink bloodwood (*C. intermedia*), lemon scented gum, and swamp box (*Lophostemon suaveolens).*

Owanyilla soil supports lemon scented gum, gum-topped box, narrow leaf ironbark, forest red gum, Moreton Bay ash, grey ironbark and Queensland peppermint (*E. exserta*).

The *Turpin, Avondale* and *Tirroan* soils have similar vegetation with trees dominated by stringy bark (*E umbra*) and rusty gum (*Angophora leiocarpa*) with scattered grey ironbark, brown bloodwood (*Corymbia trackyphloia*), pink bloodwood and paperbarks (*Melaleuca* spp.). Gum-topped box is the dominant vegetation on the *Givelda* soil.

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

Soil profile

All the Sodosols have a black or grey sandy or loamy surface over a bleached A2 horizon changing abruptly or sharply or occasionally clearly to the clay subsoil usually with coarse angular blocky or prismatic structure.

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

The *Bauple* soil is developed on syenite (an intrusive intermediate rock) and is similar to *Gigoon* however *Bauple* soil has syenite grit throughout the B horizons and has a slight acid trend.

Owanyilla soil is formed on intermediate andesites of the *Grahams Creek Formation* and often is associated with *Kolan* (Kurosol) soil formed on rhyolites, tuffs and sediments or *Jumpo* and *Tiaro* (Dermosol) soils formed on andesites. Because the rhyolites and tuffs are inter-bedded with andesite flows and then subsequently tilted, change between *Owanyilla* and *Kolan*, *Tiaro* or *Jumpo* soils can be abrupt and on any part of the landscape. As a result complex soil distribution patterns can occur and these have not always be mappable at the scale of this survey. *Owanyilla* soil is similar to *Kolan* (Kurosol) soil morphologically but has a alkaline or neutral subsoil and orange or brown mottles. *Owanyilla* usually abuts the *Timbrell* soils on local alluivum at the base of slopes.

Avondale soil always occurs in association with *Woco* soil (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 thick (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 where sandy material from the deeply weathered coarse-grained sediments has moved downslope over moderately weathered sediments and usually occurs upslope of the *Kolan* soil (Kurosol). *Kolan* and *Tirroan* soils have been separated on surface texture and thickness. *Kolan* has a thin (0.15 to 0.3 m) loamy surface while *Tirroan* soil has a relatively thick (0.25 to 0.5 m) sandy surface. *Givelda* is a minor unmapped soil similar to *Kolan* but has a brown, often neutral to alkaline clay subsoil.

Butcher, Peep and *Springs* soils on alluvia have been separated by the sediments the soils were formed from. *Butcher* and *Peep* soils have a medium to thick (0.15–0.45 m) loamy surface over 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. *Peep* frequently adjoins sandy levee soils (*Littabella* a Kandosol). *Springs* soil has a sandy and/or gritty texture throughout, a neutral clay subsoils without lime nodules, and is underlaid by sand and/or sandy clay layers sometimes occurring within 0.5 m of the surface. *Springs* grades into *Guyra* (Tenosol) up slope, and *Gutchy* (Dermosol) down slope with soil distribution being influenced by the prior streams on the alluvial fans.

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 group. Field and laboratory pH of the subsoil range from 5.0 to 6.0. Soils on moderately weathered rocks have a generally slightly higher pH reflecting less weathering: *Tirroan* soil on sedimentary rocks has a field pH 5 to 7.5; *Gigoon* and *Doongul* on granite have subsoil pH range of 6.0 to 8.5 (laboratory pH 5.3–6.8 (*Doongul))*; Bauple on syenite has subsoil a field pH range of 4.5 to 6.0 (laboratory pH 4.6 to 5.8); and *Owanyilla* on andesite has a subsoil field pH of 5.5 to 8.5. The Sodosols on alluvium (*Butcher, Peep, Springs*) 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 for *Butcher* and *Springs* soils (laboratory pH for *Springs* soil 8.6–9.0) and acid to neutral pH (pH 5 to 7) predominating for *Peep* soil.

Salinity. Salinity levels in *Avondale and Bauple* subsoils reaches medium levels (0.45–0.90 dS/m). In *Owanyilla, Butcher, Spring* and *Peep* soils, salinity reaches low levels (< 0.45 dS/m) and *Turpin, Tirroan, Doongul*, and *Gigoon* all have low amounts. 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. Overall there is a marked increase in salt levels in the subsoil to low or medium levels (surface EC 0.01–0.09 dS/m, Cl 0.001–0.007%; clay subsoils EC 0.04–0.5 dS/m, Cl 0.004–0.08%), which correspond to the abrupt texture change and strongly sodic clays. These elevated salt levels indicate impermeable subsoils.

Sodicity. All Sodosols are strongly sodic (ESP 15–51, mean 29) in the upper B horizon. The high sodicity levels contribute to the slow permeability and salt accumulation in some of the profiles.

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 11).

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

Table 11. 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	0.1 (L)	1.00 (L)	9 (VL)	3 (VL)	1.2 (L)	0.06 (L)	0.2 (L)	0.5 (L)
	0.2-0.3	0.06 (VL)	0.50 (VL)						
	0.5-0.6	0.12 (L)	0.58 (VL)						
	0.8-0.9	0.15 (L)	1.20 (L)						
	1.1-1.2	0.07 (VL)	1.50 (L)						
*Bauple**	0-0.1	0.26 (M)	2.7 (M)	10 (L)	16 (L)	2.4 (M)	0.18(M)	0.2 (L)	1.2 (M)
	0.2-0.3	0.12 (L)	0.86 (VL)						
	0.5-0.6	0.24 (M)	0.19 (VL)						
	0.8-0.9	0.30 (M)	0.27 (VL)						
	1.1-1.2	0.27 (M)	0.30 (VL)						

Table 11 (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
Butcher	0-0.1	0.21 (M)	3.0 (M)	3 (VL)	6 (VL)	1.3 (L)	0.09 (L)	0.82(M)	0.97(M)
	0.2-0.3	0.05 (VL)	2.3 (M)						
	0.5-0.6	0.13 (L)	4.1 (M)						
	0.8-0.9	0.16 (L)	4.1 (M)						
	1.1-1.2	0.11 (L)	2.0 (M)						
Owanyilla	0-0.1	0.39 (M)	2.6 (M)	5 (VL)	3 (VL)	1.9 (M)	0.11 (L)	0.15 (L)	2.7 (M)
	0.2-0.3	0.21 (M)	0.52 (VL)						
	0.5-0.6	0.16 (L)	0.10 (VL)						
	0.8-0.9	0.20 (L)	0.10 (VL)						
Peep	0-0.1	0.14 (L)	1.3 (L)	7 (VL)	8 (VL)	1.6 (M)	0.09 (L)	0.19 (L)	0.37 (L)
	0.2-0.3	0.08 (VL)	0.47 (VL)						
	0.5-0.6	0.06 (VL)	0.23 (VL)						
	0.8-0.9	0.09 (VL)	0.39 (VL)						
	1.1-1.2	0.13 (L)	0.42 (VL)						
*Springs**	0-0.1	0.13 (L)	1.9 (L)	6 (VL)	6 (VL)	1.9 (M)	0.14 (L)	0.7 (M)	0.4 (L)
	0.2-0.3	0.07 (VL)	5.7 (M)						
	0.5-0.6	0.06 (VL)	7.1 (M)						
	0.8-0.9	0.02 (VL)	7.8 (M)						
	1.1-1.2	0.02 (VL)	6.2 (M)						
*Tirroan**	0-0.1	0.10 (L)	0.50 (VL)	-	-	0.8 (L)	-	-	-
	0.2-0.3	0.10 (L)	0.20 (VL)						
	0.5-0.6	0.10 (L)	0.20 (VL)						
	0.8-0.9	0.10 (L)	0.20 (VL)						
	1.1-1.2	0.10 (L)	0.20 (VL)						
Turpin	0-0.1	0.08 (VL)	0.55(L)	4 (VL)	2 (VL)	0.88 (L)	0.03 (VL)	0.12 (L)	0.34(L)
	0.2-0.3	0.02 (L)	0.08 (VL)						
	0.5-0.6	0.1 (L)	0.16 (VL)						
	0.8-0.9	0.08 (VL)	0.08 (VL)						
	1.1-1.2								

VL –very low; L – low, M – medium
* Results derived from one analysed site only

Plant available water capacity (PAWC). PAWC (Table 12) 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.

Table 12. 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
*Bauple**	0.6	56
Butcher	0.6–0.8	62–80
*Owanyilla**	0.4	35
Peep	0.4–0.8	42–62
*Springs**	0.5	55
Turpin	0.4–0.6	37–53

* Results derived from one analysed site only

3.7 Chromosols

Chromosols are soils with strong texture contrast between the A and B horizons. The B horizon is not strongly acid and is not sodic. Two Chromosols have been mapped (Table 13). Although, *Isis* soils are dominantly Chromosols, there is a high proportion of Dermosols. Other soils *(Gooburrum, Kepnock)* have a minor Chromosol component. The Chromosols occur on 1769 ha or 4% of the survey area.

Table 13. 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	1684
HILLSLOPES ON MODERATELY WEATHERED SEDIMENTARY ROCKS			
Tirroan non sodic variant	Black or grey loamy sand, sandy loam to fine sandy loam surface over a conspicuously bleached A2 horizon (0.25 to 0.5 m) over an acid, mottled, brown or yellow sandy clay to medium clay (0.45 to 1.2 m) over weathered rock.	Brown Chromosol Yellow Chromosol	85

Landscape

The *Isis* soil occurs on hillcrests and middle to upper parts of rises or slightly elevated areas on level plains. The *Tirroan non sodic variant* occurs on gentle (5 to 8%) hillslopes of low hills.

Vegetation

The *Isis* has predominantly been cleared for sugarcane. In uncleared areas, the vegetation is dominated by pink bloodwood (*Corymbia intermedia*) and brown bloodwood (*C. trachyphloia*). Tirroan non sodic variant is dominated by stringbark (*Eucalyptus umbra*) and rusty gum (*Angophora leiocarpa*) with scattered grey ironbark (*E. siderophloia*), brown bloodwood, pink bloodwood and paperbark (*Melaleuca* spp)

Soil profile

Generally well-drained Dermosols (*Gooburrum*) occur upslope while poorly drained Hydrosols (*Alloway, Robur* associated with *Isis;* and *Woober* associated with *Tirroan non sodic variant*) occur downslope.

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

The *Tirroan non sodic variant* on moderately weathered sandstones has profile attributes similar to *Tirroan* (Sodosol) except the non sodic clay subsoil is generally brown or yellow.

Soil chemistry

Soil pH. The *Isis* is typically slightly acid in the surface (field pH 5.5 to 6.5) and slightly acid to neutral in the subsoil (field pH 5.5 to 7.0). The pH range is similar to other soils (*Gooburrum, Kepnock, Woolmer, Watalgan* and *Meadowvale)* on the deeply weathered sediments. The *Tirroan non sodic variant* has field pH similar to the *Tirroan* soil (Sodosol).

Salinity. The *Isis* soil has very low salt levels (EC <0.04 dS/m, Cl <0.004%) throughout the profile, which can be attributed to good profile drainage. The *Tirroan non-sodic variant* is non-saline and non-sodic.

Sodicity. The *Isis* soil is generally sodic (ESP <20) at depth. However, the low ECEC (5 meq/100g), low clay activity (11 meq/100 g clay) associated with 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. The nutrient levels of the *Isis* and *Tirroan non sodic variant* are shown in Table 14.

Table 14. Mean profile soil nutrients for soils of the Chromosols

	Depth (m)	K meq/100g	Ca meq/100g	Acid P mg/kg	Bicarb P mg/kg	Organic C %	Total N %	Cu mg/kg	Zn mg/kg
Isis	0-0.1	0.06(VL)	1.1 (L)	10 (L)	5 (VL)	1.4 (L)	0.17(M)	1.1(M)	0.2 (L)
	0.2-0.3	0.03 (VL)	0.39 (VL)						
	0.5-0.6	0.02 (VL)	0.38 (VL)						
	0.8-0.9	0.05 (VL)	0.34 (VL)						
	1.1-1.2	0.02 (VL)	0.39 (VL)						
Tirroan non sodic variant	0-0.1	0.29 (M)	1.5 (L)	25 (M)	21 (M)	1.6 (M)	0.1 (L)	0.6 (M)	0.5 (M)
	0.2-0.3	0.07 (VL)	1.3 (L)						
	0.5-0.6	0.07 (VL)	0.8 (VL)						
	0.8-0.9	0.04 (VL)	0.34 (VL)						
	1.1-1.2	0.05 (VL)	0.23 (VL)						

VL – very low; L – low, M – medium.

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

Table 15. Estimated PAWC (mm) and rooting depth (m) for the soils of the Chromosols

Soil	Rooting depth (m)	PAWC (mm)
Isis	>1.0	62–65
Tirroan non sodic variant	>1.0	65–86

3.8 Ferrosols

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

In the study area, two Ferrosols (Table 16) are derived from deeply weathered (lateritised) andesite mostly east of the Mary River and north of Owanyilla. Also in the study area the Dermosol (*Watalgan*) occasionally meets the requirements of the Ferrosol order (ie. have a free Fe content > 5%). Further work is required to confirm if *Watalgan* developed from deeply weathered sediments in this area is dominantly a Ferrosol. Because the Ferrosols are highly productive and extensively used for cultivation, their surface characteristics have usually been modified or lost. Therefore *Watalgan* (Dermosol) can have a similar appearance to *Bidwill* soil. *Bidwill* soil grades into *Teddington* or *Jumpo* (Dermosols) soils, while *Watalgan* grades into *Kepnock*.

Ferrosols occupy 844ha or 2% of the study area and represent the most productive soil under cultivation.

Table 16. Major attributes, classification and area for soil of the Ferrosols

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
HILLSLOPES AND PLAINS ON DEEPLY WEATHERED ANDESITE			
Bidwill	Red or occasionally black light clay to light medium clay surface (0.1 to 0.4 m) over a red light clay to light medium clay (>1.5 m) with none to few manganiferous nodules over weathered rock.	Red Ferrosol	624
Teddington	Brown or black light clay to light medium clay surface (0.15 to 0.3 m) over a mottled, red or brown light clay to light medium clay with manganiferous nodules (0.15 to 0.5 m) over a mottled, red light clay to light medium clay (>1.5 m) with manganiferous nodules over weathered rock.	Red Ferrosol	220

Landscape

The *Bidwill* soil occurs on hillcrests of rises and low hills and rarely on slightly elevated areas on plains. *Teddington* soil occurs on the middle to upper parts of gentle slopes on rises. Slopes range from 0 to 8%.

Vegetation

Vegetation has mostly been cleared with very minor remnants of vine scrub or pink bloodwood *(E. intermedia)* woodlands along road reserves.

Soil profile

The Ferrosols formed on andesite have red to black clay surfaces gradually changing to red subsoils. In cultivated fields, the original surface horizons have been lost and surfaces are now red clays. Very fine (<0.02 m) manganiferous nodules occur throughout the profiles and this helps to distinguish these soils from *Watalgan* (Dermosol) soils in cultivated fields. The Ferrosols have strong fine polyhedral peds throughout and are usually very well drained. *Teddington* soils occupy areas downslope of *Bidwill* and are less well-drained due to their landscape position; these soils are consequently mottled throughout the B horizon.

Soil chemistry

Soil pH. Both Ferrosols have field pH between 5.5 and 7.0 (laboratory pH 6.0 to 6.8 for *Bidwill* and pH 5.2 to 5.3 for *Teddington*) in the surface, with *Bidwill* being more neutral than *Teddington*. Subsoil pH ranges between 6.0 and 7.0 (laboratory pH 5.5 to 6.2 for *Bidwill* and pH 5.3 for *Teddington*).

Salinity. Both soils have negiable amounts of salt indicating they are very well drained and high in the landscape. (Maximum EC 0.03 to 0.09 dS/m).

Sodicity. Both soils are non sodic throughout their profile. (ESP <6).

Soil nutrients. Nutrient status (Table 17) of the Ferrosols reflects the parent material, leaching environment and relative age of the soils.

Table 17. Mean profile soil nutrients for soils of the Ferrosol

	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
Bidwill	0-0.1	1.04 (VH)	5.9 (M)	5 (VL)	13 (L)	3.1 (H)	0.28(H)	2.9(M)	3.4 (M)
	0.2-0.3	0.58 (H)	4.0 (M)						
	0.5-0.6	0.26 (M)	2.6 (M)						
	0.8-0.9	0.04 (VL)	1.6 (L)						
	1.1-1.2	0.03 (VL)	1.0 (L)						
Teddington *	0-0.1	0.35 (M)	7.8 (H)	2 (VL)	-	2.4 (M)	0.19(M)	-	-
	0.2-0.3	0.10 (L)	7.3 (H)						
	0.5-0.6	0.30 (M)	7.6 (H)						
	0.8-0.9	0.60 (H)	4.9 (H)						

VL –very low; L – low, M – medium, H – high, VH – very high
*Results derived from one analysed site only

Plant available water capacity (PAWC). Ferrosols in the study area have high water holding capacities due to their high clay content, organic carbon content and unrestricted plant-rooting depth (>1m). Two analysed sites on *Bidwill* soil have a estimated PAWC range of 124 to 152mm.

3.9 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 nineteen soils and two variants are included in this soil order (Table 18). They include soils formed on andesite, deeply weathered and moderately weathered sedimentary rocks, and alluvium. This group of soils occupy 10 427 ha or 21% of the study area and represent the main group of soils under cultivation for sugarcane and horticulture.

Table 18. Major attributes, classification and areas for soils of the Dermosols

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
HILLSLOPES ON MODERATELY WEATHERED ANDESITE			
Tiaro	Black or brown clay loam to light medium clay surface (0.05 to 0.35 m) over a neutral to alkaline, black or brown light clay to medium clay (0.2 to 0.65 m) over a grey light clay to medium heavy clay (0.55 to 0.85 m) with andesite fragments and occasional carbonate nodules over weathered rock.	Black Dermosol Brown Dermosol	557
Netherby	Black or grey clay loam to light medium clay over a sporadically bleached clay loam to light clay A2 horizon (0.1 to 0.2 m) over a brown or grey light medium clay to medium clay (0.3 to 0.45 m) over a mottled, brown or grey light medium clay to medium clay (0.5 to 1.7 m) with manganiferous soft segregations or nodules over weathered rock.	Brown Dermosol Grey Dermosol	1238
HILLSLOPES ON DEEPLY WEATHERED ANDESITE			
Jumpo	Grey or brown clay loam fine sandy to light medium clay surface (0.1 to 0.3m) over a mottled, neutral, brown or yellow light clay to medium heavy clay with manganiferous nodules.	Brown Dermosol Yellow Dermosol	461
HILLSLOPES ON MODERATELY WEATHERED SEDIMENTARY ROCKS			
Bucca	Grey, brown or black light clay to light medium clay surface over a sporadically bleached A2 horizon (0.15 to 0.35 m) over a mottled, grey or brown medium clay to heavy clay (0.7 to1.35 m) over a grey light clay to medium clay (0.7 to 1.5 m) with mudstone, tuff or rhyolite fragments over weathered rock.	Grey Dermosol Brown Dermosol	953

Table 18 (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	491
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	87
PLAINS AND HILLSLOPES ON DEEPLY WEATHERED FINE GRAINED SEDIMENTARY ROCKS			
Avondale Yellow variant	Grey or black fine sandy loam to clay loam fine sandy surface over a bleached fine sandy loam to clay loam fine sandy A2 (0.15 to 0.35 m) over an acid mottled, yellow light clay to light medium clay (0.4 to 0.6 m) over a mottled grey medium heavy clay to heavy clay (0.4 to 1.5 m) over a mottled acid, grey, medium clay to heavy clay with rock fragments.	Yellow Dermosol	9
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	244
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	1822
Otoo	Black or brown fine sandy clay loam to clay loam surface (0.25 to 0.45 m) over a yellow or brown fine sandy light clay to light clay (0.55 to 0.95 m) over a red light clay to light medium clay with ferruginous nodules.	Red Dermosol	11
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	35
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	Not mapped
Watalgan	Black or brown clay loam surface over an acid, red light clay to medium clay with ferruginous nodules.	Red Dermosol	1581

Table 18 (continued)

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
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	180
Copenhagen	Brown to black, loam to clay loam surface (0.05 to 0.5m) over brown, neutral, loam to fine sandy light clay A3/B1 horizon (0.5 to 0.95 m) over brown, neutral, sandy clay loam to fine sandy light clay (0.95 to 1.5 m) over brown alluvial sand or loam.	Brown Dermosol Orthic Tenosol Leptic Tenosol	343
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	2954
Mungar	Black or grey silty light to silty light medium clay over a sporadically bleached light to light medium clay A2 horizon (0.1 to 0.25 m) over a mottled, alkaline grey or brown light medium clay to medium heavy clay with manganiferous and/or calcareous nodules.	Brown Dermosol Grey Dermosol	1239
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	802
Mary Dark Variant	Black silty clay loam to silty clay surface (0.1 to 0.25 m) over an acid to neutral, black, light clay to medium clay.	Black Dermosol	98
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	437
ALLUVIAL PLAINS OF LOCAL CREEKS			
Gutchy	Black or grey alkaline light medium clay surface (0.2 to 0.4 m) over black, grey or brown medium clay to medium heavy clay (1.2 to 1.5 m) over a strongly alkaline, grey medium heavy clay with calcareous nodules, gravels and grit.	Grey Dermosol Oxyaquic Hydrosol	94

Landscape

The *Jumpo, Netherby* and *Tiaro* Dermosols on andesite occur as gently hillslopes of rises and low hills with slopes up to 15%.

Otto, Watalgan and *Woolmer* soils on the deeply weathered sedimentary rocks generally occur as hillcrests on rises and low hills or slightly elevated areas on level plains. The remaining Dermosols on sedimentary rocks, except *Bungadoo*, generally occur on hillslopes or hillcrests on gently undulating rises with slopes generally <8% or level plains. *Bungadoo* only occurs on the crests and hillslopes of the silicified *Maryborough Formation* with slopes up to 20%.

The *Granville* and *Mungar* soils occur on the elevated alluvial plains or older terraces of the Mary River. *Mungar* soil can occur anywhere on the elevated alluvial plains, however *Mungar* always occupies swamps of the backplains of these elevated plains. *Aldershot* occurs on the elevated edges of the older terraces while the *Copenhagen*, *Mary* and *Walker* soil occurs on channel benches, scrolls and floodplains of the Mary River.

Gutchy soil occurs on broad alluvial plains of small creeks draining the western side of Mt. Guyra.

Vegetation

Vegetation is variable, generally corresponding to soil wetness and geology. Soils on deeply weathered andesites (*Jumpo*) is dominated by yellow stringybark (*Eucalyptus acmenoides*), Queensland peppermint (*Eucalyptus exserta*), broad-leafed red ironbark (*E. fibrosa*), swamp box (*Lophostemon sauvelons),* pink bloodwood (*Corymbia intermedia*), forest red gum (*E. tereticornis*) and moreton bay ash (*C. tesselaris).*

Dermosols on deeply weathered sediments (*Otoo*, *Watalgan, Woolmer, Kepnock, Meadowvale, Gooburrum*) have been mostly cleared, where remnants of vegetation remain, the vegetation is dominated by pink bloodwood with grey ironbark (*E. siderophloia*) and yellow stringybark on *Watalgan* soils, with broad-leaved white mahogany (*E. umbra*) on *Kepnock* soils, and with yellow stringybark, and narrow leaved ironbark (*E. crebra*) on *Gooburrum* soils. The very rocky soils of *Bungadoo* generally have tall lemon scented gum/spotted gum (*C. citriodora*) with other scattered eucalypts and a dense understory of brushbox (*L. conferta*). The *Woco* soil is of limited extent with stringy bark (*E. umbra*) and scattered pink bloodwood and tea tree *(Melaleuca viridiflora*). Soils found on the alluvial plains of local creeks and the Mary River have been mostly cleared.

Soil profile

The Dermosols formed on moderately weathered andesite rocks generally have black or brown finely structured loamy to clayey surface overlying a mottled sodic clay which has shrink-swell characteristics. Soils on the mid to lower slopes (*Netherby*) have a sporadic bleach usually reflecting poorer drainage. Soils on the upper slopes are shallower and better structured (*Tiaro*). Soils formed on deeply weathered andesite (*Jumpo*) near Maryborough have loamy surfaces over a mottled brown well structured clayey subsoils. Mangaiferrous segregations are common. Where the soil is cultivated, the loamy surface may have been mixed with the subsoil making the surface horizon clayey. The soil usually occurs down slope of *Bidwill* (Ferrosol) soils and will usually grade into Dermosols or Sodosols on moderately weathered andesite downslope.

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

The *Walker*, *Copenhagen* and *Mary* soils occur on the alluvial plains of the Mary River. *Mary* is a moderately well drained brown clay loam to clay soil and grades into the imperfectly to poorly drained *Walker* soil (Hydrosols) on lower channel benches. *Copenhagen* soil is a lighter version of the *Mary* soil, it occurs on the levees and scrolls closer to the channel margins of the river. The structure is less developed and the soil overlies sandy subsoils. The *Granville* and *Mungar* soils have a sodic grey heavy clay subsoil with vertic properties that do not crack on the surface and have normal gilgai where not cultivated. *Granville* and *Mungar* soils grade into *Beaver* (Hydrosol) in swamps and *Butcher* (Sodosol) closer to the river margins. The *Aldershot* soil on elevated edges of terraces has a well-drained red or brown clay subsoil.

The *Gutchy* soil is developed on alluvia originating from Mt. Guyra to the east. Mt. Guyra is a granitic intrusion. Soils on the alluvial fans grade from *Guyra* (Tenosol) near the base of Mt. Guyra into *Springs* (Sodosol) soil at the base of the fans and then into *Gutchy* soil on the alluvium. *Gutchy* soil is clayey throughout, has a strong alkaline trend and has black or grey structured surface over a subsoil with lenticular structure and calcareous segregations.

Soil chemistry

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

The soils on moderately weathered andesite (*Tiaro* and *Netherby*) have a neutral to alkaline trend with a surface field pH between 6.0 and 7.5 (laboratory pH 5.4–6.5) and a subsoil field pH between 5.5 and 8.0 (laboratory pH 5.9–7.4). The *Jumpo* soil on deeply weathered andesite has a slightly acid to neutral surface (field pH 5.5–7.0, laboratory pH 6.3) over a slightly acid subsoil (field pH 5–7, laboratory pH 5.2).

The soils developed on deeply weathered sedimentary rocks (*Gooburrum, Kepnock, Meadowvale*, *Otoo*, *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 parent material. The *Granville* soil on older alluvial plains has a strongly acid to neutral pH (field pH 5.0–7.0, laboratory pH 5.2–7.7), whilst *Aldershot, Copenhagen*, *Mar*y and *Mungar* soils have a slightly acid to mildly alkaline pH (field pH 5.5–8.0, laboratory pH 6.0–7.6).

Salinity. Dermosols on moderately weathered andesite (*Tiaro* and *Netherby*) have very low salt levels throughout their profile (EC <0.1dS/m, Cl <0.011%) however soils on deeply weathered andesite (*Jumpo*) have low salt in their surface (mean field measured EC 0.12 dS/m) and moderate salt levels in subsoils (mean field measured EC 0.37 – 0.62 dS/m).

Dermosols on sedimentary rocks (*Bungadoo, Watalgan, Gooburrum, Kepnock, Meadowvale, Otoo, Woolmer*), except *Woco*, 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.

Granville and *Mungar* soils on the alluvial plains have moderate to high salinity (0.60 to 1.1 dS/m) in the subsoil corresponding to impermeable, strongly sodic subsoils. The *Mary* soil has very low salt levels due to good drainage (EC <0.16, Cl <0.008). The *Aldershot* and *Copenhagen* soil have no EC information, however they have good profile drainage and occur in elevated positions and thus would be expected to also have very low salts in their profile.

Sodicity. The Dermosols on moderately weathered andesite (*Tiaro* and *Netherby*) are non sodic throughout (ESP for *Tiaro* soil <5) however soils on deeply weathered andesite (*Jumpo*) are strongly sodic in the B horizon (ESP 18-27) and this corresponds with moderate levels of salinity in the B horizon.

The red and yellow Dermosols developed on deeply weathered sedimentary rocks (*Bungadoo, Gooburrum*, *Kepnock, Meadowvale, Otoo, Watalgan, 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 (Wilson *et al.* 1999).

The *Granville* soil on the Mary River alluvium is strongly sodic (ESP >38) at greater than 0.5 m; *Mungar* subsoil is less sodic (ESP <26). The *Aldershot*, *Copenhagen*, *Gutchy*, and *Otoo* soils have no analysed information.

Soil nutrients. Nutrient status (Table 19) of the Dermosols reflects the parent material, leaching environment and relative age of the soils.

The Dermosols developed on moderately weathered andesite (*Tiaro* and *Netherby*) and the younger alluvium of the Mary River (*Mary*) have moderate to high levels of exchangeable cations and micro elements, a neutral pH range, (favourable for nutrient availability) and have high base status throughout their profiles, indicating good fertiliser retention capacity.

The Dermosols developed on the deeply weathered sedimentary rocks (*Watalgan, Gooburrum, Bungadoo, Kepnock, Meadowvale, Woolmer, Woco)* typically have low to very low levels of all nutrients, reflecting the strong leaching environment they have endured and their poor capacity to retain nutrients (low base status). The strong surface accumulation of Ca and K indicates organic matter accumulation. 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 Dermosol developed on deeply weathered andesite (*Jumpo*), has low nutrient levels apart from exchangeable magnesium, is acidic and magnesic throughout and has a high base status. This soil reflects its strong leaching and weathering environment (low available nutrients) and its andesite parent material (andesite contributes magnesium to the profile). Because of the soil's high base status it would be expected to respond well to liming and fertiliser.

The *Aldershot, Copenhagen* and *Walker* soils on the alluvial plain have not been analysed. The *Granville* and *Mungar* soils have low to medium nutrient levels, and a strong surface accumulation of nutrients corresponding with high surface organic carbon contents.

Table 19. Mean profile soil nutrients for soils of the Dermosols

	Depth (m)	K meq/100g	Ca meq/100g	Acid P mg/kg	Bicarb P mg/kg	Organic C %	Total N %	Cu mg/kg	Zn mg/kg
*Bungadoo**	0-0.1	0.5 (M)	2.6 (M)	8 (VL)	7 (VL)	6.0 (VH)	0.27(M)	0.05 (VL)	0.72 (VL)
	0.2-0.3	0.26 (L)	0.19 (VL)						
	0.5-0.6	0.15 (L)	0.02 (VL)						
	0.8-0.9	0.14 (VL)	0.13 (VL)						
	1.1-1.2	0.18 (L)	0.06 (VL)						
Gooburrum	0-0.1	0.15 (L)	1.9 (L)	<5(VL)	7 (VL)	1.5 (M)	0.07(L)	0.09 (VL)	0.31 (L)
	0.2-0.3	0.09 VL)	0.64 (VL)						
	0.5-0.6	0.09 (VL)	0.46(VL)						
	0.8-0.9	0.07 (VL)	0.85 (VL)						
	1.1-1.2	0.1 (L)	1.1 (L)						
Granville	0-0.1	0.30 (M)	3.3 (M)	5 (VL)	7 (VL)	2.3 (M)	0.15 (L)	1.2 (M)	1.0 (M)
	0.2-0.3	0.12 (L)	2.0 (M)						
	0.5-0.6	0.16 (L)	1.3 (L)						
	0.8-0.9	0.20 (L)	1.1 (L)						
	1.1-1.2	0.29 (M)	0.38 (VL)						
*Jumpo**	0-0.1	0.21 (L)	4.1 (H)	2 (VL)	4 (VL)	2.6 (H)	0.17(M)	0.72 (L)	1.1 (M)
	0.2-0.3	0.05 (VL)	0.6 (VL)						
	0.5-0.6	0.05 (VL)	BQ						
	0.8-0.9	0.11 (L)	0.19 (VL)						
	1.1-1.2	0.17 (L)	0.51 (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)
	0.2-0.3	0.08 VL)	0.57(VL)						
	0.5-0.6	0.03(VL)	0.56 (VL)						
	0.8-0.9	0.06 (VL)	0.34 (VL)						
	1.1-1.2	0.04 (VL)	0.33 (VL)						
Mary	0-0.1	0.98 (H)	6.9 (H)	--	--	1.6 (M)	0.17(M)	2.5 (M)	2.7 (M)
	0.2-0.3	0.22 (M)	8.7 (H)						
	0.5-0.6	0.17 (L)	8.8 (H)						
	0.8-0.9	0.14 (L)	7.9 (H)						
	1.1-1.2	0.13 (L)	6.8 (H)						
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)
	0.2-0.3	0.04 (VL)	0.16 (VL)						
	0.5-0.6	0.05 (VL)	0.09 (VL)						
	0.8-0.9	0.04 (VL)	0.32 (VL)						
	1.1-1.2	0.04 (VL)	0.4 (VL)						
*Mungar**	0-0.1	0.63 (H)	9 (H)	7 (VL)	18 (L)	2.78 (H)	0.18(M)	1.3 (M)	1.7 (M)
	0.2-0.3	0.15 (L)	4.7 (M)						
	0.5-0.6	0.11 (L)	2.3 (M)						
	0.8-0.9	0.13 (L)	1.6 (L)						
	1.1-1.2	0.16 (L)	1.5 (L)						
Tiaro	0-0.1	0.36 (M)	8.0 (H)	16 (L)	12 (L)	2.1 (M)	0.24(M)	0.48(M)	1.1 (M)
	0.2-0.3	0.11 (L)	7.5 (H)						
	0.5-0.6	0.29 (M)	10.0 (H)						
	0.8-0.9	0.31 (M)	10.0 (H)						
	1.1-1.2	0.15 (L)	8.3 (H)						
Woco	0-0.1	0.22 (M)	2.0 (L)	--	1 (VL)	1.7 (M)	0.11 (L)	0.39(M)	0.93(M)
	0.2-0.3	0.10 (L)	0.75 (VL)						
	0.5-0.6	0.11 (L)	0.48 (VL)						
	0.8-0.9	0.16 (L)	0.21 (VL)						
	1.1-1.2	0.30 (M)	0.11 (VL)						
Woolmer	0-0.1	0.12 (L)	0.79 (VL)	3 (VL)	1 (VL)	0.7 (L)	0.04 (VL)	0.38(M)	0.36 (L)
	0.2-0.3	0.05 (VL)	0.44 (VL)						
	0.5-0.6	0.03 (VL)	0.09 (VL)						
	0.8-0.9	0.08 (VL)	0.15 (VL)						
	1.1-1.2	0.03 (VL)	0.08 (VL)						
Watalgan	0-0.1	0.33 (M)	3.7 (M)	5 (VL)	5 (VL)	2.4 (M)	0.18(M)	0.62(M)	1.5 (M)
	0.2-0.3	0.16 (L)	1.8 (L)						
	0.5-0.6	0.04 (VL)	0.7 (VL)						
	0.8-0.9	0.06 (VL)	0.8 (VL)						
	1.1-1.2	0.07 (VL)	0.1 (VL)						

VL – very low; L – low; M – medium; H – high; VH – very high; BQ – results less than the smallest measureable amount possible.
*Results derived from one analysed site only

Plant available water capacity (PAWC). The Dermosols on andesite (*Tiaro* and *Netherby*) have high PAWC due to their high clay content. Dermosols on deeply weathered sediments with sandy surface textures (*Gooburrum*, and *Meadowvale*) have lower PAWC compared to similar soils with loamy surface textures (*Watalgan, Kepnock, Woolmer*). The *Watalgan* soil has PAWC as high as the Ferrosols (*Bidwill* and *Teddington*) in the area. 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 (Table 20).

The *Granville* and *Mungar* soils on alluvium have a medium PAWC (73–101 mm) due to shallow rooting depth from strongly sodic subsoil and a salt bulge in the B horizon. No analysed profiles, and therefore only estimated PAWC, are available for *Aldershot, Copenhagen, Walker* and *Gutchy* soils. Based on profile morphology, rooting depth should be >1 m with a PAWC of >75 mm for *Aldershot*.

Table 20. Estimated PAWC (mm) and rooting depth (m) for soils of the Dermosols

Soil	Rooting depth (m)	PAWC (mm)
Aldershot	>1m	75–100*
Bungadoo	0.4–0.6	<50*
Copenhagen	>1.0	50-75*
Gooburrum	>1.0	63
Granville	0.4–0.6	73–101
Gutchy	0.5-1.1	80–135*
Jumpo	0.8	108
Kepnock	>1.0	74–105
Mary	>1.0	73–84
Meadowvale	>1.0	68
Mungar	<0.65	72
Netherby	0.5 – >1.0	66–115*
Otoo	>1.0	100-125*
Tiaro	>1.0	115†
Walker	>0.6	50-75*
Woco	0.4–1.0	65–105
Woolmer	>1.0	73–90
Watalgan	>1.0	117–148

† Result derived from one analysed site only.

- This is an estimate of PAWC based on soils with similar morphology.

3.10 Kandosols

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

Seven Kandosols have been recognised (Table 21). They occupy 825 ha or 2% of the study area.

Table 21. 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	223
Quart	Grey loamy sand to sandy loam surface over an acid, mottled, yellow sandy clay loam to clay loam.	Yellow Kandosol	40
PLAINS AND HILLSLOPES ON DEEPLY WEATHERED FINE GRAINED SEDIMENTARY ROCKS			
Oakwood	Brown or black clay loam fine sandy to light clay surface (0.25 to 0.35m) over a brown or red clay loam fine sandy to light clay (0.45 to 0.7m) over a red fine sandy light clay to light medium clay with ferruginous nodules.	Red Kandosol	48
ALLUVIAL PLAINS OF LOCAL CREEKS			
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	326
ALLUVIAL PLAINS OF THE MARY RIVER			
Kooringa	Black sandy loam to loam surface (0.25 to 0.3 m) over a brown sandy clay loam with none to very few manganiferrous nodules (0.5 to 1.15 m) over layered alluvial sands or loams.	Brown Kandosol	158

Table 21 (cont).

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
ALLUVIAL FANS			
Guyra	Black or grey loamy sand to coarse sandy clay loam surface over a bleached coarse sand to sandy clay loam A2 horizon (0.3 to 0.45m) over a brown coarse sand to sandy clay loam (0.5 to 1.2m) over brown gritty coarse sand layers.	Brown Kandosol Orthic Tenosol	30

Landscape

The Kandosols on deeply weathered sedimentary rocks occur on hillcrests and hillslopes 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 Kandosols on alluvium occur on channel benches of local creeks (*Littabella*), on relict scroll plains of the Mary River (*Kooringa*) above current floodplains and on prior streams of alluvial fans (*Guyra*). These landforms are all gently (1–3%) undulating on flats.

Vegetation

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

Soil profile

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

The Kandosols formed on sandstone typically have a sandy surface over a sandy clay loam to clay loam subsoil (*Farnsfield* and *Quart*). Subsoil colour changes from red (*Farnsfield*) to yellow (*Quart*) 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 downslope.

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. The Kandosol on Mary River alluvium (*Kooringa*) has a reddish brown sandy loam increasing to sandy clay loam subsoil over sands and loams. This soil is associated with relict levees and scroll plains on Quaternary Pleistocene alluvium upstream of Tiaro. The Kandosol (*Guyra*) on alluvial fans from nearby Mt. Guyra usually have moderately deep brown coarse sandy or gritty soils over gritty sediments.

Soil chemistry

Soil pH. Soil pH for the Kandosols derived from sedimentary rocks is typically strongly acid to medium acid (laboratory surface pH 4.8–6.3, subsoil pH 4.7–6.4). Lower subsoil pH is associated with lower calcium levels. The Kandosol on fans (*Guyra*) and older alluvial plains of the Mary River (*Kooringa*), have a neutral pH range throughout their profile (Field pH 6.0–7.0 surface, pH 6.5–7.0 subsoil)

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

Sodicity. The *Farnsfield, Oakwood, Quart,* and *Kooringa* soils are predominantly non sodic (ESP ≤5) at depth but occasionally sodic (ESP <11). Due to low ECEC (<6 meq/100 g) and low clay activity (15 meq/100 g clay), the effects of sodicity on dispersion are not expressed.

Soil nutrients. The *Farnsfield* and *Quart* 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 22). The better drained *Farnsfield* soil has on average, higher nutrients that the imperfectly drained *Quart*. *Oakwood* soil which has a higher clay content than the other Kandosols on deeply weathered sediments has moderate levels of nutrients in the surface and upper parts of its subsoil, however the soil becomes magnesic at depth. *Littabella* would be expected to be low in all nutrients. *Guyra* is expected to be high in exchangeable potassium due to the granite rocks, and low in all other nutrients. Favourable pH levels for the *Kooringa* soil have resulted in moderate levels of calcium being available.

Table 22. 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	0.31 (M)	2.1 (M)	4 (VL)	8 (VL)	1.2 (L)	0.11 (L)	0.7 (M)	0.6 (M)
	0.2-0.3	0.13 (L)	1.2 (L)						
	0.5-0.6	0.10 (L)	1.4 (L)						
	0.8-0.9	0.06 (VL)	1.6 (L)						
	1.1-1.2	0.04 (VL)	1.3 (L)						
*Kooringa**	0-0.1	0.63 (H)	2.9 (M)	-	-	1.89(M)	0.15 (L)	-	-
	0.2-0.3	0.60 (H)	1.6 (L)						
	0.5-0.6	0.20 (L)	2.0 (M)						
	0.8-0.9	0.20 (L)	2.4 (M)						
	1.1-1.2	0.20 (L)	2.7 (M)						
Oakwood	0-0.1	0.35 (M)	4.0 (M)	-	10 (L)	2.3 (M)	0.15 (L)	0.99(M)	-
	0.2-0.3	0.37 (M)	2.5 (M)						
	0.5-0.6	0.15 (L)	2.2 (M)						
	0.8-0.9	0.16 (L)	2.0 (M)						
	1.1-1.2	0.10 (L)	1.4 (L)						
Quart	0-0.1	0.23 (M)	1.0 (L)	3 (VL)	7 (VL)	1.0 (L)	0.05 (VL)	0.24 (L)	0.29 (L)
	0.2-0.3	0.09 (VL)	0.56 (VL)						
	0.5-0.6	0.08 (VL)	0.85 (VL)						
	0.8-0.9	0.09 (VL)	0.94 (VL)						
	1.1-1.2	0.10 (VL)	0.92 (VL)						

VL – very low; L – low; M – medium
*Results derived from one analysed site only

Plant available water capacity (PAWC). The sandy surfaces of *Farnsfield* and *Quart,* give rise to a low to medium PAWC (Table 23). *Littabella, Guyra* and *Kooringa* soils are sandy throughout and thus have very low PAWC.

Table 23. Estimated PAWC (mm) and rooting depth (m) for soils of the Kandosols

Soil	Rooting depth (m)	PAWC (mm)
Farnsfield	>1.0	43–84
Guyra	>1.0	<50*
Kooringa	>1.0	60
Littabella	>1.0	<50*
Oakwood	>1.0	100
Quart	>1.0	54–82

- This is an estimate of PAWC based on soils with similar morphology.

3.11 Rudosols

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

The *Baddow* soil is the only soil mapped in this soil order. It is confined to the alluivum along the Mary River and occupies 207 ha or 0.4% of the study area but represents an important agricultural soil (Table 24).

Table 24. Major attributes, classification and areas for the soil of the Rudosols

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
ALLUVIAL PLAINS OF THE MARY RIVER			
Baddow	Brown sand to sandy loam surface (0.1 to 0.25 m) over a layered, brown sand to loamy sand.	Stratic Rudosol	207

Landscape

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

Vegetation

The vegetation has been mostly cleared.

Soil Profile

The *Baddow* soil has brown sand to sandy loam surface over brown stratified sands. Subsoil layers can have up to a loamy sand texture. Surface soil structure can have a massive or weak structure grade; subsoil layers are usually massive or single grain in structure. The soil has a slightly acid to neutral pH throughout (Field pH 6.0 to 7.0). No analysed profiles are available for this soil.

3.12 Tenosols

Tenosols are soils with only weak pedological organisation apart from the A horizons. The Tenosols in the study area are confined to soils with conspicuously bleached A2 horizons over rock (*Takoko* and *Avondale tenic variant*), sandy soils on channel benches of the Mary River (*Tinana*), occasionally *Copenhagen* soil (Dermosol) and occasionally a sand on prior streams of a fan deposit *Guyra* soil (Kandosol). They cover 246 ha or 0.5% of the survey area. (Table 25).

Table 25. 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 COURSE GRAINED SEDIMENTARY ROCKS			
Rothchild	Black or grey sand to sandy loamy surface over a conspicuously bleached or unbleached A2 horizons (0.4 to 0.9 m) over an acid, massive, red, brown or yellow loamy sand to sandy loam (0.6 to 1.15 m) over weathered sandstone.	Bleached-Orthic Tenosol Orthic Tenosol	39
HILLSLOPES ON DEEPLY WEATHERED FINE GRAINED SEDIMENTARY ROCKS			
Avondale Tenic Variant	Grey or black fine sandy loam to clay loam fine sandy surface over a conspicuously bleached, mottled, fine sandy loam to clay loam fine sandy (0.15 to 0.3 m) over duricrusted sedimentary rock.	Bleached-Leptic Tenosol	6
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-LepticTenosol	125
ALLUVIAL PLAINS OF THE MARY RIVER			
Tinana	Grey sandy loam to clay loam sandy surface (0.05 to 0.30 m) over a brown loamy sand to sandy loam subsoil (0.3 to 1.1 m) over a brown clay loam sandy to light medium clay layers.	Orthic Tenosol	115

Landscape

The *Takoko* soil occurs on crests and hillslopes with slopes of 1–20% in association with the *Bungadoo* Dermosols. *Avondale Tenic variant* occurs in association with *Avondale* soils on deeply weathered fine grained sediments. The soil occurring along the Mary River (*Tinana*) occurs on the margins of the Mary River usually in areas subject to regular flooding.

Vegetation

The vegetation on the *Takoko* soil and associated *Bungadoo* soil (Dermosol) is dominated by tall (18–20 m) lemon scented gums/spotted gum (*Corymbia citriodora*) with other gums such as stringybark (*Eucalyptus umbra, E. acmenoides*) and brown bloodwood (*C. trachyphloia*). A dense understory of brush box (*Lophostemon confertus*) is usually present. The *Avondale Tenic variant* has similar vegetation to *Avondale* soil, dominated by broad leaved stringbark (*E. umbra*) and smooth-barked apple (*Angophora leiocarpa*). The soils on alluvium have been mostly cleared.

Soil profile

The *Takoko* soil has a black or grey clay loam surface and a conspicuously bleached A2 horizon over silicified rock of the *Maryborough Formation*. This soil has the same surface horizons as the *Bungadoo* soil. The *Avondale Tenic variant* has a loamy surface and a conspicuously bleached A2 horizon (as for the *Avondale* Sodosol) overlying deeply weathered sedimentary rocks (duricrust). This soil frequently occurs on the edge of low cliffs or remnants of deeply weathered rock on hillcrests. The duricrust (indurated, fine sandstone and siltstone) is within 0.3 m of the surface. *Avondale Tenic variant* soil is free of hard rock fragments in the A horizon, where as *Takoko* soil is dominated by more than 20% rock fragments (fragmented silicified mudstones) throughout the A horizon. The *Tinana* soil has a brown sandy fabric throughout and overlies layered loamy or clayey alluvial sediments.

Soil chemistry

No analysed profiles for the Tenosols are available in the Maryborough–Tiaro area.

Field pH in the *Avondale Tenic variant* and *Takoko* soils are typically acid (pH 5.0 to 6.5). *Tinana* soils on alluvial sediments have slightly acid to neutral field pH (pH 5.5 to 6.5) throughout their profile.

4. Limitations to irrigated land uses

The information and discussion presented in this study area is adapted from the Burdekin River Irrigation Area surveys (Donnollan 1991).

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–Tiaro 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 and cauliflowers), cucurbits (melons, and pumpkins), grape, lucerne, lychee, improved pasture, macadamia, maize, mango, navybean, peanut, pineapple, exotic pines, potato, sorghum, soybean, stonefruit, sugarcane, sweetcorn, sweet potato, and vegetables (small crops). 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–Tiaro area are listed in Table 26.

Table 26. Land use requirements and limitations for irrigated farming systems* in the Maryborough–Tiaro area

Land use requirements	Limitations
Frost free	climate (cf)
Adequate rainfall (rainfed crops only)	climate (cp)
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 (pd)
Absence of damaging floods	flooding (f)
Rock-free	rockiness (r)
Adequate production area	landscape complexity (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 (ss)
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)

(after Land Resources Branch Staff, 1990)

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–Tiaro 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 (exotic pines) decrease gradually from north-east to south-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. Hilltops and east and north of Owanyilla 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 Mary River upstream of Owanyilla 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 (salt bulge). 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 (Bourne and Harris 1985). For a soil with a PAWC of 100 mm, 100 mm irrigation could be applied every 17 days, whereas a soil with a PAWC of 50 mm 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 recharge will reduce the amount of water available for crop growth and therefore, require more frequent irrigation (see soil profile recharge limitation) (Wilson *et al.* 1999).

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 available water 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).

Bureau of Sugar Experiment Stations (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 (*Baddow*, *Kinkuna, Kooringal, Guyra, Littabella, Theodolite, Tinana, Winfield, Rothschild*), sandy surfaced sodic texture contrast soils (*Butcher sandy variant*, *Bauple*, *Doongul*, *Robur, Turpin, Tirroan*) and shallow rocky soils (*Isis Rocky Phase*, *Kolan rocky phase, Tirroan Rocky Phase, Avondale rocky phase, Bungadoo*) have very low estimated PAWC (<50 mm). Some sodic texture contrast soils (*Avondale* and *Kolan*) with very shallow rooting depth (<0.4 m) also have very low PAWC. Deep (>1 m), loamy to clayey surfaced, structured soils *(Bidwill, Teddington, Jumpo, Granville, Mungar, Woober, Walker, Oakwood, Pelion, Kepnock, Watalgan, Mary*) generally have high PAWC (>100 mm). Natural rooting depth of crops (eg. shallow rooted 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 common limitation in the survey area occurring over 11 835 ha or 26% 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 *(Alloway, Avondale, Bungadoo, Clayton, Isis, Kepnock, Kinkuna, Meadowvale, Quart, Robur, Rothchild, Theodolite, Turpin, Woco, Woolmer, 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 adsorbing 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 (Wilson *et al.* 1999).

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 27 473 ha or 60% of the area, and those with low potassium (<0.2 meq/100 g) occupy 25 103 ha or 55% of the area.

Nutrient leaching (nl)

Nutrient 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 (*Baddow, Copenhagen, Isis Rocky phase, Guyra, Kinkuna, Kooringal, Littabella, Rothchild, Tinana, Tirroan Rocky phase, Winfield*), well drained soils (*Bidwill, Farnsfield, Oakwood*), and low effective cation exchange capacity soils (*Alloway, 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 1769 ha or 3.5% of the survey 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 phosphorus (Wilson 1997). Soils with these attributes include *Beaver* and *Walker* soils. Limitation classes are shown in Appendix V.

Humic soils are very minor and only occupy 15 ha of the survey 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 (Wilson 1997). Limitation classes (Appendix V) are based on soil pH in the top 0.3 m.

Strongly acid soils (pH <5.5) occupy 6016 ha or 13% 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, using drains, using short irrigation times and ensuring adequate bed height.

Wetness can cause problems with timeliness of operations resulting in delays in seedbed preparation, 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.

Generally, soils on the deeply weathered sediments which occur in drainage depressions or lower slope positions are poorly drained *(Alloway, Clayton, Kalah, Robur, Tirroan, Winfield)*. Soils on upper slope positions are generally imperfectly to well drained (*Bungadoo, Farnsfield, Gooburrum, Kepnock, Kinkuna, Meadowvale, Oakwood, Quart, Watalgan, Woco, Woolmer).*

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 (*Butcher, Granville, Mungar, Peep, Pelion, Springs, Timbrell*, *Woober,)* have high salt levels (EC >0.7 dS/m) in the subsoil. The soil bulge at depth indicates the depth of regular wetting and seasonal watertables mobilising salts towards the surface. This suggests that surface water does not regularly penetrate to depth (otherwise salts would be leached out of the surface) 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 (Wilson 1997).

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. Limitation classes are shown in Appendix V.

Wetness is a major limitation in the survey area. A total of eight soils covering 12% of the area are classified as Hydrosols, which typically occur on lower slopes, depressions and valley or river flat. A number of other soil profile classes have Hydrosols as minor components. A total of 7178 ha or 16% of the area has been assessed as having a poorly drained horizon at 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 (Wilson 1997). Soils <0.3 m in depth are minor in the study area (1705ha or 4%).

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 (Wilson 1997).

Floods in the study area are mainly associated with rain depressions or cyclones and major floods usually occur with heavy rainfall in the upper catchment. Heavy rainfall in the local area usually results in minor flooding of limited duration (Wilson 1997).

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 (Wilson 1997).

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 (Wilson 1997).

Crop damage depends on its susceptibility to flooding. Sugar Cane 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 (Wilson 1997).

One in ten year floods or more frequent affect 2148 ha or 5% 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 (Wilson 1997).

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 which do not require regular cultivation are not effect by this limitation (Wilson 1997).

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 *Avondale rocky phase, Bauple*, *Bungadoo, Isis Rocky phase, Kolan Rocky phase, Tatako, Tirroan Rocky phase* and *Tiaro* 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 creeks 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 co-dominant 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, Mungar, Pelion, Woober*), 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 2697 ha or 6% 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 of 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, Butcher, Givelda, Kolan, Owanyilla, 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 (*Avondale, Butcher, Clayton, Kalah, Kepnock, Kolan, Kolbore, Peep, Timbrell, Woco, 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.

Strongly hardsetting soils associated with fine sandy loam to clay loam fine sandy textures are very common and affect 25 780 ha or 56% 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 (1988) showed that finer tilths were produced at soil water contents nearer the plastic limit, than with wetter profiles. However, a fine seedbed could also be produced by increasing the number of implement passes over a range of moisture contents. This is a more expensive option however, and may cause compaction problems.

The clay soils *(Bucca, Granville, Gutchy, Jumpo, Mungar, Pelion, Tiaro)* have a narrow moisture range for tillage, while the hardsetting fine sandy loam to clay loam fine sandy surface soils *(Avondale, Butcher, Clayton, Kalah, Kepnock, Kolan, Owanyilla, Peep, Timbrell, Woco, 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) occupy 8741 ha or 19% 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 (Wilson 1997).

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 slope limit are considered suitable for permanent cultivation. Land uses such as horticultural tree crops and pastures have steeper slope limits than other uses because almost no cultivation is required and there is increased plant cover (Wilson 1997).

Stable soils with <8% slopes occupy 8335 ha or 18% while unstable soils with <5% slope occupy 20 490 ha or 45% 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). 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 (Wilson *etal.* 1999). These requirements show why laser levelling is very important, especially on low slopes.

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 (ss)

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 (siltstones and mudstones) while coarse grained sandstones and granites have low salt levels.

In the Maryborough–Tiaro area, salinisation occurs from long-term evaporation and capillary rise of salts from non saline watertables close to the surface in valley flats and drainage depressions and on plains. Salinisation also occurs on lower slopes where seepages occur.

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–Tiaro area, all soils on upper slopes act as intake areas (Appendix V).

In discharge (seepage) areas, 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–Tiaro area and is mainly associated with the deeply weathered geologies. Seepage areas frequently occur also in midslope positions at contacts between permeable and impermeable layers.

Salinisation is consistently evident on the sodic duplex soils developed on deeply weathered fine grained sedimentary rocks and drainage depressions found on discharge areas (*Avondale, Gutchy*, *Kalah, Owanyilla, Timbrell, Turpin, Woco, Woober*) and occasionally on poorly drained soils on deeply weathered sandstones (*Alloway, Clayton, Robur, Theodolite*) and occasionally on moderately weathered sedimentary rocks (*Bucca*, *Kolan, Tirroan*).

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 *Avondale, Kalah, Kolan, Robur, Theodolite, Tirroan Turpin, Woco, Woolmer* soils. Any area with existing natural salinisation is considered unsuitable for development.

In the survey area, approximately 600 ha (1.0%) are currently effected by secondary salinisation due to seepage on lower slopes and shallow watertables. A further 6822 ha (13%) of land is at risk from secondary salinisation if used for irrigated agriculture or cleared, even if good land management practice were used. And another 12 228ha (24%) of land is at risk from secondary salinisation if the land is poorly managed under irrigated agriculture.

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 *(Aldershot , Avondale, Butcher, Bungadoo, Clayton, Kalah, Kepnock, Kolan, Peep, Watalgan, Woco, Woober, Woolmer)* slake and surface seal under irrigation, particularly spray irrigation. Soils with a high sodicity in the upper profile *(Avondale, Butcher, Granville, Kalah, Kolan, Timbrell, Theodolite, Tirroan, Turpin, Robur, Peep, Woco, Woober)* 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 should try to make furrows as long as possible because additional management effort is required for short furrows.

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, Gutchy, Mungar, Pelion*) 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 from Acid Sulfate Soils (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, then acid drainage is not a problem. On the other hand, ASS can contain significant volumes of acid, which can be a hazard. The problem is that 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 unoxidised pyrite (FeS_2). PASS may also have elevated pH (pH 4 to >7) and no jarosite. Quantitative assessment of the hazard posed by AASS and PASS is based on the depth and quantity of oxidisable sulphur 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).

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 acid sulfate soils 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 acid sulfate soils.

Within the study area the *Walker* soil is an ASS, which occupies 428 ha or 0.8% of the survey.

5. Land Evaluation

5.1 Land suitability

Land resource information collected during the soil survey was used to determine the suitability of the land for 36 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 1412 unique map areas (UMAs) 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, however, a combination of limitations may lead to a downgrading of the suitability class.

An assessment of the attributes, limitations and suitability ratings for each UMA and each of the different land uses is recorded in the *Soil and Land Information (SALI)* databases. Contact NR&M for access to these databases. Table 27 shows the areas of various land suitability classes for the 36 land uses.

Table 27. Irrigated land suitability classes and areas (ha) for different land uses

Land use	**Irrigated land suitability**				
	Suitable (ha)			**Marginal (ha)**	**Unsuitable (ha)**
	Class 1	**Class 2**	**Class 3**	**Class 4**	**Class 5**
asparagus		2585	6197	11694	25067
avocado		813	874	2216	41639
beans		957	4087	4990	35509
capsicum		2772	5409	12296	25067
cruciferae		3096	6020	11360	25067
curcubit (furrow/row irrigated)			420	10695	34428
curcubit (spray irrigated)		2469	5712	12296	25067
grapes	102	3048	3490	6337	32565
lucerne		1455	3474	5426	35188
lychee	797	5139	13958	12600	13049
macadamia nuts		1627	2180	6535	35201
maize (spray irrigated)	50	1844	5182	12174	26293
sweet corn (furrow/row irrigated)			10	10019	35514
sweet corn (spray irrigated)		1862	5765	11834	26082

Table 27 (continued)

Land use	Irrigated land suitability				
	Suitable (ha)			Marginal (ha)	Unsuitable (ha)*
	Class 1	Class 2	Class 3	Class 4	Class 5
mango		3186	5201	13987	23170
navy bean (furrow/row irrigated)			28	3584	41931
navy bean (spray irrigated)		814	4189	4599	35941
pasture grasses	493	5526	15548	14808	9168
peanut (furrow/row irrigated)				3612	41931
peanut (spray irrigated)		796	3313	5493	35941
pineapple	53	2347	4932	12669	25543
potato (spray irrigated)		2161	5864	9172	28346
potato (furrow/row irrigated)			450	10555	34538
exotic pine	758	6491	3466	19751	15076
sorghum (furrow/row irrigated)			10	9889	35644
sorghum (spray irrigated)	50	1844	5182	12174	26293
soya bean (furrow/row irrigated)			10	9809	35724
soya bean (spray irrigated)	50	1207	4889	9881	29517
sugarcane (furrow/row irrigated)			6196	8362	30985
sugarcane (spray irrigated)	253	3026	13274	12685	16305
sweet potato		2242	5728	11752	25821
tomato		2772	5409	12296	25067
tree crops (citrus)		1627	2685	6753	34477
tree crops (stone fruit)	102	3029	3490	6356	32565
zucchini		2772	5409	12296	25067

In Table 27, two irrigation systems are identified: spray (using travelling irrigators or other overhead systems); and furrow/row (where water is flooded down furrows/rows). When determining the land suitability for each system, two additional limitations apply to furrow irrigation systems, deep drainage (if) and profile recharge (ir). For more information on these limitations see Appendix V.

Sugar Cane is the main crop grown in the Maryborough-Tiaro area. Table 27 shows, 16553 ha or 32% of the survey area, is currently suitable (classes 1–3) for spray-irrigated sugarcane; 6196 ha or 14% is suitable for furrow-irrigated sugarcane—mainly along the alluvial plains of the Mary River and its major tributaries. Other crops such as lychees also have relatively large areas suitable for production under trickle or spray irrigation systems but few areas are suitable for furrow irrigation systems.

To locate suitable land for a particular crop easily, it is recommended that a land suitability map for the particular land use be obtained from NR&M offices in Bundaberg or Indooroopilly. The land suitability map for spray irrigated sugarcane has been included with this report as an example.

5.2 Agricultural Land Classification

To assist local authorities with strategic planning, the land suitability information has be simplified into a four category system of agricultural land classes. This is a state-wide scheme of land classification which can be used to identify valuable agricultural land. Provision has been made to highlight areas, which may be suitable for a specific crop considered important in a particular area (Land Resources Branch Staff 1990). In the Maryborough–Tiaro area, spray irrigated sugarcane, mangos, and pasture land suitability have been used to determine the land class. Table 28 shows the areas of each land class.

Table 28. Areas of each Agricultural Land Class

Agricultural Land Class	Area (ha)	Percentage
Class A – Crop land	18 834	37
Class B – Limited crop land	10 386	21
Class C – Pasture land	129	<1
Class D – Non-agricultural land	21 222	42

A total of 58% of the survey area can be considered as agricultural land (Class A and B). This land is mostly located in the Walkers Point to Owanyilla area, Tiaro to Netherby area and along the Mary River. Agricultural Land Class maps can be obtained from NR&M offices in Bundaberg and Indooroopilly.

6. References

Anon (1995). *Adoption of world best practice by the Maryborough Sugar Industry.* MacArthur Consulting Pty Ltd, Brisbane. Unpublished report.

Baker DE and Eldershaw VJ (1993). *Interpreting soil analysis for agricultural uses in Queensland.* Department of Primary Industries, Queensland Government, Project report Q093014.

Bourne JF and Harris GA (1985). *Irrigation scheduling. Timing and rate decisions.* Queensland Department of Primary Industries, Information Series QI85024.

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

Cranfield LC (1992). *Geology, Maryborough 1 : 250000, Sheet SG 56-6, First Edition*, Department of Resource Industries, Queensland, Brisbane.

Cranfield LC (1993). *Stratigraphic units of the Maryborough Basin, southeastern Queensland*. Queensland Geology, **5**, 44-87.

Cranfield LC (1994). *1:250000 Geological Series – Explanatory Notes, Maryborough, Queensland, Sheet SG56-6*, Department of Minerals and Energy, Geological Survey of Queensland, Brisbane.

Coaldrake JE (1961). *The ecosystem of the coastal lowlands ("Wallum") of Southern Queensland.* CSIRO Australia, Bulletin No. 283.

Donnollan TE (1991) *Understanding and Managing Burdekin (BRIA) Soils.* Land Resources Branch, Department of Primary Industries, Queensland.

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

DPI (1988). *Maryborough Sugar Factory area planning study.* R Miles (ed.) Unpublished report, Department of Primary Industries.

Department of Primary Industries Staff (1992). Land Management Manual Maryborough District, Department of Primary Industries Training Series QE92001, Brisbane.

Elliot PJ and McDonald WJ (1989). *Gaynor Research Site Report, dry season 1986.* Department of Primary Industries, Queensland, RQM90001.

Ellis PL (1968). *Geology of the Maryborough 1:250,000 sheet area.* Queensland Department of Mines, Brisbane, Report No. 26.

Elphinstone GD (1996). *Agricultural changes in the Mary River Catchment. Queensland.* Department of Primary Industries, Gympie. Mary River Congress, Maryborough, Queensland.

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

Haywood RW (1996). *The value of the Sugar Industry to the Maryborough Community*. Queensland LandCare conference proceedings, Bundaberg, Queensland, pp 74-77.

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

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

Isbell RF, Thompson CH, Hubble GD, Beckmann GG and Paton TR (1967). *Atlas of Australian Soils, explanatory data for sheet 4 Brisbane - Charleville - Rockhampton - Clermont area.* CSIRO/Melbourne University Press.

Keefer GD (1989). Research developments in irrigation scheduling and application of water use models, In Hazard WH, Shaw RJ and Bourne JP (eds.) *Irrigation Management Workshop Proceedings,* Queensland Agricultural College, 24-27 June 1986. Queensland Department of Primary Industries, Conference and Workshop Series, QC89009, 1019-28.

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

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

Lawrence RJ, O'Hara RJ and Connor TB (1982). Floods versus farmers - Flood management for agriculture. *Proceedings Australian Society of Sugar Cane Technologists,* 1982 Conference, 59-65.

Leverington AR (1986). *Overview of land suitability information for the district surrounding the Maryborough Sugar Factory*. Queensland Department of Primary Industries, internal report.

Leverington AR (1993). *Land suitability for sugarcane production (Tuan Forest Area).* Unpublished report.

Littleboy M (1997). *Spacial generalisation of biophysical simulation models for quantitative land evaluation: A case study for dryland wheat growing areas of Queensland.* PhD Thesis Department of Geographical Sciences and Planning, University of Queensland, April 1997.

Loveday J (1981). Soil management and amelioration. In TS Abbott CA Hawkins and PGE Searle (eds) *National Soils Conference 1980 Review Papers,* Australian Society of Soil Science Inc., Glen Osmond, South Australia.

Macnish SE and Leverington AR (1984). *Evaluation of land suitability in the proposed Lower Mary River irrigation area.*. Unpublished report, Queensland Department of Primary Industries.

McDonald RC, Isbell RF, Speight JG, Walker J and Hopkins MS (1990). *Australian Soil and Land Survey Field Handbook.* 2nd edition, Inkata Press, Melbourne.

Muchow RC and Yule DF (1983). Research for improved crop management. Irrigation. In Muchow, R.C. (ed), *Proceedings of Agro-Research Arbiatia's Semi Arid Tropics*, 21-25 March, 1983, Darwin.

Pointon SM (1998) *Land Use, Vegetation Cover and Land Disturbance Survey of The Mary River Catchment, 1997*. Land Resources Bulletin DNRQ980123. Department of Natural Resources, Brisbane, Queensland.

Pointon SM and Collins AW (2000) *Mary River Catchment Resource Atlas*. DNRQ00114. Deparment of Natural Resources, Queensland.

Queensland Coastal Lowlands Land Use Study Committee (1976a). *The Maryborough Coastal Land Use Study.* Unpublished.

Queensland Coastal Lowlands Land Use Study Committee (1976b). *Maryborough-Elliott River Land Use Study.* Unpublished.

Queensland Co-ordinator-Generals Department (1979). *Wide Bay - Burnett Resources Investigations Volume III Land resources.*

Raine SR, McClymont DJ and Smith RJ (1998). *The effect of variable infiltration on design and management guidelines for surface irrigation.* Conference Proceedings for the National Soils Conference. Australian Society of Soil Science Incorporated, pp 311-317.

Reid RE (1988). Soil survey specification. In *Australian soil and land survey handbook: Guidelines for conducting surveys* (Gunn RH, Beattie JA, Reid RE, Van der Graff HM), Inkata Press, Melbourne.

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

Shaw RJ, Thorburn PJ, McShane TJ, Maltby JE and Robson CK (1982). The effectiveness of drainage in a region of variable aquifer hydraulic conductivity in the Lower Burdekin Region, north Queensland. In RJ Smith and AJ Rixon (eds.), *Rural Drainage in Northern Australia,* proceedings of Symposium, Darling Downs Institute of Advanced Education, 129-42.

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

Smith CD (1981) *Maryborough–Tinana Soil Survey*. Department of Primary Industries, Unpublished.

Smith CD (1983). *Steep lands study of the Hervey Bay, Bauple and Yerra - Pilerwa areas.* Queensland Department of Primary Industries, Project Report QO83010.

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

Smith CD and Nevell PP, Muller AD (1981) *Maryborough – Tinana Soils Map, 1:25000 scale*. Department of Primary Industries, Unpublished.

Turner EJ and Hughes KK (1983). *Sugar Cane land suitability survey - vacant crown land, Maryborough*. Queensland Department of Primary Industries, Project Report QO83012.

Utomo QH and Dexter AR (1981). Soil friability. *Journal of Soil Science* **32**, 203-213.

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

Wilson PR (1994). *Soils and irrigated Agricultural suitability of the Beaver Rock Road area, Maryborough*. Unpublished report, Queensland Department of Primary Industries.

Wilson PR (1997). *Soils and irrigated Agricultural suitability of the Childers area, Queensland*. Queensland Department of Natural Resources, DNRQ97158.

Wilson PR, Anderson HM, and Brown DM (1999). *Soils and irrigated Agricultural suitability of the Maryborough-Hervey Bay Area, Queensland*. Department of Natural Resources,Queensland DNRQ990052.

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

APPENDIX I

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).

References

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

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

Munsel soil colour charts (1994), McBeth Division of Koll Morgan Instruments Corporation, New York.

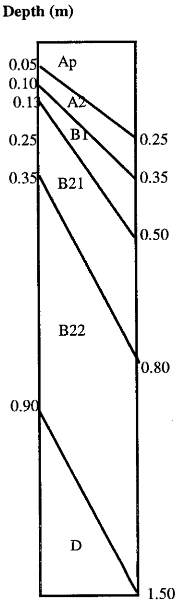
Northcote, K.H. (1979), *A Factual Key for the Recognition of Australian Soils,* 4th Ed. Rellim Technical Publications, Glenside, South Australia.

Stace, H.C.T., Hubble, G.O., Brewer, R., Northcote, K.H., Sleeman, J.R., Mulcahy, M.J. and Hallsworth, E.G. (1968), *A Handbook of Australian Soils,* Rellim Technical Publications, Glenside, South Australia.

ALDERSHOT (Ad)

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

Depth (m)



Ap: Grey, black or brown (7.5YR 3/2, 10YR 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 less disturbed soils; sandy clay loam to silty clay loam; massive; pH 6.0 to 6.5. Abrupt to clear change to

B1: Occasionally present; Brown (7.5YR 4/4; 10YR 4/3, 4/4); fine sandy light to light medium clay; weak to moderate 2 to 10 mm subangular blocky; <2 to 10% manganiferous nodules or soft segregations <2 to 6 mm; pH 6.0 to 7.0. Clear to gradual change to

B21: Occasionally mottled; red or brown (5YR 4/3, 4/4, 10YR 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 to7.0. Clear to gradual change to

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

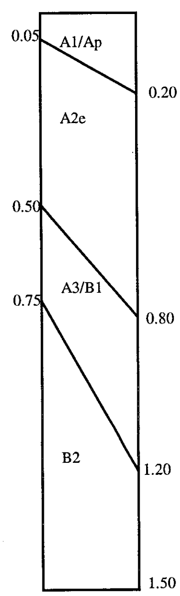
D: Occasionally occurs. Brown (7.5YR 4/6); clay loam sandy; massive; pH 7.0 to 7.5.

Sites: 211, 223, 229, 302, 348, 376, 534, 551

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:	Elliot 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 / C intermedia*

Depth (m)



A1/Ap: Grey (7.5YR 4/1, 4/2, 5/2, 10YR 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 (10YR 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 (10YR 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 <60mm; pH 5.5 to 6.5

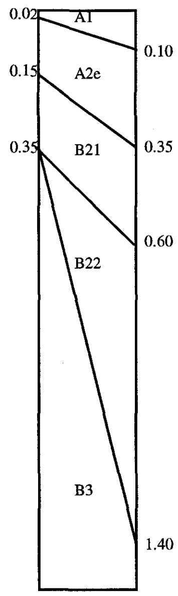
Sites: 311

Analysed sites: BUN 121

AVONDALE (Av)

Concept: Sodic texture contrast soil with a shallow (<0.35m) loamy surface containing maghemite nodules over a grey subsoil on deeply weathered fine grained sedimentary rocks
Australian Classification: Grey Sodosol, Grey Kurosol, minor Brown Sodosol, Brown Kurosol, Redoxic Hydrosol
Great Soil Group: Soloth
Principle Profile Form: Dy3.41
Surface characteristics: Hardsetting
Geology: Mudstones, siltstones, fine sandstones of the Elliot Formation (Te), Burrum Coal Measures (Kb), Maryborough Formation (Km), Grahams Creek Formation (JKg), Tiaro Coal Measures (Jdt)
Landform: Gently undulating plains and rises to undulating rises and low hills. Slopes 0 to 10%
Vegetation: 15 to 18m mid-dense *Eucalyptus umbra, Angophora leiocarpa* with scattered *Eucalyptus siderophloia / Corymbia trachyphloia / C. intermedia / Melaleuca viridiflora*

Depth (m)



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

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

B21: Mottled; grey or occasionally brown (7.5YR 5/2, 5/3 10YR 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 (7.5YR, 5/2, 6/2, 7/2, 10YR 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 (7.5YR 5/1, 5/2, 6/2, 7/1, 10YR 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.

Sites: 28, 40, 131, 140, 190, 438, 465, 469, 471
Analysed sites: QCB 136

Avondale Rocky Phase (AvRp): As above. >20% rock fragments or rock at 0.3 m.

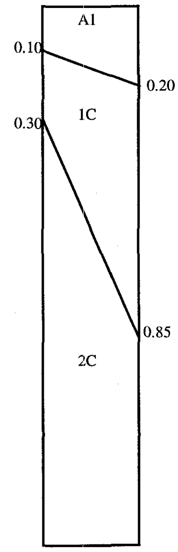
Avondale Tenic Variant (AvTv): Bleached Leptic Tenosol. A1 and A2 horizons as above over weathered rock.

Avondale Yellow Variant (AvYv): Yellow Dermosol. B21 horizon non-sodic and yellow over B22 which is grey and sodic.

BADDOW (Ba)

Concept: Layered sandy soil developed on channel benches of the Mary River
Australian Classification: Stratic Rudosol
Great Soil Group: Alluvial soil
Principle Profile Form: Uc1.23, Uc1.21
Surface characteristics: Loose or soft
Geology: Quaternary Holocene alluvium (Qhal)
Landform: Channel benches or Levees of the Mary River
Vegetation: Mostly cleared

Depth (m)



A1: Brown (10YR 4/3, 4/2); sand to sandy loam; massive; pH 6.0 to 7.0. Clear change to

1C: Brown (10YR 4/3, 4/4, 5/4); sand to loamy sand; single grain or massive; pH 6.0 to 7.0. Clear change to

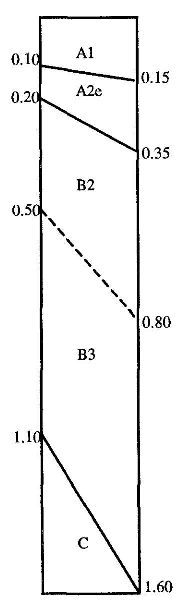
2C: Brown (10YR 4/3, 4/4); sand or fine sand; single grain; pH 6.5 to 7.5.

Sites: 221, 328, 503, 558

BAUPLE (Bp)

Concept: Sodic texture contrast soil with a sandy surface over a brown structured mottled sandy clay on syenite
Australian Classification: Brown Sodosol or Grey Kurosol
Great Soil Group: Soloth, Solodized Solonetz
Principle Profile Form: Dy4.41, Dy4.43, Dy5.41
Surface characteristics: Soft
Geology: Biotite quartz syenite of the Mt. Bauple Syenite (JKb)
Landform: Gently to undulating rises (2–10%)
Vegetation: 20–35 m sparse open forest of *Eucalyptus tereticornis, E..crebra, Corymbia tessellaris, C. intermedia, C. citrodora, Lophostemon suaveolens*

Depth (m)



A1: Black or grey (10YR 3/2, 4/2, 5/2, 7.5YR 3/2); sand to sandy loam; single grain to massive; pH 5.5–7.0. Abrupt to clear change to

A2e: Conspicuously bleached. Sand to loamy sand; single grain or massive; pH 5.5–6.5. Clear or abrupt change to

B2: Mottled grey or brown (10YR 4/2, 5/3, 5/4, 2.5Y 5/3); sandy light medium clay to sandy medium heavy clay; moderate to strong, 20–100 mm columnar or prismatic parting to moderate or strong 2–10 mm angular blocky; 0–50%; <2 mm sand, angular grit; pH 5.5–6.0. Gradual to diffuse change to

B3: Occasionally mottled, brown or yellow (7.5YR 5/5, 10YR 6/4, 2.5Y 5/3, 5/4, 6/4); sandy light medium clay to sandy medium clay; moderate 10–50 mm prismatic parting to weak to moderate 2–10 mm angular blocky; 0–20%; angular grits 2–6 mm; pH 4.5–5.5.

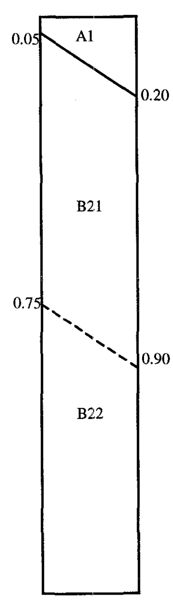
C: Weathered syenite

Sites: 568, 569, 579
Analysed site: MTL 576

BEAVER (Bv)

Concept: Humic loamy surface over a strongly mottled grey clay 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 (Qpa)
Landform: Swamps
Vegetation: *Melaleuca quinquenervia*

Depth (m)



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

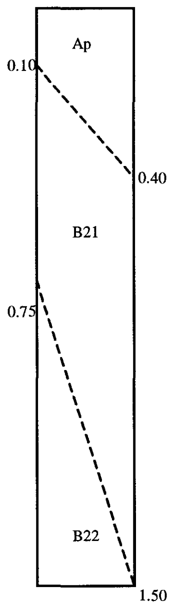
B21: Mottled; dark or grey (7.5YR 2/2 10YR 3/2, 4/1); light medium clay to medium clay; strong 2–5 mm subangular blocky; pH 5.3–5.8. Diffuse change to

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

BIDWILL (Bd)

Concept: Red structured clay soil on deeply weathered andesites of the Grahams Creek Formation
Australian Classification: Red Ferrosol
Great Soil Group: Krasnozem
Principle Profile Form: Uf6.31
Surface characteristics: Hardsetting
Geology: Andesite of the Grahams Creek Formation (Jkg)
Landform: Hillcrests of rises and low hills
Vegetation: Cleared

Depth (m)



Ap: Red or occasionally black (2.5YR 3/4, 4/4, 5YR 3/2, 3/3, 4/4); light clay to light medium clay; moderate to strong 2 to 5 mm granular; pH 5.5 to 6.5. Clear to diffuse change to

B21: Red (2.5YR 3/3, 3/6, 4/4, 4/6; 10R 4/4); light clay to light medium clay; strong 2 to 5 mm polyhedral; 0–10% manganiferous nodules <2 to 20 mm; pH 5.5 to 7.0. Clear to diffuse change to

B22: Occasionally occurs; mottled; red (10R 4/4, 2.5YR 4/4, 4/6); light clay to medium clay; strong 2 to 5 mm polyhedral; 0–10% manganiferous <2 to 10 mm; pH 6.0 to 7.0.

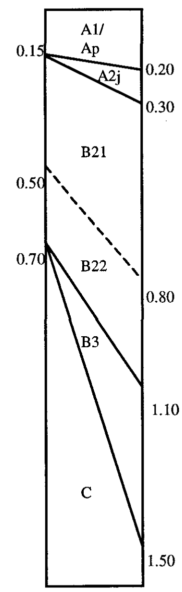
Sites: 57, 60, 61, 77, 81, 138, 148, 151, 265, 266, 274, 288, 289, 314, 356, 408, 409, 514
Analysed sites: MTL 246, BUN 111

Bidwill Rocky Phase (BdRp): Red Ferrosol
>20% Andesite outcrops throughout mapping unit

BUCCA (Bc)

Concept: Mottled grey or brown clay on moderately weathered fine grained sedimentary rocks
Australian Classification: Grey or Brown Dermosol
Great Soil Group: No suitable group, affinities with grey clay
Principle Profile Form: Uf3, Uf6.41
Surface characteristics: Hardsetting
Geology: Mustones and occasionally rhyolites and tuffs of Grahams Creek Formation (Jkg), Tiaro Coal Measures (Jdt), Maryborough Formation (Km)
Landform: Hillslopes of rises and low hills
Vegetation: 18 to 25m closed or densed scrub, *Lophostemon suaveolen / Eucalyptus siderophloia / E. moluccana / C. citriodora,* occasionally *C. tereticornis*

Depth (m)



A1/Ap: Grey, brown or occasionally black (10YR 3/2, 4/1, 4/2, 4/3); light clay to light medium clay; weak to moderate 2 to 10 mm cast or granular; pH 4.5 to 5.5. Abrupt to clear change to

A2j: Undisturbed sites have sporadically bleached. Light medium clay; moderate 2–5 mm subangular blocky. Clear change to

B21: Mottled; grey or brown (7.5YR 5/4, 10YR 4/2, 5/3, 6/2, 6/3); medium clay to heavy clay; strong 2 to 5 mm lenticular or subangular blocky; frequently with ferruginous nodules; pH 4.0 to 5.5. Gradual to diffuse change to

B22: Mottled; grey (10YR 5/2, 6/2, 6/3); medium clay to heavy clay; strong 2 to 5 mm lenticular or subangular blocky; frequently with ferruginous nodules; pH 4.0 to 5.0.

B3: Occasionally mottled; grey (10YR 5/2, 5/3, 6/2, 2.5Y 5/4); light to medium clay; moderate to strong, 2 to 10 mm, subangular blocky; 2 to 50% mudstone, tuff or rhyolite pebbles 6–20 mm. Clear to diffuse change to

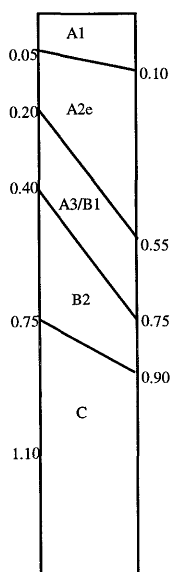
C: Weathered mudstone, tuff or rhyolite

Sites: 118, 126, 155, 162, 176, 179, 181, 240, 410, 420, 426, 430, 432, 477
Analysed sites: MTL 9002

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 60mm.
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 / C. trachyphloia / Eucalyptus umbra / Lophostemon confertus*

Depth (m)



A1: Black or grey (7.5YR 3/2, 4/2, 10YR 3/2, 4/2); clay loam; massive or weak <5mm 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 (7.5YR 4/4, 5/4, 6/4, 10YR 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 frequently becoming paler at depth (7.5YR 4/4, 4/6, 5/2, 5/3 10YR 4/2, 5/3, 6/3, 6/4); light 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

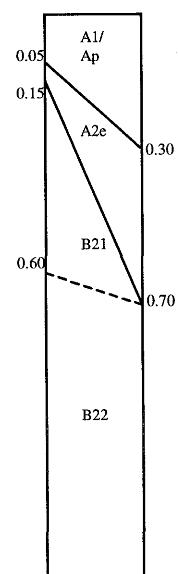
C: Silicified sedimentary rock.

Sites: 269

BUTCHER (Bt)

Concept: Fine loamy surfaced texture contrast soils on alluvial plains of the Mary River
Australian Classification: Brown Sodosol, Grey Sodosols, minor Redoxic Hydrosols
Great Soil Group: Soloth, solodic soil
Principle Profile Form: Dy3.41, Dy3.42, Dy3.43
Surface characteristics: Hardsetting
Geology: Quaternary Pleistocene Alluvium (Qpa)
Landform: Alluvial plain
Vegetation: Cleared

Depth (m)



A1/Ap: Dark or grey (7.5YR 3/2, 4/2, 10YR 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 (7.5YR 4/2, 5/2, 5/3, 10YR 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 (10YR 4/4, 5/4, 6/1, 6/2, 6/3, 2.5Y 5/2, 6/3); light medium clay to heavy clay, strong 10 to 20mm angular blocky or 20 to 50mm prismatic; pH 5.8 to 8.5.

Sites: 2, 5, 33, 36, 165, 207, 214, 215, 230, 332, 347, 462, 517, 540
Analysed sites: MTL 315, BUN 113

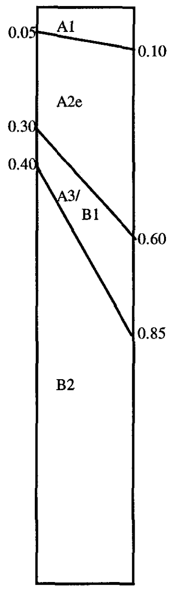
(BtRp) Butcher Rocky phase: Leptic Rudosol
Rocky prior stream of relict flood plain.

(BtSv) Butcher Sandy variant:
A1/Ap: Sandy loam to fine sandy loam textures
A2e: Sand to sandy loam textures
Sites: 398, 399, 485, 490, 508
Analysed Sites: BUN 119

CLAYTON (Cl)

Concept: Fine loamy surface over an acid or neutral, mottled, fine 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: Elliot 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 (7.5YR 3/2, 4/1, 4/2, 10YR 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/B1: Mottled; grey or occasionally yellow (10YR 6/2, 6/3, 6/4, 7/2, 7/3, 7/4, 2.5Y 6/4, 7/2, 7/4); (A3) massive or (B1) weak or moderate 2 to 5 mm subangular or polyhedral; <2 to 50% ferruginous nodules 2 to 20mm; pH 5.5 to 6. Clear to gradual change to

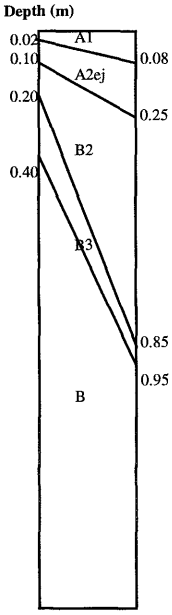
B2: Mottled; grey or occasionally yellow (10YR 6/1, 6/2, 6/3, 6/4, 7/2, 7/4, 2.5Y 6/4, 7/2, 7/4); light clay to medium heavy clay; strong 2 to 5 mm polyhedral; <2 to 50% ferruginous nodules 2 to 20 mm; pH 5.0 to 5.8.

Sites: 68, 306.

DOONGUL (Do)

Concept: Sodic texture contrast soil with a very shallow (<0.25 mm) bleached clay loam surface over a coarse structured, mottled, grey clay on weathered granite
Australian Classification: Grey Sodosol, Brown Sodosol
Great Soil Group: Soloth, solodic soil, solodized solonetz
Principle Profile Form: Dy2.41, Dy3.42, Dy3.41, Dy2.32
Geology: Hornblende-phyric microdiorite (JKi)
Landform: Hillslopes of undulating rises
Vegetation: 22 to 30 m sparse to mid-dense *Eucalyptus citriodora, Eucalyptus siderophloia / Eucalyptus moluccana / Eucalyptus tereticornis*

Depth (m)



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

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

B2: Frequently mottled especially in upper B2; grey or brown (5YR 5/2, 5/3, 7.5YR 4/2, 5/2, 5/3, 10YR 5/2, 5/3); light medium to medium clay; moderate or strong 20 to 100 mm prismatic or columnar or 10 to 20 mm angular blocky; pH 5.5 to 7. Clear to gradual change to

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

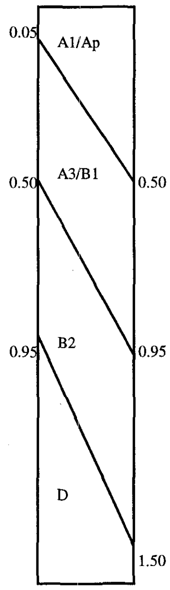
C: Weathered rock

Sites: 482, 486, 496, 499

COPENHAGEN (Co)

Concept: Loamy surface over brown structured subsoil over sandy D horizon developed on active flood plains of the Mary River
Australian Classification: Brown Dermosol
Great Soil Group: Prairie soil, Alluvial soil
Principle Profile Form: Gn3.22, Um6.32
Surface characteristics: Firm or soft
Geology: Quaternary holocene alluvium (Qha1)
Landform: Channel benches or levees of the Mary River
Vegetation: Mostly cleared

Depth (m)



A1/Ap: Brown or black (10YR 4/4, 4/3, 4/2; 7.5YR 3/2); loam to clay loam; massive to strongly 2–5 mm subangular blocky; pH 6.0 to 7.5. Clear to gradual change to

A3/B1: Brown (10YR 4/3, 4/4); loam to fine sandy light clay; weak 2–5 mm subangular blocky; pH 6.0 to 7.5. Clear to diffuse change to

B2: Brown (10YR 4/3, 4/4); sandy clay loam to fine sandy light clay; moderate 2–5 mm subangular blocky; pH 6.5 to 7.5. Clear to diffuse change to

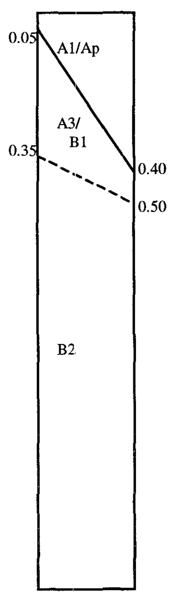
D: Brown (10YR 4/3, 4/4, 5/4); fine sand to fine loamy sand; single grain; pH 6.5–7.5.

Sites: 312, 337, 461, 498, 521, 527

FARNSFIELD (Ff)

Concept: Sandy surface over a red, massive subsoil on deeply weathered coarse grained sedimentary rocks
Australian Classification: Red Kandosol
Great Soil Group: Red earth
Principle Profile Form: Gn2.11, Gn2.12
Surface characteristics: Firm to loose
Geology: Sandstones of the Elliot Formation (Te)
Landform: Level plains to hillslopes on gently undulating plains and rises
Vegetation: Cleared

Depth (m)



A1/Ap: Red, brown or black (2.5YR3/3, 4/2, 4/3, 5YR 3/2, 4/2, 4/3, 7.5YR 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 (2.5YR 3/4, 4/3, 5/6, 5YR 3/3, 3/6, 4/4, 7.5YR 4/4); light sandy clay loam to sandy clay loam; massive; pH 5.5 to 7.0. Diffuse change to

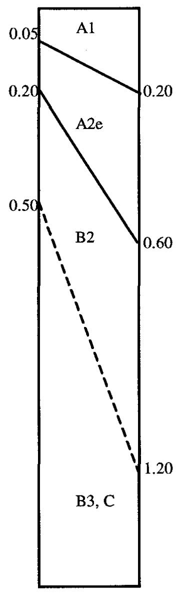
B2: Red (10R 4/6, 4/8, 2.5YR 4/6, 4/8); sandy clay loam, clay loam sandy, clay loam, light clay; massive or weak 2 to 10 mm subangular blocky or polyhedral; pH 5.5 to 7.

Sites: 48, 121, 122, 226, 227
Analysed sites: ATB 2, QCB 143, MBS 88, BUN 110

GIGOON (Gn)

Concept: Sodic texture contrast with a coarse sandy surface over a brown or grey clay subsoil on weathered granite
Australian Classification: Brown Sodosol, Grey Sodosol
Great Soil Group: Soloth, solodized solonetz, solodic soil
Principle Profile Form: Dy5.41, Dy3.42, Dy3.41, Dy3.43, Dg4.41
Geology: Hornblende-phyric microdiorite (JKi)
Landform: Hillslopes of rises, low hills and hills
Vegetation: 15 to 25 m mid-dense *Eucalyptus crebra, Corymbia citriodora, Eucalyptus tereticornis, Corymbia intermedia / Eucalyptus exserta / Eucalyptus siderophloia*

Depth (m)



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

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

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

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

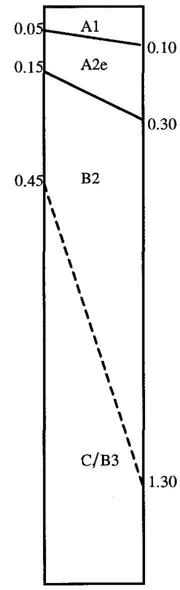
C: Weathered rock

Sites: 487

GIVELDA (Gv)

Concept: Sodic texture contrast soil with a very shallow (<0.3 mm) loamy surface over a brown or yellow clay subsoil on moderately weathered fine grained sedimentary rocks.
Australian Classification: Brown Sodosol, Yellow Sodosol.
Great Soil Group: Soloth, solodic soil.
Principle Profile Form: Dy3.41, Dy3.42.
Geology: Siltstones and fine sandstones of the Burrum Coal Measures (Kb), Maryborough Formation (Km) and Grahams Creek Formation (JKg).
Landform: Hillslopes on rises and low hills.
Vegetation: 18 to 20m mid-dense *Eucalyptus moluccana / Eucalyptus crebra / Eucalyptus citriodora / Eucalyptus tereticornis.*

Depth (m)



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

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

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

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

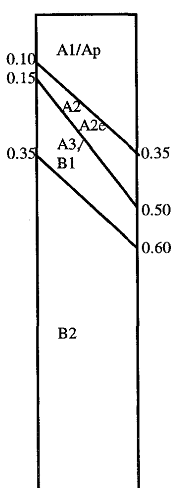
Sites: 41, 99, 151, 166, 218, 253, 588, 590, 594, 910, 911, 914, 916, 923, 951, 1221, 1224, 1301

Analysed sites: CBW911

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: Elliot Formation (Te)
Landform: Plains and hillslopes on rises
Vegetation: Mostly cleared

Depth (m)



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

A2/A2e: Occurs in undisturbed soils (minor). Occasionally conspicuously bleached. Loamy sand to sandy loam; pH 5.5 to 6.5. Abrupt to diffuse change to

A3/B1: Red or brown (2. YR 4/3, 4/4, 4/6, 5/6, 5YR 3/3, 4/3, 4/4, 4/6, 5/6, 7.5YR 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 (10R 3/6, 4/6, 4/8, 2.5YR 3/6, 4/6, 4/8, 5YR 5/6); clay loam sandy, clay loam, sandy light clay, light clay; moderate or strong 2 to 5 polyhedral; pH 5.8 to 6.5

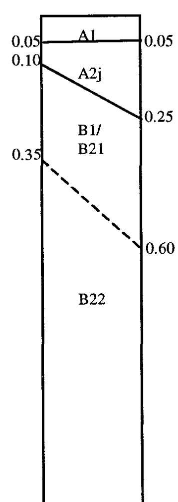
Sites: 100, 119, 331, 353, 442
Analysed sites: QCB 142

(GbMv) Goomburrum Mottled Variant: Mottled B2 horizon.
Sites: 232

GRANVILLE (Gr)

Concept: Sporadically bleached acid grey clay on alluvial plains of the Mary River
Australian Classification: Grey or Brown Dermosol, Redoxic Hydrosol, Brown Vertosol
Great Soil Group: No suitable group
Principle Profile Form: Uf3, Ug3.2
Surface characteristics: Hardsetting, usually with normal gilgai
Geology: Quaternary Pleistocene Alluvium (Qpa)
Landform: Relict alluvial plains and terrace flats
Vegetation: Mostly Cleared

Depth (m)



A1: Black or grey (10YR 41, 4/2, 5/2, 6/2); light clay to light medium clay; moderate to strong 2 to 5 mm granular or subangular blocky; 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; 0 to 10% manganiferous nodules or soft segregation <2–6 mm; pH 5.5 to 6.0. Clear change to

B1/B21: Mottled; grey or brown (7.5YR, 10YR 4/2, 5/2, 5/3); light medium clay to medium clay; strong 2 to 10 mm subangular blocky; 0 to 10% manganiferous nodules or soft segregations <2–6 mm; pH 5.0 to 6.0. Gradual to diffuse change to

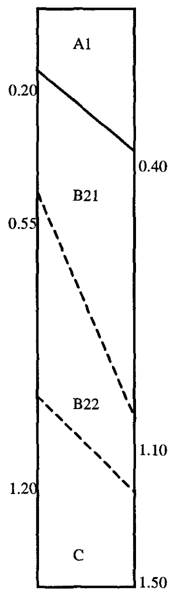
B22: Mottled; grey (7.5YR 5/1, 5/2, 10YR 5/2, 6/2, 2.5Y 6/1, 6/2); medium heavy to heavy clay; strong 2 to 5 mm lenticular. None to 10% manganiferous nodules or soft segregations <2–6 mm; pH 5.0 to 6.5.

Sites: 13, 15, 22, 24, 45, 172, 209, 210, 217, 218, 222, 335, 378, 453, 510
Analysed sites: BUN 109, MBS 17

GUTCHY (Gy)

Concept: Gilgaied Black clayey soil developed on alluvial fans
Australian Classification: Grey Dermosol, Redoxic or Oxyaquic Hydrosol
Great Soil Group: No suitable group, affinity with Prairie Soil
Principle Profile Form: Uf6.32, Uf6.33
Surface characteristics: Firm
Geology: Quaternary Pleistocene Alluivium (Qa)
Landform: Level to gently sloping alluvial fans of Mt Bauple
Vegetation: Mostly cleared with isolated trees of *Eucalyptus tereticornis, E. siderophloia, Corymbia tessellaris, Angophora floribunda*

Depth (m)



A1: Black or grey (10YR 2/1, 3/2, 4/1); light medium clay; strong, <2–10 mm granular or subangular blocky; pH: 6.0–7.0. Abrupt to clear change to

B21: Black or grey (10YR3/1, 2.5Y 4/2); medium to medium heavy clay; strong, 2–10 mm, lenticular or angular blocky; pH 8.0–8.5. Diffuse change to

B22: Occasionally mottled, grey or brown (5Y 4/1, 5/1, 2.5Y 4/1, 5/3); medium clay to medium heavy clay; strong 2–10 mm, lenticular structure; <2%, ferruginous and calcareous nodules 2–20 mm; pH 8.5. Diffuse change to

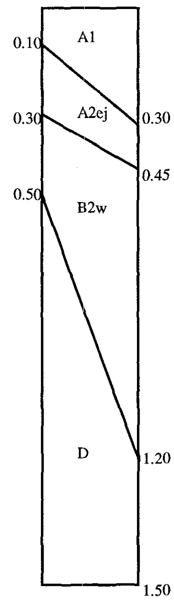
C: Occasionally present, Grey (5Y 4/1); medium heavy clay; weak structure; <2, calcareous nodules; 10–20%, angular grit 2–6 mm; pH 9.0.

Sites: 571, 572

GUYRA (Gu)

Concept: Sandy massive soil on prior streams and fan deposits of Mt Bauple
Australian Classification: Brown Kandosol, Orthic Tenosols
Great Soil Group: Earthy sand, no suitable group
Principle Profile Form: Gn2.92, Um2.21, Uc2.21
Surface characteristics: Loose or soft
Geology: Quaternary Pleistocene Alluivium (Qa)
Landform: Prior streams and gently sloping alluvial fan of Mt Bauple
Vegetation: Mostly cleared

Depth (m)



A1: Black or grey (10YR 3/2, 4/2); loamy sand to coarse sandy clay loam; massive to weak structure; <2%, angular grit 2–6 mm; pH: 6.0–7.0. Abrupt change to

A2ej: Conspicuously or sporadically bleached. Coarse sand to sandy clay loam; single grain to weak structure; <2–20%, angular grit 2–6 mm; pH 6.5–7.0.

B2w: Brown (10YR 5/3, 7.5YR 5/3, 5/4); coarse sand to sandy clay loam; single grain to weak structure; 2–50%, angular grit 2–6 mm; pH 7.0.

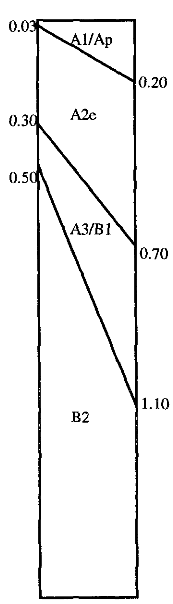
D: Brown (10YR 5/4); coarse sand; single grain structure; 20–50%, angular grit 2–6 mm; pH 7.0–7.5.

Sites: 567, 570, 580

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: Elliot Formation (Te)
Landform: Level plains to hillslopes on gently undulating rises
Vegetation: Mostly cleared

Depth (m)



A1/Ap: Grey or occasionally black (7.5YR 4/1, 4/2, 5/1, 5/2, 10YR 3/1, 4/1 4/2, 5/1, 5/2, 5/3, 2.5Y 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 (10YR 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 (5YR 6/6, 7/5, 10YR 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.

Sites: 43, 49, 54, 70, 95, 97, 103, 112, 116, 133, 185, 295, 320, 358, 472, 511
Analysed Sites: MBS 31, 50, 62, QCB 137

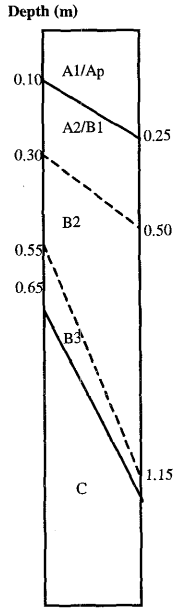
(IsRp) Isis Rocky phase: as above with R horizon of conglomerate at <0.6 m depth and/or >10% surface coarse fragments which are >0.06 m in size.

Sites: 42, 310, 355, 360, 379, 480, 481, 512

JUMPO (Jp)

Concept: Loamy to clayey surface over a acid to neutral mottled brown well structured clay subsoil with manganiferous nodules throughout on deeply weathered andesite of the Grahams Creek Formation.
Australian Classification: Brown Dermosol, Yellow Dermosol
Great Soil Group: Xanthnozem
Principle Profile Form: Uf6.41, Uf4.4, Gn3.72
Surface characteristics: Hardsetting
Geology: Deeply weathered andesite of the Grahams Creek Formation (Jkg)
Landform: Gently undulating hillslopes (3–8%) on rises
Vegetation: 18 to 25m mid-dense *Eucalyptus tereticornis / Lophostemon suaveolens / Eucalyptus sideropholia*

Depth (m)



A1/Ap: Grey or brown (10YR 4/2, 4/3, 5/3); sandy clay loam to silty light medium clay; weak to strong 2 to 5 mm granular or subangular blocky; 2 to 20% manganiferous nodules 2–6 mm; pH 6.0 to 7.0. Clear to gradual change to

A2/B1: Occasionally occurs; Brown occasionally grey (10YR 5/4; 2.5Y 5/2, 5/4); light clay to light medium clay; moderate to strong 2 to 5 mm subangular blocky; 2 to 20% manganiferous nodules <2–6 mm; pH 6.0 to 6.5. Gradual change to

B2: Mottled; brown or occasionally yellow (10YR 5/4, 5/6, 6/6; 2.5Y 5/4); light clay to medium heavy clay; strong 2–10 mm subangular blocky or polyhedral; 2 to 50% manganiferous nodules <2–6 mm; pH 6.0 to 7.0. Diffuse to gradual change to

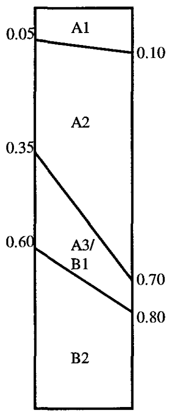
B3: Mottled; brown grey (2.5Y 5/3, 6/2, 10YR 5/4, 6/2, 6/4); medium clay to heavy clay; moderate 2 to 10 mm angular blocky or 2 to 50 mm lenticular; 2 to 50 % manganiferous < 2–6 mm; pH 5.0 to 6.0. Clear change to

C: Weathered andesite.
Sites: 143, 270, 272, 281, 290, 305, 401
Analysed sites: MTL 9000

KALAH (Kh)

Concept: Sodic texture contrast soil with a fine loamy surface over a grey clay subsoil on deeply weathered fine grained sedementary rocks
Australian Classification: Redoxic Hydrosol
Great Soil Group: Soloth, solodic soil
Principle Profile Form: Dy3.41, Dy3.43, Dg2.41, Dy3.42, Dg2.42, Gn3.04
Surface characteristics: Hardsetting
Geology: Elliot Formation (Te)
Landform: Level plains
Vegetation: 10 to 18 sparse to mid-dense *Melaleuca viridiflora, Eucalyptus umbra*, frequently with scattered *Corymbia intermedia / C. trachyphloia / Angophora leiocarpa*

Depth (m)



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

A2: 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 (7.5YR 4/2, 5/4, 6/2, 6/3, 7/3, 10YR 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

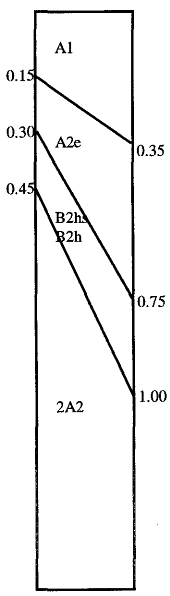
B2: Mottled; grey or occasionally brown (7.5YR 5/2, 5/3, 6/2, 7/1, 7/2, 10YR 5/1, 5/2, 5/3, 6/2, 7/2, 2.5Y 6/2); usually paler at depth; light medium clay to heavy clay; strong 10 to 20 mm angular blocky or 20 to 50 mm prismatic parting to angular blocky; pH 5.5 to 8.

Sites: 75, 108
Analysed sites: QCB 181

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 charactertistics: Loose
Geology: Elliot Formation (Te)
Landform: Level plains to hillslopes on undulating rises. Slopes 0 to 6%
Vegetation: 3to 6m, sparse to mid-dense *Banksia aemula, Eucalyptus umbra* with an understory of heath. Occasionally 0.5 to 1 m heath.

Depth (m)



A1: Black or grey (7.5YR 2/1, 10YR 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 hange to

B2hs/h: Brown or black (5YR, 7.5YR 3/2, 3/3, 4/3, 4/4, 10YR 3/3, 4/2); sand to loamy sand; orstein pan or coffee rock pan; pH 4.5 to 6. Clear to diffuse change to

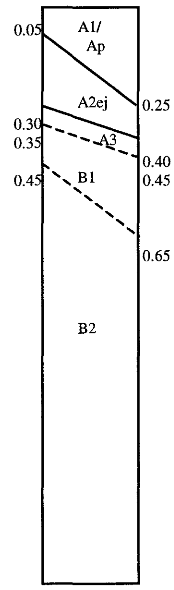
2A2: Grey (7.5YR 5/2, 6/2, 6/3, 7/3, 8/2, 10YR 7/3, 7/4, 8/3, 8/4); sand to sandy loam; single grain or massive; pH 5 to 6.

Sites: 115
Analysed sites: QCB 144
Variant: Colour B2 (no pan)

KEPNOCK (Kp)

Concept: 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 Elliot 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 on black (7.5YR 3/2, 4/1, 4/2, 10YR 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

A2ej: 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 (10YR 5/4, 6/4, 6/6); clay loam, clay loam fine sandy; massive or weak 2 to 5 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 (7.5YR 5/5, 6/5, 10YR 6/4, 6/5, 6/6); clay loam sandy to light clay; weak or moderate 2 to 5mm polyhedral or subangular blocky; 2 to 50% ferruginous or ferromanganiferous nodules <6 mm; pH 5.5 to 6.5. Gradual to diffuse change to

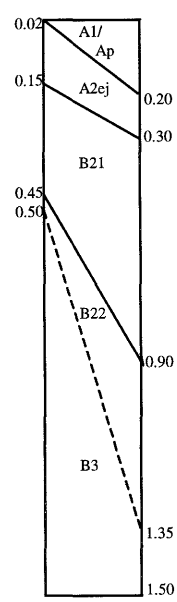
B2: Mottled; yellow or brown (7.5YR 6/5, 6/6, 7/6, 10YR 5/5, 6/5, 6/6, 6/8); light clay to medium clay; moderate or strong 2 to 5 mm polyhedral or subangular blocky; 10 to 50% ferruginous or ferromanganiferous nodules <20 mm; pH5.5 to 6.5.

Sites: 10, 12, 16, 17, 19, 23, 27, 32, 37, 38, 39, 53, 58, 67, 69, 167, 341, 357, 431, 460, 464, 475.

KOLAN (Ko)

Concept: Sodic textured contrast soil with a shallow (< 0.3 m), loamy surface over a red mottled, grey or brown clay subsoil on moderately weathered fine-grained sedimentary rocks
Australian Classification: Grey Kurosol, Brown Kurosol, Grey Sodosol, Brown Sodosol
Great Soil Group: Soloth
Principle Profile Form: Dy3.41, Dy3.31
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 siderophloia, Eucalyptus moluccana /Eucalyptus acmenoides / Eucalyptus exserta /Eucalyptus fibrosa. Eucalyptus moluccana* may be locally dominant.

Depth (m)



A1/Ap: Black or grey (10YR 3/1,3/2, 4/2, 4/3, 5/2, 5/3); loam fine sandy to clay loam fine sandy; massive to moderate 2 to 5mm granular or subangular blocky; pH 5.5 to 6.5. Abrupt to clear change to

A2ej: Occurs in undisturbed soils. Conspicuously or sporadically bleached. Loam fine sandy to clay loam fine sandy, massive or weak structure; frequently <2 to 50% ferruginous nodules <6 mm; pH 5.5 to 6. Sharp to abrupt change to

B21: Mottled; grey or brown (10YR 4/2, 5/2, 5/3, 6/2, 6/3, 6/4, 2.5Y 5/4); medium clay to heavy clay; strong 2 to 10 mm angular to subangular blocky; frequently 2 to 20% ferruginous nodules < 20 mm; pH. 5.0 to 6.0. Clear to gradual change to

B22: Red mottled; grey or brown (10YR 5/1, 5/2, 5/3, 6/1, 6/2, 6/3; 2.5Y 5/2, 5/4); medium clay to heavy clay; strong 20–50mm prismatic parting to moderate to strong 5 to 20mm angular blocky or moderate to strong 2 to 5 mm lenticular; frequently <2 to 10% ferruginous nodules 2–6 mm occasional slickensides present; pH 4.5 to 6.0. Gradual to diffuse change to

B3: Mottled; grey (10YR 5/3, 6/1, 6/2, 6/3, 7/1, 7/2, 2.5YR 7/2, 7/3); medium clay to heavy clay; moderate to strong 5 to 20 mm angular blocky or lenticular; fragments of mudstone or siltstone; pH 4.5 to 6.0

Sites: 82, 88, 89, 91, 99, 117, 124, 154, 156, 177, 238, 264, 280, 300, 308, 324, 345, 352, 359, 371, 382, 403, 414, 427, 429, 441, 443, 450, 476, 478, 479, 483, 493, 505, 524
Analysed sites: BUN C3, MBS 52

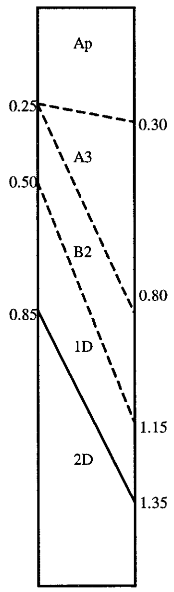
Kolan Red Variant (KoRv): Red Kurosol. Red B2 with 20 to 50% grey mottles.
Analysed sites: MBS 80.

Kolan Rocky Phase (KoRp): Grey Kurosol. As above with >20% coarse fragments in the surface or rock within 30cm of the surface

KOORINGA (Kr)

Concept:	Brown earthy sand on older alluvial terraces of the Mary River
Australian Classification:	Brown Kandosol, Orthic Tenasol
Great Soil Group:	No suitable group, earthy sand
Principle Profile Form:	Gn2.42, Uc4.32
Surface characteristics:	Soft to firm
Geology:	Quaternary Pleistocene Alluvium (Qpa)
Landform:	Scroll plains on terraces of the Mary River
Vegetation:	Mostly cleared

Depth (m)



Ap: Black or grey (7.5YR 3/2, 4/2); sandy loam to loam; massive; pH 6.5–7.5. Gradual to diffuse change to

A3: Occasionally present. Black (7.5YR 3/2); loam; massive; pH 7.5. Diffuse change to

B2w: Brown (7.5YR 4/3, 4/4, 4/6); sandy loam to sandy clay loam; massive; 0–<2% manganiferous nodules <2 mm; pH 6.5–7.5. Gradual to diffuse change to

1D: Brown (7.5YR 4/4, 4/6); loamy sand to sandy loam; massive; <2% manganiferous nodules <2 mm; pH 7.0–7.5. Diffuse change to

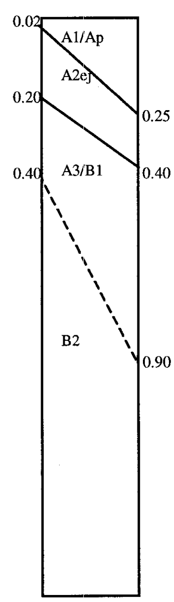
2D: Brown (7.5YR 4/6); sandy loam; massive, pH 7.5.

Sites: 535, 541, 550
Analysed site: MTL 9004

LITTABELLA (Lt)

Concept:	Massive, yellow or grey, sandy to loamy soils and sandy red soils on local alluvium
Australian Classification:	Yellow Kandosol, Grey Kandosol, Red Kandosol, Orthic Tenosol
Great Soil Group:	Yellow earth, no suitable group, earthy sand, podzol
Principle Profile Form:	Um5.52, Um4.23, Gn2.71, Gn2.94, Uc5.22
Surface characteristics:	Soft or loose
Geology:	Quaternary alluvium (Qa)
Landform:	Levees and scrolls on alluvial plains of local creeks
Vegetation:	Mostly cleared, minor dense scrub

Depth (m)



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

A2ej: Occasionally occurs as a colour, sporadically or conspicuously bleached. Sandy loam, fine sandy loam, loam fine sandy; massive or single grain; pH 5.5 to 6.5

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

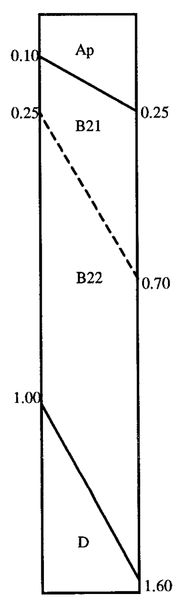
B2: Occasionally mottled; yellow or grey, occasionally red (5 YR 5/6, 7.5YR 6/3, 10 YR 6/2, 6/6, 7/1); sandy loam, loam fine sandy, sandy clay loam, clay loam sandy; massive or single grain; pH 6 to 8.

Sites: 107, 109, 150, 160, 182, 365

MARY (My)

Concept:	Brown structured clay on alluvium of the Mary River
Australian Classification:	Brown Dermosol, Brown Chromosol
Great Soil Group:	Brown Earth
Principle Profile Form:	Gn3.21, Uf6.33, Db112
Surface Characteristics:	Hardsetting
Geology:	Quaternary alluvium (Qa)
Landform:	Alluvial plains
Vegetation:	Cleared

Depth (m)



Ap: Black or brown (10YR 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 (10YR 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 (10YR 4/3, 5/4); medium clay to heavy clay; strong 5 to 10 mm subangular blocky or angular blocky; 0–20% managaniferous nodules or soft segregations <2 to 6 mm, pH 5.5 to 7.5.

D: Occasionally present; brown (7.5YR 5/8, 10YR 3/6, 5/4); loamy fine sand to fine sandy light clay; massive to weak subangular blocky; pH 7.0–8.0.

Sites: 30, 163, 213, 224, 334, 342, 349, 497, 513, 518, 520, 528
Analysed site: MTL350

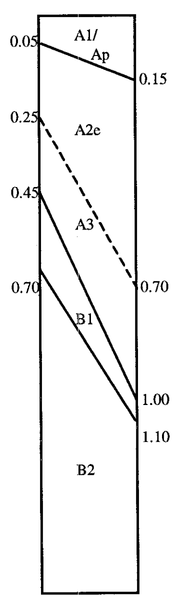
(MySv) Mary Shallow Variant: Brown Dermosol
D horizons occur within 0.6 m of the surface.

(MyDv) Mary Dark Variant: Black Dermosol
Black (7.5 YR 3/2) throughout profile.
Sites: 346, 504

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:	Elliot Formation (Te)
Landform:	Level plains to hillslopes on undulating rises. Slopes 0 to 5%.
Vegetation:	15 to 25m mid-dense *Eucalyptus umbra, Corymbia trachyphloia / Corymbia intermedia.*

Depth (m)



A1/Ap: Grey (7.5YR 4/1, 4/2, 5/2, 10YR 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 (10YR 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 (10YR 5/5, 5/6, 6/5, 6/6, 7/5, 7/6); sandy clay loam, clay loam sandy, sandy clay; massive or weak 2 to 10 mm subangular blocky or polyhedral; frequently ferruginous nodules 2 to 20 mm; pH 5.5 to 6. Clear to diffuse change to

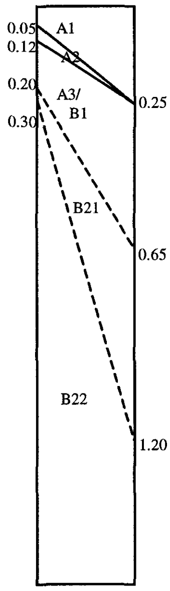
B2: Mottled; yellow or brown (10YR 5/5, 5/6, 6/4, 6/5, 6/6, 6/8, 7/4, 7/5, 7/6); sandy clay, light clay to medium clay; moderate or strong 2 to 10 mm subangular blocky or polyhedral; frequently ferruginous nodules 2 to 20 mm; pH 5.5 to 5.8.

Sites: 141, 445
Analysed site: BUN 118

MUNGAR (Mg)

Concept: Sporadically bleached alkaline grey clay on alluvial plains of the Mary River
Australian Classification: Brown Dermosol, Grey Dermosol
Great Soil Group: No suitable group, affinities with grey clay
Principle Profile Form: Uf3, Uf6.41
Surface characteristics: Occasionally present hardsetting, with normal gilgai when not cultivated
Geology: Quaternary Pleistocene Alluvium (Qpa)
Landform: Relict alluvial plains, backplains and terrace flats
Vegetation: Mostly cleared

Depth (m)



A1: Black or grey (10YR 3/2, 4/2, 2.5Y 5/2); silty light clay to silty light medium clay; moderate to strong 2 to 5 mm granular or subangular blocky; pH 6.5 to 7.0. Clear to gradual change to

A2j: Occasionally present. Sporadically bleached. Light clay to light medium clay; moderate 2 to 10 mm subangular blocky; none to 20% manganiferous soft segregation <2–6 mm; pH 6.5 to 7.0. Clear to gradual change to

A3/B1: Occasionally mottled; grey or brown (10YR 3/2, 4/4, 2.5Y 4/2, 5/2, 5/3); light medium clay to medium clay; strong 2 to 10 mm subangular blocky; none to 20% manganiferous nodules or soft segregations <2–6 mm; pH 7.0–8.0. Gradual change to

B21: Mottled; grey or brown (10YR 5/4, 5/6, 2.5Y 5/2, 5/3, 5/4, 6/1, 6/2); medium clay to medium heavy clay; weak to moderate prismatic 10–20 mm parting to strong 2 to 10 mm lenticular or subangular blocky; <2 to 20% manganiferous nodules <2–6mm; pH 7.5 to 9.5. Gradual change to

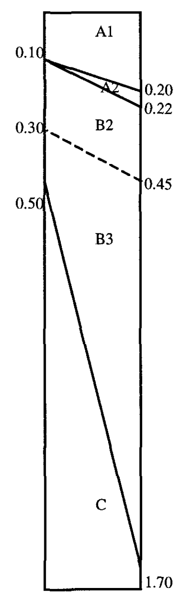
B22: Mottled; brown or grey (10YR 4/4, 5/3, 5/4; 2.5Y 5/3, 5/4, 6/3); medium clay to medium heavy clay; strong 2 to 50mm lenticular structure; <2–10% manganiferous nodules <2–6 mm none to <2% calcareous nodules or soft segregations 2–6 mm; slickenslides present; pH 8.5 to 9.5.

Sites: 11, 203, 205, 206, 234, 319, 351, 489, 509
Analysed site: MTL 9006

NETHERBY (Nb)

Concept: Black or grey structured clayey surface, frequently with a sporadically bleached horizon, overlying a brown or grey structured clay developed from andesite
Australian Classification: Eutrophic, Brown or Grey Dermosol
Great Soil Group: No suitable group, affinity with prairie soil
Principle Profile Form: Gn3.63, Gn3.83
Surface characteristics: Firm
Geology: Andesite of the Grahams Creek Formation (JKg)
Landform: Hillslopes on undulating or rolling undulating rises and low hills. (4–20%)
Vegetation: Mostly cleared

Depth (m)



A1: Black or grey (10YR 3/1, 3/2, 4/2, 7.5YR 3/2); clay loam to light medium clay; strong <2 mm granular or 2–5 mm subangular blocky; occasionally <2 to 10% ferruginous nodules <2–6 mm; andesite fragments 2–6 mm; pH 6.0–7.0. Clear to gradual change to

A2j: Sporadically bleached. Clay loam to light clay; moderate to strong 2–5 mm subangular blocky 2–10% manganiferous soft segregations and nodules <2–6 mm; 0–20% andesite fragments 2–6 mm; pH 7.0–7.5. Clear change to

B2: Occasionally mottled; brown or grey (10YR 4/1, 4/3, 5/3, 5/6, 2.5Y 4/2); light medium clay to medium clay; strong 2–5 mm subangular blocky structure; 0–10% manganiferous nodules <2–6 mm; pH 7.0–8.0. Gradual change to

B3: Mottled; brown or grey (10YR 5/6, 2.5Y 4/2, 5/1); light medium clay to medium clay; moderate 10–20 mm prismatic; <2% manganiferous soft segregations and/or nodules 2–6 mm; 0–<2% andesite fragments 2–6 mm; pH 8.0–9.5. Abrupt change to

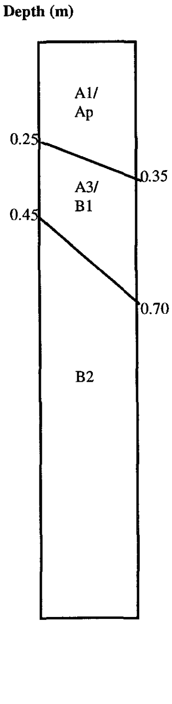
C: Weathered andesite fragments 2–60 mm.

Sites: 531, 543, 545.

OAKWOOD (Ok)

Concept: Brown or black loamy or clayey surface over a red earthy subsoil on deeply weathered sedimentary rock
Australian Classification: Red Kandosol
Great Soil Group: Red Earth
Principle Profile Form: Gn2.11, Gn2.12, Gn2.21, Uf6.53
Surface characteristics: Hardsetting
Geology: Elliott Formation (Te)
Landform: Level plains and upper slopes and crests of rises.
Vegetation: Cleared

Depth (m)



A1/Ap: Brown or black (10YR 2/2, 2/3, 3/2, 3/3, 7.5YR 3/3, 4/3, 4/4, 5YR 3/1,2.5YR 3/2); clay loam fine sandy, clay loam to light clay, massive to weak 2–5 mm subangular blocky or polyhedral, pH 5.5 to 7.0. Clear change to.

A3/B1: Brown or red (10YR 4/3, 4/4, 7.5YR 4/4, 4/6, 5/6, 5/8, 5YR 3/6, 4/4, 4/6), clay loam fine sandy to light clay, massive to weak 2–5 mm polyhedral, <2% to <10% ferruginous nodules; pH 5.5 to 7.0. Clear change to.

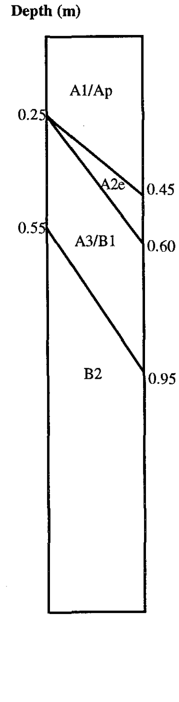
B2: Red (10R 3/6, 4/6, 2.5YR 3/3, 3/4, 3/6, 4/6, 4/8, 5YR 4/6, 4/8, 5/6); fine sandy light clay to light medium clay, massive to weak 2–5 mm subangular blocky or polyhedral, <2% to <10% ferruginous nodules; pH 5.5 to 7.0.

Sites: 144
Anaylsed sites: BUN 105, BSS 2, 6, 7, 8, 24, 26

OTOO (Ot)

Concept: Black or brown massive loamy surface over a yellow clay subsurface over a mottled, red structured clay subsoil on deeply weathered fine grained sedimentary rocks
Australian Classification: Red Dermosol
Great Soil Group: Red Podzolic soil
Principle Profile Form: Gn3.51, Gn3.54, Gn3.71, Gn3.74, Gn3.64
Surface characteristics: Hardsetting
Geology: Elliott Formation (Te)
Landform: Plains, upper slopes and crests of rises
Vegetation: Cleared

Depth (m)



A1/Ap: Black or brown (7.5YR 3/2, 10YR 3/2, 4/2, 4/3); fine sandy clay loam to clay loam; massive to weak 2–5 mm subangular blocky, <2% to 20% ferruginous nodules pH 6.0 to7.0. Abrupt to clear change to

A2e: Occurs occasionally. Conspicuously bleached, Massive; fine sandy clay loam to light clay; <2% to <10% ferruginous nodules; pH 6.0 to 7.0. Abrupt to clear change to

A3/B1: Occasionally mottled, yellow or brown, (2.5Y 6/4, 10YR 5/6, 6/6, 6/8, 7.5YR 5/6, 5/8, 6/6); fine sandy light clay to light clay; massive to moderate (2–5 mm) subangular blocky; < 2% to <20% ferruginous nodules; pH 5.0–6.0. Clear to diffuse change to

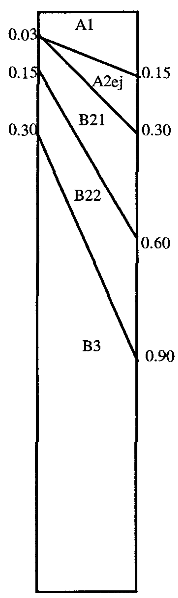
B2: Mottled, red (2.5YR 4/6, 4/8, 5YR 3/6, 4/6, 4/8, 5/8); light clay to light medium clay; moderate to strong 2 to 20 mm polyhedral or subangular blocky; < 2% to 50% ferruginous nodules; pH 5.0–6.0.

Site: 263

OWANYILLA (Ow)

Concept: Sodic texture contrast soil with a loamy surface over a mottled brown or grey subsoil on moderately weathered andesite of the Grahams Creek Formation
Australian Classification: Brown Sodosol, Grey Sodosol
Great Soil Group: Solodic soil
Principle Profile Form: Dy3.32, Dy3.33, Dy3.43, Dy3.42, Dy3.43
Surface characteristics: Hardsetting
Geology: Andesite of the Grahams Creek Formation (Jkg)
Landform: Hillslopes on gently undulating to undulating rises
Vegetation: 12 to 20 m mid-dense *Corymbia citriodora / Eucalyptus moluccana / Eucalyptus siderophloia*

Depth (m)



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

A2ej: Conspicuously or occasionally sporadically bleached. Fine sandy loam to clay loam; massive to weak 2 to 5 mm granular; pH 5.5 to 6.5. Abrupt to sharp change to

B21: Mottled; brown or occasionally grey (10YR 5/2, 5/3, 5/4); light medium clay to medium heavy clay; moderate to strong 5 to 10 mm angular blocky or 20 to 100 mm prismatic; frequently ferromanganiferous nodules 2 to 20 mm; pH 5.5 to 7.0. Gradual to diffuse change to

B22: Mottled; brown, grey or occasionally yellow (2.5YR 5/3, 7.5YR 5/2, 10YR 5/3, 6/4); medium clay to heavy clay; moderate to strong 2 to 5 mm lenticular or 20 to 100 mm prismatic; frequently 2 to 20 mm ferromanganiferous nodules; pH 6.0 to 7.0. Gradual to diffuse change to

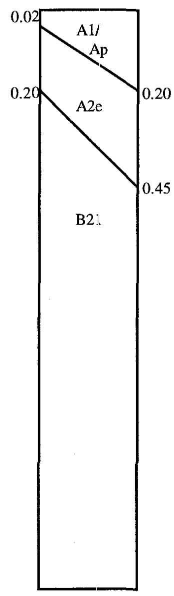
B3: Mottled; brown, grey or yellow (2.5YR 5/3, 5/4, 7.5YR 5/2, 10YR 6/4); medium clay to heavy clay with rock fragments; moderate 5 to 20 mm angular blocky; pH 6.5 to 9.0.

Sites: 128, 129, 130, 146, 152, 188, 273, 285, 385, 392, 425, 435, 436, 549, 552
Analysed sites: MTL 282, MBS 10.
(OwRp) Owanyilla Rocky phase: Leptic Rudosol
Weathered rock within 20cm of the surface.
Site: 454

PEEP (Pp)

Concept: Sodic texture contrast soil on local alluvium.
Australian Classification: Grey Sodosol, Brown Sodosol, Grey Kurosol, minor Redoxic Hydrosol
Great Soil Group: Solodic soil, soloth
Principle Profile Form: Dy3.42, Dy3.41, Dy3.43
Surface Characteristics: Hardsetting or soft
Geology: Quarternary alluvium (Qa)
Landform: Alluvial plain
Vegetation: 15 to 20 m sparse to mid-dense, variable, *Eucalyptus umbra, Angophora leiocarpa / Eucalyptus exserta / Melaleuca* species or *E. moluccana / E..tereticornis.*

Depth (m)



A1/Ap: Grey or black (7.5YR 3/2, 4/2, 5/1, 5/2, 5/3 10YR 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; 0–10% manganiferous nodules, <2–6 mm; pH 5.5 to 6. Abrupt to clear change to

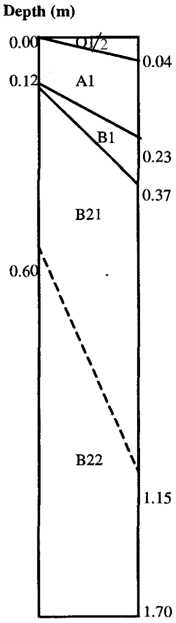
B21: Mottled; grey or brown (7.5YR 4/2, 5/2, 5/3, 6/2, 6/3, 10YR 4/2, 5/1, 5/2, 5/3, 6/2, 6/3, 7/1, 7/2); light medium clay to medium heavy clay; moderate or strong 5 to 20 mm angular blocky or 20 to 50 mm prismatic parting to angular blocky; 0–10% manganiferous soft segregations; none to few mangan cutans; pH 5.5 to 8.

Sites: 47, 59, 64, 120, 147, 159, 366, 466, 474
Analysed sites: BUN 117

PELION (Pe)

Concept: Cracking clay on alluvial plains derived from andesite of the Grahams Creek Formation
Australian Classification: Aquic Vertosol, Brown or Grey Vertosol
Great Soil Group: Weisenboden, Brown or Grey Clay
Principle Profile Form: Ug5.33, Uf6.42
Surface characteristics: Self mulching, and cracking if not in a swamp
Geology: Alluvium (Qa) derived from andesite of the Grahams Creek Formation (Jkg)
Landform: Swamps and alluvial plains
Vegetation: Mostly cleared

Depth (m)



O1/2: Occasionally present, root mat.

A1: Root mottling; black or grey (10YR 3/2, 4/1, 2.5Y 4/1); light medium clay to medium clay; strong <2 mm granular or 2–5 mm subangular blocky; pH 6.0–8.5. Clear to diffuse change to

B1: Occasionally present. Black or brown (10YR 3/2, 2.5Y 4/3); light medium clay to medium clay; strong 10–20 mm prismatic parting to strong 2–5 mm subangular or lenticular structure; 0–<2% manganiferous nodules <2 mm; clay cutans present; pH 7.0–8.5. Diffuse change to

B21: Occasionally mottled; black, brown or grey (10YR 3/1, 4/1, 4/2, 5/3, 2.5Y 2/1, 3/1); medium clay; strong 2–20 mm lenticular; 0–<2% manganiferous nodules <2 mm and/or <2% calcareous nodules 20–60 mm; clay cutans present; pH 8.0–9.0. Gradual to diffuse change to

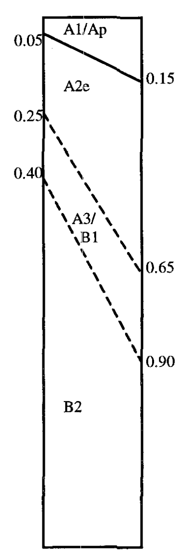
B22: Mottled; brown or grey (2.5Y 4/1, 5/2, 5/3); light medium clay to medium clay; weak 10–20 mm lenticular parting to strong 2–5 mm lenticular; <2% manganiferous nodules <2 mm; pH 9.0–9.5.

Sites: 530, 542, 546,566
Analysed site: MTL 9003

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 Elliot 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 (7.5YR, 10YR 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 (7.5YR 7/6, 10 YR 6/4, 6/5, 6/6, 7/4, 7/6, 2.5Y 7/6); sandy loam, light sandy clay loam, sandy clay loam, clay loam sandy; massive; pH 5.5 to 6. Diffuse change to

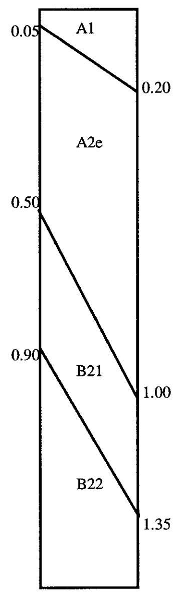
B2: Mottled; yellow (7.5YR 6/5, 6/6, 7/6, 10YR 6/5, 6/6, 7/5, 7/6, 8/4, 8/6. 2.5Y 7/4, 7/5); sandy clay loam, clay loam sandy, clay loam; massive; frequently ferruginous nodules 2 to 20 mm; pH 5.5 to 6.5

Analysed sites: BUN 114, 122

ROBUR (Rb)

Concept:	Sodic texture contrast soil with moderately deep (0.5–1 m) 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:	Elliot Formation (Te)
Landform:	Level plains
Vegetation:	10 to 18m sparse to mid-dense *Eucalyptus umbra, Melaleuca viridiflora / Corymbia trachyphloia*, frequently with an understory of *Banksia oblongifolia / B. robur*

Depth (m)



A1: Grey (7.5YR 4/1, 4/2, 5/1, 5/2, 10YR 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 (10YR 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 (10YR 6/1, 6/2, 6/3, 7/1, 7/2, 8/1, 2.5YR 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.

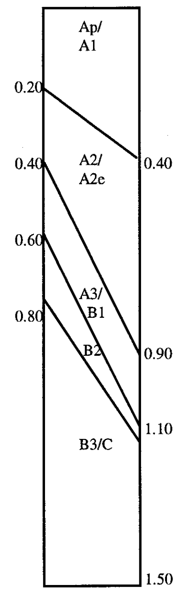
Sites: 55, 96, 123, 136, 225, 318, 468, 470
Analysed sites: BUN 103, 107, QCB 178, 216

(RbRp) Robur Rocky Phase: Tenosolic Oxyaquic Hydrosol
Rock within 30cm of the surface
Site: 473

ROTHCHILD (Rt)

Concept:	Bleached massive sandy surface over a mottled brown or yellow sandy loam to loamy sand on deeply weathered coarse grained sedimentary rocks
Australian Classification:	Brown Kandosol, Yellow Kandosol
Great Soil Group:	(Bleached) Earthy sand, Earthy sand
Principle Profile Form:	Uc2.21, Uc4.21, Uc4.22.
Surface Characteristics:	Hardsetting
Geology:	Elliott Formation (Te)
Landform:	Plains, and hillslopes and hillcrests on gently undulating rises. Slopes 0-5%.
Vegetation:	10 to 18 m mid-*dense Eucalyptus umbra / Eucalyptus trachyfolia / Eucalyptus hallii / Eucalyptus intermedia.*

Depth (m)



Ap/A1: Black to grey (7.5YR 2/2, 3/2, 3/1, 4/1, 10YR 3/1, 3/2, 4/2); loamy sand to sandy loam; single grained or massive. Clear to

A2/A2e: Conspicuously bleached; occasionally coloured (10YR 4/4, 5/4, 6/2, 6/3); loamy sand to sandy loam; massive. Gradual to diffuse to

A3/B1: (Occasionally present) Brown to yellow (7.5YR 4/3, 4/4, 5/6, 10YR 5/6); loamy sand to sandy loam; single grained or massive; occasionally 2 to 10%; 2 to 20 mm ferromanganiferous nodules; 2 to 10%, 6 to 20 mm quartz coarse fragments. Clear change to

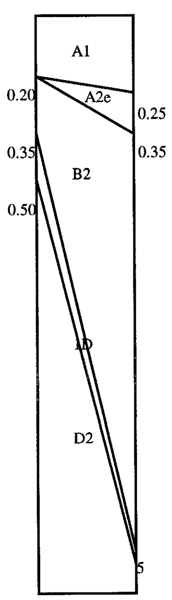
B2: Occasionally mottled; brown to yellow; massive (7.5YR 4/6, 6/4, 10YR 5/4, 5/6, 6/4, 6/6); loamy sand to sandy loam; massive; occasionally 10 to 20%; 2 to 20 mm ferromanganiferous nodules; frequently with 10 to 20% 6 to 20 mm quartz coarse fragments. Diffuse to

B3/C: Decomposing sandstone, massive.

SPRINGS (Sp)

Concept:	Sodic texture contrast soil with a sandy surface over a gritty mottled grey clay on alluvial fans
Australian Classification:	Grey Sodosols, Brown Sodosol
Great Soil Group:	Solodised Solonetz Solodic
Principle Profile Form:	Dy2.12p, Dy3.42, Dy4.22, Dy4.52
Surface characteristics:	Loose to soft
Geology:	Quaternary Pleistocene Alluvial fans (Qa)
Landform:	Lower to middle part of a gently sloping alluvial fan of Mt Bauple
Vegetation:	Mostly cleared

Depth (m)



A1: Black or grey (10YR 3/2, 4/2, 5/2); sandy loam to sandy clay loam; single grain to weak granular; 0–10%, angular grit 2–6 mm; pH: 5.5–6.5. Abrupt to clear change to

A2e: Conspicuously bleached. Sandy loam to sandy clay loam; single grain to massive; 0–<2%, angular grit 2–6 mm, pH 6.5–7.0. Abrupt or clear change to

B2: Occasionally mottled, grey or brown (10YR 5/2, 5/3, 5/4, 2.5Y 5/3); coarse sandy light medium clay to sandy medium clay; weak to strong 10–50 mm columnar on prismatic parting to moderate to strong, 2–10 mm angular blocky; 0–10%, <2 mm manganiferous soft segregations or nodules; 0–20%, angular grit 2–6 mm; pH 6.5–7.5. Clear to diffuse change to

1D: Brown (10YR 4/3, 5/3, 5/4); Coarse sand to coarse sandy loam; single grain; <2–90%, angular grit 2–6 mm; pH 7.0. Clear change to

2D: Grey (10YR 4/2, 5/2; 2.5Y 4/1); coarse sandy light clay to coarse sandy medium clay; massive; 0–10%, angular grit 2–6 mm; pH 7.0–7.5.

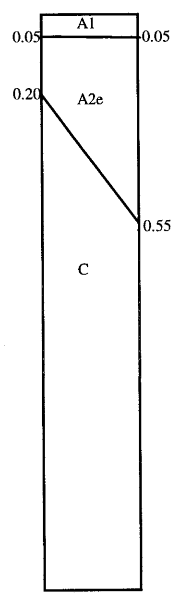
Sites: 564, 565, 574, 578
Analysed site: MTL 9005

(SpCv) Springs Clayey Variant. A1/A2e have sandy clay surfaces. B & D horizons same as above.

TAKOKO (Tk)

Concept:	Bleached loam on Silicified Maryborough Formation
Australian Classification:	Bleached-Leptic Tenosol
Great Soil Group:	No suitable group, affinities with (bleached) lithosol
Principle Profile Form:	No provision
Surface Characteristics:	Hardsetting with >20% coarse fragments 60 t o 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 20m mid-dense *Eucalyptus citrodora / E. acemenoides / E. trachyphloia / E. umbra / Lophostemon confertus.*

Depth (m)



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

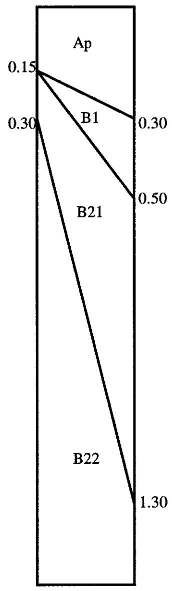
A2e: Conspicuously bleached; clay loam; massive; >20% rock fragments 20 to 600 mm; pH 5.0 to 5.5. Clear to gradual change to

C: Silicified sedimentary rocks

TEDDINGTON (Td)

Concept: Brown or black surface over a red mottled clay subsoil containing manganiferous nodules on the deeply weathered andesite of the Grahams Creek Formation
Australian Classification: Red Ferrosol
Great Soil Group: Krasnozem
Principle Profile Form: Uf6.4
Geology: Andesite of the Graham Creek Formation (Jkg)
Landform: Hillslopes on rises and low hills
Vegetation: Cleared

Depth (m)



Ap: Brown or black (5YR 3/2, 7.5YR 4/3, 10YR 4/3); light clay to light medium clay; weak to moderate 2 to 10 mm granular; frequently <2 to 50% manganiferious nodules <20 mm; pH 6.0 to 7.0. Clear change to

B1: Mottled; red or brown (5YR 5/5, 10YR 5/6); light clay to light medium clay; moderate to strong 2 to 5 mm polyhedral; <2 to 50% manganiferous nodules < 20 mm; pH 6.0 to 7.0. Clear change to

B21: Mottled; red (2.5YR 4/4, 4/6); light clay to light medium clay; strong 2 to 5 mm polyhedral; <2 to 50% manganiferous nodules <20 mm; pH 6.0 to 7.0. Clear to diffuse change to

B22: Mottled; red (10R 4/4, 2.5YR 4/8); light clay to medium clay; strong 2 to 5 mm polyhedral; <2 to 50% manganiferous nodules; pH 6.0 to 7.0.

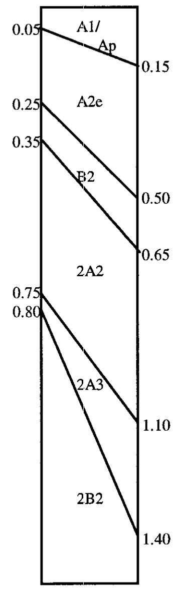
Sites: 56, 66, 76, 292

Analysed site: MBS 83

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: Elliot Formation (Te)
Landform: Level plains
Vegetation: 3 to 6 m very sparse to sparse *Eucalyptus umbra* with an understorey of heath or 1 to 3 m mid-dense to dense *Melaleuca nodosa* mixed with heath species

Depth (m)



A1/Ap: Grey (7.5YR 4/1, 5/1, 5/2, 10YR 4/1, 5/1); sand to sandy loam; single gram; 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

B2hs//h: Brown or occasionally grey with brown or yellow mottle (7.5YR 4/3, 5/3, 5/4, 10YR 4/2, 4/3, 5/3, 6/3, 7/1); sand loamy sand; single grain; occasionally orstein 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 (7.5YR 7/3, 10YR 6/4, 7/1, 7/2, 7/4, 8/2, 2.5YR 7/2, 8/2); sandy loam to sandy clay loam; massive; pH 5 to 6.2. Clear to abrupt change to

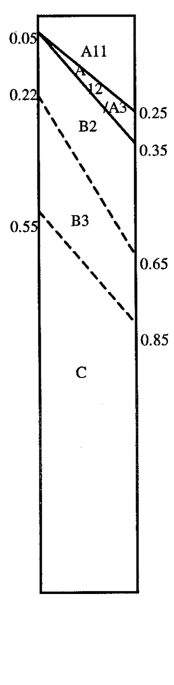
2B2: Mottled; grey (7.5YR 6/2, 7/2, 10YR 6/4, 7/2, 7/3, 8/2, 2.5Y 8/2); sandy light clay to sandy medium clay; moderate >20 mm blocky or prismatic; pH 5 to 6.

Sites: 46

TIARO (Ta)

Concept: Structure black or brown clayey soil overlying weathering andesite
Australian Classification: Eutrophic Black or Brown Dermosol
Great Soil Group: Praire Soil
Principle Profile Form: Uf6.32, Gn3.92, Gn3.22
Surface Characteristics: Firm. Very few to common andesite cobbles and stones
Geology: Andesite of the Grahams Creek Formation (JKg)
Landform: Hillcrests and hillslopes on gentle to rolling undulating rises and low hills (2–15%)
Vegetation: Mostly cleared, occasional remnants of vine scrub species

Depth (m)



A11: Black (10YR 3/1, 3/2; 7.5YR 3/2);clay loam to light clay; strong <2 mm granular or 2–5 mm subangular blocky; occasionally <2 to 10% ferruginous nodules 2–6 mm; pH 6.0–7.0. Sharp to abrupt change to

A12/A3: Black or brown (10YR 3/2, 3/3); light clay to light medium clay; strong 2–5 mm subangular blocky or polyhedral; 0–10% manganiferous or ferromanganiferous nodules <2–6 mm; occasionally <2% weathered andersite fragments 2–6 mm; pH 6.0–7.0. Abrupt to clear change to

B2: Black or brown (10YR 3/2, 3/3, 5/4); light medium to medium clay; strong 2–5mm subangular blocky; 0–10% manganiferous nodule or soft segregations, <2mm to 6 mm; 0–20% weathered andersite fragments 2–20 mm; pH 7.0–8.0. Gradual to diffuse change to

B3: Grey (10YR 4/2, 5/3, 2.5Y 5/2, 6/3); light clay to medium heavy clay; moderate 2–5 mm subaugular blocky; 10–20% weathered andersite fragments 2–20 mm; occasionally carbonate nodules, pH 7.5–8.0. Gradual to diffuse change to

C: Weathered andersite.

Sites: 419, 428, 434, 447, 492,522, 523, 529, 547

Analysed sites: MBS 89; BUN C2

Tiaro Rocky phase (TaRp)

A1: as above

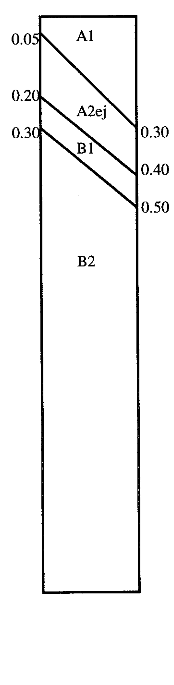
C: within 30 cm of the surface

Sites: 491, 532

TIMBRELL (Tb)

Concept: Bleached non-cracking alkaline sodic clay on local alluvial plains
Australian Classification: Redoxic Hydrosol, Oxyaquic Hydrosol
Great Soil Group: No suitable group, affinities with solodic soil
Principle Profile Form: Uf6.41, Gn3.03, Gn3.06, Gn3.93
Surface Characteristics: Hardsetting
Geology: Quaternary 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 (10YR 3/2, 4/2, 5/2); silty clay loam, silty clay to light medium clay; moderate to strong 2 to 5mm subangular blocky or granular; none to <2% ferruginous nodules 2–6 mm; pH 5.5 to 6.5. Abrupt or clear change to

A2ej: Sporadically or conspicuously bleached; mottled; silty clay loam, silty clay, light medium clay; massive to moderate 2–5mm subangular blocky; none to <2% ferruginous or manganiferous nodules 2–6 mm; pH 5.5 to 7.0. Abrupt or clear change to

B1: Occasionally mottled; grey (10YR 5/2, 6/1, 6/2; 2.5Y 6/2, 6/3); silty light clay to light medium clay; moderate to strong 2 to 5mm blocky or lenticular; none to <2% ferruginous or manganiferous nodules 2–6 mm; pH 6.0 to 7.5. Abrupt, clear or gradual change to

B2: Mottled; grey or brown (10YR, 2.5Y 5/1, 5/2, 5/3, 5/4, 6/2, 6/3); light medium clay to medium heavy clay; moderate to strong 2 to 10 mm lenticular; occasional slickensides; <2–20% manganiferous or calcareous nodules <2–6 mm; pH 7.5 to 9.5.

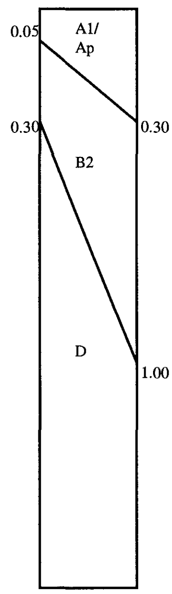
Sites: 241, 242, 245, 255, 283, 287, 406, 437, 515, 526, 537

Analysed site: MTL 299

TINANA (Ti)

Concept: Brown massive sandy soil over buried mottled loamy to clay soil on alluvium of the Mary River
Australian Classification: OrthicTenosol
Great Soil Group: Earthy sand
Principle Profile Form: Uc5.11, Uc5.21
Surface characteristics: Firm or loose
Geology: Quaternary alluvium (Qa)
Landform: Channel benches, levees and scrolls on alluvial plains
Vegetation: Mostly cleared

Depth (m)



A1/Ap: Grey (10YR 4/2); sandy loam to clay loam sandy; massive or weak 2 to 5 mm granular; pH 5.5 to 6.0. Clear to diffuse change to

B2: Brown (10YR 4/3, 4/4, 5/4); loamy sand to sandy loam; massive or single grain; pH 5.5 to 6.5.

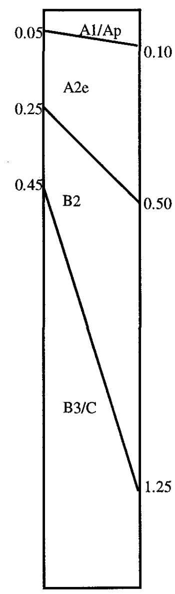
D: Mottled; brown (10YR 5/4); clay loam sandy to light medium clay; pH 6.5.

Sites: 26, 34, 381

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 Elliot Formation (Te). Tiaro coal measures (Jdt) and Myrtle Creek sandstone (RJdm)
Landform: Hillslopes on undulating rises and low hills
Vegetation: 18 to 22m mid-dense, variable, *Eucalyptus acmenoides, Corymbia trachyphloia / Eucalyptus umbra / Eucalyptus exserta / Corymbia intermedia/ Corymbia citriodora / Angophora leiocarpa.*

Depth (m)



A1/ Ap: Black or grey (7.5YR 3/2, 4/2, 10YR 4/2); sandy loam, loamy fine sand, fine sandy loam; massive; pH 5.5 to 6. Clear change to

A2e: Conspicuously bleached. Mottled; loamy sand; massive; pH 5.5 to 6. Abrupt to sharp change to

B2: Mottled; grey (7.5YR 4/2, 5/2, 6/1, 6/2 10YR 5/2, 5/3, 6/2) frequently becoming paler at depth; sandy light medium clay to sandy medium heavy clay; weak to strong 10 to 50 mm prismatic or angular blocky; pH 5.5 to 6.0 rarely up to 8.0. Abrupt to gradual to change to

B3/C: Mottled; grey (7.5YR 5/1, 5/2, 5/3, 6/1, 6/3, 2.5Y 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.

Sites: 135, 145, 298, 301, 322, 336, 368, 404, 405, 422, 500, 555, 557

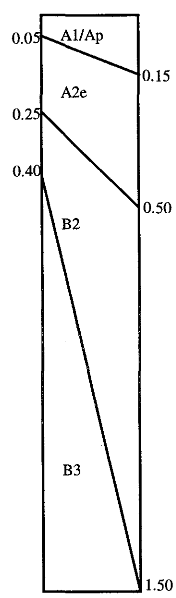
Tirroan non sodic variant (TrPv):
Brown or Yellow Chromosol
A1/Ap/A2: as per Tirroan.
B2: Mottled; brown or yellow (7.5YR 5/3, 6/3; 10YR 5/6, 6/3, 6/6); sandy clay to medium clay; moderate or strong 2 to 10 mm subangular blocky; pH 5.5 to 6.0.
Sites: 339

Tirroan Rocky Phase (TrRp): Bleached Orthic Tenosol
A1/Ap/A2e: as per Tirroan.
Rock encountered at less than 30 cm depth.

TURPIN (Tp)

Concept: Sodic texture contrast soil with a shallow (0.25 to 0.5 m) sandy surface containing 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 with frequently >10% ferruginous nodules 2 to 6 mm
Geology: Mudstones, siltstones, fine sandstones of the Elliot 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 leiocarpa / Corymbia trachyphloia / Corymbia intermedia / Eucalyptus exserta / Melaleuca viridiflora*

Depth (m)



A1/Ap: Grey or occasionally black (7.5YR 3/2, 4/2 10YR 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 (7.5YR 5/2, 5/3, 6/2, 6/3, 10YR 5/2, 5/3, 6/1, 6/2, 6/3, 7/1, 7/2) becoming paler at depth; light medium clay to heavy clay; strong 2 to 10mm angular blocky 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

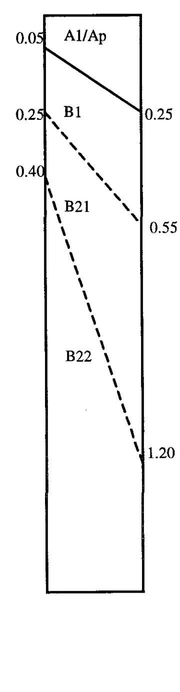
B3: Mottled; grey (7.5YR 5/2, 6/1, 6/2, 10YR 6/1, 6/2, 7/1, 7/2, 8/1, 8/2); clay with rock fragments.

Sites: 41, 44, 51, 73, 74, 202, 243.

WALKER (Wk)

Concept: Dark clay loam to clay surface over a mottled grey clay subsoil on alluvium of the Mary River
Australian Classification: Grey, Brown or Black Dermosol Redoxic Hydrosol
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 (7.5YR 2/2, 3/2, 4/2, 10YR 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: Mottled; brown, black or occasionally grey (7.5YR 2/2, 3/1, 3/2, 10YR 3/2, 2.5Y 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: Mottled; grey, or occasionally black (7.5YR 2/2, 4/2 10YR 3/2, 4/1, 4/2); light medium clay to heavy clay; strong 2 to 10 mm subangular blocky; occasionally <2% maganiferous nodules <2 mm; pH 5.7 to 7. Gradual to diffuse change to

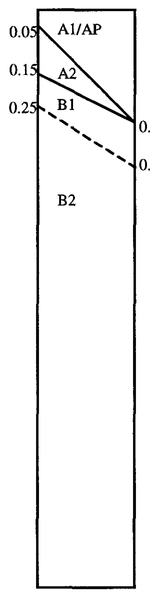
B22: Mottled grey (10YR 5/1, 5/2, 6/2, 2.5Y 4/1, 5/1); medium clay to heavy clay; strong 2 to 5 mm subangular blocky or lenticular; occasionally <2% maganiferous nodules <2 mm; pH 5.5 to 7.

Sites: 20, 164, 168, 220
Analysed site: BUN 108

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, Red Ferrosol
Great Soil Group: Red podzolic soil
Principle Profile Form: Gn3.14, Dr2.21, Gn3.11p, Uf6.31p
Surface Characteristics: Hardsetting frequently >10% ferruginous nodules 2 to 6 mm
Geology: Mudstones, siltstones, fine sandstones of the Elliot Formation (Te), Burrum Coal Measures (Kb), Maryborough Formation (Km)
Landform: Level plains to hillslopes of rises and low hills
Vegetation: Mostly cleared. Minor 8 to 25 m mid-dense *Eucalyptus citriodora, E. acmenoides / E. siderophloia / E. crebra*

Depth (m)



A1/Ap: Black or brown (5YR 2/2, 3/2, 3/3, 7.5YR 2/3, 3/3, 4/3, 10YR 2/2, 2/3, 4/3, 4/4); clay loam; weak to strong 1 to 5 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 (2.5YR 3/3, 4/3, 5Y 4/3, 4/4, 4/6, 7.5YR 4/4, 10YR 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 5 mm subangular blocky or polyhedral; <2% to >50% ferruginous nodules < 20 mm; pH 5.5 to 6. Gradual to diffuse change to

B2: Red (10R 3/6, 4/4, 4/6, 2.5YR 3/4, 3/6, 4/4 4/6, 4/8, 5YR 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.

Sites: 98, 153, 157, 161, 175, 180, 184, 189, 237, 271, 279, 307, 326, 370, 407, 418, 539, 556
Analysed sites: BUN 3, 112, MBS 4, 5, 28, MTL 9001

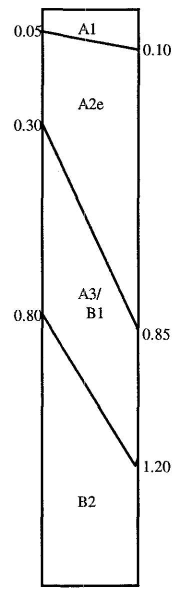
(WtMv) Watalgan Mottled Variant: Mottled B2
Sites: 110, 125, 178, 252, 440, 449, 560.
Analysed Sites: BUN 115, 123.

(WtRp) Watalgan Rocky Phase: Red Dermosol >20% rock outcrop throughout

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: Elliot 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 (7.5YR 3/1, 4/1, 4/2, 10YR 4/1, 5/1); sand to loamy sand; single grain or massive; pH 5 to 6. Clear to gradual change to

A2e: Conspicuously bleached. Sand to loamy sand; single grain or massive; pH 5.5 to 6. Diffuse change to

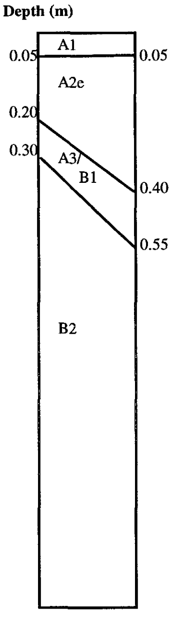
A3/B1: Mottled; grey, brown or yellow (7.5YR 5/3, 10 YR 7/3, 7/4); loamy sand to sandy loam; massive; pH 5.5 to 6. Diffuse change to

B2: Mottled; grey (7.5YR 6/3, 10 YR 7/2, 8/3); loamy sand to sandy loam; massive; frequently < 50% ferromanganiferous nodules 2 to 20mm; pH 5.5 to 6.

WOCO (Wo)

Concept: Loamy surface over a strongly acid, mottled, sodic, grey or brown clay subsoil with polyhedral structure on deeply weathered fine grained sedimentary rocks
Australian Classification: Grey Dermosol, Brown Dermosol, Grey Kurosol, Brown Kurosol, Redoxic Hydrosol
Great Soil Group: Soloth
Principle Profile Form: Gn3.04, Dy3.41
Surface Characteristics: Hardsetting
Geology: Mudstones, siltstones, fine sandstones of the Elliot 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 (7.5YR 3/2, 4/2, 10YR 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. Clear to gradual change to

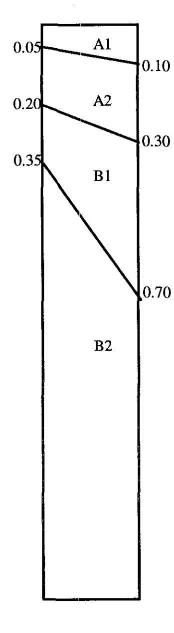
A3/B1: Mottled; brown, grey or yellow (7.5YR 4/3, 5/3, 6/4, 10YR 5/4, 6/4, 7/3); clay loam to light clay; 2 to 50% ferruginous (maghemite) nodules <2 to 6 mm; weak or moderate 2 to 5 mm subangular blocky or polyhedral; pH 5.0 to 6.0. Clear to diffuse change to

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

WOOBER (Wb)

Concept: Bleached non-cracking acid 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: Quaternary 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: Dark or grey (7.5YR 2/1, 3/2, 4/2, 10YR 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: 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 (7.5YR, 10YR 5/2, 6/1, 6/2; 2.5Y 6/2, 6/3); 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 or brown (7.5YR 5/1, 5/2, 6/2, 10YR 5/1, 5/2, 5/3, 6/2, 2.5Y 5/2, 5/3, 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.

Sites: 18, 134, 244, 251, 254, 257, 261, 384, 386, 412, 433, 451, 458

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

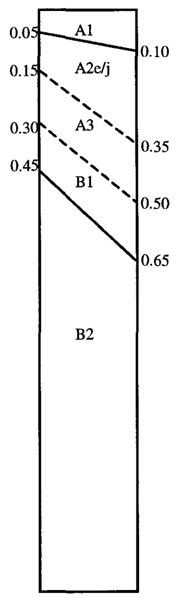
Surface Characteristics: Hardsetting

Geology: Mudstones, siltstones, fine sandstones of the Elliot 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 (7.5YR 4/1, 4/2, 10YR 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 (7.5YR 5/4, 6/4, 6/5, 10YR 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 (7.5YR 5/5, 6/6, 10YR 5/5, 5/6, 6/6); sandy clay loam, clay loam sandy, clay loam fine sandy; massive or weak 2 to 5 mm polyhedral or subangular blocky; 2 to 50% ferruginous (maghemite) nodules <20 mm; pH 5.5 to 5.8. Clear change to

B2: Mottled; yellow or brown (7.5YR 5/5, 6/6, 10YR 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 (maghemite) nodules <20 mm; pH 5 to 6.8

Sites: 354

APPENDIX II

A key to the soils of the Maryborough - Tiaro 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 deeply weathered sedimentary rock……………...……..	•• A Bhs, Bh horizon over sand…………………………….	…………………………	• **Kinkuna** (Kn)
	•• A Bhs, Bh horizon over a structured clay …..............…….	…………………………	• **Theodolite** (Th)
••• Soils on alluvium ….	•• Along local creeks ………….	………………………….	• **Littabella** (Lt)

****

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 alluvial plains or swamps of local creeks.....……………….	•• Alkaline clay B horizons……	…………………………..	• **Pelion (Pe)**

****

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 rock............................	•• Sandy*surface ……….	• massive, sand to sandy loam throughout profile …………..……	• **Winfield** (Wf)
		• Structured, non sodic clay B horizon.........…………………….	• **Alloway** (Al)
		• Structured, sodic clay B horizon	
		- rock < 0.3m …………...……..	• **Robur Rocky Phase** (RbRp)
		- clay < 0.5m and iron (maghemite) nodules……………..	• **Turpin** (Tp)
		- clay > 0.5m ....…………	• **Robur** (Rb)
	•• Loamy* surface............	• Structured, non sodic clay B horizon..........………..…………	• **Clayton** (Cl)
		• Structured, sodic clay B horizon - no pan in profile.....……………..	• **Kalah** (Kh)
••• Soils on alluvium...	•• Along the Mary River…	• Bleached loamy* surface with a sharp to abrupt change to mottled grey or brown clay……………..….	• **Butcher** (Bt)
		•Black humic loamy* surface with an abrupt to clear change to an acid, yellow and red mottled, grey clay...................…………………..……	• **Beaver** (Bv)
		• Black or grey loamy* to clay surface gradually changing to an acid to neutral, brown mottled grey clay………………………….…….....	• **Walker** (Wk)
	•• Along local creeks.........	• Loamy* or clay bleached surface gradually changing to mottled grey acidic or neutral (pH < 7.5) sodic clay at depth…….....…..	• **Woober** (Wb)
		• Loamy* or clay bleached surface gradually changing to mottled grey alkaline (pH > 7.5) sodic clay at depth..................	• **Timbrell** (Tb)
	•• On fan deposits from Mt Guyra and Mt. Bauple ……	• clay surface over a grey alkaline clay……………………………….	• **Gutchy** (Gy)

****

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

⇒ KUROSOLS

••• Soils on moderately weathered sedimentary rock……	•• 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 rock.............................	•• 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)
••• Soils on syenite …	………………………………….	…………………………..	• **Bauple** (Bp)
••• Soils on alluvium ..	•• Local creeks only……………	…………………………..	• **Peep** (Pp)

****

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

⇒ SODOSOLS

••• Soils on granites…	•• Sandy* A horizon over a mottled brown or grey B horizon	…………………………..	• **Gigoon** (Gn)
	•• Loamy* A horizon over a grey or brown B horizon ………	…………………………..	• **Doongul** (Do)
••• Soils on syenite…..	•• Sandy* A horizons over sandy clays……………………………	…………………………..	• **Bauple** (Bp)
••• Soils on moderately weathered sedimentary rock..…..	•• Sandy* A horizons…….........	…………………………..	• **Tirroan** (Tr)
	•• Loamy* A horizons. ………...	• Mottled brown clay subsoil ,pH > 6.0……….	• **Givelda** (Gv)
		• red mottled grey or brown clay, pH < 6.0 …..	• **Kolan** (Ko)
••• Soils on moderately weathered andesite ………………	•• Loamy* A horizon…………..	…………………………..	• **Owanyilla** (Ow)
••• Soils on deeply weathered sedimentary rock..............….........	•• Sandy* A horizon..........……	• A horizon >0.5 m..........	• **Robur** (Rb)
		• A horizon <0.5 m with iron (maghemite) nodules........................	• **Turpin** (Tp)
	•• 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…...…….	• Loamy* surface over mottled grey or brown B horizon………………	• **Butcher** (Bt)
		• Sandy* surface over mottled grey or brown B horizon…………………	• **Butcher sandy Variant** (BtSv)
	•• Along local creeks …………	• Mottled, grey or brown B horizon............….........	• **Peep** (Pp)
	•• On alluvial fans deposits from Mt Guyra and Mt. Bauple………	....	• **Springs** (Sp)

****

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 moderately weathered sedimentary rock……	•• Sandy* A horizon over yellow or grey B horizons ……………..	....	• **Tirroan non-sodic variant** (TrPv)
••• Soils on deeply weathered sedimentary rock………………….	•• Sandy* A horizon.................	• Red B horizon................	• **Gooburrum** (Gb)
		• Sandy* surface with greater than 10% cobbles or larger stones (>0.06m) or rock within 0.6m of surface…………………..	• **Isis Rocky Phase** (IsRp)
		• Mottled, yellow or brown B horizon…..…	• **Isis** (Is)
	•• Loamy* A horizon................	• Mottled, yellow or brown B horizon...........	• **Kepnock** (Kp)
••• Soils on alluvium...	•• Along Mary River…………....	• Loamy surface over brown b horizon. No A2 horizon………………….	• **Mary** (My)

****

G. Soils with B2 horizons in which the major part* has a free iron oxide content greater than 5% Fe in the clay horizons (Usually soils developed from basic rocks such as Basalt or Andesite) and excluding soils with B2 horizons with vertic properties*.

⇒ FERROSOLS

••• Soils on deeply weathered andesite rock…………………	•• Mottled red B2 horizons…….	....	• **Teddington** (Td)
	•• Red B2 horizon……………...	....	• **Bidwill** (Bd)
••• Soils on deeply weathered sedimentary rock ………………...	•• Loamy* A horizons………..	•• Red B Horizons……...	• **Watalgan** (Wt)

****

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

⇒ DERMOSOLS

••• Soils on moderately weathered andesite rock……….	•• Brown or grey clays with a sporadically bleached A2 horizon…….	……………………………………..	• **Netherby** (Nb)
	•• Black or brown structured clay…………..	……………………………………..	• **Tiaro** (Ta)
••• Soils on deeply weathered andesite rock…………………..	•• Loamy* to clay surface	• Maganiferous nodules throughout profile………………………………	• **Jumpo** (Jp)
••• Soils on deeply weathered sedimentary rock...........................	•• Sandy* surface......…..	• Red, B horizon...........……………	• **Gooburrum** (Gb)
		• Yellow massive thick A3 horizon >0.3m over mottled. yellow B horizon.....................……………...	• **Meadowvale**(Md)
		• Mottled, yellow or brown B horizon........……………………….……	• **Isis** (Is)
	•• Loamy* surface ….....	• Red B horizon...........……………	• **Watalgan** (Wt)
		• Yellow or brown A3/B1 over a red B2 horizon………………………....	• **Otoo** (Ot)
		• Yellow massive A3 horizon >0.3m thick over mottled, yellow or brown B horizon.....……………......	• **Woolmer** (Wr)
		• Mottled, brown, grey or yellow B horizon with silicified rock from Maryborough Formation	• **Bungadoo** (Bg)
		• 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)
••• Soils on alluvium...	•• Along Mary River …..	• Red clay B horizon......…………...	• **Aldershot** (Ad)
		• Brown clay B horizon…………….	• **Mary** (My)
		• Brown loamy* B horizon ……….	• **Copenhagen** (Co)
		• Black or grey loam to clay surface over a acid to neutral, brown mottled, grey clay......………………	• **Walker** (Wk)
		• Sporadically bleached, mottled, grey or brown acid (pH < 6.5) clay...	• **Granville** (Gr)
		• Sporadically bleached, mottled, grey or brown alkaline (pH > 6.5) clay…………………………………	• **Mungar** (Mg)
	•• On fan deposits from Mt Guyra or Mt Bauple…………………....	• clay surface over a alkaline grey clay…………………………….....	• **Gutchy** (Gy)

****

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 rock………………….	•• Sandy* surface…………..	•• Red B Horizon ……………...	• **Farnsfield** (Ff)
		•• Yellow B horizon……………	• **Quart** (Qr)
	•• Loamy* surface…..……..	•• Red B Horizon …………..…	• **Oakwood** (Ok)
••• Soils on alluvium	•• Along Mary River …..…..	……………………………….	• **Kooringa** (Kr)
	•• Along local creeks ……...	…………………………………	• **Littabella** (Lt)
	•• On fan deposits from Mt. Guyra and Mt. Bauple ……...	……………………………….	• **Guyra** (Gu)

****

I. Other soils with negligible (rudimentary) pedological organisation apart from minimal development of an A1 horizon, or the presence of less than 10% of B horizon material in fissures in the parent rock or saprolite. The soils are apedal or only weakly structured in the A1 horizon. There is little or no texture or colour change with depth unless stratifed or buried soils are present

⇒ RUDOSOLS

••• Soils on alluvium.…….	•• Along Mary River……..	• layered sandy soil………..……..	• **Baddow** (Ba)

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

⇒ **TENOSOLS**

••• Soils on moderately weathered andesite rock……….	•• Black clay A horizon over rock with andesite stones and boulders frequently on the surface………………………	....	• **Tiaro Rocky Phase** (TaRp)
••• Soils on moderately weathered sedimentary rock..……	•• Sandy* surface A horizon…..…………………...	•• Rock at <0.3m……………...	• **Tirroan Rocky Phase** (TrRp)
••• Soils on deeply weathered sedimentary rock…………………...	•• Loamy* surface with a bleached A2 horizon……………………..….	•• Silicified rock from Maryborough Formation throughout profile.....................………....	• **Takoko** (Tk)
		•• A2 over duricrusted* rock....	• **Avondale Tenic Variant** (AvTv)
		•• >20% course fragments or rock at <0.3m depth…………………………....	• **Avondale Rocky Phase** (AvRp)
••• Soils on alluvium...	•• Along Mary River ………	• Brown sand B horizon………	• **Tinana** (Ti)
	•• Along local creeks …….....	………………………………..	• **Littabella** (Lt)
	•• On fan deposits from Mt. Guyra and Mt. Bauple…….....	………………………………..	• **Guyra** (Gu)

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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.

Duricrusted. The process of weathering rock and soil material by iron and silica rich water forming a hardened rock like pan. Usually massive and brittle.

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

Humic. A humus rich surface layer with 4-12% organic carbon if no clay present or 6-8% organic carbon if > 60% clay.

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.

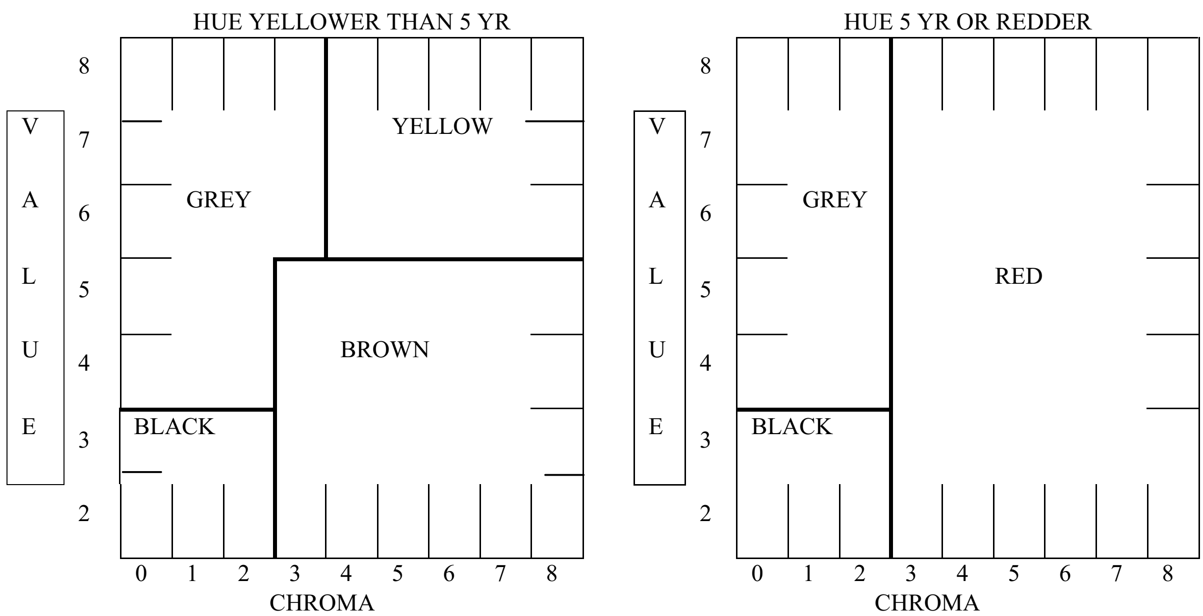
Sandy. Soil textures of sand, loamy sand to sandy loam.

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.

Lenticular Peds Natural soil aggregate (ped) which has elliptical planes with acute vertices(angles >90^{o}). See McDonald *et al* 1990.

Soil colour class limits.



APPENDIX III

Morphological and analytical data

Soil Type: Bidwill (Bd)
Site No: 246
A.M.G. Reference: 464704 mE 7171657 mN ZONE 56
Australian Soil Classification: Haplic, Mesotrophic, Red Ferrosol.
Great Soil Group: Krasnozem
Principle Profile Form: Uf6.31
Type of microrelief: No microrelief
Condition of surface soil when dry: Soft

Slope: 1 %
Landform element type: Hillcrest
Landform pattern type: Rises
Vegetation: Cleared

Profile morphology:

Horizon	Depth (m)	Description
A1p	0.00 to 0.15	Dark brown (7.5YR33); clay loam; strong, <2mm, granular structure; moist; weak strength. Gradual to
B21	0.15 to 0.35	Dark reddish brown (2.5YR34); light clay; moderate, <2mm, granular structure; moist; weak strength. Diffuse change to
B22	0.35 to 0.65	Reddish brown (2.5YR44); clay loam; moderate, 2-5mm, polyhedral structure; moist; weak strength; Diffuse change to
B31	0.65 to 0.90	Dark red (2.5YR36); clay loam; weak, 2-5mm, polyhedral structure; moist; very weak strength; very few, <2mm, ferruginous nodules. Diffuse change to
B32	0.90 to 1.40	Red (10R46); clay loam; weak, 2-5mm, polyhedral structure; moist; very weak strength; very few, <2-6mm, ferruginous nodules.

						Particle size					Exchangeable (Aqueous cations)					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	6.2	0.07	.001						10	4.9	3.3	BQ	1.3								4.9
0-0.10	6.0	0.05	.001	1.45	13	24	22	40	7	3.7	2.4	BQ	0.68			14	.34	0.62	0.135	0.044	4.7
0.20-0.30	6.2	0.03	BQ	1.37	11	22	21	48	5	3.2	1.9	BQ	0..05			14	.32	0.40	0.077	0.028	4.8
0.50-0.60	6.2	0.03	.002	1.33	6	15	16	63	4	2.3	2.1	BQ	0.03			19	.06	0.39	0.111	0.028	5.4
0.80-0.90	6.8	0.04	.004	1.30	6	13	16	67	5	2.0	2.7	BQ	BQ			20	.06	0.34	0.102	0.021	5.7
1.10-1.20	6.4	0.04	.004	1.28	4	11	16	69	5	1.7	3.3	BQ	BQ					0.31	0.098	0.021	5.7

			Extract P		Repl		DTPA Extractable			Cit/Dith
	%	%	mg/kg		meq%		mg/kg			%
Depth	Org C	Tot N	Acid	Bic	K	Fe	Mn	Cu	Zn	Free Fe
B0-0.10	3.4	0.26	6.0	11	1.2	59	70	1.7	1.6	
0.20-0.30										6.6

Soil Type: Kolan (Ko)
Site No: 282
A.M.G. Reference: 464348 mE 7167942 mN ZONE 56
Australian Soil Classification: Bleached-Vertic, Magnesic-Natric, Brown, Kurosol
Great Soil Group: Soloth
Principle Profile Form: Dy3.41
Type of Microrelief: No microrelief
Surface coarse fragments: Few 2%-10%, small pebbles 2-6mm, Ironstone
Condition of surface soil when dry: Loose

Slope: 4 %
Landform element type: Hillslope
Landform pattern type: Rises
Vegetation
Structural form: Tall isolated trees (12-20m)
Dominant species: *Eucalyptus tereticornis; Eucalyptus crebra; Eucalyptus exserta; Corymbia tessellaris; Angophora leiocarpa.*

Profile Morphology:

Horizon	Depth (m)	Description
A1	0.00 to 0.12	Brown (10YR43)fine sandy loam; massive structure; moist; very weak strength; few 2-6mm ferruginous nodules; abrupt change to
A2e	0.12 to 0.25	Dull yellowish brown (10YR54); few 2%-10% medium 5mm-15mm faint orange mottles; loamy fine sand; massive; moist, very weak strength; few 2-6mm ferruginous nodules; abrupt change to
A2ec	0.25 to 0.30	Dull yellowish brown (10YR54); massive structures; moist; very weak strength; abundant 2-6mm ferruginous nodules; sharp change to
B21	0.30 to 0.60	Light olive brown (2.5Y54); few 2%-10% coarse 15mm-30mm faint orange mottles; medium heavy clay; moderate 5-10mm lenticular structure; few faint stress cutans; moist; firm strength; clear change to
B22	0.60 to 0.75	Light yellowish brown (2.5Y64); common 10%-20% medium 5mm-15mm mottles; medium heavy clay; weak 5-10mm lenticular structure; moderately moist; firm strength; very few 2-6mm ferruginous nodules; gradual change to
B3	0.75 to 1.10	Greyish brown (2.5Y53); very few < 2% medium 5mm-15mm distinct red mottles; very few <2% medium distinct orange mottles; medium clay; common 6-20mm round ironstone; common marl coarse fragments; massive structure; moderately moist; very firm strength; diffuse change to
C	1.10 to 1.30	Abundant 50%-90% coarse fragments

				Particle size						Exchangeable (Aqueous cations)							BAR	Dispersion	Total element			
	mS/cm		%	%	%	%	%	%				meq%					%	Ratio	%	%	%	CaCl₂
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	5.6	0.04	0.002						6	1.1	2.8	0.19	0.20	0.61	1.32						4.0
0.10-0.20	5.9	0.09	0.006	0.98	19	50	14	16	8	2.7	4.1	0.49	0.42	1.0	0.30	6	0.64	.018	.185	.033	4.5
0.15-0.25	5.9	0.11	0.011	0.63	19	53	14	14	5	0.34	2.7	0.80	0.19	0.14	0.57	4	0.82	.009	.154	.016	4.3
0.50-0.60	5.4	0.52	0.070	1.50	15	36	12	37	16	BQ	9.4	5.1	0.13	1.28	1.66	14	0.83	.007	.244	.043	4.0
0.80-0.90	5.4	0.54	0.080	1.81	18	33	16	31	23	BQ	14	7.5	0.16	IS	1.50	15	0.93	.013	.494	.036	4.1

			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	2.2	0.10	2	3	0.20	300	3.9	0.15	2.7	13

*BQ – below measurable quantity.

Soil Type: Timbrell (Tb)
Site No: 299
A.M.G. Reference: 464420 mE 7168687 mN ZONE 56
Australian Soil Classification: Vertic, Dermosolic, Oxyaquic, Hydrosol
Great Soil Group: No suitable group, affinity with Grey Clay
Principle Profile Form: Uf6.4
Type of Microrelief: No microrelief
Surface coarse fragments: No coarse fragments
Condition of surface soil when dry: Firm

Slope: 0 %
Landform element type: Plain
Landform pattern type: Alluvial plain
Vegetation: Cleared

Horizon	**Depth (m)**	**Description**
A11	0.00 to 0.10	Dark greyish brown (10YR42); light medium clay; moderate 2-5mm granular structure; moist; weak strength; very few 2-6mm ferruginous nodules; non-calcareous
A12	0.10 to 0.22	Dark greyish brown (10YR42); common 10%-20% fine < 5mm faint brown mottles; light medium clay; strong 2-5mm granular structure; moist; firm strength; very few 2-6mm manganiferous nodules; non-calcareous
B21	0.22 to 0.50	Greyish brown (2.5Y52); common 10%-20% fine < 5mm faint yellow mottles; medium clay; strong 2-5mm subangular blocky structure; moist; firm strength; very few 2-6mm manganiferous nodules; non-calcareous
B22	0.50 to 1.15	Light olive grey (5Y62); many 20%-50% fine < 5mm faint yellow mottles; medium clay; strong 2-5mm lenticular structure; moist; firm strength; very few 2-6mm manganiferous nodules; non-calcareous
B23	1.15 to 1.30	Greenish grey (10Y61); many 20%-50% fine < 5mm faint yellow mottles; medium heavy clay; strong 2-5mm lenticular structure; few distinct slickensides; moist; firm strength; slightly calcareous
B24	1.30 to 1.65	Light greenish grey (10Y71) moist colour; many 20%-50% medium 5mm-15mm distinct orange mottles; medium heavy clay; strong 2-5mm lenticular structure; moist; firm strength; very few 2-6mm calcareous nodules; calcareous.

				Particle size					Exchangeable Cations (Aqueous cations)							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	0.52	0.073						16	4.7	8.7	2.7	0.15								4.8
0-0.10	6.0	0.54	0.082	2.01	7	17	28	43	18	4.8	9.2	3.5	0.17			18	0.64	.039	0.123	0.056	5.0
0.20-0.30	6.0	0.79	0.096	2.57	8	11	20	62	25	4.5	14	6.0	0.10			21	0.69	.013	0.125	0.056	5.1
0.50-0.60	8.5	0.63	0.079	2.40	6	14	28	54	30	5.6	17	7.5	0.11			21	0.95	.008	0.134	0.022	7.3
0.80-0.90	9.2	0.77	0.073	2.53	4	15	27	55	37	10	19	8.2	0.15			20	0.95	.006	0.150	0.017	8.0
1.10-1.20	9.5	0.76	0.064	2.08	9	20	24	47	47	23	16	7.5	0.12					.006	0.162	0.033	8.3

			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	2.8	0.20	3	19	BQ	220	110	1.2	1.1	40

Exchangeable Cations (pH 8.5 Alcoholic cations)					
			meq%		
Depth	CEC	Ca	Mg	Na	K
B0-0.10	21	2.8	6.5	1.4	0.20
0-0.10	21	2.7	7.3	2.2	0.23
0.20-0.30	25	3.5	10	4.2	0.38
0.50-0.60	23	5.2	15	6.2	0.11
0.80-0.90	24	7.3	17	7.2	0.26
1.10-1.20	20	4.8	13	5.8	0.09

Soil Type: Butcher (Bt)
Site No: 315
A.M.G. Reference: 462147 mE 7164687 mN ZONE 56
Australian Soil Classification: Vertic, Subnatric, Brown, Sodosol
Great Soil Group: Solodic soil
Principle Profile Form: Dy3.43
Type of microrelief: No microrelief
Condition of surface soil when dry: Hard setting
Slope: 1%
Landform element type: Terrace flat
Landform pattern type: Terrace
Vegetation: No record
Profile Morphology:

Horizon	**Depth (m)**	**Description**
A11	0.00 to 0.10	Very dark greyish brown (10YR32); sandy clay loam; weak structure; abrupt change to
A2e	0.10 to 0.35	Greyish yellow brown (10YR42); sandy clay loam; weak 2-5mm subangular blocky structure; moderately moist; very weak strength; very few 2-6mm manganiferous nodules; clear change to
B1j	0.35 to 0.45	Dark greyish brown (2.5Y42); light medium clay; moderate 2-5mm subangular blocky structure; moderately moist; weak strength; very few 2-6mm maganiferous nodules; clear change to
B21j	0.45 to 0.60	Dark greyish brown (2.5Y42); medium clay; moderate 2-5mm subangular blocky structure; moderately moist; weak strength; very few 2-6mm maganiferous nodules; abrupt change to
B22	0.60 to 0.80	Light olive brown (2.5Y54); very few < 2% fine < 5mm faint brown mottles; medium clay; moderate 2-5mm lenticular structure; few faint clay skins; few faint stress cutans; moist; weak strength; few 2-6mm manganiferous nodules; very few 2-6mm calcareous nodules.
B23k	0.80 to 0.95	Greyish brown (2.5Y53); very few < 2% fine < 5mm faint brown mottles; medium clay; strong 2-5mm lenticular structure; few distinct stress cutans; moist; firm strength; few 2-6mm maganiferous nodules; abundant 2-6mm calcareous soft segregations.
C	0.95 to 1.05	Greyish brown (2.5Y53); medium heavy clay; strong 2-5mm lenticular structure; moist; firm strength.

					Particle size				Exchangeable (Aqueous cations)							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	6.6	0.05	0.003						6	2.4	3.5	0.19	0.23								4.8
0-00.10	6.5	0.04	0.002	1.18	14	46	19	21	8	4.0	4.0	0.06	0.21			9	0.33	.035	0.839	0.023	4.9
0.20-0.30	6.2	0.03	0.001	1.09	17	43	16	24	5	1.4	3.6	0.27	0.06			9	0.59	.030	0.783	0.021	4.4
0.50-0.60	7.9	0.08	0.006	1.99	8	31	19	42	18	6.1	9.8	1.8	0.13			16	0.76	.015	0.829	0.013	6.3
0.80-0.90	9.3	0.30	0.012	1.92	11	33	20	38	42	25	14	2.9	0.12			15	0.81	.013	0.690	0.011	7.8
1.10-1.20	9.4	0.43	0.028	2.14	7	33	20	41	38	16	17	4.5	0.16					.010	0.678	0.011	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
B0-0.10	1.4	0.09	3	6	0.20	85	27	0.85	0.44	12

Exchangeable Cations (pH 8.5 Alcoholic cations) meq%

Depth	CEC	Ca	Mg	Na	K
B0-0.10	11	1.6	3.1	0.21	0.34
0-0.10	13	2.5	3.3	0.16	0.21
0.20-0.30	11	3.4	2.9	0.35	0.09
0.50-0.60	16	6.2	8.7	1.6	0.09
0.80-0.90	16	6.8	12	2.5	0.18
1.10-1.20	20	4.9	15	3.7	0.08

Soil Type: Mary (My)
Site No: 350
A.M.G. Reference: 457811 mE 7160836 mN ZONE 56
Australian Soil Classification: Haplic, Eutrophic, Brown, Dermosol
Great Soil Group: Prairie soil
Principle Profile Form: Uf6.33
Type of microrelief: No microrelief
Condition of surface soil when dry: firm

Slope: 7%
Landform element type: Swale
Landform pattern type: Flood plain
Vegetation: Cleared

Profile Morphology:

Horizon	**Depth (m)**	**Description**
Ap	0.00 to 0.20	Dark greyish brown (10YR42); fine sandy light clay; strong 2-5mm subangular blocky structure; moist; very weak strength; gradual change to
B21	0.20 to 0.35	Dark greyish brown (10YR42); light medium clay; moderate 2-5mm subangular blocky structure; moderately moist; firm strength; gradual change to
B22	0.35 to 1.55	Yellowish brown (10YR54); light medium clay; strong 2-5mm subangular blocky structure; moist; weak strength.

						Particle size						Exchangeable (Aqueous cations)				BAR	Dispersion		Total element		
	mS/cm		%	%	%	%	%	%				meq%				%	Ratio	%0	%	%	CaCl₂
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	6.8	0.07	0.001						14	8.1	5.5	BQ	0.26								5.4
0-00.10	6.2	0.16	0.008	1.24	3	48	24	26	14	8.2	5.2	BQ	0.56			12	0.65	.089	1.44	0.022	5.1
0.20-0.30	7.1	0.06	0.003	1.47	1	41	26	31	17	11	5.5	0.3	0.16			13	0.66	.046	1.34	0.019	5.8
0.50-0.60	7.5	0.04	0.001	1.52	BQ	42	21	35	17	11	5.8	0.41	0.15			11	0.68	.042	1.40	0.013	6.0
0.80-0.90	7.8	0.04	0.001	1.65	BQ	45	25	32	19	11	7.4	0.52	0.15			11	0.71	.040	1.38	0.011	6.1
1.10-1.20	7.4	0.04	0.002	1.63	BQ	43	27	30	18	9.5	8.1	0.47	0.16					.049	1.38	0.013	6.2

			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	1.2	0.11	74	94	0.30	71	25	2.1	2.3	7.6

Soil Type: Bauple (Bp)
Site No: 576
A.M.G. Reference: 455734 mE 7144123 mN ZONE 56
Australian Soil Classification: Bleached-sodic, Magnesic-natric, Grey, Kurosol
Great Soil Group: Soloth
Principle Profile Form: Dy5.41
Type of microrelief: No microrelief
Condition of surface soil when dry: Soft

Slope: 5%
Landform element type: Hillslope
Landform pattern type: Rises
Vegetation:
Structure: Very tall woodland (20-35m)
Dominant species: *Eucalyptus tereticornis; Corymbia tessellaris; C. citriodora; C. intermedia; Lophostemon suaveolens*

Profile Morphology:

Horizon	**Depth (m)**	**Description**
A1	0.00 to 0.12	Dark greyish brown (10YR42); loamy sand; weak 2-5mm subangular blocky; dry; very weak strength; clear change to
A2e	0.12 to 0.35	Greyish yellow brown (10YR52); loamy sand; massive structure; dry; very weak strength; few <2mm ferruginous nodules; abrupt change to
B21	0.35 to 0.40	Dark greyish brown (10YR42); common 10%-20% medium 5mm-15mm distinct mottles; sandy medium clay; strong 10-20mm prismatic structure; moderately moist; firm strength; gradual change to
B22	0.40 to 0.80	Brown (10YR53) moist colour; common 10%-20% fine < 5mm distinct orange mottles; sandy medium heavy clay; strong 10-20mm prismatic parting to moderate 5-10mm angular blocky structure; moderately moist; firm strength; diffuse change to
B3	0.80 to 1.60	Light yellowish brown (10YR64); sandy medium clay; few <6mm gravel; moderate 10-20mm prismatic structure; moderately moist; firm strength.

					Particle size					Exchangeable (Aqueous cations)						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	Ex Acid	15	R1	P	K	S	PH
B0-0.10	5.8	0.06	0.003						7	3.7	2.6	0.27	0.35	<0.5	<0.5						
0-0.10	5.8	0.05	0.004	0.7	50	33	9	9	5	2.7	2.0	0.21	0.26	<0.5	<0.5	3.9	0.51	.015	0.653	0.014	
0.20-0.30	5.8	0.02	0.002	0.4	50	35	10	7	3	0.86	1.3	0.17	0.12	<0.5	<0.5	3	0.72	.007	0.602	0.004	
0.50-0.60	4.8	0.353	0.049	2.57	32	20	7	43	19	0.19	8.6	3.6	0.24	6.1	6.6	15	0.79	.004	0.648	0.009	
0.80-0.90	4.6	0.631	0.075	3.03	28	20	11	42	29	0.27	13	6.6	0.30	7.5	8.4	18	0.84	.006	1.010	0.032	
1.10-1.20	4.6	0.640	0.089	3.40	22	20	17	41	32	0.30	15	7.3	0.27	8.2	9.3			.009	1.490	0.017	

			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	2.4	0.16	10	16	0.4	140	14	0.2	1.2	7.4

Soil Type: Owanyilla (Ow)
Site No: 583
A.M.G. Reference: 453047 mE 7145396 mN ZONE 56
Australian Soil Classification: Eutrophic, Mottled-Subnatric, Brown, Sodosol
Great Soil Group: Solodic soil
Principle Profile Form: Dy3.42
Type of microrelief: No microrelief
Condition of surface soil when dry: Hard setting

Slope: 8%
Landform element type: Hillslope
Landform pattern type: Rises
Vegetation:
Structural: Very tall isolated trees (20-35m
Dominant species: *Eucalyptus exserta; Eucalyptus tereticornis; Eucalyptus crebra; Corymbia citriodora*

Profile Morphology:

Horizon	**Depth (m)**	**Description**
A1	0.00 to 0.16	Dark greyish brown (10YR42; loam fine sandy; weak 2-5mm subangular blocky structure; moderately moist; very weak strength; very few 2-6mm ferruginous nodules; Clear change to
A2e	0.16 to 0.20	Dull yellowish brown (10YR43); loam fine sandy; massive structure; Abrupt change to
B21	0.20 to 0.35	Dark greyish brown (10YR42); many 20%-50% medium 5mm-15mm prominent red mottles; light medium clay; moderate 10-20mm prismatic structure parting to strong 2-5mm angular blocky; moderately moist; weak strength; clear change to
B22	0.35 to 0.46	Brown (10YR53); common 10%-20% medium 5mm-15mm distinct orange, very few small 2-5mm distinct red mottles; light medium clay; strong 10-20mm prismatic structure; moderately moist; weak strength; clear change to
C	0.46 to 0.82	Sandy clay loam; common 10%-20% small pebbles 2-6mm angular gravel coarse fragments; moderate 2-5mm angular blocky structure.

				Particle size						Exchangeable (Aqueous cations)						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	Ex Acid	15	R1	P	K	S	pH
B0-0.10	5.5	0.05	0.004						6	2.5	1.9	0.24	0.40	<0.5	0.5						
0-0.10	5.3	0.03	0.003	1.02	8	59	24	12	5	1.7	1.8	0.16	0.11	0.7	0.9	5.3	0.52	.013	0.412	0.010	
0.25-0.35	6.2	0.03	0.002	3.43	12	31	16	42	13	5.0	7.2	0.64	0.13			15	0.62	.014	1.240	0.007	
0.50-0.60	6.8	0.03	0.001	1.54	44	27	10	20	12	6.2	5.0	0.65	0.06			7.1	0.67	.068	1.600	0.002	

			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	2.76	0.15	6	20	0.4	250	19	0.1	0.9	9.2

Soil Type: Jumpo (Jp)
Site No: 9000
A.M.G. Reference: 464573 mE 7168402 mN ZONE 56
Australian Soil Classification: Acidic-sodic, Magnesic, Brown, Dermosol
Great Soil Group: No suitable group
Principle Profile Form: Uf6.41
Type of microrelief: No microrelief
Condition of surface soil when dry: Firm

Slope: 6%
Landform element type: Hillslope
Landform pattern type: Rises
Vegetation:
Structure: Very tall open forest (20-35m)
Dominant species: *Eucalyptus exserta; E. siderophloia; E. tereticornis*

Profile Morphology:

Horizon	**Depth (m)**	**Description**
A1	0.00 to 0.07	Dark greyish brown (10YR42); light medium clay; moderate 2-5mm subangular blocky; moist; very weak strength; few 2-6mm maganiferous nodules. Abrupt change to
A2j	0.07 to 0.27	Dull yellowish brown (10YR53) light clay; strong 2-5mm subangular blocky structure; moist; very weak strength; common 2-6mm manganiferous nodules; clear change to
B1	0.27 to 0.37	Light olive brown (2.5Y54); light medium clay ; moderate 2-5mm subangular blocky structure; moist; very weak strength; common <2mm manganiferous soft segregations; diffuse change to
B2	0.37 to 0.78	Light olive brown (2.5Y54); common 10%-20% medium 5mm-15mm prominent mottles; light medium clay; moderate 2-5mm subangular blocky structure; moist; weak strength; very few <2mm manganiferous nodules; clear change to
B31	0.78 to 1.15	Light brownish grey (2.5Y62); many 20%-50% fine < 5mm prominent red mottles; medium heavy clay; moderate 5-10mm lenticular structure; moderately moist; very firm strength; very few <2mm ferruginous nodules; abrupt change to
B32	1.15 to 1.35	Olive brown (2.5Y46); common 10%-20% medium 5mm-15mm prominent grey mottles; heavy clay; moderate 5-10mm lenticular structure; moderately moist; very firm strength; very few <2mm ferruginous nodules.

				Particle size						Exchangeable (Aqueous cations)						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	0.06	0.003						12	6.6	5.0	0.22	0.15								5.3
0-0.10	6.3	0.05	0.001	1.59	21	26	28	25	9	4.1	4.9	0.18	0.21			11	0.59	.035	0.184	0.036	4.8
0.17-0.27	6.1	0.06	0.006	1.68	27	21	21	33	7	0.60	5.7	0.44	0.05			13	0.63	.029	0.185	0.028	4.6
0.50-0.60	5.2	0.25	0.041	2.20	6	13	15	67	14	BQ	10	2.5	0.05	1.79	1.94	20	0.09	.013	0.103	0.073	4.0
0.80-0.90	5.1	0.22	0.052	2.28	9	22	19	52	21	0.19	14	4.6	0.11	1.14	1.77	18	0.80	.009	0.094	0.067	3.8
1.10-1.20	5.0	0.61	0.078	2.61	6	20	18	57	26	0.51	17	7.1	0.17	1.03	1.52			.008	0.130	0.048	3.9

			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	2.6	0.17	2	4	BQ	52	73	0.72	1.1	14

Soil Type: Watalgan (Wt)
Site No: 9001
A.M.G. Reference: 464814 mE 7167642 mN ZONE 56
Australian Soil Classification: Haplic, Magnesic, Red, Ferrosol
Great Soil Group: Red podzolic soil
Principle Profile Form: Uf6.31
Type of microrelief: No microrelief
Surface coarse fragments: No coarse fragments
Condition of surface soil when dry: Firm

Slope: 1%
Landform element type: Hillcrest
Landform pattern type: Rises
Vegetation:
Structural: Tall woodland (12-20m)
Dominant species*: Corymbia intermedia; Eucalyptus microcorys; E.siderophloia*

Profile Morphology:

Horizon	**Depth (m)**	**Description**
A1	0.00 to 0.07	Brown (10YR43); clay loam; massive structure; moderately moist; very weak strength; very few <2mm ferromanganiferous nodules; abrupt change to
A3	0.07 to 0.19	Brown (10YR44); clay loam; massive structures; moderately moist; very weak strength; very few <2mm ferromanganiferous nodules; abrupt change to
B21	0.19 to 0.50	Red (2.5YR46); very few < 2% fine < 5mm faint yellow mottles; light medium clay; massive structure; moderately moist; firm strength; very few <2mm ferromanganiferous nodules; clear change to
B22	0.50 to 0.95	Red (2.5YR46); clay loam; strong 2-5mm polyhedral structure; moderately moist; weak strength; very few <2mm ferromanganiferous nodules; gradual change to
B23	0.95 to 1.40	Red (2.5YR46); few 2%-10% medium 5mm-15mm distinct yellow mottles; clay loam; strong 2-5mm subangular blocky structure; moderately moist; firm strength; very few <2mm ferromanganiferous nodules.

					Particle size					Exchangeable (Aqueous cations)						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	6.1	0.05	0.004						5	1.9	2.5	0.04	0.22								4.8
0-0.10	6.2	0.05	0.002	1.72	7	29	38	22	6	2.6	2.9	0.07	0.24			8	0.53	.025	0.067	0.031	4.8
0.20-0.30	6.0	0.04	0.002	1.07	7	29	32	35	2	0.13	2.1	0.09	0.08			10	0.58	.015	0.056	0.017	4.4
0.50-0.60	5.7	0.06	0.006	1.53	3	11	18	70	5	BQ	4.7	0.38	0.04	0.23	0.26	21	0.04	.021	0.089	0.041	4.4
0.80-0.90	5.8	0.05	0.006	1.54	1	10	21	70	6	BQ	5.2	0.37	0.03	BQ	BQ	22	0.04	.016	0.083	0.039	4.7
1.10-1.20	5.7	0.05	0.006	1.49	2	8	19	69	5	BQ	4.9	0.34	0.03	0.1	BQ			.016	0.087	0.046	4.5

			Extract P		Repl		DTPA Extractable				Cit/Dith
	%	%	mg/kg		meq%		mg/kg			mg/kg	%
Depth	Org C	Tot N	Acid	Bic	K	Fe	Mn	Cu	Zn	SO4-S	Free Fe
B0-0.10	2.6	0.13	3	2	0.20	51	14	0.16	0.33	10	
0.50-0.60											6.7

Soil Type: Bucca (Bc)
Site No: 9002
A.M.G. Reference: 463604 mE 7159708 mN ZONE 56
Australian Soil Classification: Acidic-mottled, Magnesic, Brown, Dermosol
Great Soil Group: No suitable group, affinity with Brown clay
Principle Profile Form: Uf6.4
Type of microrelief: No microrelief
Condition of surface soil when dry: Hard setting

Slope: 0%
Landform element type: Plain
Landform pattern type: Level plain
Vegetation:
Structure: Very tall woodland (20-35m)
Dominant species: *Eucalyptus siderophloia*

Profile Morphology:

Horizon	**Depth (m)**	**Description**
A1	0.00 to 0.10	Brown (10YR43); light clay; strong <2mm granular structure; moderately moist; very weak strength; few <2mm manganiferous nodules; clear change to
A3	0.10 to 0.30	Yellowish brown (10YR54); light clay, heavy ; strong 2-5mm subangular blocky structure; moderately moist; weak strength; few manganiferous <2mm nodules
B1	0.30 to 0.45	Dark yellowish brown (10YR44); light clay ,heavy ; strong 2-5mm subangular blocky structure; moderately moist; weak strength; few 2-6mm manganiferous nodules; few <2mm manganiferous veins;
B21	0.45 to 0.60	Yellowish brown (10YR56); common 10%-20% medium 5mm-15mm faint red mottles; light medium clay; strong 10-20mm subangular blocky; moderately moist; weak strength; very few 2-6mm manganiferous nodules; very few 2-6mm ferruginous nodules
B22	0.60 to 1.00	Light olive brown (2.5Y56); many 20%-50% medium 5mm-15mm distinct red mottles; medium clay; strong 5-10mm subangular blocky structure; moderately moist; very firm strength; few 6-20mm ferruginous nodules
B23	1.00 to 1.40	Light olive brown (2.5Y54); many 20%-50% medium 5mm-15mm prominent red mottles; medium heavy clay ;very few < 2% small pebbles 2-6mm angular mudstone coarse fragments; moderate 5-10mm subangular blocky structures; very few < 2% medium 2-6 mm ferruginous nodules segregations; moderately moist strong strength;

					Particle size					Exchangeable (Aqueous cations)						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	5.4	0.05	0.001						5	1.3	1.8	BQ	0.21	1.26	1.52						4.0
0-0.10	5.4	0.05	0.001	1.55	14	28	20	35	4	0.72	1.9	BQ	0.24	1.01	1.30	12	0.41	.041	0.171	0.039	4.0
0.20-0.30	5.4	0.03	BQ	1.25	12	28	22	39	3	0.07	0.90	0.02	0.05	2.30	2.45	12	0.40	.029	0.164	0.031	3.9
0.50-0.60	5.3	0.04	0.001	1.23	8	26	24	43	5	BQ	1.2	0.05	0.03	3.90	3.96	14	0.20	.028	0.186	0.029	3.8
0.80-0.90	5.1	0.06	0.003	1.70	8	17	15	60	10	BQ	2.7	0.23	0.07	6.84	7.03	19	0.21	.025	0.297	0.039	3.6
1.10-1.20	5.1	0.06	0.004	1.75	6	17	15	64	11	BQ	3.8	0.34	0.08	6.82	7.09			.020	0.306	0.044	3.6

			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	2.2	0.20	3	12	0.20	50	160	0.78	1.1	56

Soil Type: Pelion (Pe)
Site No: 9003
A.M.G. Reference: 458136 mE 7151862 mN ZONE 56
Australian Soil Classification: Epicalcareous-epihypersodic, Epipedal, Aquic, Vertosol
Great Soil Group: Wiesenboden
Principle Profile Form: Ug5.11
Type of microrelief: Normal gilgai
Condition of surface soil when dry: periodic cracking, hard setting

Slope: 1%
Landform element type: Valley-flat
Landform pattern type: Alluvial plain
Vegetation: Cleared

Profile Morphology:

Horizon	**Depth (m)**	**Description**
A11	0.00 to 0.10	Dark greyish brown (2.5Y42); clay loam; strong 2-5mm subangular blocky; moist; very firm strength; slightly calcareous; clear change to
A12	0.10 to 0.24	Dark grey (2.5Y41); light medium clay; moderate 10-20mm prismatic parting to strong subangular blocky structure; few distinct slickensides; moist; weak strength; slightly calcareous; clear change to
B1	0.24 to 0.34	Black (2.5Y21); light medium clay, heavy; strong 2-5mm lenticular structure; few distinct slickensides; moist; weak strength; slightly calcareous; gradual change
B21	0.34 to 0.90	Black (2.5Y21); medium clay; strong 10-20mm lenticular structure; many prominent slickensides; moist; firm strength; slightly calcareous; gradual change to
B22	0.90 to 1.04	Dark grey (5Y41); many 20%-50% medium 5mm-15mm faint yellow mottles; medium clay; strong 2-5mm lenticular structure; common prominent stress cutans; moist; weak strength; few 2-6mm manganiferous nodules; slightly calcareous; diffuse change to
B23	1.04 to 1.50	Olive grey (5Y52); many 20%-50% medium 5mm-15mm distinct orange mottles; medium clay; strong 2-5mm lenticular structure; few prominent slickensides; moist; weak strength; few ferruginous nodules; slightly calcareous; diffuse change to
B24	1.50 to 1.67	Light olive grey (5Y62); few 2%-10% medium 5mm-15mm distinct orange mottles; light medium clay; common 10%-20% medium 2-6 mm calcareous nodules; very highly calcareous.

						Particle size				Exchangeable (alcoholic cations)						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	8.3	0.568	0.031						38	12	17	7.5	0.22								
0-0.10	8.1	0.374	0.025	4.58	8	16	27	41	36	14	14	7.0	0.19			29	0.84	.033	0.285	0.047	
0.20-0.30	8.9	0.563	0.044	4.13	2	19	30	48	31	13	14	10	0.08			23	0.88	.018	0.264	0.024	
0.50-0.60	8.9	0.922	0.080	7.15	2	8	18	71	41	11	19	20	0.08			32	0.85	.015	0.160	0.039	
0.80-0.90	8.9	0.599	0.041	8.14	2	8	17	72	45	13	20	15	0.06			31	0.96	.010	0.153	0.019	
1.10-1.20	9.0	0.314	0.003	3.71	16	20	23	43	26	11	15	4.2	0.015					.006	0.170	0.009	

			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	4.75	0.28	22	10	0.3	66	60	1.2	1.8	39

Soil Type: Kooringa (Kr)
Site No: 9004
A.M.G. Reference: 453346 mE 7154106 mN ZONE 56
Australian Soil Classification: Basic, Regolithic, Orthic, Tenosol
Great Soil Group: Earthy sand
Principle Profile Form: Uc4.32
Type of microrelief: No microrelief
Condition of surface soil when dry: firm

Slope: 2%
Landform element type: Scroll
Landform pattern type: Alluvial Plain
Vegetation: Cleared

Profile Morphology:

Horizon	**Depth (m)**	**Description**
Ap	0.00 to 0.26	Brown (7.5YR42); sandy loam; massive structure; dry; very weak strength
A21	0.26 to 0.71	Brown (7.5YR42); loamy sand; single grain structure; dry; very weak
A22	0.71 to 1.10	Dull brown (7.5 YR53); loamy sand; single grain; dry; very weak strength
B2w	1.10 to 1.40	Strong brown (7.5YR46); sandy loam; very few < 2% <6mm gravel; weak structure; moderately moist; weak structure.

				Particle size					Exchangeable (Aqueous cations)							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	6.5	0.02	0.002						7	4.7	1.5	0.14	0.60								
0-0.10	6.5	0.06	0.003	0.8	37	42	14	9	5	2.9	1.5	0.13	0.63			4.1	0.58	.039	1.98	0.010	
0.20-0.30	6.1	0.04	0.002	0.6	36	44	10	9	3	1.6	0.89	0.15	0.60			3.9	0.64	NA	0.034	0.008	
0.50-0.60	6.6	0.03	0.001	0.4	33	47	10	10	3	2.0	0.70	0.21	0.20			3.5	0.82	.025	2.06	0.004	
0.80-0.90	7.0	0.04	0.002	0.6	35	44	8	12	4	2.4	0.91	0.31	0.20			3.8	0.83	.024	2.10	0.002	
1.10-1.20	6.9	0.05	0.004	0.6	38	40	8	13	5	2.7	1.2	0.41	0.20			0.17		.024	2.09	0.002	

			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	1.89	0.15	340	NA	.7	48	21	14	5.4	8.8

Soil Type: Springs (Sp)
Site No: 9005
A.M.G. Reference: 455528 mE 7143907 mN ZONE 56
Australian Soil Classification: Hypocalcic, Effervescent, Grey, Sodosol
Great Soil Group: Solodic
Principle Profile Form: Dy5.43
Type of microrelief: No microrelief
Condition of surface soil when dry: Soft

Slope: 2%
Landform element type: Fan
Landform pattern type: Alluvial fan
Vegetation: Cleared

Profile Morphology:

Horizon	**Depth (m)**	**Description**
A1	0.00 to 0.18	Dark greyish brown (10YR42); few 2%-10% fine < 5mm distinct brown mottles; sandy loam; massive structure; moderately moist; very weak strength; non-calcareous.
A2e	0.18 to 0.20	Dark greyish brown (10YR42); Few 2%-10% fine < 5mm distinct brown mottles; sandy loam; massive structure; moderately moist; very weak; very few 2-6mm manganiferous nodules; non-calcareous.
B21	0.20 to 0.48	Light brownish grey (2.5Y62); common 10%-20% fine < 5mm prominent mottles; sandy light medium clay; moderate 10-20mm prismatic parting to 2-5mm angular blocky structure; moist; firm strength; common 2-5mm manganiferous nodules; very few <2mm calcareous nodules; slightly calcareous
B22	0.48 to 0.90	Light olive grey (5Y62); common 10%-20% fine < 5mm prominent brown mottles; common 10%-20% medium 5mm-15mm prominent gley mottles; sandy medium clay; weak 10-20mm prismatic structures; common 10%-20% medium 2-6 mm calcareous nodules segregations; moist firm strength; slightly calcareous.
1 D	0.90 to 1.10	Light brownish grey (2.5Y63); many 20%-50% medium 5mm-15mm prominent mottles; course sandy light clay; common <6mm angular gravel; weak structure; moist; weak strength; few manganiferous soft segregations; very highly calcareous.
2 D	1.10 to 1.27	Greyish brown (10YR52); common 10%-20% medium 5mm-15mm prominent mottles; course sandy clay loam; many <6mm angular gravel; massive structure; moist; very weak strength; very few <2mm manganiferous soft segregations; slightly calcareous.

					Particle size					Exchangeable (alcoholic cations)						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	7.1	0.05	0.003						7	3.9	3.0	0.21	0.10								
0-0.10	6.5	0.03	0.002	0.5	40	39	15	5	5	1.9	1.3	<0.09	0.13			2.8	0.73	.008	3.01	0.008	
0.20-0.30	8.6	0.129	0.002	1.42	32	26	11	30	12	5.7	6.4	1.3	0.07			11	0.60	.005	2.59	0.004	
0.50-0.60	8.7	0.173	0.005	2.01	24	27	13	37	17	7.1	7.5	3.0	0.06			15	0.86	.006	2.32	0.013	
0.80-0.90	9.0	0.276	0.005	1.65	39	26	10	26	14	7.8	6.6	2.6	<0.02			11	0.89	.003	2.61	0.005	
1.10-1.20	8.7	0.08	0.003	1.38	51	25	8	17	11	6.2	5.3	1.5	<0.02					.004	2.89	<0.002	

			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	1.86	0.14	6	6	<0.2	38	12	0.7	0.4	5

Soil Type: Mungar (Mg)
Site No: 9006
A.M.G. Reference: 456022 mE 7155888 mN ZONE 56
Australian Soil Classification: Bleached-vertic, Eutrophic, Brown, Dermosol
Great Soil Group: No suitable group
Principle Profile Form: Db2.42
Type of microrelief: Normal gilgai
Condition of surface soil when dry: Hardsetting

Slope: 0%
Landform element type: Backplain
Landform pattern type: Alluvial plain
Vegetation: Cleared

Profile Morphology:

Horizon	**Depth (m)**	**Description**
Ap	0.00 to 0.16	Dark brown (7.5YR32); few 2%-10% fine < 5mm faint brown mottles; clay loam; moderate 2-5mm subangular blocky; dry; weak strength; very few 2-6mm manganiferous soft segregations; abrupt change to
A2e	0.16 to 0.22	Dark greyish brown (10YR42); Very few < 2% fine < 5mm faint brown mottles; clay loam ; weak structure; moderately moist; weak strength; common <2mm manganiferous soft segregations; abrupt change to
B1	0.22 to 0.31	Dark yellowish brown (10YR44); many 20%-50% medium 5mm-15mm faint red mottles; light medium clay; strong 2-5mm subangular blocky structure; moderately moist; firm strength; very few 2-6mm manganiferous nodules; clear change to
B21	0.31 to 0.65	Yellowish brown (10YR58); medium clay; strong 2-5mm subangular blocky structure; moderately moist; firm strength; very few 2-6mm manganiferous nodules; clear change to
B22	0.65 to 0.91	Brown (10YR53); medium heavy clay; strong 2-5mm lenticular structure; few distinct slickensides; moderately moist; very firm strength; common <2mm manganiferous soft segregations; gradual change to
B23	0.91 to 1.40	Brown (10YR53); common 10%-20% medium 5mm-15mm distinct dark mottles; medium heavy clay; strong 2-5mm lenticular structure; common prominent stress cutans; moderately moist; very firm strength.

					Particle size					Exchangeable (Aqueous cations)						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	5.9	0.06	0.003						8	2.6	4.6	0.52	0.35								
0-0.10	6.0	0.09	0.004	2.49	14	39	30	NA	17	9.0	6.4	0.51	0.63			18	0.56	.038	0.421	0.038	
0.22-0.32	6.2	.126	0.013	2.23	8	32	26	36	14	4.7	7.8	1.4	0.15			14	0.69	.015	0.545	0.011	
0.50-0.60	5.4	.363	0.051	2.31	6	25	24	46	17	2.3	11	3.1	0.11	<0.5	<0.5	16	0.70	.009	0.319	0.017	
0.80-0.90	6.4	.513	0.074	2.58	6	27	25	43	23	1.6	15	5.9	0.13			17	0.94	.007	0.367	0.019	
1.10-1.20	7.6	.628	0.089	2.90	3	26	26	46	26	1.5	17	7.6	0.16					.006	0.344	0.004	

			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	2.78	0.18	7	18	0.4	240	57	1.3	1.7	13

*NA – not available

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
Cruciferae (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)
Sugar Cane (spray irrigation)
Sugar Cane (furrow irrigation)
Sweet corn
Sweet potato
Vegetables (capsicum, zucchini tomato)

CLIMATE (cf and cp)

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.

Limitation level	Suitability subclasses 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: cf 1	2	1	1	1	1
Regular frosts Code: cf 2	5	3	3	2	1
Severe frosts (channel benches, depressions in lower terraces) Code: cf 3	5	4	4	3	1
Rainfall >1000 mm cp 1			0**		
<1000 mm cp 2			4		

* All other crops refers to crops listed in this appendix. Seasonal adaptation is not considered, eg. 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.

Suitability subclass 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.

Limitation level	Suitability subclasses 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 1	1	2	1	1	1
150-125 mm Code: 2	1	2	1	1	1
125-100 mm Code: 3	1	2	1	1	1
75-100 mm Code: 4	1	2	1	2	1
50-75 mm Code: 5	1	2	2	3	2
<50 mm Code: 6	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 (w1, w2 and w3)

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)

Limitation level	Suitability subclasses 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 (pd)

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.

Attributes/Limitation level	Suitability subclasses for various crops			
Effective soil depth	Tree crops	Sugar cane	*Pinus*	All other crops
> 1 m Code: 1	1	1	1	1
0.6 to 1 m Code: 2	2	1	2	1
0.4 to 0.6 m Code: 3	3	1	4	1
0.3 to 0.4 m Code: 4	4	2	5	1
< 0.3 m Code: 5	5	5	5	5

SOIL NUTRIENT SUPPLY (nd, nf, nl, nr)

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 (nr).

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.

Attributes/Limitation levels	Suitability subclasses for various crops	
	Pinus	Other crops
Nutrient deficiency (nd) (A combination of P and K levels)		
P>40 ppm and K >0.6 meq Code: P1K1	1	1
P>40 ppm and K 0.2-0.6 meq Code: P1K2	1	1
P>40 ppm and K <0.2 meq Code: P1K3	2	2
P 20-40 ppm and K >0.6 meq Code: P2K1	1	1
P 20-40 ppm and K 0.2-0.6 meq Code: P2K2	1	1
P 20-40 ppm and K <0.2 meq Code: P2K3	2	2
P 10-20 ppm and K >0.6 meq Code: P3K1	1	2
P 10-20 ppm and K 0.2-0.6 meq Code: P3K2	1	2
P 10-20 ppm and K <0.2 meq Code: P3K3	2	2
P <10 ppm and K >0.6 meq Code: P4K1	2	2
P <10 ppm and K 0.2-0.6 meq Code: P4K2	2	2
P <10 ppm and K <0.2 meq Code: P4K3	2	2
Nutrient leaching (nl)		
No restriction: Code 0	1	1
Highly permeable soils with water table fluctuations deeper than 1.5 m (where W3 limitation between 3H and 6H): Code 1	2	2
Nutrient fixation (nf)		
No restriction: Code 0	1	1
Humic/organic soils. Code:1	2	2
Nutrient recation (nr)		
Soil pH to 0.3 m:		
pH >6.5 Code: 5	1	1
pH 6.0-6.5 Code: 4	1	1
pH 5.5-6.0 Code: 3	1	1
pH 5.0-5.5 Code: 2	1	2
pH <5.0 Code: 1	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.

Attributes		Limit. level	Suitability subclasses for various crops				
Size	Amt %	Code	Avocado, Macadamias, Citrus, Mango, Lychee, Stone fruit, Grapes, Pastures	SugarCane, Pineapple *Pinus*	Maize, Sorghum (forage), Sweet corn	Soybean, Veges, Cucurbits, Lucerne, Cruciferae, Asparagus, Beans	Peanut, Sweet potato, Potato, Navybean
	None	R0	1	1	1	1	1
6-20 mm	<2	P1	1	1	1	1	2
(Pebbles)	2-10	P2	1	1	1	2	3
	10-20	P3	1	1	2	3	4
	20-50	P4	1	2	3	4	5
	>50	P5	2	3	4	5	5
20-60 mm	<2	G1	1	1	1	2	3
(Gravel)	2-10	G2	1	1	2	3	4
	10-20	G3	1	2	3	4	5
	20-50	G4	2	3	4	5	5
	>50	G5	3	4	5	5	3
60-200	<2	C1	1	1	2	3	4
mm	2-10	C2	1	2	3	4	5
(Cobble)	10-20	C3	2	3	4	5	5
	20-50	C4	3	4	5	5	5
	>50	C5	4	5	5	5	5
	<2	S1	1	2	3	4	5
200-600	2-10	S2	2	3	4	5	5
mm	10-20	S3	3	4	5	5	5
(Stone)	20-50	S4	4	5	5	5	5
	>50	S5	5	5	5	5	5
	<2	B1/R1	2	3	4	5	5
>600 mm	2-10	B2/R2	3	4	5	5	5
(Boulders	10-20	B3/R3	4	5	5	5	5
or rock)	20-50	B4/R4	5	5	5	5	5
	>50	B5/R5	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.

MICROLIEF (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.

Attribute Vertical interval	Limitation level	Suitability subclasses for various crops All crops
<0.1m	Code: 0	1
0.1 to 0.3 m	Code: 1	3
0.3 to 0.6 m	Code: 2	4
>0.6 m	Code: 3	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.

Attribute/Limitation level	Suitability subclasses 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: 0, 1	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: 2	0	5	0	1
Flooding frequency approaches annual occurrence - lower channel benches. Code: 3	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.

Attribute/Limitation level	Suitability subclasses 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: 0	1	1	1	1	1	1	1
5-10 Code: 1	1	1	1	4	1	1	1
2.5-5 Code: 2	1	1	3	5	2	4	1
1.5-2.5 Code: 3	1	2	4	5	2-3	5	1
<1.5 Code: 4	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.

Attribute/Limitation level	Suitability subclasses 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: 0	1	1	1
15-20% Code: 1	2	4	1
20-30% Code: 2	4	5	2
>30% Code: 3	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 (ps, pm, pa)

Effect
- Germination and seedling development problems are associated with adverse conditions of the surface soil such as hardsetting, coarse aggregates, and crusting clays (ps).
- Soils with a narrow moisture range for cultivation can create difficulties in achieving favourable tilth (pm).
- Soil adhesiveness can cause harvest difficulties and affect the quality of subsurface harvest material (pa).

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.

Attribute/Limitation level ps, pm, pa	Suitability subclasses 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: 0	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: ps 1	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: ps 2	3	3	2	3	2	3	1	3
Crusting clays Code: ps 3	2	2	2	2	1	3	1	2
Large Aggregate size >20 mm Code: ps 4	4	4	3	2	2	4	1	3
Moderate moisture range Code: pm 1	2	2	2	2	2	2	1	1
Narrow moisture range Code: pm 2	3	3	3	3	3	3	1	2
Slightly adhesive soils Code: pa 1	2	1	1	1	1	1	1	1
Moderately adhesive soils Code: pa 2	3	1	1	2	1	1	1	1
Strongly adhesive soils Code: pa 3	4	1	1	3	1	1	1	1

SECONDARY SALINISATION (ss)

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.

Limitation levels	Suitability subclasses 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.

Attribute/Limitation		Suitability subclasses 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 (Deep drainage) (if)

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.

Attribute level	Suitability subclasses 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	Suitability subclasses 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^2 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

Attribute/Limitation level Depth (m) to oxidisable sulfur		Suitability subclasses 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.