Department of Natural Resources, Mines and Energy

Soils and Agricultural Suitability of the Miara-Winfield Area

Wide Bay-Burnett

Queensland

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This publication has been compiled by W Brown, J McClurg and M Sugars of Resource Assessment, Department of Natural Resources, Mines and Energy.

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Summary

Spatial information on the soils and landscapes of the area between Miara and Baffle Creek is one of the last remaining gaps in the foundational soil and land resource data within the Coastal Burnett region of Queensland. Dominant land uses in this area include beef cattle grazing on improved pastures, irrigated and dryland sugarcane and horticultural crops including pineapples, macadamias and mangoes.

Data collected during this project can be used to inform and support sustainable agriculture, land degradation studies, natural resource and catchment management planning, local government and regional planning decisions and Reef Catchment studies in the area.

This soil survey was undertaken at a medium intensity scale of 1:50 000 and largely includes the same geological setting and soils as found in the Bundaberg and Childers Land Resource Assessment projects. The broad landform patterns of the area include marine and beach ridge plains, alluvial plains associated with major rivers/creeks and local streams, plains, rises and low hills on sedimentary rocks, acid and intermediate volcanic rocks and basalt.

Soil profile classes (SPCs) and agricultural suitability classifications were based on existing data from surrounding projects and modified where necessary to account for the uniqueness of the Miara-Winfield-Watalgan (WIN) study area. Major soils and their corresponding limitations affecting agricultural land use and possible mitigation management strategies have been documented.

The lithology and degree of weathering, erosion, deposition, hydrology and geomorphology are the major determining factors of soil type within the WIN project. Cropped soils developed on deeply weathered sedimentary rocks are texture contrast and gradational with sandy to loamy surfaces over red and yellow to clay subsoils. These soils are currently used for a mixture of sugarcane, pineapples and horticultural crops. Significant areas of deep uniform sands and gradational red soils also occur on deeply weathered sedimentary rocks in the north of the study area on broad hillcrests. These soils are predominantly used for horticultural production. Wet uniform clays are present in the study area on the marine plains and in the tidal and inter-tidal flats. Where developed for agriculture these soil are used for sugarcane production and grazing. The undulating areas to the west of the coastal plains comprise of texture contrast soils with loamy surface horizons with grey, brown and yellow subsoils developed on moderately weathered sedimentary rocks. In places, deeply weathered fine grained sedimentary rocks overlie moderately weathered fine grained sedimentary rocks. These soils forming on deeply weathered fine grained rock on hillcrests and upper slopes have loamy surfaces over red or brown subsoils and are generally cropped for sugarcane and small crops. The cropped area often extends onto adjacent mid to lower slopes of the moderately weathered fine grained sedimentary soils. There are also large areas of soils developed on intermediate to acid volcanic rocks which are typically texture contrast with deep sandy to loamy surfaces over red, brown, yellow and grey subsoils. Only a small area of soils developed on basic volcanic rocks exists in the south of the study area. These soils are mostly used for grazing, forestry and conservation.

A land evaluation of a number of crops have been undertaken in the WIN study area. Agricultural Land Classes derived from the suitability classification of the soils and landscapes of the area have been identified and discussed in the report. The results indicate that 14 479 ha (or 23%) of the total area is Class A land and 6 658 ha (11%) is Class B. The area of Class C Land is 35 604 ha, or 58% of the total area, while the area assessed as non-agricultural land (Class D) is 5035 ha (8%).

Forms of land degradation occurring in the study area include salinisation, soil erosion, nutrient leaching, waterlogging, exposure of acid sulfate soils and weed infestation. Ninety-four UMAs occupying 3543 ha have the potential for secondary salinity to develop, with 1000 ha currently severely salt affected at the time of survey. Ninety-two UMAs, which cover 4860 ha, were recorded as having being partly affected by sheet or gully erosion at the time of the survey. Reports, maps, datasets and data from this land resource assessment are available online through various Queensland Government portals including QSpatial, Queensland Globe and the Queensland Government Publication portal.

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Additional Note:

- The Soils and Irrigated Land Suitability of the Bundaberg Area (Donnollan *et al.*, 1988) report has been used extensively in the development of this report. This is due to the similarity of the soils and landscapes across the Bundaberg-Miara-Winfield areas.

List of Acronyms Used in this Report

ALC	Agricultural Land Class
BAB	Bundaberg Land Resource Assessment project
CBW	Childers Land Resource Assessment project
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEM	Digital Elevation Model
DES	Department of Environment & Science
DNRME	Department of Natural Resources, Mines and Energy
DSITI	Department of Science, Information Technology and Innovation
EC	Electrical conductivity
GIS	Geographic Information System
LiDAR	Light Detection and Ranging
MVK	Land Resources of the Miriam Vale and Kolan Shires
PAWC	Plant Available Water Capacity
QLUMP	Queensland Land Use Mapping Program
SALI	Soil and Land Information Database
SEQ	South East Queensland
SILO	Scientific information for Landholders
SIR	Spatial Information Repository
SPC	Soil Profile Class
UMA	Unique Mapping Area
WIN	Miara–Winfield-Watalgan Project

1. Introduction

An important land resource and data knowledge gap exists for the area north of the Bundaberg Land Resource Assessment project (BAB, 1:50 000 scale, Donnollan *et al.* 1998) and east of the Miriam Vale-Kolan Land Systems project (MVK, 1:250 000 scale, Donnollan *et al.* 2004). This knowledge gap makes it difficult to address current and future land management issues, provide land resource data inputs into water quality modelling and assess agricultural land classes over the area. The Winfield-Miara-Watalgan Land Resource Assessment project (WIN) was initiated to fill this knowledge gap in land resource data.

The land resource information collected during the WIN project provides information that is essential to assist in the sustainable use of land resources of the area. The project involved a land resource survey at 1:50 000 scale over an area of 62 472 ha (Figure 1).

Major objectives of the project were to:

- Compile soil and land resource data for the study area and thereby complete the land resource data inventory for the coastal area north of Bundaberg.
- Identify areas of Agricultural Land Classes (ALC) and provide other land resource information to assist in informing a strategic plan for the Bundaberg Regional Council.
- Identify the extent of land within the study area that is degraded and/or prone to land degradation, including erosion and secondary salinisation.
- Provide land resources data to assist with water quality modelling and the prediction of sediment and nutrient delivery to the reef lagoon.
- Provide an appropriate planning base for the expansion of sugarcane, horticultural and other rural industries.
- Provide soils, land suitability and land management recommendations for landholders to address existing land management issues.

Details of the land resources, suitability for selected irrigated and dryland crops, limitations to agricultural production and management recommendations, land degradation and land use planning considerations of the area are provided in the report. This information is available in both electronic format through Geographical Information Systems (GIS), electronic maps (PDF format) and this report. GIS packages can be used to interrogate the digital data to obtain information to assist in understanding the land resources of the WIN Area.

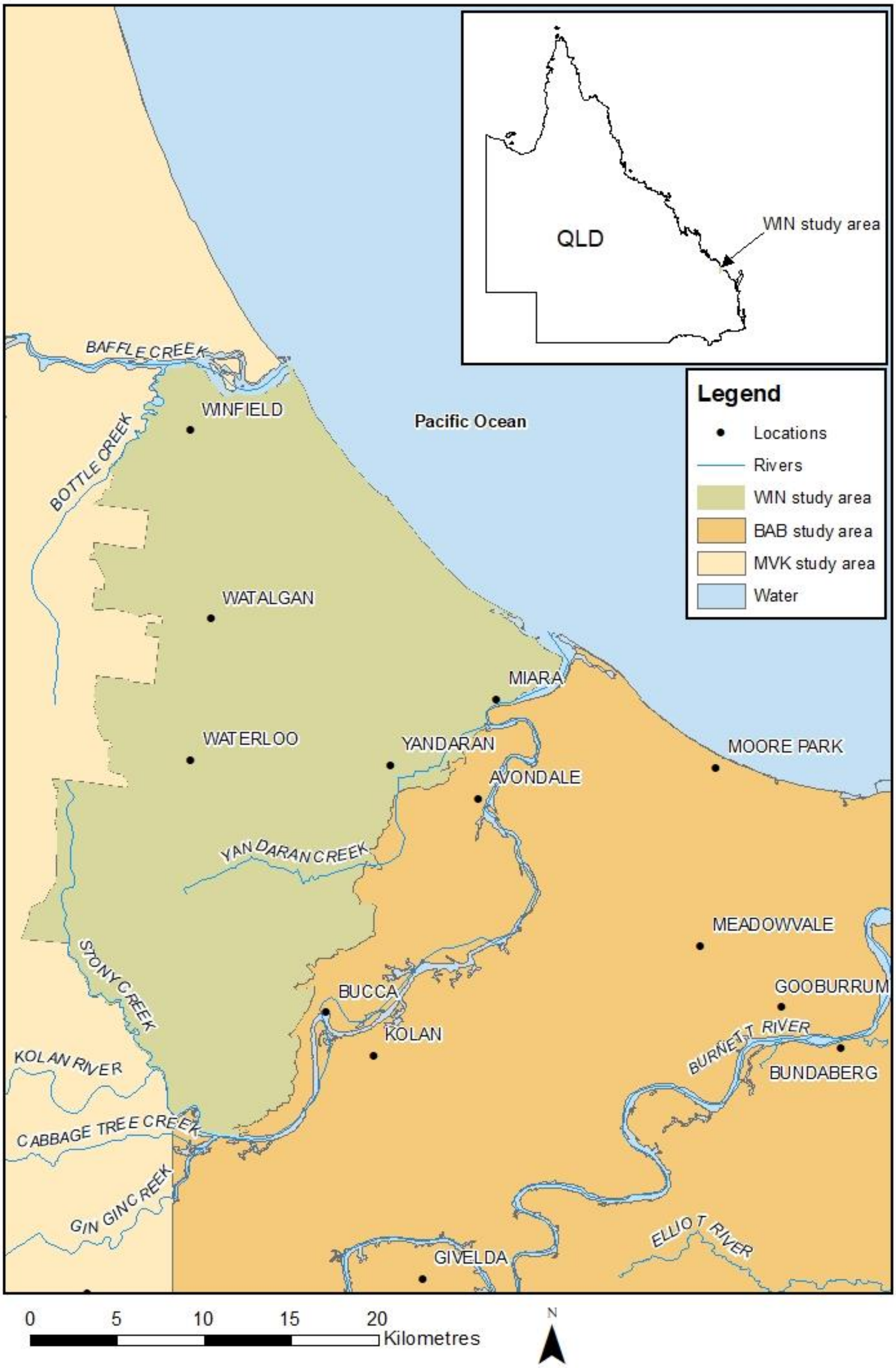

Figure 1 Locality map of the WIN study area

2. Survey methodology

Field work was undertaken at a medium intensity (1:50 000) by free survey (Reid, 1988). Preliminary soil and landscape boundaries were identified using geographic information system (GIS) software and data sets including 100 000 scale surface geology, vegetation regional ecosystem mapping, Capricorn Wide Bay 2017 20 cm imagery, stereo interpretation from 1:25 000 scale coloured aerial photographs, LiDAR digital elevation model with a resolution of 1 m, radiometric data and the existing Bundaberg soils mapping.

Sites were described in the field to identify the landscapes, soil types and soil boundaries. A total of 884 soil sites were described and entered into the Soil and Land Information (SALI) database, with most sites being Class I or Class IV (according to McKenzie *et al.* 2008 definitions). A soil profile to a depth of 1.5 m, or shallower if hard layers were encountered, was described and soil morphology and land attributes such as slope, gilgai, amount of rock, vegetation and current land use recorded at the 567 Class I sites. Less detail was described and recorded at the 275 Class IV sites. The soil profile was examined to 3 m at one site (Class II sites) while soil samples were taken from 41 soil profile (Class III) sites. The terminology and codes of the Australian Soil and Land Survey Field Handbook (NCST, 2009) were used for soil morphological descriptions at all sites.

Each site described was allocated to a Soil Profile Class (SPC). All soils were classified using the Australian Soil Classification (ASC) (NCST, 2016). Phases and Variants of the SPCs were used to distinguish soils which were similar to an existing SPC but differed in one or more soil or land attributes. Site locations and their descriptions were recorded within the Queensland Government's Soil and Land Information (SALI) database.

Wilson (1997) developed soil profile classes (SPCs) for the Childers 1:100 000 scale land resource survey (referred to as CBW). These SPCs formed the basis of the mapping of Donnollan *et al.* (1998) for the Bundaberg 1:50 000 land resource survey (referred to as the BAB report). An SPC may be defined as a three dimensional soil body such that any profile within the body has a similar number and arrangement of horizons whose attributes are within a defined range (Donnollan *et al.* 1998). As the geology, climate and geomorphology of the Miara, Winfield, Bundaberg and Childers areas are similar, the SPCs developed for the Childers and Bundaberg surveys provided the basis for soil mapping in this study area.

A total of 55 SPCs were identified and mapped within the WIN study area. Throughout this report the names of the SPCs are in italics for ease of identification. Two new SPCs were developed during the mapping phase to accommodate soils that had not been identified in the Childers and Bundaberg areas, or the wider Burnett-Mary coast. Detailed descriptions of the SPCs are given in Appendix 1.

Mapping units (Beckett and Webster, 1971) were named after the major SPC found in each unit, where that SPC occupied more than 60–70% of the area. Soil phases were used to separate those areas in which land use or land management would be affected due to the presence of certain soil or land properties not normally present within a SPC. For instance, a rocky phase indicates the presence of surface rock and stone. Soil variants identify minor areas with soil profile attributes outside the defined range of any SPC (e.g. *Kolan* Red Variant). Descriptions of phases and variants are given in Appendix 2 and appear on the map legend.

Each occurrence of a mapping unit was named a unique map area or UMA (after Basinski, 1978) and allocated a unique number for ease of data retrieval. Miscellaneous units such as water, marine, and quarries were also identified and mapped within the study area and allocated a UMA and UMA number.

The dominant SPC and the range of associated SPCs vary among the UMAs. An estimate of the percentage occurrence of SPCs, as well as land use, soil and land attributes, limitations to land uses, land suitability for a range of crops, size of UMA and other information for the UMA are stored in the SALI database. For simplicity SPCs are referred to as soils in the remainder of this report.

Spatial data (UMAs) and selected associated data are available from the Government's spatial catalogue (QSpatial).

3. Resources of the area

3.1 Climate

The climate of the Bundaberg region is subtropical with long, hot summers and mild winters (Donnollan *et al.* 1998). January is usually the hottest month of the year with an average of 17 days with temperatures > 30 ˚C, while July is the coolest.

Figure 2 shows the mean monthly rainfall and mean daily temperatures for the Miara weather recording station located 30 km NNW of Bundaberg (The State of Queensland 2018a). The climate data at Miara shows similar rainfall and temperature patterns to Bundaberg. Mean annual rainfall from 1889 to 2016 is 1004 mm. Rainfall is summer dominant, with 66% falling over the summer months. Variability in mean monthly rainfall over the summer months is extremely high, with rainfall in one in 10 years at least two times the mean. These very wet years are likely to have skewed the monthly mean and to some extent disguised the very dry summer months that can occur.

Frosts (screen temperatures < 2˚C) are extremely rare at Miara, with frequency < 1 per 2–3 years, but are more frequent within parts of the WIN study area in lower landscape positions of the more undulating landscape remote from the coast.

Mean monthly daily pan evaporation was sourced from Australian Rainman (Clewett *et al.* 1994), calculated from temperature records using the Fitzpatrick (1963) equation. Evaporation varies from 5.3 to 6.7 mm/day in January and December to close to 3 mm/day in the winter months May, June and July. The high evaporation rates in the summer months result in the need for more frequent irrigation, especially on the lighter textured soils within the study area, to avoid crop moisture stress.

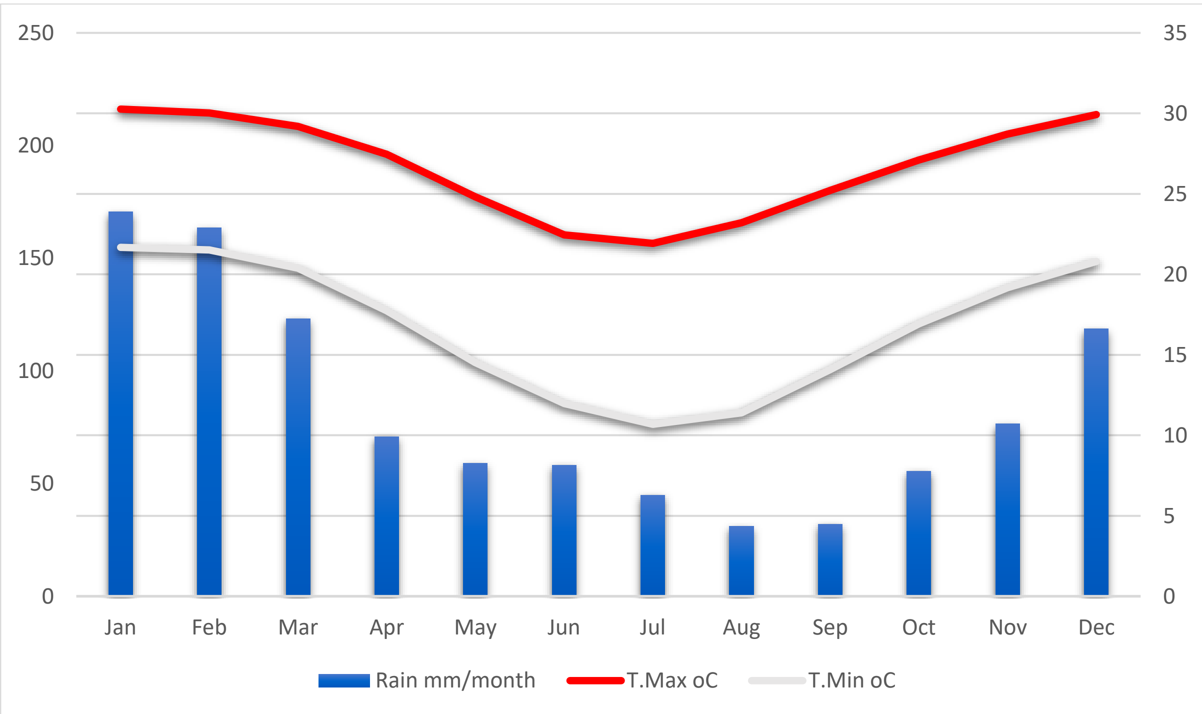

Figure 2 Miara mean climate data 1889-2016 (The State of Queensland 2018b)

3.2 Irrigation water sources

Average rainfall for the study area is approximately 1000 mm and is extremely variable. The high infiltration/evapotranspiration deficit drives the need for irrigation to achieve viable crop yields. However, within the study area, many sugarcane and pineapple growers are growing under dryland conditions and in some instances with some limited supplementary irrigations during extreme dry periods within critical times in the growing season. All horticultural crops in the study area rely on frequent irrigation.

During the technical assessment associated with the development of the Baffle Creek Basin Water Plan 2010, the Department of Natural Resources, Mines and Energy (DNRME) gathered data on the available water resources in the WIN study area. This data on overland flow storages was compiled through the ground-truthing of the Littabella Creek sub catchment. Overland flow storages provide the bulk of the irrigation water within the WIN study area. Individual storages range in capacity from 20 to 1000 ML. The total combined overland flow storage is 4172 ML, with details given in Table 1 below.

Table 1 Overland flow storages, Littabella Creek sub catchment

Land use	Water storage (ML)
avocado, mangoes, lychees	1490
sugarcane	1213
lime trees & stock water	90
not used	243
pasture	374
small crops	206
stock and domestic	194
sugarcane & small crops	292
unknown	70
Total	**4172**

Licenses to harvest water from Littabella, Walsh, Mullet, Arthur and Landsborough Creeks also exist within the study area. Irrigation water is used to irrigate sugarcane, tree crops, small crops and pasture. The total volume of water harvest licenses from creeks within the WIN study area is approximately 2939 ML.

3.3 Geomorphology and geology

The study area is situated geologically within the Maryborough Basin which occupies 9100 km^2 onshore and 15 500 km^2 offshore (Geoscience Australia 2014). The Basin has been formed through a sequence of depositional (marine and terrestrial), volcanic, tectonic and weathering events resulting in the formation of the current geological Formations consisting of two main successions:

1) Latest Triassic to Middle Jurassic continental sediments of the Duckinwilla Group
2) Latest Jurassic to Early Cretaceous Grahams Creek Formation and two conformable Early Cretaceous units, the Maryborough Formation and Burrum Coal Measure (Geoscience Australia 2014).

The geological Formations generally increase in age from east to west within the study area with the exception of some minor igneous units and relict isolated capping of younger sedimentary formations. Large areas of moderately weathered and deeply weathered fine grained and coarse grained sedimentary rocks of varying ages dominate the study area with some moderate areas of acid intrusive rocks in the more undulating western portion of the study area (Figure 3). Detailed information of the geology of this area is also described in Ellis and Whitaker (1976) and Robertson (1979).

The WIN study area may be divided into five broad landform patterns based on geomorphology and geology and include:

1) Marine and beach ridge plains
2) Alluvial plains associated with major rivers/creeks and local streams
3) Plains, rises and low hills on sedimentary rocks
4) Rises and low hills on acid and intermediate volcanic rocks
5) Rises and low hills on basalt

Quaternary Holocene and Pleistocene sediments form the marine and beach ridge plains that lie between the Kolan River and Baffle Creek east of the Neogene Elliott Formation scarp. Quaternary alluvial plains occur along the Kolan River and Littabella Creek as well as along the local streams. Rises and low hills on acid and intermediate volcanic rocks are located in the central-west to south-west of the WIN study area, while a small area of Neogene Maroondan Basalt occurs in the south-western corner. The remaining area between the igneous formations to the west and the marine and beach ridge plains along the coast consists of plains, rises and low hills on highly to moderately weathered sedimentary rocks (Figure 3).

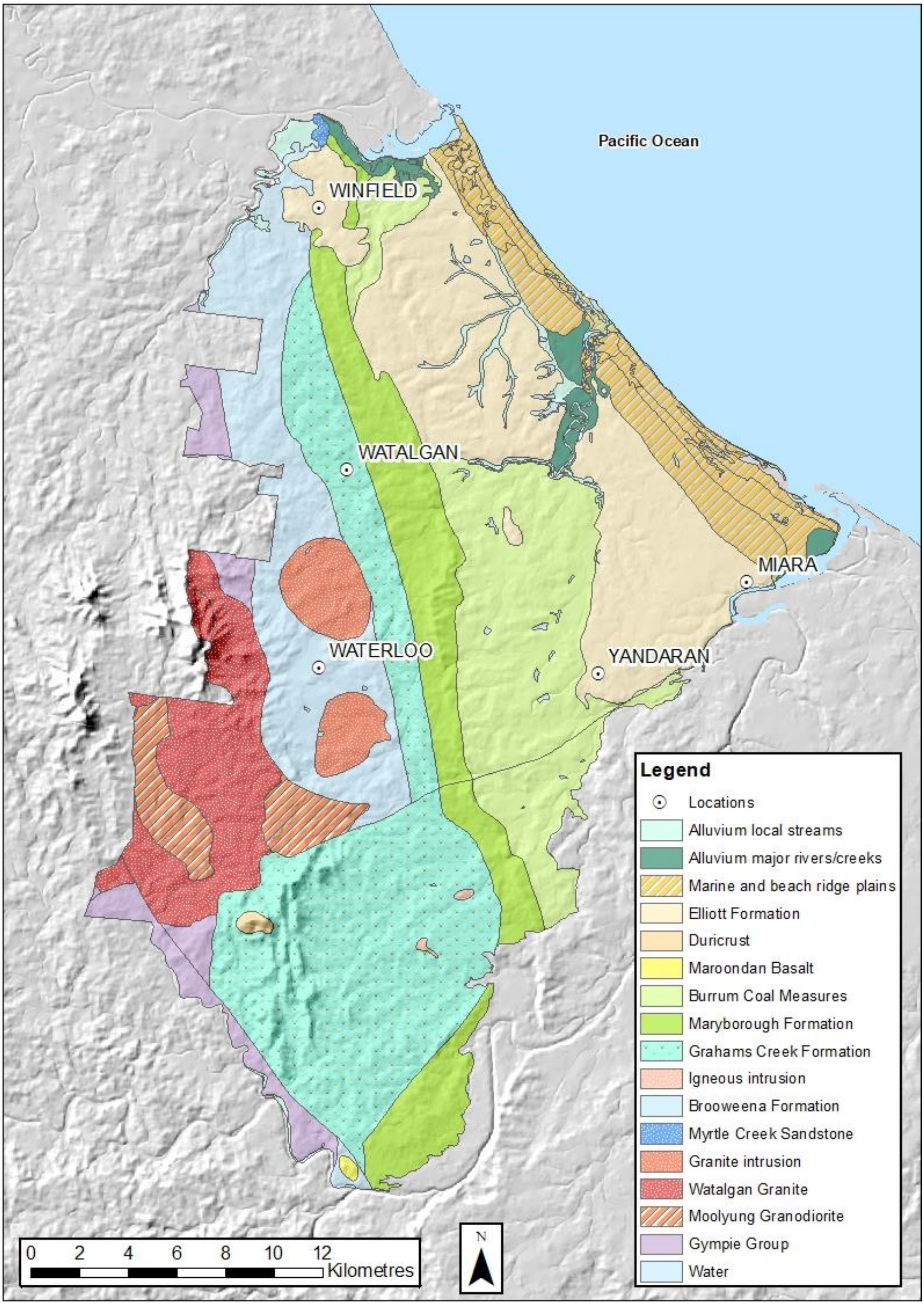

Figure 3 Miara–Winfield geology map (Data sourced from Department of Mines and Energy *et al*. 2008)

1) Marine and beach ridge plains

The coastal fringe, including the areas between the Baffle Creek and Burnett River, was inundated by the sea which was several metres higher than the present sea level during the Late Pleistocene (Robertson, 1979). During this period the Elliott Formation scarp was developed and formed the south-western extremity of sea inundation. Sea subsidence to the present level following sea level rises 6500 to 4000 years before present (Wilson *et al.* 2012) have developed a series of depressions (swales) and beach ridges lying roughly parallel to the present coastline (Donnollan *et al.* 1998).

The area is presently one to five metres above sea level. Frontal dunes (2.5–6 m high) protect this area from inundation by the sea. During periods of higher sea level (6500 to 4000 years BP) sediments high in iron and organic matter were deposited in estuarine areas in anaerobic environments allowing the formation of pyritic sediments. With subsequent lowering of sea levels, some of this pyrite has oxidised where aerobic conditions exist and some has remained unaltered where it is still anaerobic below water tables, forming sulfidic sediments on the marine plains. Beach ridge plains with beach ridges (sand dunes formed by wave action) and swales have formed over the marine plains as sea levels have changed. Closer to the Kolan River in the vicinity of Miara, alluvium from river flooding has deposited over sulfidic sediments. Sulfuric material is also present as a result of the very recent oxidation of these sulfidic materials (Donnollan *et al.* 1998).

High groundwater levels are often present in the marine plains. In some areas a network of drains has been constructed to lower groundwater to manageable levels and to assist in surface drainage where sugarcane is cropped.

2) Alluvial plains

(a) Kolan River and major creeks

The Quaternary alluvial plains of the Kolan River and Littabella Creek have been formed from the deposition of sediment from these watercourses. Two relative ages of deposition have been recognised with the youngest sediments occupying the lower landscape usually adjacent to the stream channels. The younger alluvium consists of levees, scrolls, plains, backplains, lower terraces, scroll plains and terrace plains.

The older alluvial deposits, which are up to five metres higher than the recent alluvial plains, were deposited when sea levels were higher than the present level (Late Pleistocene 140 000 to 10 000 years BP (Wilson *et al*. 2012). Plains, terrace plains and minor drainage depressions are the major landform elements in the older alluvial plains.

(b) Local streams

Plains, terrace flats, backplains and levees are the common elements associated with the Quaternary alluvial plains derived from the local streams, mainly Mullet, Walsh, Arthur and Landsborough Creeks.

3) Plains, rises and low hills on sedimentary rocks

A range of fine and coarse grained sedimentary rock formations occur throughout the study area and include the Early Neogene Elliott Formation, Early Cretaceous Burrum Coal Measures, Early Cretaceous Maryborough Formation, Early Cretaceous to Late Jurassic Grahams Creek Formation and the Early Triassic to Middle Triassic Brooweena Formation. Sandstone, siltstone, mudstone, shale and conglomerate are the major rock types of these formations although the Grahams Creek Formation consists of intermediate to acid volcanic flows, pyroclastic, tuffaceous sandstone and siltstone.

The Elliott Formation has been deeply weathered and often ferruginised in the upper part while the other formations have been weathered to various degrees. The soils developed on these Formations are usually related more closely to the rock type and degree of weathering rather than the Formation.

The youngest Formation, the Early Neogene Elliott Formation, occupies the eastern proportion of the study area, occurring on plains and rises extending from the north to the south-west of the Elliott scarp. It also occurs as relict hillcrests and upper hillslopes overlying other sedimentary rock Formations and volcanic rocks. Erosion and dissection have exposed the underlying, gently dipping formations namely the Burrum Coal Measures, Maryborough Formation, Graham's Creek Formation and the Brooweena Formation.

The underlying geology of the south-west portion of the study area is predominantly the Maryborough Formation and the Grahams Creek Formation. The more undulating landscape and the greater occurrence of outcrop in this area is largely due to the folding and faulting that occurred in this area as well as the silicified highly weather resistant upper stratum of the inclined Maryborough Formation.

4) Rises and low hills on acid and intermediate volcanic rocks

Rises and low hills have developed on volcanic rocks, including areas of the Late Jurassic to Early Cretaceous Grahams Creek Formation, the Late Triassic Watalgan Granite Formation, the Late Permian to Early Triassic Moolyung Granodiorite Formation and areas of the Permian Gympie Group Formation in the north-west section of the study area.

5) Rises and low hills on un-weathered basalt

Late Neogene Maroondan Basalt is also present on a very small area adjacent to the Kolan River in the far southern extent of the study area.

3.4 Soils morphology and chemistry

Fifty-five soils have been recognised and mapped within the study area. Detailed soil descriptions are given in Appendix 1, including landform, dominant vegetation, geology, permeability, drainage and soil morphology. Conventions used in these descriptions are also detailed in Appendix 1. A list of all soil variants and phases used in the study area is provided in Appendix 2.

A soil key to identify soils in the field is provided in Appendix 3. To assist with the understanding of the geomorphic arrangement of soils in the study area, idealised landscape cross sections showing relationships between landform element, soil and vegetation have been developed (Appendix 4).

Soils of the WIN area classify into 11 of the 14 Australian Soil Classification (ASC) soil Orders (NCST, 2016) and reflect the diverse geology (lithology) and geomorphological processes affecting soil formation within the study area. A brief description of the 11 soil Orders is listed in Table 2. The three soil Orders not represented are Anthroposols (soils resulting from human activities), Organosols (soils with organic materials) and Calcarosols (calcareous soils).

The most common ASC orders within the study area, in terms of area, are Kurosols and Sodosols (38 099 ha or 67%), followed by Hydrosols (5853 ha or 10%), Dermosols (5784 ha or 10%), Tenosols (3340 ha or 6%) and Podosols (1744 ha or 3%). This data is presented in Appendix 5.

Kurosols and Sodosols dominate the areas of all landform patterns except marine and beach ridge plains, alluvial plains of the Kolan River and major creeks and plains, rises and low hills on deeply weathered fine grained sedimentary rocks. Hydrosols dominate marine and beach ridge plains and Dermosols dominate the plains, rises and low hills on deeply weathered fine grained sedimentary rocks. Alluvial plains of the Kolan River and major creeks are occupied by Hydrosols, Sodosols, Dermosols and Tenosols, with minor areas of Vertosols. Table 3 lists the soil, ASC and area for each of the major landform patterns in the WIN study area.

Table 2 Brief description of the ASC Soil Orders (NCST, 2016) within the WIN study area

Soil Order	Brief description
Podosols	Soils with B horizons dominated by the accumulation of compounds of organic matter, aluminium and/or iron.
Vertosols	Clay soils with shrink-swell properties that exhibit strong cracking when dry and at depth have slickensides and/or lenticular structural aggregates.
Hydrosols	Soils in which the greater part of the profile is saturated for at least 2–3 months in most years.
Kurosols	Soils with strong texture contrast between the A horizons and the strongly acid B horizons.
Sodosols	Soils with strong texture contrast between the A horizons and B horizons which are not strongly acid but are sodic in the upper 0.2 m.
Chromosols	Soils with strong texture contrast between A and B horizons. The latter are not strongly acid and are not sodic.
Ferrosols	Soils with B2 horizons which are high in free iron oxide and which lack strong texture contrast between the A and B horizons.
Dermosols	Soils with structured B horizons and lacking strong texture contrast between A and B horizons.
Kandosols	Soils which lack strong texture contrast, have massive or only weakly structured B horizons, and are not calcareous throughout.
Rudosols	Soils with negligible pedologic organisation.
Tenosols	Soils with weak pedologic organisation apart from the A horizons.

Table 3 Geomorphic units, landform patterns, ASC and Soil Profile Classes (SPC) within the WIN study area

Geomorphic unit and landform pattern	SPC and map code	Australian Soil Classification Order & Suborder	Area (ha)
Marine and beach ridge plains			**3817**
a) Beach ridges	*Colvin* (Cv)	Semiaquic Podosol, Bleached-Orthic Tenosol	966
	Moore Park (Mp)	Brown-Orthic Tenosol	593
	Tantitha (Tt)	Red-Orthic Tenosol	222
b) Plains, swamps, extratidal flats, swales	*Fairydale* (Fd)	Redoxic Hydrosol	556
	Fairymead (Fm)	Redoxic Hydrosol	1333
	Maroom (Mm)	Redoxic Hydrosol	148
Alluvial plains of the Kolan River and major creeks			**1546**
(a) Recent alluvium; levees, backplains, scroll pains and streambanks	*Barubbra* (Bb)	Brown-Orthic Tenosol, Stratic Rudosol	311
	Burnett (Bn)	Stratic Rudosol, Chemic Tenosol	2
	Flagstone (Fs)	Brown or Black Dermosol	74
	Gahan (Gh)	Brown or Black Dermosol	48
	Sugarmill (Sm)	Redoxic Hydrosol, Black or Grey Dermosol	329
(b) Older alluvial plains; terrace plains and drainage lines	*Auburn* (Ab)	Brown or Grey Sodosol	645
	Crossing (Cg)	Brown or Grey Sodosol	64
	Walla (Wl)	Grey Vertosol	73
Alluvial plains of local streams			**7174**
	Littabella (Lt)	Brown or Red Kandosol, Brown-Orthic Tenosol	314
	Peep (Pp)	Grey or Brown Sodosol	5892
	Weithew (Wh)	Grey Dermosol or Vertosol	968
Plains, rises and low hills on sedimentary rocks			**34396**

Geomorphic unit and landform pattern	SPC and map code	Australian Soil Classification Order & Suborder	Area (ha)
(1) Deeply weathered coarse grained sedimentary rocks			**12180**
(a) Plains, hillcrests and upper and mid hillslopes of rises	*Calavos* (Ca)	Brown or Yellow Dermosol	125
	Farnsfield (Ff)	Red Kandosol	708
	Gooburrum (Gb)	Red Dermosol	183
	Isis (Is)	Brown or Yellow Kurosol	683
	Meadowvale (Md)	Yellow or Brown Dermosol	832
	Quart (Qr)	Yellow or Brown Kandosol	347
	Rothchild (Rt)	Bleached, Brown or Yellow Orthic Tenosol	795
	Yandaran (Yd)	Yellow or Brown Kurosol	3990
(b) Plains, drainage depressions and lower hillslopes of rises	*Alloway* (Al)	Redoxic Hydrosol	375
	Kinkuna (Kn)	Semiaquic Podosol	621
	Robur (Rb)	Redoxic Hydrosol	2807
	Theodolite (Th)	Aquic Podosol, Redoxic Hydrosol	125
	Wallum (Wm)	Aquic or Semiaquic Podosol	103
	Winfield (Wf)	Redoxic Hydrosol, Bleached-Orthic Tenosol	485
(2) Deeply weathered fine grained sedimentary rocks			**3043**
(a) Plains and hillcrests, upper and mid hillslopes of rises	*Cedars* (Cr)	Brown Dermosol	50
	Gillen (Gi)	Yellow or Brown Kandosol	20
	Howes (Hs)	Red Ferrosol	135
	Kepnock (Kp)	Brown or Yellow Dermosol	343
	Oakwood (Ok)	Red Kandosol	57
	Watalgan (Wt)	Red Dermosol	1279
	Woolmer (Wr)	Yellow or Brown Dermosol	23

Geomorphic unit and landform pattern	SPC and map code	Australian Soil Classification Order & Suborder	Area (ha)
(b) Plains, drainage depressions of plains and lower hillslopes of rises	*Avondale* (Av)	Grey Kurosol or Sodosol	5
	Turpin (Tp)	Grey or Brown Kurosol or Sodosol	116
(c) Hillcrests and hillslopes of rises and low hills	*Bungadoo* (Bg)	Brown or Yellow Dermosol	259
	Takoko (Tk)	Bleached-Leptic Tenosol, Leptic Rudosol	756
(3) Moderately weathered sedimentary rocks			**19173**
(a) Hillcrests and mid to upper hillslopes of rises and low hills	*Brooweena* (Bw)	Grey or Brown Kurosol or Sodosol	3831
	Bucca (Bc)	Brown or Black Dermosol	1670
(b) Plains, drainage depressions and lower hillslopes of rises	*Givelda* (Gv)	Brown Sodosol	6041
	Kolan (Ko)	Grey or Brown Kurosol	5607
	Tirroan (Tr)	Grey or Brown Kurosol or Sodosol	2024
Rises and low hills on acid and intermediate igneous rocks			**9778**
	Booyal (Bl)	Red or Brown Dermosol or Chromosol	1100
	Doongul (Do)	Grey Sodosol or Kurosol	677
	Gigoon (Gn)	Brown or Grey Sodosol or Kurosol	3571
	Moolyung (My)	Bleached-Leptic or Leptic Tenosol or Leptic Rudosol	3961
	Owanyilla (Ow)	Brown or Grey Sodosol	464
	Tiaro (Ta)	Black or Brown Dermosol	6
Rises and low hills on basalt rocks			**49**
	Berren (Be)	Brown Ferrosol	24
	Kowbi (Kb)	Brown Dermosol	25

Geomorphic unit and landform pattern	SPC and map code	Australian Soil Classification Order & Suborder	Area (ha)
Land Systems of Miriam Vale and Kolan Shires (MVK)			**3495**
	Brooweena (Bw)		47
	Rosedale 1 (Rd1)		2110
	Watalgan 2 (Wt2)		*1338*
Miscellaneous units			**2218**
	wetlands and water		780
	marine		1438
		Total area	**62473**

Eighty-five soil samples from 39 soil profiles representing 17 Soil Profile Classes (SPC), including five variants, were analysed for chemical and physical properties in the WIN study area. Eight soil profiles within the WIN study area were analysed as type profiles, with chemical data obtained from standard analyses at standard profile depths. Spot samples were analysed for specific properties, usually pH, electrical conductivity, chloride, cations and at times free iron content. Seven soil profiles were also sampled for surface fertility. The soil chemistry results defined the range of key chemical attributes of SPCs within the WIN study area (Appendix 6). The detailed chemistry results for all SPCs utilising BAB, CBW and WIN data is represented in Appendix 7. Soil chemistry data from relevant soils were utilised from adjacent soil mapping projects (BAB & CBW).

Morphology and chemistry of the soils within the geomorphic units and landform patterns are discussed below. Appendix 8 tables the complete list of effective rooting depths and plant available water content for every SPC.

3.4.1 Soils of marine and beach ridge plains

The marine and beach ridge plains, situated near the coast between the Kolan River and Baffle Creek, occupy 3754 ha. Six soils have been identified in this area. Hydrosols are the major soils on the plains and sandy Tenosols on the beach ridges. Podosols can occur on the lower edges of the beach ridges. The major soils of the plains and swales of the marine plains can be very strongly acid at depth associated with acid sulfate soil properties. These soils often have moderate to high salinity throughout and where cleared and left bare are susceptible to surface salinity scalds. Just over 40% of the area of this landform geomorphic unit has been cleared and used for sugarcane production, with minor areas of horticultural crops such as avocadoes, snow peas, sweet potato and flowers also grown on the beach ridges.

Soils of beach ridges

Morphology

Three soils have been described on the beach ridges. All are sandy to > 1.50 m, but clay marine sediments with quantities of pyrite and/or jarosite may occur below this depth. A typical landscape found on the beach ridges is shown in Figure 4, while a *Moore Park* soil profile is shown in Figure 5.

Tantitha and *Moore Park*, which are both Tenosols, are the most extensive soils on these ridges. *Moore Park* is brown at depth while *Tantitha* is red at depth and is found on the older more elevated beach ridges. *Colvin* is usually a weekly developed Podosol and has a thick, bleached A2 horizon, but may be classified as a bleached Tenosol where Podosol diagnostic horizons are absent. It is often found on more gently sloping broad beach ridges and may be impacted by a shallow water table depending on season.

Figure 4 Beach ridge landscape

Figure 5 *Moore Park* soil profile

Chemistry

No soils of the beach ridges were analysed in the WIN study area. The sandy textured soils of the beach ridges are expected to have low: sodicity, salinity, fertility and plant available water capacity (PAWC). However, the chemical data from one *Moore Park* soil profile presented in the BAB report showed high levels of calcium and phosphorous and other nutrients in the surface, most likely reflecting recent fertiliser applications for sugarcane production and organic matter recycling due to green cane trash blanketing.

Soils of marine plains

Three soils have been identified in the marine plains *Fairymead, Fairydale* and *Maroom*. A typical landscape on the marine plains is shown in Figure 6, while a typical *Fairymead* soil profile is shown in Figure 7.

Morphology

Fairymead and *Fairydale* (Hydrosols) are similar, with both having a black clay loam to clay surface horizon over mottled grey clay subsoils. The clay continues to depths greater than 1.5 m in *Fairymead* (Figure 7), while buried layers of variable texture (often sand) occur below 0.85 to 1.00 m in *Fairydale*. Jarosite and prominent red and orange mottling are often found in the lower horizons of both soils indicating recent oxidation. *Fairydale* and *Fairymead* soils usually have a standing water table between 0.8 to 1.5 m depth which can fluctuate depending on the season and if a drainage system has been implemented. At these depths potential acid sulfate soil may be found. If these soils are disturbed or drained, there is the potential for acid and heavy metal leachate to be released off-site.

Maroom is also a Hydrosol and is usually found near the beach ridges and on the more elevated marine plains. This soil has a bleached sand to sandy clay loam topsoil and has no acid sulfate soil properties in the upper 1.50 m of soil.

Figure 6 Marine plain landscape with forest of *Melaleuca quinquenervia* in the background

Figure 7 *Fairymead* soil profile

Chemistry

No soils of the marine plains were analysed in the WIN study area. Two Fairydale and one Fairymead soil profiles were analysed in the BAB report and results are discussed below.

Soil pH: All sampled profiles were very strongly acid throughout (pH < 4.5), most likely due to acid sulfate soil properties.

Salinity: *Fairydale* has low to very low salinity to 1.50 m (electrical conductivity (EC) 0.12–0.20 (dS/m) and chloride < 200 (mg/kg). *Fairymead* has moderate salinity (EC 0.36–0.48 dS/m) and similar low or very low chloride values to *Fairydale*. This may reflect the presence of other salts reacting with the sulfuric acid in the acid sulfate soil (Donnollan *et al*. 1998). A number of field EC measurements indicate that both *Fairymead* and *Fairydale* soils can be highly saline at the surface and throughout the profile reflecting the presence of a shallow water table (DERM 2011).

Cation exchange capacity (CEC): ECEC decreases with depth, the higher values at the surface corresponding to surface accumulation of organic matter.

Sodicity: *Fairymead* is sodic (exchangeable sodium percentage (ESP) 11%) in the surface increasing to strongly sodic (ESP 30-40%) in the subsoil. *Fairydale* has a similar trend but with lower ESP. Exchangeable aluminium levels were high in both soils (up to 70 % of effective cation exchange capacity (ECEC)), which will likely mitigate subsoil soil dispersion, however could cause aluminium toxicity to plant roots.

Soil nutrients: Calcium levels are variable, possibly reflecting past liming at the site where some samples were collected. Generally, calcium decreases from low to very low levels (0.22–0.41 meq/100 g) at depth, corresponding to a decrease in pH, a strong decrease in calcium/magnesium ratio (surface 0.88–1.9, subsurface 0.12–0.3), and an increase in exchangeable acidity (up to 80% of ECEC). The low pH and high exchangeable acidity may be due to the oxidation of pyrites from past drainage. Total sulphur (S) (0.17–0.7%) and potassium (K) (1.2–1.6%) are high at the surface, which also may be due to oxidation of pyrite. Other soil surface nutrients are medium to high (organic carbon (OC) 1.5-2.2%, total nitrogen (TN) 0.12-0.16% mg/kg, acid phosphorus (P) 25–41 mg/kg, copper (Cu) 0.35–0.91 mg/kg, zinc (Zn) 0.85–1 mg/kg).

3.4.2 Soils of alluvial plains of the Kolan River and major creeks

The alluvial plains of the Kolan River and major creeks (notably Littabella Creek) occupy 1525 ha. Eight soils have been identified on the alluvial plains, levees, channel benches and swales.

Sodosols with minor areas of Vertosols are found on the older alluvium, while Dermosols, Rudosols and Tenosols are found on the more recent alluvium. The Sodosols and Vertosols have medium to high salinity and high sodicity in the subsoil, while the recent alluvium soils have low salinity and sodicity to 1.5 m. A Hydrosol occurs where the alluvial plain has buried the marine plain. Almost two thirds of the area of the alluvial plains has been cleared and used for grazing beef cattle on improved pastures, although some dryland sugarcane is also grown on this landform type.

Soils of the recent alluvium

Morphology

The two soils on the levees, channel benches and scrolls of the recent alluvium are *Barubbra* and *Burnett* (Tenosols and Rudosols). *Barubbra* is sandy throughout while *Burnett* contains a number of depositional layers of varying thickness and texture. A typical landscape on alluvium is shown in Figure 8, while a *Barubbra* soil profile is shown in Figure 9.

On the plains, three soils have been identified. *Flagstone*, *Gahan* and *Sugarmill.* All soils have clay loam to light clay topsoil and subsoil. The clayey subsoil of *Flagstone* continues to > 1.5 m. However, *Gahan* has buried horizons of loamy sand to sandy loam starting at 0.5 to 0.9 m. *Sugarmill* has buried mottled grey clay at 0.5 to 0.9 m which is similar to the subsoils of *Fairymead* and *Fairydale* of the marine sediments described above.

Figure 8 Landscape of the major creeks

Figure 9 ***Barubbra*** **soil profile**

Chemistry

No soils of the recent alluvium were analysed in WIN. One *Burnett* and three *Flagstone* soil profiles were analysed in the BAB report and the results are discussed below.

Soil pH: The *Burnett* and *Flagstone* soils are generally slightly acid to neutral (pH 6.2–7.3) in the surface and neutral to slightly alkaline (pH 7.1–7.7) in the subsoil.

Salinity: Both soils have very low electrical conductivity (< 0.12 dS/m) and chloride (< 100 mg/kg) levels, reflecting the generally moderately-well or well-drained, moderately permeable profiles.

Sodicity: Soils of the recent alluvial plains are non-sodic.

Cation exchange capacity (CEC): The CEC of the soils reflects soil texture and origin with the *Burnett* soil having low CEC (< 5 meq/100 g) due to the sandy textures. *Flagstone* has a much higher clay content and CEC (15-23 meq/100 g) throughout.

Soil nutrients: These soils generally have medium to high surface fertility. Calcium and phosphorus are high to very high (Ca 2.1–18 meq/100 g, acid P 0.56–0.86 mg/kg, bicarb P 43–130 mg/kg) while potassium, copper and zinc are medium (K 0.33–0.84 meq/100 g, Cu 0.7–3 mg/kg, Zn 1.5–2.3 mg/kg). Calcium/magnesium ratios (1.3–3.9) indicate calcium dominance throughout the profile. Soils generally have low organic carbon (0.6–1.5%) and total nitrogen (0.03–0.11%) in the surface. There are lower potassium levels at depth compared with the surface, reflecting accumulation of organic matter (Donnollan *et al*. 1998).

Older alluvium

Morphology

Three soils *Auburn*, *Crossing* and *Walla* occupy 700 ha of the older alluvial plains within the study area. *Auburn* and *Crossing* are Sodosols with grey or brown subsoils. *Crossing* has a thicker and sandier surface horizon (A horizon) than *Auburn. Walla* is a grey or brown Vertosol which is found on plains and drainage depressions. A general landscape photo of the older alluvium is shown in Figure 10, while a typical *Auburn* soil profile is shown in Figure 11.

Figure 10 Landscape of older alluvium

Figure 11 ***Auburn*** **soil profile**

Chemistry

One *Auburn* soil profile was analysed in the WIN study area, and four *Auburn*, one *Crossing* and two *Walla* soil profiles were analysed in the BAB study area.

Soil pH: Surface pH ranges from strongly acid to slightly acid (pH 5.4–6.2) while subsoil pH is extremely variable, ranging from moderately acid to very strongly alkaline (pH 5.5–9.2) for the *Auburn and Crossing* profiles analysed. *Walla* is moderately acid throughout (pH 5.5–5.9).

Cation exchange capacity (CEC): The ECEC or CEC values strongly reflect changes in textures between the topsoil and subsoil. The relatively high clay activity ratio of 0.5–0.6 in the subsoil of the sampled soil profiles indicates a moderate proportion of montmorillonite clay. This is frequently reflected as vertic properties in the subsoil (lenticular structure, slickensides).

Salinity: Very low to low EC (0.04–0.1 dS/m) and Cl (20–90 mg/kg) values occur in the surface of the sampled profiles with medium to very high (EC 0.5–1.21 dS/m, Cl 530–1780 mg/kg) values at depth. The high salinity corresponds to impermeable clay subsoils. The *Auburn* soil profile sampled in WIN had very low salinity in the top of the B horizon.

Sodicity: The analysed soils are non-sodic in the surface but become strongly sodic at depth (ESP 18–48%).

Soil nutrients: Calcium levels are generally high (0.5–7.6 meq/100 g) but may be low (< 2 meq/100 g) usually corresponding to a lower pH. Magnesium is high (6.6–17 meq/100 g) at depth resulting in a rapid decrease in calcium/magnesium ratio with depth (0.28–5.5 surface, 0.03–0.48 subsurface). Potassium is generally medium (0.15–1 meq/100 g) in the surface corresponding to organic matter accumulation but decreases with depth (0.1–0.38 meq/100 g). Surface organic carbon, total nitrogen and phosphorus are very low to medium (C 1.1–2.8%, TN 0.07–0.2%, acid P 5–39 mg/kg, bicarb P 9–29 mg/kg) while Cu and Zn are medium (Cu 0.7–2.7 mg/kg, Zn 1.1–3.3 mg/kg) (Donnollan *et al.* 1998a).

3.4.3 Soils of the alluvial plains of local streams

Sodosols, Dermosols and minor Kandosols occupy the 7171 ha of the alluvial plains of local streams. The Sodosols and Dermosols have low fertility levels with medium to high levels of salinity and high sodicity at depth compared to the Kandosols, which have higher fertility and lower salinity and sodicity. It is important to note that the variability of soils found on the alluvial plains of local streams is high.

Approximately half of this landform type has been cleared and is used for beef cattle production on improved pastures, notably Rhodes grass as well as dryland sugarcane, maize and other fodder crops. A general landscape photo of the alluvium of the local streams is shown in Figure 12, while a typical *Peep* soil profile is shown in Figure 13.

Morphology

Littabella, a Kandosol has a sandy loam to loam topsoil and a massive yellow, grey or rarely red, sandy loam to clay loam soil. It occurs on the levees and scrolls of local creeks. *Peep* is a Sodosol with topsoil textures ranging from sandy loam to clay loam over a mottled grey to brown medium clay subsoil. *Weithew*, is a black or grey Dermosol or Vertosol. *Peep* is more common in valley flats and narrow alluvial plains associated with local streams while *Weithew* is more common where the alluvial plains are wider, corresponding with a backplain.

Figure 12 Landscape photo of the alluvium associated with local streams

Figure 13 *Peep* soil profile

Chemistry

Four *Peep* and three *Weithew* soil profiles were analysed in the WIN study area and three *Peep* soil profiles in the BAB report.

Soil pH: *Littabella* soil is strongly acid to neutral throughout. The surface pH of *Peep* and *Weithew* are slightly to very strongly acid (pH 4.8–6.1) with subsoil pH ranging from strongly acid to strongly alkaline (pH 5.0–9.7).

Salinity: EC values are very low throughout the profile for *Littabella* soil. For *Peep* and *Weithew* soils, EC and chloride are very low (EC 0.04–0.07 dS/m, Cl 30–70 mg/kg) in the surface and generally low to medium (EC 0.14–0.72 dS/m, Cl 470–1000 mg/kg) at depth. Higher EC values correspond to lower permeability subsoils. The *Peep* profiles analysed in WIN study area had higher salinity than the *Peep* soils in the neighbouring BAB study area.

Sodicity: The clay subsoils of *Peep* and *Weithew* are strongly sodic (ESP 20–55%).

Cation exchange capacity (CEC): No CEC data is available for *Littabella*. For *Peep* and *Weithew* ECEC or CEC increases with clay content down the profile.

Soil nutrients: All nutrients are very low to low (Ca 0.53–0.2 meq/100 g, K 0.07–0.2 meq/100 g, OC 1.1–2.3%, TN 0.08–0.12%, acid P 5–7 mg/kg, bicarb P 3 mg/kg, Cu 0.1–0.21 mg/kg, Zn 0.3–0.35 mg/kg) reflecting the predominance of deeply weathered geology in the local catchments. Soils are calcium dominant (Ca/Mg > 1.1) in the surface becoming strongly magnesium dominant (Ca/Mg 0.02–0.83) at depth (Donnollan *et al*. 1998b)

3.4.4 Soils of plains, rises and low hills on sedimentary rocks

Thirty soils and two variants have been identified and mapped on sedimentary rocks, which occupy 34 146 ha (or 55%) of the WIN study area. Most of these soils have acid to strongly acid subsoils and are generally half to one unit more acidic than similar soils mapped in the BAB study area.

The area of sedimentary rocks has been divided into (i) deeply weathered coarse grained sedimentary rocks (mainly sandstone); (ii) deeply weathered fine grained sedimentary rocks (mainly siltstone, mudstone shale and fine sandstone); and (iii) moderately weathered sedimentary rocks (includes coarse and fine sandstone, siltstone, mudstone and shale).

(i) Soils of deeply weathered coarse grained sedimentary rocks

Soils of hillcrests, upper and mid hillslopes of rises

Eight soils, mainly Kandosols, Dermosols and Kurosols, are found on the 7866 ha of hillcrests, upper and mid-hillslopes of rises on the deeply weathered coarse grained sedimentary rocks. All have sandy topsoils. Just under one-third of the area of this landform type has been cleared and used for grazing on improved pastures, notably Rhodes (*Chloris gayana*) and Signal (*Brachiaria decumbens*) grasses. Pineapples, sugarcane (dryland and irrigated), avocados, macadamias, lychees and mangos are also grown where water and land suitability allows.

Morphology

The well drained *Farnsfield* and *Gooburrum* have red subsoils and are usually found on the hillcrests and upper-hillslopes of the rises, and slight rises within the plains. *Gooburrum* has a structured subsoil (Dermosol) while the subsoil of *Farnsfield* is massive (Kandosol). Subsoil textures range from clay loam to light or light medium clay (Donnollan *et al.* 1998). A sandy variant of *Farnsfield* soil (Tenosol), which is sandy to sandy loam to at least 1.50 m, has been mapped in the WIN study area.

The other soils, *Calavos, Isis, Meadowvale, Quart, Rothchild* and *Yandaran* have brown or yellow subsoils. *Calavos, Isis, Meadowvale* and *Yandaran* have structured clay subsoils (Dermosols or Kurosols) while *Quart has a* massive subsoil (Kandosol) and *Rothchild* has sandy textures throughout (Tenosol) often grading to a sandy loam (Kandosol).

Isis, Meadowvale and *Yandaran* have bleached A2 horizons while *Calavos* has no A2 horizon. *Meadowvale* is a Dermosol while *Isis* is a Kurosol. *Isis, Meadowvale* and *Yandaran* can also occur on gently undulating to undulating plains.

Yandaran is a new soil identified in the WIN study area. It has a very thick (> 0.60 m) sandy A horizon over an acid, light to medium clay subsoil. A new variant of *Isis* soil has also been identified in the WIN study area, *Isis* grey subsoil variant, to identify areas of *Isis* soil that have mottled, grey medium to medium heavy clay lower B or BC horizons below 0.60–1.30 m. This variant is developed where deeply weathered coarse grained sedimentary rocks occur as shallow capping over often moderately weathered sedimentary formations.

A typical landscape of upper-hillslopes of deeply weathered coarse grained sedimentary rocks is shown in Figure 14, while a typical *Yandaran* soil profile is shown in Figure 15.

Figure 14 Landscape of upper hillslopes of deeply weathered coarse grained sedimentary rocks with forest of *Eucalyptus acmenoides* and *Allocasuarina littoralis*

Figure 15 Deep sandy surface texture contrast profile of *Yandaran* soil

Chemistry

Six soil profiles were analysed in the WIN study area and 24 in the BAB study area on the hillcrests, upper and mid hillslopes of the rises of deeply weathered coarse grained sedimentary rocks. These soil profiles represent all of the soils found on this landform unit, except for *Calavos*.

Soil pH: All soils are slightly to very strongly acid (pH 4.8–6.3) throughout the profile.

Salinity: All soils have very low EC (0.01–0.24 dS/m) and Cl (10–140 mg/kg) levels throughout the profile.

Sodicity: All soils are non-sodic (ESP < 6) in the surface and generally non sodic to weakly sodic (ESP up to 10) or occasionally strongly sodic (ESP > 20) in the lower subsoil. Soils with strongly sodic subsoils do not display typical dispersive nature due to the strong acidity, very low ECEC and high exchangeable aluminium.

Cation exchange capacity (CEC): ECEC or CEC is predominantly very low (< 5 meq/100 g) and may be generally higher in the surface in undisturbed areas due to organic matter accumulation. Increases at depth correspond to increases in clay content. Clay activity ratio of < 0.2 meq/100 g clay and predominantly < 10 meq/100 g clay of all soils analysed indicates a dominance of kaolinitic and goethite type clays associated with the deeply weathered geology (Donnollan *et al.* 1998).

Soil nutrients: Generally, all soils have low to very low surface fertility in their natural state (Ca 0.06–4.5 meq/100 g, Mg 0.09–2.32 meq/100g, OC 0.3–0.41%, TN 0.01–0.13%, acid P 2–22 mg/kg, bicarb P 1–15 mg/kg, Cu 0.05–2.3 mg/kg, Zn 0.1–1 mg/kg). Higher values for some analysed profiles reflect fertiliser additions due to recent cropping.

Soils of plains, drainage depressions, and lower hillslopes of rises

Six soils, Hydrosols and Podosols, are mostly associated with the poorly drained areas of the lower hillslopes of the rises, drainage depressions and plains on the coarse-grained deeply weathered sedimentary rocks. These soils occupy just over 4300 ha of the WIN study area. Small areas of well drained Podosols can also be found in upper landscape positions.

Morphology

All these soils have a grey subsoil and thick sandy surface horizons and most have some restrictions in the subsoils including pans or clay layers. Perched water tables may develop in these soils during wet periods, which may result in secondary salinity. The potential for secondary salinity to develop on these soils is increased by vegetation clearing, which allows salt accumulation from increased evaporation of shallow water tables, or vegetation clearing and/or irrigation on adjacent 'upslope' areas resulting in increased inputs into the perched water tables (DERM 2011).

Robur and *Alloway* are Hydrosols. *Robur* has a strongly sodic clay horizon between 0.5 and 0.9 m while *Alloway* has a non-sodic to weakly sodic clay horizon between 0.75 to 1.1 m. *Kinkuna, Wallum* and *Theodolite* are Podosols with differing subsoils. *Kinkuna* has a thin orstein or coffee rock pan below 0.45 to 1 m, *Wallum,* a sandy clay loam to sandy clay subsoil below 0.65 to 1.1 m and *Theodolite*, a buried sodic clay horizon below 0.75 to 1.1 m. *Winfield* is generally a Hydrosol, but within the WIN study area can vary between a Hydrosol or a Tenosol depending on site location and drainage characteristics.

A typical landscape of lower hillslopes and drainage depressions of deeply weathered coarse grained sedimentary rocks is shown in Figure 16, while a typical *Robur* soil profile is shown in Figure 17.

Figure 16 Landscape of lower hillslopes and drainage lines on deeply weathered coarse grained sedimentary rocks with vegetation of *Melaleuca viridiflora* and an understory of *Banksia oblongifolia* and *Banksia robur*

Figure 17 Soil profile of *Robur* soil

Chemistry

Three soil profiles were analysed in the WIN study area and 19 in the BAB study area on the plains, drainage depressions and lower hillslopes of the rises of deeply weathered coarse grained sedimentary rocks.

Soil pH: The surface pH of the soils range from very strongly to slightly acid (pH 4.2–6.2) in their natural state. Subsoil pH is very strongly acid to neutral (pH 4.6–6.7). The very strongly acid pH of the surface of the Podosols soil profile analysed (*Kinkuna* and *Theodolite*) reflects the presence of organic acids in the organic matter surface accumulation.

Salinity: All soils have very low EC (0.01–0.24 dS/m) and Cl (10–140 mg/kg) throughout the profile. However, surface salinity expressions are common on cleared, poorly drained soils due to increased evaporation of the water from shallow water tables.

Sodicity: The analysed soils with clay loam to clay subsoils are predominantly sodic to strongly sodic (ESP 9–36%) in the subsoil. This sodicity is always associated with high magnesium and very low calcium levels. These soils with sodic to strongly sodic subsoils do not display a dispersive nature due to the strong acidity, very low ECEC and high exchangeable aluminium.

Cation exchange capacity (CEC): ECEC is predominantly very low (< 5 meq/100 g) and is generally higher in the surface due to organic matter accumulation. Increases at depth correspond to increases in clay content. Clay activity ratio of < 0.2 and predominantly < 0.1 of all soils analysed indicates a dominance of kaolinitic clays which is expected for these deeply weathered geologies (Donnollan *et al.* 1998).

Soil nutrients: Generally, these soils are low to very low in all nutrients, but higher values for some analysed profiles reflect fertiliser additions due to recent cropping or past fertiliser applications. (Ca 0.06–4.5 meq/100 g, Mg 0.09–2.32 meq/100 g, OC 0.3–4.1%, TN 0.01–0.13%, acid P 2–22 mg/kg, bicarb P 1–15 mg/kg, Cu 0.05–2.3 mg/kg, Zn 0.1–1 mg/kg) (Donnollan *et al.* 1998).

Potassium shows a strong surface accumulation corresponding to organic matter accumulation (surface 0.05–0.63 meq/100 g, subsurface 0.01–0.15 meq/100 g). Calcium and magnesium show a strong correlation to soil wetness. As soils become more poorly drained, calcium decreases in the subsoil while magnesium increases. Most subsoils of the poorly drained soils group are magnesic (Ca/Mg < 0.1).

(ii) Soils of deeply weathered fine grained sedimentary rocks

Soils of plains, hillcrests, upper and mid hillslopes of rises

Nine soils including Kandosols, Dermosols, Tenosols and rarely Ferrosols occupy the plains, hillcrests, upper and mid-hillslopes of rises developing on deeply weathered sedimentary rocks. These soils occupy 2643 ha of the WIN study area. Most soils have clay loam to light clay topsoils. Approximately 30% of this landform pattern is cleared of which the majority are red soils used for beef cattle grazing on improved pastures, dryland and irrigated sugarcane and irrigated small crops such as tomatoes and zucchinis.

Morphology

Well drained soils with red subsoils (*Howes, Oakwood* and *Watalgan*) are found on the hillcrests and upper-hillslopes of rises and plains as well as on residual hillcrests over lying moderately weathered sediments.

Howes is a Red Ferrosol with clay texture throughout the soil profile. *Oakwood* is a Red Kandosol with sandy clay loam to light clay topsoil. *Watalgan* is a Red Dermosol, with gravelly, clay loam topsoil and ferruginous nodules in the subsoil. A new variant of *Watalgan* soil has also been identified in the WIN study area; *Watalgan*, grey subsoil variant, which identifies areas of *Watalgan* soil that have mottled, grey medium clay in the lower B or BC horizons below 0.80–1.10 m. This variant is developed where deeply weathered fine grained sedimentary rocks with imperfective to poor drainage at depth occur as a shallow capping over other sedimentary layers.

Takoko and *Bungadoo* are shallow to moderately deep, rocky soils (Dermosols and Tenosols) found on hillcrests and upper hillslopes developed on silicified sediments. *Takoko* is shallow to hard rock (< 0.50 m) and *Bungadoo* is moderately deep (0.75–0.90 m to hard rock).

Moderately well-drained and imperfectly drained soils with yellow to brown subsoils, *Cedars*, *Gillen*, *Kepnock* and *Woolmer*, are found on the mid-hillslopes of the rises and on the plains. *Cedars*, *Woolmer* and *Kepnock* are Dermosols while *Gillen* is a Kandosol. *Cedars* has a uniform clay profile throughout while *Kepnock* and *Woolmer* both have bleached A2 horizons with clay subsoils. *Kepnock* usually has a clay loam topsoil while *Woolmer* has loamy topsoil. *Gillen* with a clay loam topsoil, has a clay loam to light clay massive subsoil with many to abundant iron nodules.

A typical landscape found on the hillslopes of deeply weathered fine grained sedimentary rocks is shown in Figure 18, while a typical *Howes* soil profile is shown in Figure 19.

Figure 18 Landscape of upper hillslopes on deeply weathered fine grained sedimentary rocks with forest of *Eucalyptus acmenoides* and *Eucalyptus crebra*

Figure 19 Soil profile of *Watalgan* soil

Chemistry

Three soil profiles were analysed within the WIN study area and 22 soil profiles have been analysed within the BAB project on the soils of plains hillcrests, upper and mid-hillslopes of rises on deeply weathered fine grained sedimentary rocks.

Free Iron Content: Two samples analysed from two different *Howes* profiles confirmed that *Howes* is a Ferrosol. Free iron content was 5-9 %.

Soil pH: Surface and subsoil pH ranges from very strongly acid to neutral (pH 4.7–7.4). The pH of all soils is strongly acid to slightly acid throughout. Strongly acid pH in the subsoil corresponds to very low calcium in all soils of the unit.

Salinity: EC and chloride levels are typically very low (EC 0.02–0.14 dS/m, Cl 10–100 mg/kg) throughout the profile.

Sodicity: The soils are predominantly non-sodic in the surface (ESP 2–10%, predominantly < 6%) and weakly sodic in the subsoil (ESP 4–11%) with the exception of *Kepnock* soil which can be occasionally strongly sodic in the lower subsoil (ESP 27%). However, soils with sodic to strongly sodic subsoils do not display a dispersive nature due to the strong acidity, very low ECEC and high exchangeable aluminium.

Cation exchange capacity (CEC): ECEC is typically very low (< 10 meq/100 g) with higher levels corresponding to surface organic matter and increase in clay content with depth. Clay activity ratio is very low (approximately 0.1). These low ratios indicate predominantly kaolinitic type clays associated with deeply weathered geology.

Soil nutrients: Surface calcium levels range from very low to high (0.1–8.2 meq/100 g) and decrease with depth (0.04–3.2 meq/100 g). Lower calcium is associated with lower pH. Calcium levels decrease while magnesium levels increase in these soils as soil drainage changes from well drained to imperfectly drained (Donnollan *et al.* 1998). Potassium is low to medium in the surface (0.04–1.3 meq/100 g) and decreases with depth (0.01–0.63 meq/100 g). Phosphorus in undisturbed soils is typically very low phosphorus (acid P < 10 mg/kg) while copper and zinc are generally low to medium (Cu 0.05–4.7 mg/kg, Zn 0.05–4.2 mg/kg). Organic matter and total nitrogen are moderate (OC 0.9–3.3%, TN 0.04-0.3% mg/kg) (Donnollan *et al.* 1998).

Soils of plains, drainage depression of plains and lower hillslopes of rises

Lower hillslopes and drainage depressions within the rises and plains on the fine grained deeply weathered sedimentary rocks occupy only 87 ha within the WIN study area. Kurosols or Sodosols are found in this area. They have low fertility in the virgin state and medium to high salinity and sodicity in their often magnesic subsoils.

Morphology

Two soils, *Avondale* and *Turpin*, are associated with the imperfectly or poorly drained areas on the lower hillslopes of rises, drainage depressions and plains. Both soils have grey or brown sodic subsoils and are either Kurosols or Sodosols, but can be Hydrosols depending on site drainage. The surface texture of *Turpin* is sandy while the surface texture of *Avondale* is loamy to clay loamy.

A typical landscape found on lower hillslopes of deeply weathered fine grained sedimentary rocks is shown in Figure 20, while a typical *Turpin* soil profile is shown in Figure 21.

Figure 20 Landscape of lower hillslopes of deeply weathered fine grained sedimentary rocks with vegetation of *Melaleuca viridiflora*, and *Eucalyptus suaveolens*

Figure 21 Soil profile *Turpin* soil

Chemistry

No soil profiles of these soils were analysed within the WIN study area, but 8 soil profiles were analysed within the adjacent BAB study area.

Soil pH: The pH of all soils is strongly acid to slightly acid throughout. Strongly acid pH in the subsoil corresponds to very low calcium in all soils.

Salinity: The soils have low EC (0.01–0.03 dS/m) and Cl (< 40 mg/kg) in the surface, frequently increasing to medium levels (EC 0.04–0.59 dS/m, Cl 220–850 mg/kg) at depth associated with the strongly sodic subsoils levels.

Sodicity: The soils are sodic to strongly sodic (ESP 19–51%) in the subsoil. High sodicity in these soils is always associated with low calcium and relatively high magnesium.

Cation exchange capacity (CEC): ECEC is typically very low (< 10 meq/100 g) with higher levels corresponding to surface organic matter and increase in clay content with depth. Clay activity ratio is 0.2–0.4 in the clay subsoil for the soils forming on the the lower hillslopes and higher compared to soils of the plains, hillcrests, and mid to upper hillslopes of rises.

Soil nutrients: Surface calcium levels range from very low to high (0.1–8.2 meq/100 g) and decrease with depth (0.04–3.2 meq/100 g). Lower calcium seems to be associated with lower pH. Calcium levels decrease while magnesium levels increase in these soils as soil drainage changes from well drained to poorly drained. Subsoil magnesium levels are generally high (1.7–12.1 meq/100 g). Soils are predominantly magnesic (Ca/Mg < 0.1). Potassium is low to medium in the surface (0.04–1.3 meq/100 g) due to surface accumulation of organic matter decreasing with depth (0.01–0.63 meq/100 g). Phosphorus in undisturbed soils is typically very low (acid P < 10 mg/kg) while copper and zinc are generally low to medium (Cu 0.05–4.7 mg/kg, Zn 0.05–4.2 mg/kg). Organic matter and total nitrogen are generally lower in the poorly drained soils (OC 0.54–1.9%, TN 0.03–0.07%) compared to soils of the plains, hillcrests, upper and mid hillslopes of rises (Donnollan *et al.* 1998).

(iii) Moderately weathered sedimentary rocks

The study area is highly dissected, with much of the overlying deeply weathered sediments eroded, exposing the underlying moderately weathered sedimentary rock. The soils formed from these moderately weathered sediments occupy 19 426 ha and are predominantly formed from fine grained sedimentary rocks.

Sodosols and Kurosols are the major soils developed on these moderately weathered rocks and are generally more fertile than those of the deeply weathered rocks. Subsoils have moderate to high salinity with high sodicity and are magnesic. The exception is a Dermosol found on the hillcrests and upper hillslopes which has low salinity and sodicity.

Thirty-eight percent of the area of this geomorphic unit is cleared within the WIN study area, mostly for beef cattle grazing on improved pastures.

Soils of hillcrests and upper hillslopes

Morphology

Two soils are found on the hillcrests and upper or mid hillslopes of rises and low hills, which occupy 5390 ha within the WIN study area. *Bucca* is a brown or black Dermosol with clay throughout the shallow to deep profile. *Brooweena* soil is a very rocky, grey or brown Kurosol or Sodosol. Soil depth, colour, pH and rock content can vary over short distances in both soils due to exposure of underlying steeply dipping sedimentary rock strata.

The landscape of the upper hillslopes developed on moderately weathered sedimentary rocks is shown in Figure 22, while a typical *Brooweena* soil profile is shown in Figure 23.

Figure 22 Landscape of the upper hillslopes on moderately weathered sedimentary rocks with forest of *Eucalyptus moluccana*

Figure 23 Soil profile *Broweena* soil

Chemistry

One *Broweena* profile was analysed within the WIN study area while 2 *Broweena* profiles have been analysed in the neighbouring BAB study area.

Soil pH: Surface pH ranges from very strongly acid to slightly acid (pH 4.7–6.4) while subsoil pH varies from very strongly acid to strongly alkaline (pH 4.5-9.0) in the sampled soil profiles. Within the WIN study area, pH of the soils were more commonly associated with the lithology and age of the parent material. The older sedimentary formations of the study area dip steeply to the east exposing a number of different layers within the formation at the land surface leading to a variation in soil parent material and soil pH.

Salinity: All soils have very low EC (0.03–0.14 dS/m) and Cl (10–110 mg/kg) levels in the surface and very low to medium levels (EC 0.48–0.56 dS/m, Cl 50–850 mg/kg) in the subsoil. Higher salinity levels are associated with the strongly sodic subsoils.

Sodicity: Soils are non-sodic to weakly sodic (ESP 3–12%) in the surface and generally strongly sodic (ESP 18–40%) in the subsoil of *Brooweena* and non-sodic to sodic (ESP 4-10%) in the subsoil of *Bucca* soil. The higher sodium levels at depth are associated with very low calcium and high magnesium. Dispersion ratios in the subsoil of *Brooweena* are high (0.92–0.99).

Cation exchange capacity (CEC): ECEC in these soils is strongly related to clay content and pH value. A clay activity ratio of 0.3–0.6 meq/100 g clay indicates a mixture of montmorillonitic and kaolinitic clays. The clay activity ratio is consistently higher compared to texture contrast soils on deeply weathered rocks. This is also consistent with vertic properties, such as slickensides and lenticular structure, often occurring in the clay subsoils.

Soil nutrients: Calcium is low to high in the surface (0.5–3.2 meq/100 g) decreasing with depth (0.2–0.47 meq/100 g) while magnesium is low to high in the surface (0.5–4.4 meq/100 g) increasing with depth (3.9–18 meq/100 g). Soils generally have low to medium potassium levels (0.13–0.48 meq/100 g) throughout the profile consistent with higher total potassium (0.235–1.34%) in soils on fresher rocks compared to lower total potassium in soils on deeply weathered rocks. Total nitrogen is medium (0.1–0.19%) phosphorus is low (acid P 2–15 mg/kg) on undisturbed soils while copper and zinc are low to medium (Cu 0.18–0.37 mg/kg, Zn 0.77–3.8 mg/kg) (Donnollan *et al.* 1998).

Soils of plains, drainage depressions and lower hillslopes of rises

Morphology

Three soils are found on the plains, drainage depressions and lower hillslopes of rises and low hills, which occupy 13 856 ha within the WIN study area. All are Sodosols or Kurosols. *Tirroan* has a sandy surface while *Givelda* and *Kolan* have loamy to clay loamy surfaces. *Givelda* is a brown Sodosol with a moderately acid to strongly alkaline subsoil, while *Kolan* is a Grey Kurosol with very strongly acid subsoil.

Typical native vegetation on lower hillslopes of moderately weathered sedimentary rocks is shown in Figure 24, while a typical *Kolan* soil profile is shown in Figure 25.

Figure 24 Landscape and vegetation of lower hillslopes of moderately weathered sedimentary rocks with forest of *Eucalyptus moluccana and Corymbia citriodora*

Figure 25 Soil profile *Kolan* soil

Chemistry

Eleven soil profiles were analysed within the WIN study area and 8 soil profiles have been analysed in the neighbouring BAB study area.

Soil pH: Surface pH ranges from very strongly acid to slightly acid (pH 4.7–6.4) while subsoil pH varies from very strongly acid to mildly alkaline (pH 4.5–7.7). Subsoil pH is strongly related to calcium levels, decreasing with increasing acidity.

Salinity: All soils have very low EC (0.03–0.14 dS/m) and Cl (10–110 mg/kg) in the surface and very low to medium values (EC 0.48–0.56 dS/m, Cl 50–850 mg/kg) in the subsoil. Higher salinity is associated with the strongly sodic subsoils.

Sodicity: Soils are non-sodic to sodic (ESP 3–12%) in the surface and generally strongly sodic (ESP 18–40%) in the subsoil. The higher sodium at depth is associated with very low calcium and high magnesium. Dispersion ratios are generally high (0.92–0.99) but strongly acid soil pH in some soils may override the effects of sodicity, especially *Kolan* soil (Donnollan *et al.* 1998). The relevance of ESP as an indicator of soil physical properties, such as dispersion, is questionable in *Kolan* soils due to the strong acidity and high exchangeable aluminium levels.

Cation exchange capacity (CEC): ECEC is strongly related to clay content and pH levels. A clay activity ratio of 0.3–0.6 meq/100 g clay indicates a mixture of montmorillonitic and kaolinitic clays. The clay activity ratio is consistently higher compared to similar soils on deeply weathered rocks. This is also consistent with vertic properties, such as slickensides and lenticular structure, often occurring in the clay subsoils (Donnollan *et al.* 1998).

Soil nutrients: Calcium is low to high in the surface (0.5–3.2 meq/100 g) decreasing with depth (0.2–0.47 meq/100 g) while magnesium is low to high in the surface (0.5–4.4 meq/100 g) increasing with depth (3.9–18 meq/100 g). Soils generally have low to medium potassium levels (0.13–0.48 meq/100 g) throughout the profile consistent with higher total potassium (0.235–1.34%) in soils on fresher rocks compared to lower total potassium in soils on deeply weathered rocks. Total nitrogen is medium (0.1–0.19%) phosphorus is low (acid P 2–15 mg/kg) on undisturbed soils while copper and zinc are low to medium (Cu 0.18–0.37 mg/kg, Zn 0.77–3.8 mg/kg) (Donnollan *et al.* 1998). High exchangeable aluminium levels in the subsoil of *Kolan* may be toxic to susceptible plants.

3.4.5 Soils of rises and low hills on acid and intermediate volcanic rocks

Just over 10 000 ha of soils formed on acid and intermediate volcanic rocks occupy the western portion of the study area, and are scattered throughout the central parts of the study area. These soils are low in plant available nutrients and have sandy or loamy surfaces. The major soils on the upper hillslopes and hillcrests are Dermosols, Tenosols and Chromosols, which are non-saline and non-sodic, while on the mid to lower hillslopes Sodosols and Kurosols occur which have low to moderate salinity and are strongly sodic. Almost half of this landform area is cleared and mostly used for beef cattle grazing on improved pastures.

Six soils occur on hillcrests and hillslopes of rises and low hills on acid volcanic rocks in the WIN study area. These soils have not been subdivided on landscape position as their distribution is not related to landform.

Morphology

Booyal is a non-sodic soil with a red or brown subsoil (Chromosol or Dermosol). *Tiaro* is a black Dermosol formed on decomposing andesite of the Graham’s Creek Formation. *Doongul* and *Gigoon* are grey and brown soils with sodic subsoils (Sodosol). *Doongul* has a clay loam topsoil while *Gigoon* has a sandy topsoil. *Owanyilla* is grey and brown soil with a sodic subsoil (Sodosol) formed on decomposing andesite of the Graham’s Creek Formation. *Moolyung* is a new soil concept developed for the WIN study area that has a sandy texture directly overlying acid volcanic rocks (Tenosol).

A typical landscape on acid and intermediate volcanic rocks is shown in Figure 26, while a typical *Gigoon* soil profile is shown in Figure 27.

Figure 26 Landscape on acid and intermediate volcanic rocks with forest of *Corymbia citriodora* and *Eucalyptus moluccana*

Figure 27 Soil profile *Gigoon* soil

Chemistry

Three *Gigoon* soil profiles were analysed within the WIN study area. One *Gigoon* and one *Booyal* soil profile were analysed within the CBW study area.

Soil pH: Surface pH ranges from very strongly to moderately acid (pH 4.6–5.8) while subsoil pH varies from slightly acid to neutral (pH 5.9–7.0) in the profiles sampled.

Salinity: All soils have very low EC (0.03–0.14 dS/m) and Cl (< 200 mg/kg) in the surface and very low to medium values (EC 0.07–0.41 dS/m, Cl < 100–4700 mg/kg) in the subsoil. The strongly sodic subsoils are more saline.

Sodicity: Soils are non-sodic to sodic (ESP 3–12%) in the surface and generally strongly sodic (ESP 18–40%) in the subsoil, except for *Booyal* which is non-sodic. Higher sodium at depth are associated with magnesic soils (very low calcium and very high magnesium).

Cation exchange capacity (CEC): ECEC is strongly related to clay content with very low values in the sandy surface (1 meq/100 g) and moderate levels (15–18 meq/100 g) in the clay subsoil. A clay activity ratio of 0.3–0.6 meq/100 g clay indicates a mixture of illite and kaolinite clays.

Soil nutrients: Calcium is very low throughout the soil profile while magnesium is low in the surface (< 1.0 meq/100 g) increasing with depth to high/very high levels (4.3–12.6 meq/100 g). Ca/Mg ratio is very low (< 0.1). All soils have very low potassium levels (0.08–0.20 meq/100 g) throughout the profile. Total nitrogen (0.08%), phosphorus (acid P < 5 mg/kg) and copper (< 0.1 mg/kg) are all low to very low.

3.4.6 Soils of rises and low hills on un-weathered basalt

Soils formed on a basalt rise occupy 52 ha in the south-west corner of the WIN study area. Ferrosols and Dermosols with rock fragments throughout the soil profile are found in this area, which is 70% cleared and used for beef cattle grazing.

Morphology

Two soils occur on the upper hillslopes of the WIN study area. *Kowbi* is a brown non-cracking clay (Dermosol) with few rock fragments while *Berren* is a rocky, brown non-cracking clay (Ferrosol).

Chemistry

No soil profiles were chemically analysed from the minor area of Monduran Basalt in the WIN study area. Only small areas of this geological unit occur in the western extent of the BAB study areas.

3.4.7 Comparison of key soil chemistry properties between geomorphic units

To compare selected soil chemistry properties across the major geomorphic units, data from the WIN study area and neighbouring projects (CBW, BAB) were examined. Seven major soils were chosen to represent the major geomorphic units within the WIN study area. These include:

- *Fairymead* - marine plains;
- *Peep* - alluvial plains of local streams;
- *Yandaran* - upper and mid hillslopes of rises on deeply weathered coarse grained sedimentary rocks;
- *Watalgan* - upper and mid hillslopes of rises on deeply weathered fine grained sedimentary rocks; and
- *Givelda* and *Kolan* - drainage depressions and lower hillslopes of rises on moderately weathered sedimentary rocks.

Where multiple sites with chemistry data exist for a specific depth interval and soil type, the values were averaged. These values have been plotted on the graphs shown in Figure 28 to Figure 32.

Soil pH

Soil pH is often a reflection of soil parent material and the state of weathering. Climatic condition, land management practices (past and present), and biology also impact soil pH. Soil pH influences soil processes such as soil fertility and structural stability. The soils in the WIN study area are predominantly slightly to strongly acidic throughout, reflecting the strong leaching environment of these landscapes. Soils that have been cropped may have neutral to slightly alkaline pH at the surface as a result of the application of lime.

Figure 28 below shows that all soil profiles on sedimentary rocks are strongly acid to acid (pH <6.5) below 0.30 m, except for *Givelda*, which has neutral pH values in the subsoil. The soil profile on the marine sediments (*Fairymead*) has strongly acid pH values, reflecting acid sulfate soil processes. *Peep* soil profiles, formed on recent local alluvia, have neutral to alkaline pH in the subsoil.

Soil salinity

Chloride concentration indicates the contribution of chloride ions, usually as sodium chloride salts, to the EC. Generally, soil parent material, positon in the landscape and profile permeability are the key factors influencing soil salinity. Apart from cyclic salts, the weathering of fine grained rocks yields most of the dissolved salts in this landscape. Secondary salinity processes are discussed in Section 7.1.

Figure 29 shows EC trends of six soils. All soil profiles on deeply weathered sedimentary rocks (*Yandaran* and *Watalgan*), have very low to low EC to at least 1.5 m profile depth. The local alluvial soil, *Peep*, has low salinity to 1m and then increases to moderate levels below this depth (EC ~ 0.4 dS/m). Soil profiles on lower slopes of moderately weathered sedimentary rocks (*Givelda* and *Kolan*) have moderate or high salinity below 0.5m (EC > 0.4 dS/m). These elevated EC levels of *Peep*, *Givelda* and *Kolan* reflect the reduced permeability of the subsoil. Fairymead soil of the marine plains also has moderate salinity at depth due to the marine influence in soil formation. The surface (0.00-0.10 m depth) of the *Fairymead* soil is higher in salinity levels than immediately below (0.20 -0.30 m depth) due to surface accumulation of salt from evaporation of shallow seasonal watertables.

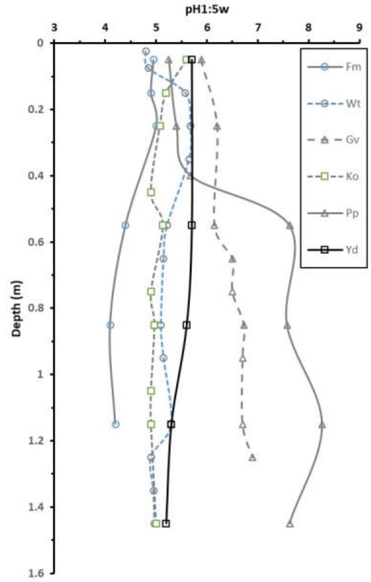

Figure 28 pH profiles in Fairymead, Watalgan, Givelda,Kolan, Peep and Yandaran soils

Chloride profiles for *Fairymead* and *Watalgan* soils show similar trends to EC profiles suggesting soil salinity levels are predominantly due to sodium chloride salts, however *Givelda* and *Kolan* soils show some deviation that suggests the presence non-chloride salts (Figure 29 & Figure 30).

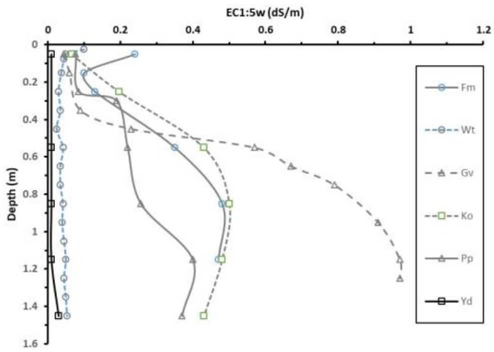

Figure 29 EC profiles in *Fairymead*, *Watalgan*, *Givelda*, *Kolan, Peep* and *Yandaran* soils

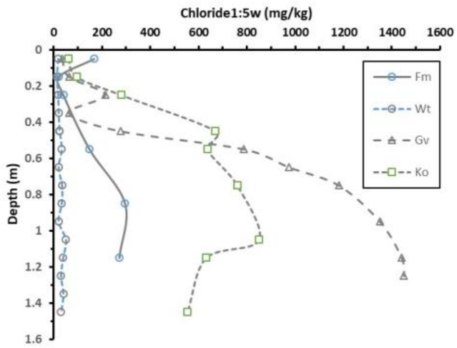

Figure 30 Chloride profiles in *Fairymead*, *Watalgan*, *Givelda* and *Kolan* soils

Soil cations and cation exchange capacity (CEC)

CEC affects many aspects of soil chemistry, including soil fertility, as it indicates the capacity of the soil to retain cations in plant-available form. The concentration and ratio of the major cations can impact soil physical properties such as structural stability.

Exchangeable sodium percentage (ESP) is generally accepted as a measure of how sodic and unstable a soil is (for soils with a significant clay fraction), but this is not always an accurate predictor of soil stability. Other soil properties such as concentration of soluble ions, clay mineralogy, soil pH, and the concentration of aluminium all influence soil stability. An understanding of the interaction of these properties is necessary for predicting how dispersive or stable a soil is. Many of the WIN soils are strongly acidic (pH < 5.5) and have high levels of exchangeable aluminium which tend to counteract the effect of moderate to high ESP on soil stability.

Cation exchange capacity (CEC) or effective cation exchange capacity (ECEC) (where exchangeable aluminium and hydrogen cations are included for acid soils) is shown in Figure 31. Most soils on deeply weathered sedimentary rocks have low to very low CEC/ECEC (< 10 meq/100g). Soils with low to very low CEC/ECEC values, combined with strongly acid pH have low clay dispersion in the subsoil due to the high levels of exchangeable aluminium. The moderately weathered *Kolan* soil has similar aluminium levels and therefore similar properties to other strongly acid soils.

Calcium values for most of the representative soils are very low to low (Figure 32). Calcium levels of < 2 meq/100g generally impede root growth of crops such as sugarcane. *Fairymead* has high levels of calcium from the surface (0.00-0.10 m) to 0.20-0.30 m due to organic matter accumulation. The high values at the surface of the *Watalgan* soil profiles analysed reflects the samples being taken from fertilised sugarcane paddocks.

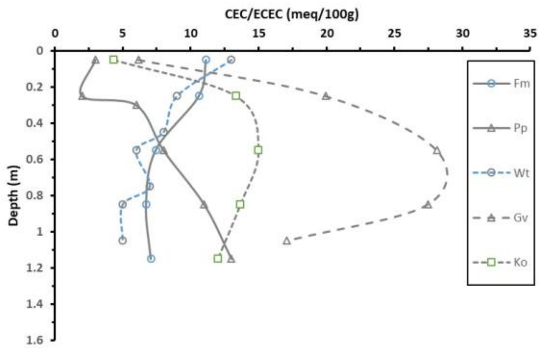

Figure 31 CEC or ECEC profiles in *Fairymead*, *Peep*, *Watalgan*, *Givelda* and *Kolan* soils

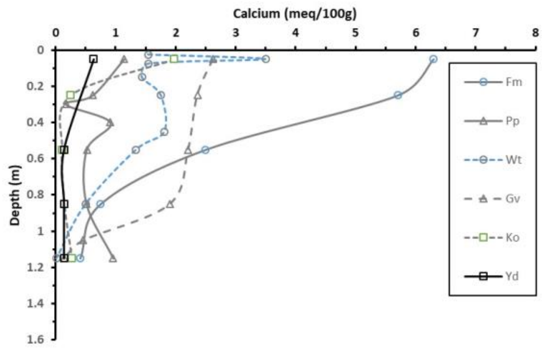

Figure 32 Calcium profiles in *Fairymead*, *Peep*, *Watalgan*, *Givelda*, *Kolan* and *Yandaran*, soils

4. Land Use

4.1 Present land use

The main agricultural land use within the study area is beef cattle production, mostly on improved pastures, such as Signal and Rhodes grasses. Dryland and irrigated sugarcane and pineapples are the main agricultural crops within the study area. Other irrigated horticultural crops including avocadoes, mangoes, lychees and macadamias are also grown within the study area, with minor areas of tomatoes and sweet corn. There are also areas of aquaculture and plantation timber production and regulated management of native vegetation, mainly for grazing and selective timber production. In recent years, there has been an interest in clearing for farm infrastructure (such as dams) and expanding cropping areas.

As a result of high power costs or lack of water, many sugarcane and pineapple producers are choosing to grow their crops under dryland conditions with either no or only very minimal irrigation during critical growth stages when field conditions are dry. The loss in productivity from not irrigating is compensated by reduced production costs.

Approximately half of the marine plains area within the WIN study area is currently under dryland sugarcane production. Historically the wetness and drainage limitations of this area have been overcome by the construction of drains to improve drainage and therefore increase the most limiting nutrient (oxygen). Although this has improved sugarcane productivity in these areas, it is not recommended due to the high likelihood of environmental impacts due to acid drainage.

4.2 Agricultural land suitability

Land suitability assessment evaluates the potential of land for alternative forms of agricultural land use, called land management options. The procedures of land suitability assessment involves defining the land use requirements for each land management option considered, and the limitations which cause land to have less than optimum conditions for a particular land management option. Limitations are soil and land properties or attributes that may affect land preparation, crop growth, crop harvesting and environmental sustainability and are assessed against each land management option. Furrow, spray or micro-sprinkler irrigated or dryland production systems for the same crop are assessed as different land management options.

Land and soil attributes to measure and estimate the effects of each limitation on each land management option were selected, and then ranked in terms of an increasing degree of severity. Limitation ranking ranges from the least severe to the most severe on a one to five scale (DSITI, DNRME 2015). The overall land suitability class for each land management option considered is then determined by the most severe limitation or by a combination of two or more limitations.

The land suitability classes for a specified land use are defined as:

- Class 1 Suitable land with negligible limitations
- Class 2 Suitable land with minor limitations
- Class 3 Suitable land with moderate limitations
- Class 4 Unsuitable land with severe limitations
- Class 5 Unsuitable land

The agricultural land suitability scheme for the WIN study area is detailed in Appendix 9. The eighteen limitations identified are listed in Table 2 in Appendix 9.

The suitability schemes across the Coastal Wide Bay region have been correlated and for the WIN project have been updated with the help of specific agronomic industry experts. The land suitability was assessed in each unique mapping area (UMA) for 36 land management options listed in Table 1 in Appendix 9. Soil and Land Information (SALI) data relating to land suitability, limitations and soil attributes used to evaluate the suitability of the major soils of each UMA is stored in the Queensland Government database.

The suitability scheme assesses the suitability of each land management option for each UMA and includes some indication of off-site effects from agricultural land uses, such as in the risk of salinity and waterlogging. Off-site effects from agricultural activities are complex and require a detailed understanding of the soil properties, underlying rock, vegetation and the interaction of this with land use. The off-site effects can only be determined in general terms in the WIN suitability scheme, due to the mapping scale and fieldwork involved. More detailed studies will be required to determine the severity of off-site effects from agricultural activities at the paddock scale. Therefore, some localities or UMAs may be assessed as suitable for a particular land management option within the WIN study area, but may not be recommended for that particular land management option due to potential or existing off-site impacts, environmental considerations or requirements of other applicable Government regulation at the time.

The effects of many of the limitations may be reduced by appropriate inputs and management techniques. However, areas assessed as Class 5 for a land management option have extreme limitations that preclude development for that option in terms of crop yield potential, due to soil or land properties, or unacceptable environmental or safety risks.

Appendix 10 outlines the major limitations and some possible management techniques for major soil management groups and may assist in reducing the impacts of these limitations. Areas of land suitability classes for six irrigated land uses within the WIN study area are given in Table 4.

Table 4 Areas (ha) of land and suitability classes for selected land management options

Land Management Option						
Land Class	**Sugarcane dryland**	**Sugarcane spray irrigated**	**Macadamia microsprinkler irrigated**	**Pineapple dryland**	**Pineapple spray irrigated**	**Mango microsprinkler irrigated**
Class 1	0	0	0	223	223	0
Class 2	26	493	0	31	1217	3240
Class 3	2851	8124	9372	2875	6594	9667
Total area Suitable Class 1-3	**2877**	**8617**	**9372**	**3129**	**8034**	**12908**
Class 4	14631	25987	6785	23717	14328	7264
Class 5	39219	22123	40570	29882	34364	36556

4.2.1 Dryland Cropping

Due to the limited amount of irrigation water and the increasing cost of energy, many sugarcane growers within the WIN study area are choosing to grow sugarcane under dryland conditions. The lower average yield from dryland compared to irrigated cropping is often offset by a reduction in costs. However, plant available water capacity (PAWC), climate and the financial structure of the enterprise are key considerations in determining the long term viability and profitability of these cropping systems.

For the WIN land suitability scheme, a minimum of 75mm of PAWC over the rooting depth of the crop or at least per meter of soil is required for dryland cropping. However, successful dryland cropping is often driven by the economic circumstances and the specific farming practices undertaken by individual growers.

Dryland crops within the WIN study area have been successful on landscapes where shallow fresh water tables seasonally occur. Evaluating the spatial complexity and seasonal variability of these water tables was very difficult at the scale of this project and as such, the contribution of shallow water tables to soil water storage for crop growth was not assessed in the WIN suitability scheme.

Generally, erosion, soil moisture and rockiness limitations, are the primary suitability limitations for dryland sugarcane within the WIN study area. Secondary salinity and wetness limitations are also limiting on lower slopes and in drainage depressions. All other limitations assessed are generally non-limiting for dryland sugarcane.

5. Agricultural land classes (ALC)

Agricultural land classification follows a hierarchical scheme that indicates the location and extent of agricultural land that can be used sustainably for a range of land uses with minimal land degradation (DSITI, DNRM 2015). The classes imply a decreasing range of land use choice and an increase in the severity of limitations and/or land degradation hazard.

The classification includes four classes and five subclasses, which are defined in Table 5 below. A map showing the extent of each class and subclass within the WIN study area is given below in Figure 33, while the areas of each ALC are given in Table 6. ALC assumes irrigated cropping with adequate available water quantity and quality.

Table 5 Definition of Agricultural Land Classes Agricultural Land Classes (ALC), from DSITI and DNRM (2015)

ALC class	Definitions
A	**Crop land** that is suitable for a wide range of current and potential crops with nil to moderate limitations to production.
A1	Suitable for a wide range of current and potential broad acre and horticultural crops.
A2	Suitable for a wide range of current and potential horticultural crops only.
B	**Limited crop land** that is suitable for a narrow range of crops. The land is suitable for sown pastures and may be suitable for a wider range of crops with changes to knowledge, economics or technology.
C	**Pasture land** that is suitable only for improved or native pastures due to limitations that preclude continuous cultivation for crop production. Some areas may tolerate a short period of ground disturbance for pasture establishment.
C1	Suitable for grazing sown pastures requiring ground disturbance for establishment; or native pastures on higher fertility soils.
C2	Suitable for grazing native pastures, with or without the introduction of pasture species, and with lower fertility soils than C1.
C3	Suitable for light grazing of native pastures in accessible areas, and includes steep land more suited to forestry or catchment protection.
D	**Non-agricultural land** not suitable for agricultural use, including land alienated from agricultural use.
A/C A/D B/C C/D	Land that is a complex of class A, B, C or D land where it is not possible to delineate the land class at the map scale. The dominant class is the first code in the sequence and is assumed to be > 50% of the area, but < 70%.

Class A land has the greatest potential for producing the widest range of crops, and has been subdivided into subclasses of A1, land suitable for a wide range of broad acre crops and A2, land suitable for horticultural crops only. Class B land is limited crop land. Class C (pasture land) is subdivided into three subclasses. Class D land is unsuitable for agricultural use. It should be noted that Class A and B land are also generally suitable for pastures and crops.

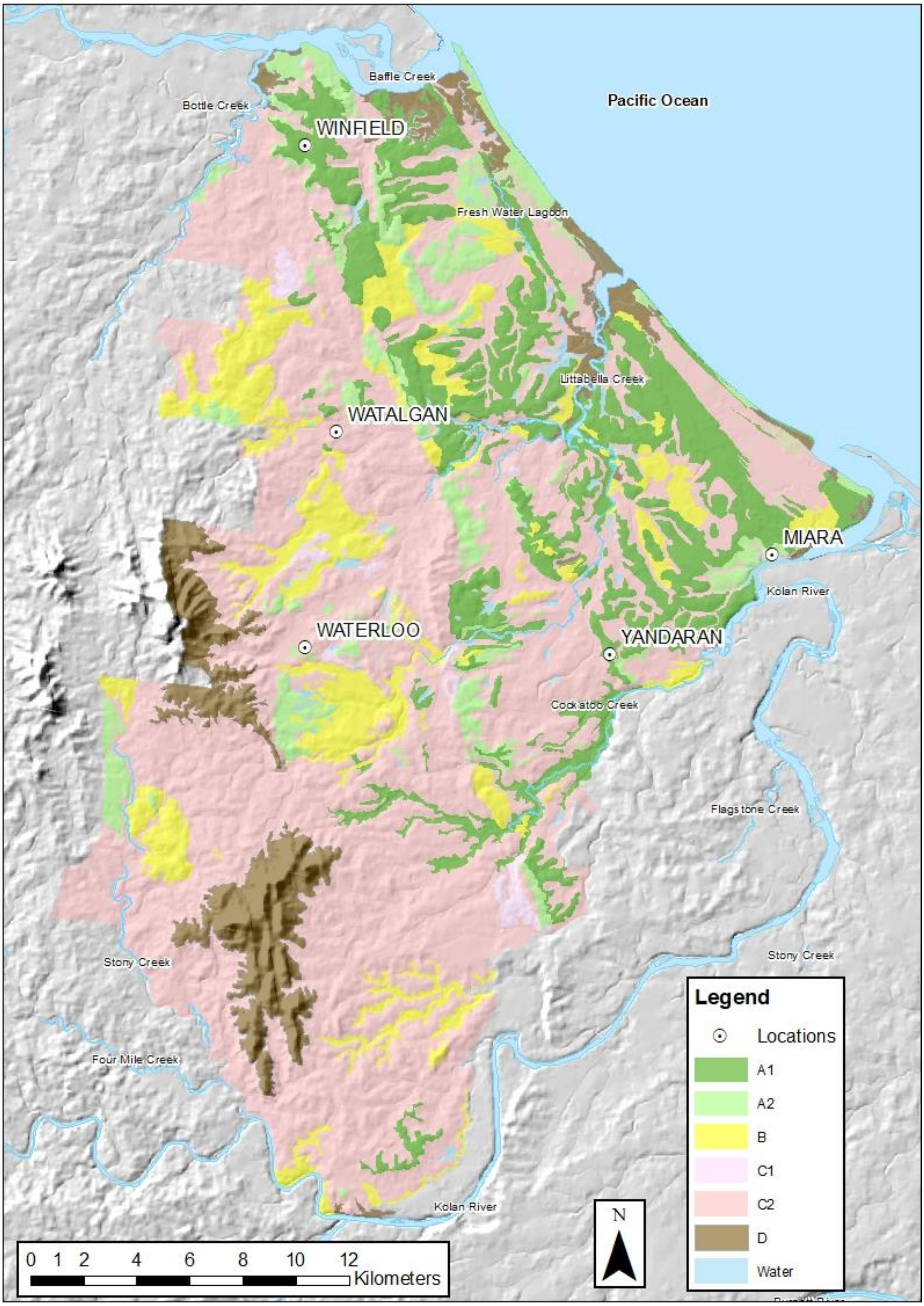

Figure 33 ALC map of WIN study area.

Table 6 Areas of each Agricultural Land Class within the WIN Study area

ALC Class	Area (ha)	% of total area
A1-Suitable for a wide range of crops	10181	16
A2-Suitable for horticultural crops only	4298	7
B-Suitable for a narrow range of crops	6658	11
C1-Suitable for improved pasture	601	1
C2-Suitable for grazing native pasture	35003	57
D-Non-agricultural land	5035	8
Total	**61777**	**100**

6. Reef catchments

The WIN study area forms part of the much larger catchment of the Great Barrier Reef Lagoon. Consequently, the study area is part of an area where there has been a concerted effort to improve water quality. The main water parameters targeted for improvement are nutrient, sediment and pesticide loads.

The development of a Water Quality Improvement Plan (WQIP) (BMRG 2015) for the Burnett Mary region, by the Burnett Mary Regional Group (BMRG) aims to improve water quality through the adoption of Best Management Practice's (BMP's) across the agricultural industries within the region. Through the increased adoption of BMP's within each agricultural industry, the plan aims to improve water quality.

There is a diverse range of agricultural industries within the WIN study area including broad-acre cropping, horticulture and grazing. Through the adoption of BMP's, producers are not only improving water quality to the Great Barrier Reef, but are also improving the efficiency of their production systems, through improved irrigation scheduling and reduced nutrient and pesticide applications. BMP's also reduce the risk of land degradation processes such as erosion and salinity.

The goal of the WQIP for the Burnett Mary is that through the increased adoption of BMP's across all agricultural industries, the long-term economic, social and environmental sustainability of agriculture and the Great Barrier Reef Lagoon is maintained (BMRG 2015).

7. Land degradation

Forms of land degradation occurring in the study area include salinisation, soil erosion, nutrient leaching, waterlogging, exposure of acid sulfate soils and weed infestation. Correct management of acid sulfate soils is also an important issue where they occur.

7.1 Salinity

Salinity is often associated with discharge areas where there is an upward component to groundwater flow near the soil surface. Discharge areas occur at break of slope, in flat and incised areas or in regions of concave slope (Donnollan et al. 1998a).

In the WIN study area, salinity outbreaks can occur in the lower hillslopes and drainage lines within the areas of fine grained sedimentary rocks and associated alluvial plains of local streams. Soils in these areas are usually imperfectly to poorly drained due to restrictions such as pans or strongly sodic clay layers and often have low slopes (< 2%). Salinity expressions are also evident on the poorly drained coastal marine plains, particularly where cleared.

Shallow seasonal water tables often occur in lower landscape positions, depending on the season and current land use. The water tables can be fresh to slightly saline pending on the geological source of the transmitted water. Irrespective of the salt content of the water, if the water tables rise to within 1–1.5 m of the surface, salinisation may occur due to salt concentration from evaporation (DERM 2011). Figure 34 shows a saline outbreak area in lower landscape position of the Elliott Formation. Other land management factors such as clearing and cropping (with or without irrigation) can also increase the likelihood of secondary salinity. This is primarily due to the changes to landscape hydrology resulting in increased discharge in the lower parts of the landscape.

In discharge areas, where water seeps/springs and or shallow watertables occur, surface salinity can develop. Surface salinity is more likely to develop where ground cover is poor and greater rates of evaporation at the soil surface occurs and can yield EC values of greater than 10 dS/m irrespective of geomorphic unit.

Ninety-four UMAs occupying 3543 ha have the potential for secondary salinity to develop with a suitability subclass for secondary salinity (Ss) of 4 or 5 (Appendix 9), with 1000 ha currently severely salt affected with salinity expressions at the soil surface at sites within the UMA at the time of survey.

Management strategies that minimise the potential for salinity outbreaks are summarised in Appendix 10 and include;

- Maintaining deep rooted vegetation above the poorly drained areas.
- Installing and maintaining interceptor drains above the discharge areas and conveying the water to a safe disposal area may reduce the incidence of salinity.
- Maintain a healthy grass cover in the discharge areas to reduce evaporation at the soil surface.
- Choosing appropriate irrigation methods on permeable soils, usually located higher in the landscape, to minimise deep drainage losses and water inputs into lower landscape positions.

Figure 34 Salinity outbreak on poorly drained soil within the WIN study area.

7.2 Soil erosion

Soil erosion causes soil loss and consequently reduces productivity by removing plant nutrients and organic matter in addition to exporting material and nutrients into the Great Barrier Reef Lagoon. Land use, slope, including both length and steepness, and soil erodibility are the major factors influencing soil erosion in this area.

Management practices such as contour tillage, contour banks as well as maintaining surface cover are useful management procedures to reduce erosion or erosion risk. Avoiding exposure of sodic subsoils, which are a common feature of many soils on moderately weathered sedimentary rocks, older alluvial plains of major rivers and alluvial plains of local streams, is important in minimising erosion risk.

Ninety two UMAs, which cover 4860 ha, were recorded as having being at least partly affected by sheet or gully erosion (Figure 35) at the time of the survey.

Soils were classified as unstable due to having a hard setting surface with weak to massive surface structure and fine sandy or silty textures (silty loam to fine sandy light clay), moderately to slowly permeable surface horizons with low organic matter and slowly to very slowly permeable (usually sodic) subsoils. Unstable soils dominate the study area. The total area of stable and unstable soils are 27 and 64% respectively. There were no soils classified as very stable within the study area. Thirty percent of the study area was mapped as having unstable soils with a slope of 5-8%, making these soils unsuitable for most land management options except for improved pasture and tree crops.

Half of the WIN study area had a hillslope < 5%, with 60% of this area classed as unstable soils. This highlights the need for best management practices to ensure sustainable agriculture over the study area, to reduce sediment loads to the Great Barrier Reef Lagoon.

Figure 35 Gully erosion on *Givelda* soil within WIN study area

7.3 Nutrient leaching

Many of the soils identified in the WIN study area are very infertile in their natural state, and have a very low CEC. Leaching of applied fertilisers below the root zone and into the creeks and tributaries of the Kolan River, Baffle and Littabella Creeks and ultimately the Great Barrier Reef Lagoon, is expected to be a major problem on these soils. Management strategies to minimise leaching of applied nutrients are given in Appendix 10. These can be summarised as:

- Incorporating crop residues to improve surface organic matter levels
- Applying fertilisers based on crop need and soil type
- Applying split fertiliser applications or slow release fertilisers

Nutrient leaching to groundwater is an important issue especially on the highly permeable, well drained soils. Irrigation management techniques such as trickle irrigation or more frequent light irrigations to reduce leaching are important considerations on these soils (Donnollan et al. 1998a).

7.4 Waterlogging

Waterlogging can occur on the lower hillslopes and drainage depressions of the rises and low hills within the WIN study area. This can lead to a decrease in agricultural productivity by creating unfavourable conditions for plant growth and agricultural activities. Installing and maintaining drains at strategic positions to intercept the perched shallow water table and to convey the water to a suitable reservoir for subsequent reuse is a means of decreasing the effects of this problem (Donnollan et al. 1998a). However, this may lead to a build-up of cyclic salts in the system over time resulting in an increase in salinity of irrigation water.

Using more efficient irrigation techniques such as microspray or trickle irrigation and lateral move equipment to minimise deep drainage losses may also reduce the incidence of waterlogging.

7.5 Exposure of acid sulfate soils

Acid sulfate soils (ASS) are present in the study area on the marine plains and in the tidal flats of the rivers and creeks. The existing cropped area east of the Elliott escarpment between the Kolan River and Baffle Creek needs to be managed appropriately to prevent detrimental environmental impacts. The water table must remain at its present level to prevent the oxidation of any pyrite present in sediments which may cause a subsequent release of sulphuric acid leading to undesirable environmental consequences. The tidal flats are best left undisturbed to avoid acid drainage. For this reason, undeveloped land with pyritic layers at depths likely to be disturbed, is considered as unsuitable for agricultural development due to unacceptable environmental risks (Donnollan et al. 1998a).

An acid sulfate soil survey was not undertaken as part of this project. Instead, areas of soils with pyritic layers at depth were identified within the study area. Acid drainage water hazard from ASS was therefore not considered as a separate limitation within the agricultural suitability scheme for this project. It is recognised that any development of lands that may contain or will intercept ASS layers will require detailed ASS analyses and management plans under applicable regulation.

7.6 Weed infestations

Weed infestations in the grazing country within the WIN study area are a major land degradation issue. The major weed is giant rat's tail grass (*Sporobolus pyramidalis*), which has spread to various degrees throughout the WIN study area, and poses a major risk to beef cattle production where it aggressively overtakes native pastures and is generally unpalatable to cattle apart from when it is young. General options to control giant rat's tail grass include good pasture management, spot spraying, slashing to encourage growth of new shoots and where practical establishing improved pastures to try to compete with giant rat tail grass seedlings. Maintaining property hygiene is also important.

8. Land Evaluation

8.1 Additional erosion suitability considerations

The assessment of the soil erosion (E) limitation in this study is consistent with the surrounding soil surveys (BAB & CBW). However, following a recent review focused on improving the quality of runoff water leaving agricultural areas a revised assessment of the soil erosion risk (E) limitation has been undertaken. This assessment used more conservative slope thresholds with the aim of reducing the export of sediment, nutrients and pesticides into waterways, off-stream water storages and downstream estuarine environments.

While this more conservative E limitation has not been used in the derivation of land suitability for this study, the impacts of a modified E limitation has been considered. In the figures following (Figure 39 to Figure 41), areas currently suitable for a selection of crops are shown along with areas (shown in red hatching) identified as being at higher risk of erosion.

All crop suitabilities would be impacted by a reduction in suitable area under this modified E limitation. Areas most impacted include the alluvial soils of Yandaran Creek, the eastern facing slopes of the Burrum Coal Measures adjacent to the Maryborough Formation and the steeper slopes on the edge and on isolated cappings of the Elliott Formation.

Heightened consideration of erosion risk will not necessarily preclude these areas from agricultural production but it draws attention to areas where increased erosion awareness is warranted and where additional management practices designed to minimise erosion risks should be considered.

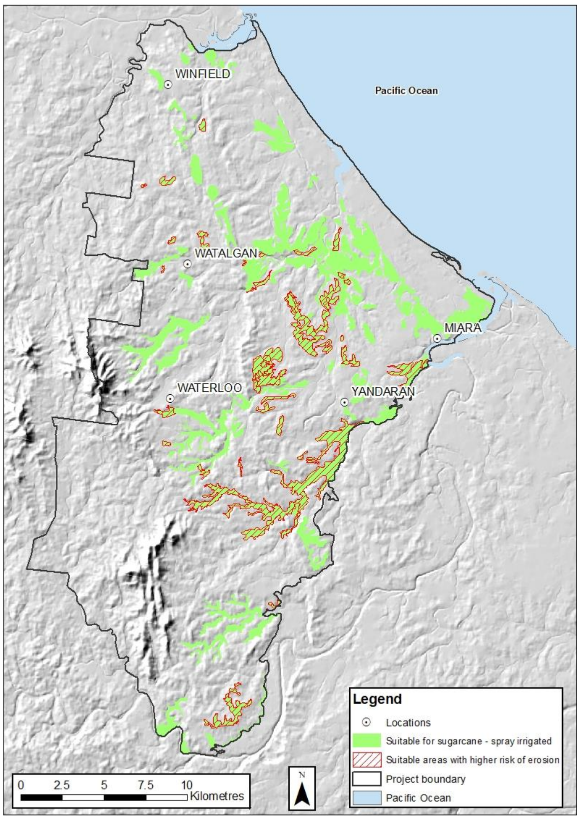

Figure 36 Areas of the WIN project suited to spray irrigated sugarcane and identified areas of suitable land with higher erosion risk

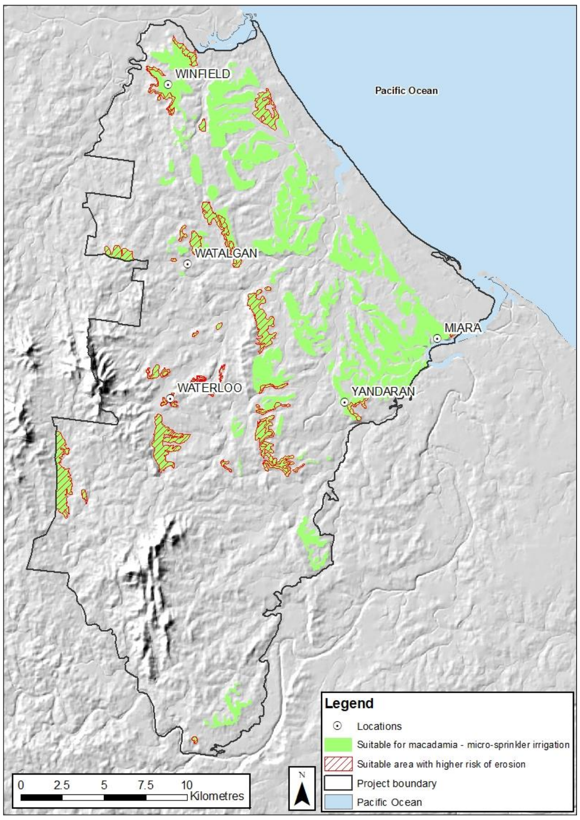

Figure 37 Areas of the WIN project suited to micro-sprinkler irrigated macadamia and identified areas of suitable land with higher erosion risk

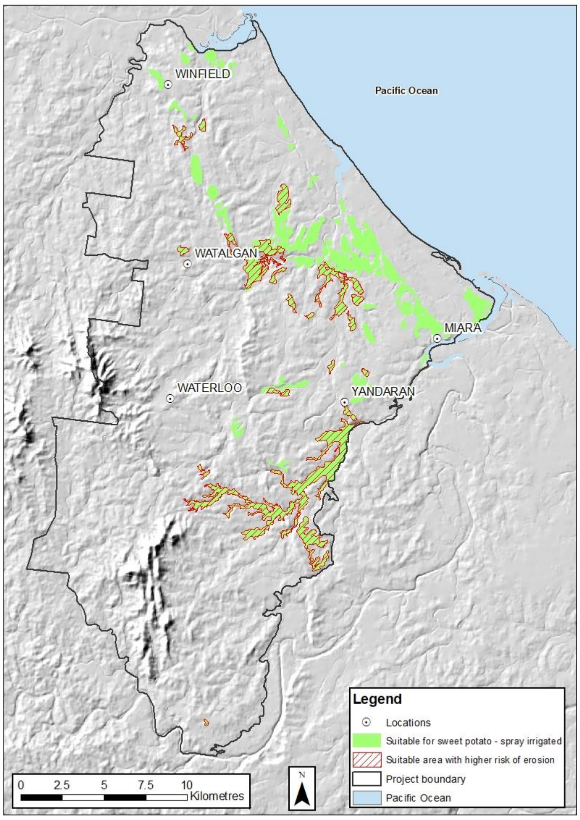

Figure 38 Areas of the WIN project suited to spray irrigated sweet potato and identified areas of suitable land with higher erosion risk

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10. Spatial data sets used

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Appendix 1: Soil profile class descriptions for WIN study area.

A **soil profile class** (SPC) is a three dimensional soil body, such that any profile within it 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, or as defined in the SPC description.

A **soil variant** is a soil with profile attributes clearly outside the range of defined soil types, but does not occupying an area within the project to justify defining a new SPC, e.g. *Bucca*, red variant (BvRv)

A **soil phase** is a subdivision of a SPC based on attributes that have particular significance in the use of the soil that are not within the defined SPC attributes, for example, *Avondale* rocky phase (AvRp).

The letters used (suffixes) to identify each variant or phase are defined elsewhere in the report, and on the accompanying soils map.

Australian Soil Classification (ASC), as defined in Isbell (Second Edition 2016), is listed in order of frequency of occurrence, with the most frequently occurring displayed in bold print.

Landform, Vegetation form, Surface characteristics, Permeability and Drainage are as defined in the *Australian Soil and Land Survey Field Handbook* or 'Yellow Book' (2009)

Geology as defined on the map sheets,

Terminology and horizon names (except for pH and thickness of A horizon) **within horizon descriptions** are as defined in the *Australian Soil and Land Survey Field Handbook* (2009) or 'Yellow Book'

The **pH** is based on field determination (Raupach test) within each horizon

Thickness of A horizon (surface) is defined as:

Thin	< 0.10 m	Thick	0.30-0.60 m
Moderately thick	0.10-0.30 m	Very thick	> 0.60 m.

Frequency of occurrence

Frequently	>30% of occasions
Occasionally	10–30% of occasions
Rarely	<10% of occasions

Horizon boundaries in Profile Diagrams

———	Lower horizon always present
-------	Lower horizon not always present

Colour codes (moist only) are those of Munsell soil colour charts (2000), with colour nomenclature based on the colour class limits of Isbell (2016). Only the most frequently occurring Munsell colours, based on described soil profiles, have been listed in the horizon descriptions.

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Profile Horizon Key: Horizons within the Profile diagrams are coloured as defined below:

A horizons (topsoil)

B horizons (subsoil)

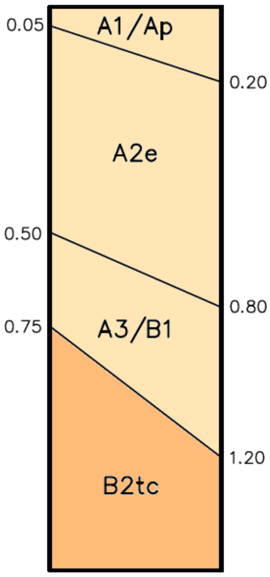
BC or C horizons (parent material)

D (buried horizons)

Alloway (Al)

CONCEPT	Very thick, bleached, sandy surface over acid, mottled, grey, non-sodic to weakly sodic clay on deeply weathered coarse grained sedimentary rocks.
ASC	**Redoxic Hydrosol,** Grey Dermosol, Grey Kurosol
LANDFORM	Level plains to lower hillslopes of gently undulating rises. Slopes < 2%
GEOLOGY	Elliott Formation (Te)
VEGETATION	Tall mid-dense forest of *Eucalyptus latisinensis, Eucalyptus acmenoides, Corymbia trachyphloia, Corymbia intermedia;* Scattered understorey of *Melaleuca viridiflora*
PERMEABILITY	Slowly to moderately permeable
DRAINAGE	Poorly or imperfectly drained
SURFACE	Firm or hard setting

Depth (m)



HORIZON	**DESCRIPTION**
A1 / Ap	Grey (7.5YR, 10YR 4/1 to 5/2); loamy sand to sandy loam; massive; pH 5.0-6.0. Clear or diffuse change to:
A2e	Grey (10YR 5/2, 6/2, 7/2) with conspicuous bleach; loamy sand to sandy loam; massive; pH 5.0-6.0. Clear or diffuse change to:
A3 / B1	Mottled; grey or yellow (10YR 6/4, 7/2 to 7/4, 8/3); sandy clay loam to sandy light clay; massive or weak polyhedral or blocky structure; frequently very few to many ferromanganiferous nodules; pH 5.5-6.5. Clear or diffuse change to:
B2tc	Mottled; grey or occasionally yellow (10YR 7/2 to 8/3, 8/4, 2.5Y 7/1, 7/2, 8/2); light to medium clay; moderate or strong, polyhedral or blocky structure; frequently common to many ferromanganiferous nodules; pH 5.0-6.5.

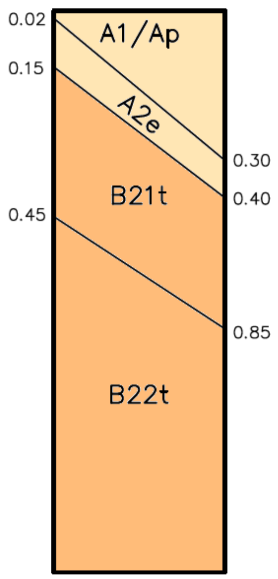
Sites 131, 132, 249, 268

Distribution Four small polygons in the east of the WIN study area.

Auburn (Ab)

CONCEPT	Moderately thick, bleached, loamy to clay loamy surface over acid to strongly alkaline, mottled, brown or grey, strongly sodic clay on alluvial plains.
ASC	**Brown or Grey Sodosol**
LANDFORM	Alluvial plains. Slopes < 1%
GEOLOGY	Older plains of Quaternary Alluvium (Qa)
VEGETATION	Mostly cleared. Some *Eucalyptus tereticornis, E. moluccana, Corymbia clarksoniana, Lophostemon* species; Scattered understorey of *Melaleuca viridiflora*
PERMEABILITY	Slowly permeable
DRAINAGE	Imperfectly drained
SURFACE	Firm or hard setting

Depth (m)



HORIZON	DESCRIPTION
A1 / Ap	Black or grey (7.5YR, 10YR 3/2, 4/2); loam fine sandy to clay loam fine sandy (occasionally silty); massive; pH 5.5-6.5. Clear change to:
A2e	Grey (10YR 5/2, 6/2) with conspicuous bleach; loam fine sandy to clay loam fine sandy (occasionally silty); massive; pH 5.5-6.5. Abrupt or sharp change to:
B21t	Mottled; brown or occasionally grey (7.5YR 4/3, 5/3, 10YR 4/3, 4/4, 5/3, 6/3, 4/2 to 6/2); light medium to heavy clay; strong blocky, prismatic or occasionally columnar structure; occasionally few manganiferous nodules; pH 5.5-9.5. Clear change to:
B22t	Mottled; grey or brown (10YR 5/2, 5/3, 5/4, 7.5YR 4/4, 5/4); light to heavy clay; strong blocky or prismatic structure; occasionally few calcareous nodules; pH 5.5-9.5.

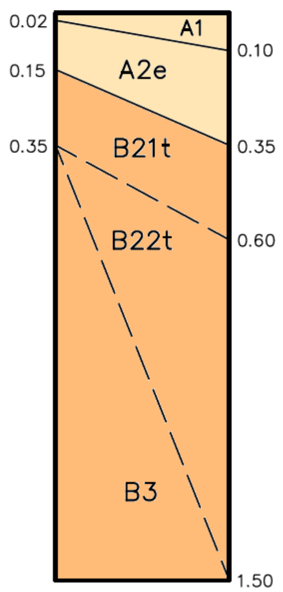
Sites 34, 238, 273, 573, 575, 603, 688
Sampled 262

Distribution Alluvium associated with the Kolan River.

Avondale (Av)

CONCEPT	Moderately thick, bleached, loamy to clay loamy surface over acid, mottled, grey, strongly sodic clay on deeply weathered fine grained sedimentary rocks. Few to many maghemite small pebbles in A and B21 horizons.
ASC	**Grey Kurosol or Sodosol**, Brown Kurosol or Sodosol, Redoxic Hydrosol
LANDFORM	Gently undulating plains and rises to undulating rises and low hills. Slopes 1-10%
GEOLOGY	Elliott Formation (Te), Burrum Coal Measures (Kb), Grahams Creek Formation (Jkr)
VEGETATION	Tall mid-dense forest of *Eucalyptus latisinensis, Angophora leiocarpa* with scattered *E. crebra, Corymbia trachyphloia, C. intermedia*; Scattered understorey of *Melaleuca* species
PERMEABILITY	Slowly permeable
DRAINAGE	Imperfectly or poorly drained
SURFACE	Firm or hard setting; common maghemite small pebbles

Depth (m)



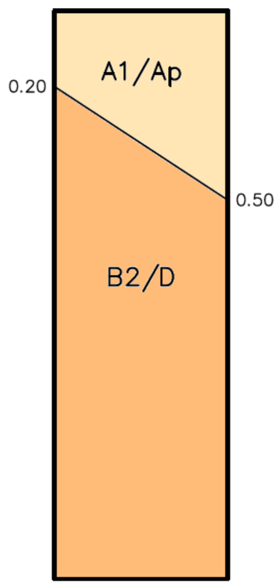
HORIZON	**DESCRIPTION**
A1	Grey or black (7.5YR 3/2, 4/2, 5/2); fine sandy loam to clay loam, fine sandy; massive; few to many small maghemite pebbles; pH 5.0-6.0. Clear or abrupt change to:
A2e	Grey (7.5YR 5/2, 6/2, 7/2) with conspicuous bleach; fine sandy loam to clay loam, fine sandy; massive; few to many small maghemite pebbles; pH 5.0-6.0. Abrupt or sharp change to:
B21t	Mottled; grey or occasionally brown (7.5YR 4/2 to 6/2, 5/3; 10YR 5/2, 5/3); medium to medium heavy clay; strong blocky or prismatic structure; few to many small maghemite pebbles; pH 5.0-6.0. Clear or diffuse change to:
B22t	Where present; mottled, grey or brown (10YR 5/2, 5/3, 5/4, 7.5YR 4/4, 5/4); light to heavy clay; strong blocky or prismatic structure; frequently with slickensides; pH 5.0-5.8. Clear or diffuse change to:
B3	Where present; mottled; grey (7.5YR 5/1 to 6/2, 10YR 5/2 to 7/2, 6/3); medium to heavy clay; strong blocky structure; rock fragments; pH 5.0-5.5.

Sites	387
Distribution	One small polygon within the WIN study area.
Notes	B21 horizon may directly overlie B3 horizon in some shallow soil profiles; similarly in some deeper soil profiles B22 may continue to 1.5m and greater.

Barubbra (Bb)

CONCEPT	Brown or yellow sand on recent alluvium.
ASC	**Brown-Orthic Tenosol**; Stratic Rudosol
LANDFORM	Levees, scrolls and alluvial plains. Slopes < 2%
GEOLOGY	Recent alluvium (Qa)
VEGETATION	Tall mid-dense forest of *Eucalyptus tessellaris, Lophostemon* species; Understorey of *Acacia* species
PERMEABILITY	Highly permeable
DRAINAGE	Rapidly drained; occasionally moderately well-drained
SURFACE	Loose, soft or firm

Depth (m)



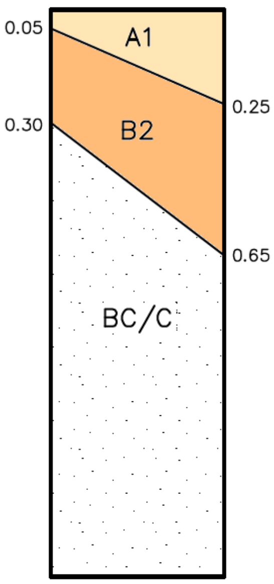
HORIZON	**DESCRIPTION**
A1 / Ap	Black or brown (10YR 2/2, 3/2 to 4/3); loamy sand to sandy loam; massive or single grain; pH 6.0-7.0. Clear change to:
B2 / D	Brown (10YR 3/3, 3/4, 4/4, 5/4); sand to sandy loam; massive or single grain; pH 6.0-7.0.

Sites	145, 283, 284
Distribution	Small polygons near Baffle Creek in the north-west of the WIN study area.
Notes	B2 or D horizon of *Barubbra* soils may be yellow (10YR 6/4, 7/4, 7/6) in the WIN study area.

Berren (Be)

CONCEPT	Acid to neutral, brown non-sodic clay on basalt; abundant basalt fragments throughout shallow to moderately deep soil profile.
ASC	**Brown Ferrosol**
LANDFORM	Hillslopes on undulating rises to rolling low hills. Slopes 8 to 30%
GEOLOGY	Maroondan Basalt (Tbm)
VEGETATION	Cleared, originally *Eucalyptus* species woodland
PERMEABILITY	Moderately permeable
DRAINAGE	Well-drained
SURFACE	Firm; abundant basalt pebbles to cobbles

Depth (m)



HORIZON	**DESCRIPTION**
A1	Black or brown (7.5YR 2/2; 10YR 3/2, 3/3); light clay; strong granular structure; many to abundant basalt gravels to cobbles; pH 6.0-7.0. Clear change to:
B2	Brown (7.5YR 3/3; 10YR 3/4); light medium clay; strong blocky structure; many to abundant basalt gravels to cobbles; pH 6.0-7.0. Clear or gradual change to:
BC / C	Weathering and hard basalt.

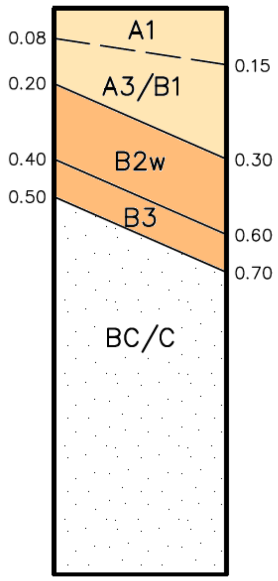
Sites 684

Distribution A limited area of basalt close to the southern boundary of the WIN study area.

Booyal (Bl)

CONCEPT	Moderately thick, loamy to clay loamy surface over acid to neutral, red or brown non-sodic clay on granodiorite and acid volcanic rocks.
ASC	**Red Dermosol or Chromosol**, Brown Dermosol or Chromosol
LANDFORM	Upper hillslopes to hillcrests on rises, low hills and hills. Slopes 5-15%
GEOLOGY	Undifferentiated granite (Rg), Watalgan granite (Rgwt), Moolyung granodiorite (PRgmy)
VEGETATION	Tall mid-dense forest of *Eucalyptus acmenoides, Angophora leiocarpa, E. exserta, Corymbia intermedia, E. citriodora.*
PERMEABILITY	Moderately Permeable
DRAINAGE	Moderately well or well-drained
SURFACE	Firm or hard setting

Depth (m)



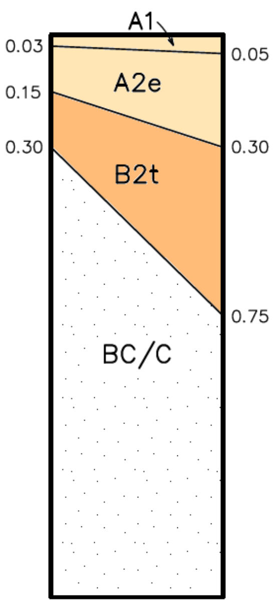
HORIZON	**DESCRIPTION**
A1	Black (5YR 2/2, 7.5YR 3/1, 3/2, 10YR 3/1); loam to clay loam; massive to moderate granular structure; pH 6.0-6.5. Clear change to:
A3 / B1	Where present; red, brown or occasionally black (5YR 3/3, 4/3, 7.5YR 3/2, 4/3); clay loam to light clay (often sandy); moderate blocky structure; pH 6.0-6.5. Gradual or clear change to:
B2w	Red or brown (2.5YR 3/3, 4/4, 4/6; 5YR 4/3, 4/4, 4/6, 7.5YR 4/3, 10YR 4/3); light medium to medium clay; strong blocky structure; pH 6.0-7.5. Gradual or clear change to:
B3	Mottled; brown or red (5YR, 4/4, 5/3, 7.5YR 4/3, 5/3, 5/4, 10YR 5/3 to 5/6); sandy light clay to light medium clay; weak to moderate blocky or prismatic structure; pH 6.5-8.5. Gradual or diffuse change to:
BC / C	Weathered and hard rock.

Sites	494, 537, 542, 551, 716
Distribution	Small polygons on granite in the west of the WIN study area.
Notes	Occasionally surface texture may be light clay in the WIN study area.

Brooweena (Bw)

CONCEPT	Moderately thick, bleached, loamy to clay loamy surface over acid to alkaline, mottled, grey or brown, strongly sodic clay on moderately weathered sedimentary rocks. Abundant rock fragments throughout shallow to moderately deep soil profile.
ASC	**Grey or Brown Kurosol**, Grey or Brown Sodosol
LANDFORM	Mid to upper hillslopes on rises. Slopes 1-10%
GEOLOGY	Brooweena formation (Rb), Graham's Creek Formation (Jkr), Gympie Group (Py)
VEGETATION	Tall mid-dense forest of *Eucalyptus citriodora, E. crebra, E. moluccana, E. exserta.*
PERMEABILITY	Slowly permeable
DRAINAGE	Imperfectly drained
SURFACE	Hard setting; usually abundant coarse gravels to cobbles

Depth (m)



HORIZON	**DESCRIPTION**
A1	Black or grey (10YR 3/1, 3/2, 4/2); sandy loam to clay loam; massive; common to many pebbles to cobbles; pH 5.0-6.0. Clear change to:
A2e	Grey (10YR 5/2, 6/2, 7/2) with conspicuous bleach; sandy loam to clay loam; massive; common to many pebbles to cobbles; pH 5.0 - 6.0. Clear or abrupt change to:
B2t	Mottled; grey or brown (10YR 4/2 to 4/4); light medium to medium heavy clay; moderate or strong blocky, prismatic or columnar structure; common to many pebbles to cobbles; pH 4.5-9.0. Clear or gradual change to:
BC / C	Weathering and hard sedimentary rock.

Sites 66, 70, 76, 86, 306, 481, 505, 517, 622, 644, 699, 717, 730

Sampled 90, 289

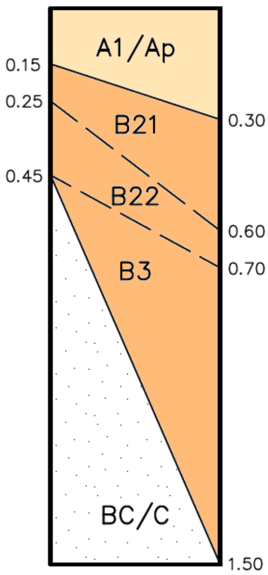
Distribution All areas where sedimentary rocks of Rb, Jkr or Py geology occurs.

Notes Similar soil profiles with red B2 horizons (2.5YR 3/4, 3/5; 5YR 3/3, 3/4, 4/6) have been allocated to *Broweena*, red variant (BwRv). Soil depth, colour, pH and rock content can vary over short distances due to exposure of underlying steeply dipping sedimentary rock strata. The pH range in B2 horizon of *Broweena* soil profiles within the WIN study area includes more acid values than described for *Broweena* soil profiles in other study areas.

Bucca (Bc)

CONCEPT	Acid, mottled, brown clay on moderately weathered sedimentary rocks.
ASC	**Brown Dermosol**, Black Dermosol
LANDFORM	Hillslopes of rises and low hills. Slopes 5-15%
GEOLOGY	Brooweena formation (Rb), Graham's Creek Formation (Jkr), Maryborough formation (Km).
VEGETATION	Tall mid-dense to closed forest of *Eucalyptus citriodora, E. crebra, E. moluccana, Corymbia intermedia, Lophostemon suaveolens, E. tereticornis*. Frequently *E. acmenoides, Melaleuca* and *Acacia* species associated. Many areas cleared.
PERMEABILITY	Slowly or moderately permeable
DRAINAGE	Moderately well or imperfectly drained
SURFACE	Hard setting, usually abundant coarse gravels to cobbles

Depth (m)



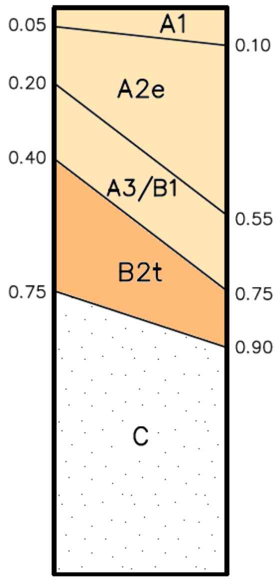
HORIZON	DESCRIPTION
A1 / Ap	Black or brown (10YR 2/2, 3/1 to 3/3, 4/3); light to medium clay; moderate or strong blocky structure; few to many pebbles to gravels; pH 5.0-6.5. Clear change to:
B21	Mottled; brown or black (7.5YR 4/3, 10YR 3/1, 4/3, 4/6, 5/3, 5/6); light medium to medium heavy clay; moderate or strong blocky or lenticular structure; few to abundant pebbles to gravels; few ironstone pebbles; pH 4.5-6.0. Clear change to:
B22	Where present; mottled; grey, brown or yellow (2.5Y 7/1, 10YR 6/2, 6/6, 7.5YR 4/4); medium to medium heavy clay; moderate or strong blocky or lenticular structure; few to many pebbles to gravels; few ironstone pebbles; pH 4.0-5.5. Clear or gradual change to:
B3	Where present; prominently red-mottled, grey (2.5Y 7/1, 10YR 5/2, 5Y 7/1); medium to medium heavy clay; weak to moderate blocky to lenticular structure; common to many pebbles to gravels; few ironstone pebbles; pH 4.0-5.5. Clear or gradual change to:
BC / C	Weathering or hard rock. Layers of mottled grey clay and weathering rock may occur in deeper soil profiles.

Sites	63, 100, 382, 419, 422, 496, 506, 636, 737
Distribution	All areas where sedimentary rocks of Rb, Jkr or Km geology occurs.
Notes	Similar soil profiles formed on Tuff or Rhyolite are included in *Bucca* soil profile class. Similar soil profiles with B21 horizon red (5YR 3/4, 4/6), (ASC Red Dermosol), have been allocated to *Bucca*, red variant (BcRv). Occasionally a thin A2 horizon bleached (A2e) occurs.

Bungadoo (Bg)

CONCEPT	Thick, bleached, clay loamy surface over acid, mottled, brown or yellow clay on silicified sediments. Many to abundant rock fragments throughout moderately deep soil profile.
ASC	**Brown or Yellow Dermosol**
LANDFORM	Hillslopes and hillcrests on rises and low hills. Slopes 1-20%
GEOLOGY	Silicified mudstones and siltstones of Maryborough formation (Km), silicified sediments of Graham's Creek formation (Jkr).
VEGETATION	Tall mid-dense forest of *Eucalyptus citriodora, E. acmenoides, Corymbia trachyphloia, Lophostemon* species.
PERMEABILITY	Moderately permeable
DRAINAGE	Moderately well-drained
SURFACE	Firm or hard setting. Frequently abundant silicified coarse gravels to cobbles.

Depth (m)



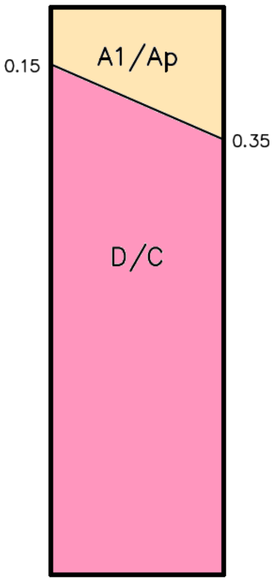
HORIZON	DESCRIPTION
A1	Black or grey (7.5 YR 3/2, 4/2, 5/3); clay loam; massive or weakly structured; many silicified sedimentary coarse gravels to cobbles; pH 5.5-6.5. Clear change to:
A2e	Grey (7.5 YR 5/2, 5/3, 6/3) with conspicuous bleach; clay loam; massive or weakly structured; many or abundant silicified sedimentary coarse gravels to cobbles; pH 5.5-6.5. Clear or gradual change to:
A3 / B1	Mottled; brown, yellow or occasionally grey (7.5YR 5/4, 10YR 5/2, 5/3, 5/4, 6/3, 6/4, 6/6); light clay; moderate blocky structure; many or abundant silicified sedimentary coarse gravels to cobbles; pH 5.0-5.5. Diffuse change to:
B2t	Mottled; brown or yellow (10YR 5/3, 5/4, 7.5YR 4/4, 4/6, 5/4); light clay; strong polyhedral or blocky structure; many or abundant silicified sedimentary coarse gravels to cobbles; pH 5.0-5.5. Clear or diffuse change to:
C	Silicified sedimentary rock.

Sites	281, 494, 622, 624, 731
Distribution	Small polygon in the north and centre of the WIN study area.
Notes	Occasionally B2 horizon red (5YR 5/8) in the WIN study area. A3/B1 horizon occasionally absent (ASC Brown Kurosol) in the WIN study area.

Burnett (Bn)

CONCEPT	Layered alluvial soil.
ASC	**Stratic Rudosol**, Chernic Tenosol
LANDFORM	Levees, scrolls and alluvial plains. Slopes <2 %
GEOLOGY	Recent alluvium (Qa)
VEGETATION	Tall mid-dense forest of *Eucalyptus tessellaris, E. tereticornis*, *Lophostemon* species. Understorey of *Acacia* species.
PERMEABILITY	Highly or moderately permeable
DRAINAGE	Rapidly or well-drained
SURFACE	Soft or firm

Depth (m)



HORIZON	**DESCRIPTION**
A1 / Ap	Brown or black (7.5YR 3/2 to 4/3, 10YR 3/2, 3/3); sandy loam to clay loam (frequently fine sandy); massive to moderate granular; pH 6.0-7.0. Abrupt or clear change to:
D / C	Brown (7.5YR 4/3, 4/4, 5/4, 10YR 4/4, 5/ 4); layers of sand to clay loam (frequently fine sandy); massive to moderate blocky; pH 6.0-8.0. Clear or diffuse boundaries between individual layers.

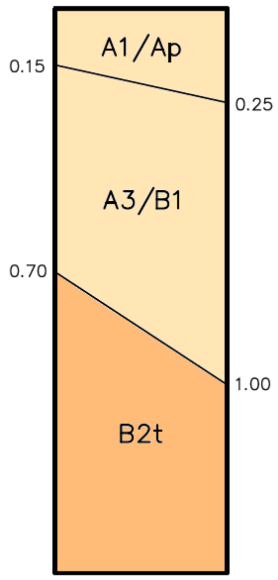
Sites

Distribution One small UMA of alluvium associated with Mullet Creek in the centre of the WIN study area.

Calavos (Ca)

CONCEPT	Moderately thick sandy surface over acid, mottled, brown or yellow, clay loam to light clay on deeply weathered coarse grained sedimentary rocks.
ASC	**Brown Dermosol**, Yellow Dermosol, Brown Kurosol
LANDFORM	Hillcrests, mid to upper hillslopes of rises. Slopes < 4%
GEOLOGY	Elliott Formation (Te)
VEGETATION	Tall mid-dense forest of *Eucalyptus latisinensis, Corymbia intermedia, C. citriodora, E. exserta, Angophora leiocarpa.* Understorey of *Acacia* species, frequently with *Xanthorrhoea* species. Mostly cleared.
PERMEABILITY	Moderately permeable
DRAINAGE	Moderately well-drained
SURFACE	Hard setting

Depth (m)



HORIZON	DESCRIPTION
A1 / Ap	Black, grey or brown (10YR 2/2, 3/2, 3/3, 4/2); loamy sand to sandy loam; massive; pH 5.0-6.0. Clear or gradual change to:
A3 / B1	Brown or yellow (10YR 4/6, 5/3 to 5/6, 6/6); sandy clay loam to clay loam, sandy; massive; very few to many, *Quartz* or sedimentary pebbles to gravels; occasionally few ferromanganiferous nodules; pH 4.5-6.5. Clear change to:
B2t	Mottled; brown or yellow (10YR 4/3, 4/4, 4/6, 5/3, 5/6, 5/8, 6/4, 7.5YR 4/6, 5/6, 2.5Y 7/4); clay loam to light clay; moderate to strong blocky structure; frequently few to abundant sedimentary or *Quartz* pebbles; pH 4.0-6.5.

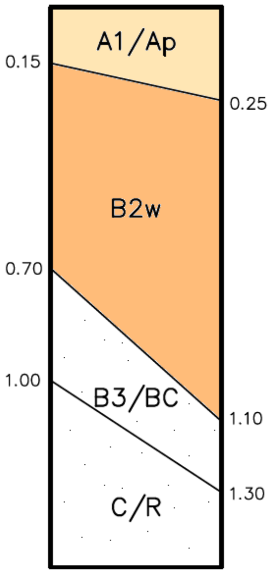
Sites 207, 235, 267, 568, 732

Distribution Occurs in two small polygons in the south east of the WIN study area.

Cedars (Cr)

CONCEPT	Acid, brown clay on deeply weathered fine grained sedimentary rocks.
ASC	**Brown Dermosol**
LANDFORM	Plains, hillcrests and mid to upper hillslopes of rises. Slopes < 5%
GEOLOGY	Burrum Coal Measures (Kb), Elliott Formation (Te)
VEGETATION	Cleared. Some *Eucalyptus acmenoides*.
PERMEABILITY	Moderately permeable
DRAINAGE	Imperfectly drained
SURFACE	Hard setting

Depth (m)



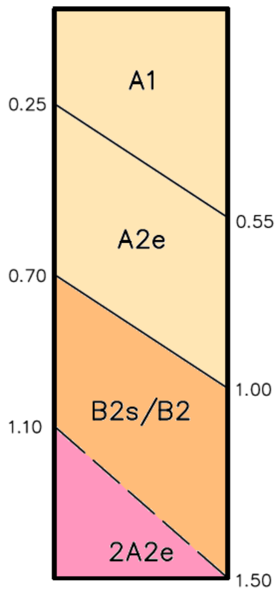
HORIZON	**DESCRIPTION**
A1 / Ap	Black or brown (7.5YR, 10YR 3/2, 3/3, 4/3); light clay, weak to strong blocky structure; few to many *Quartz* pebbles; pH 5.0-6.0. Clear change to:
B2w	Frequently mottled; brown (7.5YR, 10YR 4/4, 5/4, 5/6); light to medium clay; strong blocky structure; pH 4.5-5.5. Clear change to:
B3 / BC	Prominently red mottled; grey or yellow (10YR 6/1, 6/2, 7/2, 6/4); light medium to heavy clay; strong blocky structure; common to abundant pebbles; pH 4.0-5.5. Clear to gradual change to:
C / R	Hard, fine grained sedimentary rock.

Sites	395
Distribution	One small polygon near the centre of the WIN study area.

Colvin (Cv)

CONCEPT	Acid, bleached, brown or yellow sand on marine alluvium.
ASC	**Semiaquic Podosol**, Bleached-Orthic Tenosol, Redoxic and Oxyaquic Hydrosol.
LANDFORM	Beach ridges
GEOLOGY	Recent alluvium with marine influence. Slopes < 1-4%
VEGETATION	Tall mid-dense to closed forest of *Corymbia tessellaris, C. intermedia, Eucalyptus tereticornis, Livistonia australis, Lophostemon suaveolens* and *Melaleuca* species. Mostly cleared
PERMEABILITY	Highly permeable
DRAINAGE	Poorly or imperfectly drained
SURFACE	Loose or soft

Depth (m)



HORIZON	**DESCRIPTION**
A1	Black (10YR 2/1 to 3/3); sand to loamy sand; massive or single grain; pH 5.0-6.5. Clear change to:
A2e	Grey, brown or yellow (10YR 5/2, 5/3, 6/2, 6/3, 6/4, 7/1 to 7/3, 2.5Y 7/1, 7/2) with conspicuous bleach; sand to sandy loam; massive or single grain; pH 5.0-6.0. Clear change to:
B2s / B2	Mottled; brown, yellow or grey (10YR 4/2 to 4/4, 5/6, 5/8, 6/6, 6/8, 2.5Y 5/6, 6/4, 6/6); sand to sandy loam; massive or single grain; pH 5.0-6.0. Clear change to:
2A2e	Where present; grey or yellow (10YR 5/3 to 7/4) with conspicuous bleach; sand to sandy loam; massive or single grain; pH 5.0-6.0.

Sites 195, 341, 442, 453, 460, 589, 590, 592, 593, 594, 596, 599

Distribution All areas where marine plains occurs.

Notes Bleached A2 horizon may continue to 1.50 + m in some *Colvin* soil profiles within the WIN study area (B2 horizon is absent).

Water table may be present below 0.80 m, depending on time of year and season.

Crossing (Cg)

CONCEPT Thick, bleached, sandy to loamy surface over acid to neutral, mottled, brown or grey, strongly sodic clay on alluvial plains.

ASC **Brown or Grey Sodosol**

LANDFORM Alluvial plains. Slopes < 1%

GEOLOGY Older plains of Quaternary alluvium (Qa)

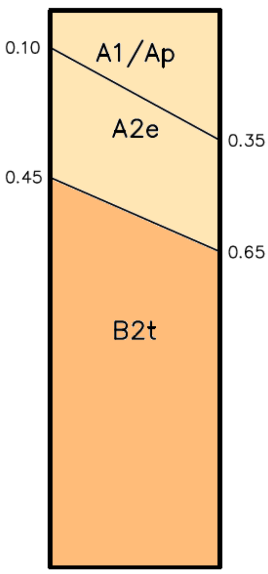
VEGETATION Mostly cleared originally *Eucalyptus tereticornis, E. moluccana, Corymbia clarksoniana, Lophostemon* species. Scattered understorey of *Melaleuca viridiflora.*

PERMEABILITY Slowly permeable

DRAINAGE Imperfectly drained

SURFACE Firm or hard setting

Depth (m)



HORIZON	DESCRIPTION
A1 / Ap	Black or grey (7.5YR, 10YR 3/2, 4/2); loamy sand to fine sandy loam; massive; pH 5.5-6.5. Clear change to:
A2e	Grey (10YR 5/2, 6/2) with conspicuous bleach; loamy sand to fine sandy loam; massive; pH 5.5-6.5. Abrupt or sharp change to:
B2t	Mottled; brown or grey (7.5YR 4/4, 10YR 5/1 to 5/4, 6/2 to 6/4); light medium to medium heavy clay (may be sandy); strong blocky, prismatic or occasionally columnar structure; occasionally few manganiferous nodules; pH 5.5- 8.0.

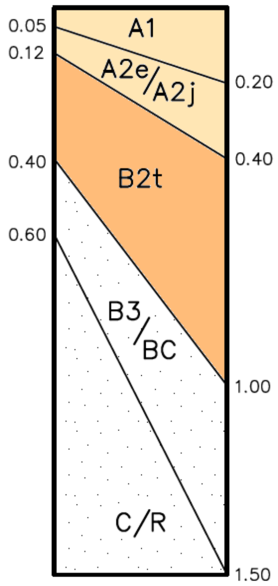
Sites 683

Distribution One small polygon in the south-west of the WIN study area.

Doongul (Do)

CONCEPT	Moderately thick, bleached, clay loamy surface over acid to neutral, mottled, grey, strongly sodic clay on acid volcanic rocks.
ASC	**Grey Sodosol or Kurosol**, Brown Kurosol or Sodosol, Black Kurosol.
LANDFORM	Hillslopes and hillcrests of rises and low hills. Slopes < 10%
GEOLOGY	Acid volcanics of Grahams Creek Formation (Jkr), Watalgan Granite (Rgwt), Undifferentiated granite (Rg).
VEGETATION	Tall sparse to mid-dense forest of *Corymbia citriodora, Eucalyptus crebra, E. moluccana, E. tereticornis, C. tessellaris, C.* intermedia. Understorey *of Acacia* species.
PERMEABILITY	Slowly permeable
DRAINAGE	Imperfectly drained
SURFACE	Hard setting

Depth (m)



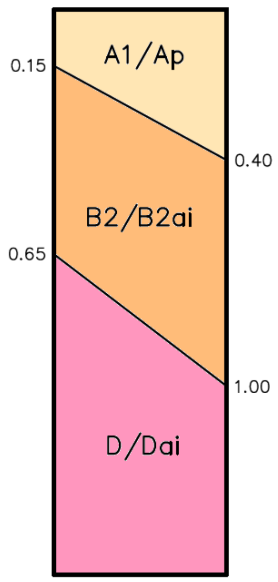
HORIZON	DESCRIPTION
A1	Black or brown (10YR 2/2, 3/1, 32/, 3/3, 4/3); sandy clay loam to clay loam, fine sandy; massive; pH 5.0-6.0. Clear change to:
A2e / A2j	Grey to yellow (10YR 4/2, 5/2, 2.5Y 6/4, 8/1) with conspicuous or sporadic bleach; sandy clay loam to clay loam, fine sandy; massive; occasionally few to common *quartz* gravels; pH 5.0-6.0. Clear or abrupt change to:
B2t	Frequently mottled; grey or occasionally black or brown (10YR 2/1, 3/1, 4/2, 4/6, 5/2, 6/2, 2.5Y 4/4, 6/1, 7.5YR 4/4); light medium to medium heavy clay; strong blocky, prismatic or occasionally columnar structure; very few to many *quartz* or acid volcanic pebbles; pH 5.0-7.0. Clear or diffuse change to:
B3 / BC	Mottled; grey or brown (7.5YR 4/6, 5/2, 5/3, 10YR 4/1, 4/2); sandy light clay to medium clay with rock fragments; moderate or strong prismatic or blocky structure; pH 5.0-7.5. Clear or gradual change to:
C / R	Hard acid volcanic rock.

Sites	64, 65, 257, 524, 539, 546, 647, 715
Distribution	Western part of the WIN study area.

Fairydale (Fd)

CONCEPT	Moderately thick, clay loamy to clayey surface over acid, mottled, grey clay with buried layers on marine plains.
ASC	**Redoxic Hydrosol,** minor Extratidal Hydrosol
LANDFORM	Plains or swamps on marine plains; occasionally extratidal flats or swales Slopes < 1%
GEOLOGY	Quaternary coastal deposits (Qhcb, Qha, Qpcp, Qhed)
VEGETATION	Tall mid-dense to closed forest of *Melaleuca quinquenervia* with scattered *Eucalyptus tereticornis*, *Corymbia tessellaris, Casuarina glauca*. Ground cover of *Sporobolis virginicus* in most areas. Grassland of *Sporobolis virginicus* may occur. Some areas cleared
PERMEABILITY	Slowly permeable
DRAINAGE	Poorly or imperfectly drained
SURFACE	Hard setting to weakly cracking when dry, frequently salt affected.

Depth (m)



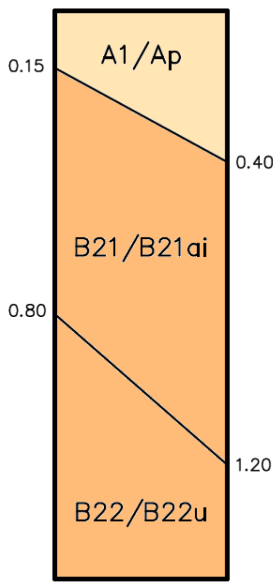
HORIZON	DESCRIPTION
A1 / Ap	Black (7.5YR, 10YR 2/1 to 3/2); clay loam to light medium clay; strong blocky structure; pH 4.5-7.0. Clear change to:
B2 / B2ai	Mottled; grey (10YR 4/1 to 5/2, 6/2); light medium to medium clay; strong blocky or prismatic structure; jarosite may be present; pH 3.0 to 6.0. Gradual change to:
D / Dai	Mottled; grey or gley (10YR 4/1, 5/1, 5/2, 6/2, 2.5Y 4/1, 5/1, 7/2, N 4/0); sand to loamy sand (frequently coarse); massive or single grain; frequently with jarosite; pH 3.5-5.0.

Sites	1, 2, 436, 438, 441, 443, 446, 450, 580, 584
Distribution	All areas where marine plains occurs.
Notes	Grey (10YR 5/2) organic layer 10 cm thick or less (O1 horizon) may occur at the soil surface, associated with marine couch grasslands. Water table (usually non-saline), frequently present below 0.60 m. Where soil profiles are not Hydrosols, ASC may be Grey Dermosol or Epipedal, Grey Vertosol where surface is cracking and lenticular structure occurs in the B horizon. D horizon frequently underlain before 1.50 m by mottled, grey, black or gley (10YR 2/2, 5/2, 6/1, 2.5Y 6/1, 5Y 5/1, N 4/0, 5/0), sandy loam to heavy clay (frequently coarse); massive or weak blocky structure (medium to heavy clay layers may have moderate to strong blocky or lenticular structure); frequently reduced or with jarosite. The pH range in B2 horizon of *Fairydale* soil profiles within the WIN study area includes more acid values than described for *Fairydale* soil profiles in other study areas. *Fairydale* soil profiles in the WIN study area usually non-saline to 1.50 m, apart from salt accumulation at the soil surface.

Fairymead (Fm)

CONCEPT	Black clay loamy to clayey surface over acid, mottled, grey clay on marine plains.
ASC	**Redoxic Hydrosol**, minor Extratidal Hydrosol
LANDFORM	Plains or swamps on marine plains; occasionally extratidal flats or swales. Slopes < 1%
GEOLOGY	Quaternary coastal deposits (Qhcb, Qha, Qpcp)
VEGETATION	Tall mid-dense to closed forest of *Melaleuca quinquenervia* with scattered *Eucalyptus tereticornis* and *Casuarina glauca*. Ground cover of *Sporobolis virginicus* in most areas. Grassland of *Sporobolis virginicus* may occur. Some areas cleared.
PERMEABILITY	Slowly permeable
DRAINAGE	Poorly or imperfectly drained
SURFACE	Hard setting to weakly cracking when dry, frequently salt affected.

Depth (m)

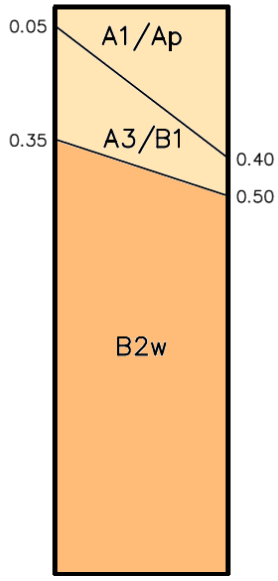


HORIZON	**DESCRIPTION**
A1 / Ap	Black (7.5YR, 10YR 2/1 to 3/2); clay loam to light medium clay; strong blocky structure; pH 3.5-6.0. Clear change to:
B21 / B21ai	Mottled; grey (10YR 4/1 to 6/2); light medium to medium heavy clay; strong blocky, prismatic or occasionally lenticular structure; jarosite frequently present; pH 3.0 to 4.5. Gradual change to:
B22 / B22u	Mottled; grey (10YR, 2.5Y 4/1 to 5/2, 7/2, 5Y 4/1); light medium to medium heavy clay; strong blocky, prismatic or occasionally lenticular structure; pH 3.5-6.0.
Sites	310, 439, 445, 558, 572, 574, 582, 587, 600
Distribution	All areas where marine plains occurs.
Notes	Salty water table frequently present below 0.50-1.00 m, depending on time of year, season and site characteristics. Grey (10YR 5/2) organic layer 10 cm thick or less (O1 or P1 horizon) may occur at the soil surface, associated with marine couch grasslands. *Fairymead* soil profiles in the WIN study area are usually saline (EC > 1.0 dSm^{-1}) at and below 0.60.

Farnsfield (Ff)

CONCEPT	Moderately thick to thick, sandy surface over acid to neutral, massive, red clay loam to light clay on deeply weathered coarse grained sedimentary rocks.
ASC	**Red Kandosol**
LANDFORM	Level plains, hillslopes and hillcrests on plains and rises. Slopes < 3%
GEOLOGY	Sandstones of the Elliott Formation (Te)
VEGETATION	Tall mid-dense forest of *Eucalyptus latisinensis, Corymbia trachyphloia, E. crebra, C. tessellaris.* Most areas cleared.
PERMEABILITY	Moderately permeable
DRAINAGE	Well-drained
SURFACE	Firm to hard setting

Depth (m)



HORIZON	DESCRIPTION
A1 / Ap	Red, brown or black (2.5YR 3/3, 4/2, 4/3, 5YR 3/2, 4/2 to 4/4, 7.5YR 3/3, 4/3); loamy sand to sandy loam; massive; pH 5.5- 6.5. Clear change to:
A3 / B1	Red or brown (2.5YR 3/4, 4/3, 5/6, 5YR 3/3, 3/6, 4/4, 7.5YR 3/4, 4/4, 4/6); sandy clay loam to clay loam, fine sandy; massive; pH 5.5-7.0. Clear or diffuse change to:
B2w	Red (10R, 2.5YR 3/6, 4/4, 4/6, 4/8); clay loam, fine sandy to light clay; massive to weak blocky structure; pH 5.5-7.0.

Sites 114, 142, 286, 293, 299, 315, 318, 320, 570, 663, 695

Sampled 279 (FfSv)

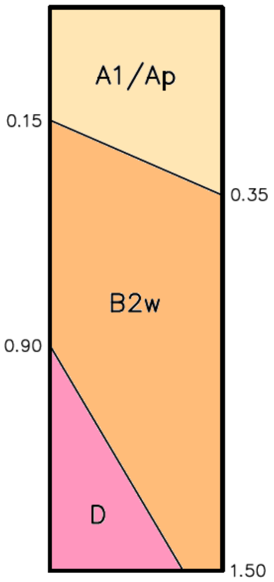
Distribution All areas where Elliott Formation geology occurs.

Notes A horizon texture occasionally clay loam, fine sandy, particularly where disturbed by ploughing (Ap horizon). A3/B1 may be absent. Similar soil profiles with texture of loamy sand to sandy loam to 1.50 m (ASC Red-Orthic Tenosol) have been allocated to *Farnsfield*, sandy variant (FfSv).

Flagstone (Fs)

CONCEPT	Brown or black, acid to neutral clay loam to light clay on recent alluvium. Sandy to clay loamy D horizons, if present, occur below 0.90 m.
ASC	**Brown Dermosol**, Black Dermosol
LANDFORM	Plains, swales, levees, scrolls. Slopes < 1 to 3%
GEOLOGY	Recent alluvium (Qa) of major streams
VEGETATION	Mostly cleared, originally *Eucalyptus* species woodland.
PERMEABILITY	Moderately permeable
DRAINAGE	Moderately well-drained
SURFACE	Firm

Depth (m)



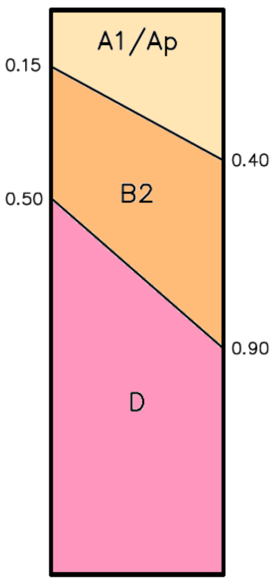
HORIZON	**DESCRIPTION**
A1 / Ap	Black (7.5YR 2.5/2, 3/2, 10YR 2/2, 3/2); clay loam to light clay; moderate or strong granular or blocky structure; pH 6.0-6.5. Clear or gradual change to:
B2w	Brown or black (7.5YR 3/2, 4/3, 4/4, 10YR 2/2, 3/1 to 3/4); clay loam to light medium clay; moderate or strong prismatic or blocky structure; pH 6.0-7.5. Clear or diffuse change to:
D	Brown or black (7.5YR 3/2, 4/3, 4/4, 5/4); loamy sand to sandy clay loam; massive; pH 6.0-7.5.

Sites	239, 252
Distribution	Alluvium associated with *Littabella* Creek or Kolan River.
Notes	Similar profiles with grey (10YR 5/2) lower B2 horizon within the WIN study area have been allocated to *Flagstone*, grey subsoil variant (FsGsv).

Gahan (Gh)

CONCEPT	Brown or black, acid to neutral clay loam to light clay on recent alluvium. Sandy or loamy D horizon present by 0.90 m.
ASC	**Brown Dermosol**, Black Dermosol
LANDFORM	Plains, swales, levees, scrolls
GEOLOGY	Recent alluvium (Qa) of major streams. < 1 to 3%
VEGETATION	Mostly cleared, originally *Eucalyptus* species woodland.
PERMEABILITY	Moderately permeable
DRAINAGE	Moderately well-drained
SURFACE	Firm

Depth (m)



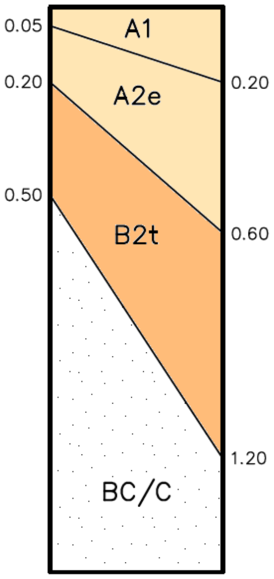
HORIZON	**DESCRIPTION**
A1 / Ap	Black (7.5YR 2.5/1, 2.5/2, 10YR 2/2, 3/1, 3/2); clay loam to light clay (maybe fine sandy or silty); moderate or strong granular or blocky structure; pH 5.5-6.5. Clear change to:
B2	Black or brown (10YR 2/2, 3/2 to 3/4, 4/3); clay loam to light clay (maybe fine sandy or silty); moderate or strong blocky structure; pH 5.5-7.0. Clear change to:
D	Brown or occasionally yellow (7.5YR 5/3, 10YR 3/4, 4/3 to 5/4, 6/6); sand to loam, fine sandy; massive or single grain; pH 6.0-7.5.

Sites	253, 743
Distribution	Two small polygons in the Baffle Creek area in the north of the WIN study area.
Notes	Occasionally D2 horizon of grey to brown (10YR 4/1 to 4/3), clay loam to light clay occurs below 1.00 m.

Gigoon (Gn)

CONCEPT	Moderately thick to thick, bleached sandy surface over acid to alkaline, mottled, brown or grey, strongly sodic clay on acid volcanic rocks.
ASC	**Brown or Grey Sodosol**, Brown or Grey Kurosol, minor Yellow Sodosol
LANDFORM	Hillslopes of rises, low hills and hills. Slopes 3 to 12%
GEOLOGY	Undifferentiated granite (Rg), Grahams Creek Formation (Jkr), *Moolyung* Granodiorite (PRgmy).
VEGETATION	Tall mid-dense to sparse forest of *Eucalyptus crebra, Corymbia citriodora, E. tereticornis, C. intermedia, E. exserta, C. tessellaris, E. moluccana.*
PERMEABILITY	Slowly permeable
DRAINAGE	Imperfectly drained
SURFACE	Hard setting, occasionally rock outcrop

Depth (m)

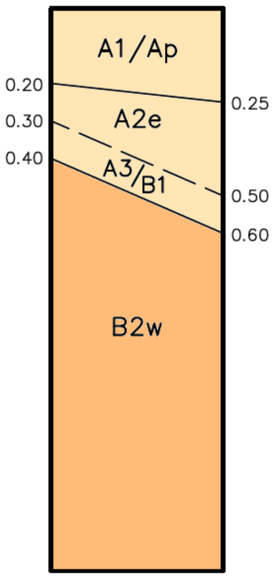


HORIZON	DESCRIPTION
A1	Black, grey or occasionally brown (7.5YR 2/2, 3/2, 3/3, 4/1, 4/2); loamy sand to sandy loam; massive; pH 5.0-6.50. Clear change to:
A2e	Grey or brown (10YR 4/2, 4/3, 5/3, 5/4, 2.5Y 7/1, 7/2) with conspicuous bleach; loamy sand to sandy loam; massive; pH 5.0-6.0. Abrupt or sharp change to:
B2t	Mottled, brown, grey or occasionally yellow (7.5YR 4/2, 4/6, 5/2 to 5/6, 10YR 4/2, 5/1 to 5/3, 6/1 to 6/6, 7/2, 7/3, 2.5Y 5/2, 5/6); sandy light clay to medium heavy clay; moderate or strong columnar, blocky or prismatic structure; pH 5.0-9.5. Gradual or diffuse change to:
BC / C	Weathering or hard rock.
Sites	76, 255, 529, 532, 535, 549, 703, 707, 710 **Sampled** 254, 256
Distribution	Western part of the WIN study area
Notes	Similar soil profiles with A3/B1 horizon and non-sodic B2 horizon (ASC Yellow Dermosol) have been allocated to *Gigoon*, non-sodic variant (GnPv).

Gillen (Gi)

CONCEPT	Thick, bleached clay loamy surface over acid to neutral, mottled, massive, yellow or brown, weakly sodic clay on deeply weathered fine grained sedimentary rocks.
ASC	**Yellow or Brown Kandosol**
LANDFORM	Plains
GEOLOGY	Elliott Formation (Te). Slopes < 3%
VEGETATION	Cleared, originally *Eucalyptus* species woodland.
PERMEABILITY	Moderately permeable
DRAINAGE	Imperfectly drained
SURFACE	Firm or hard setting

Depth (m)



HORIZON	**DESCRIPTION**
A1 / Ap	Grey or brown (10YR 4/2, 4/3, 5/3); clay loam (frequently sandy); massive; pH 6.0-7.0. Abrupt or clear change to:
A2e	As above, with conspicuous bleach; pH 5.5-6.0. Diffuse change to:
A3 / B1	Where present; yellow or brown (10YR 5/4 to 6/6); clay loam; massive; frequently few to many ferruginous nodules; pH 6.0-7.0. Gradual or diffuse change to:
B2w	Mottled; yellow or brown (10YR 5/4 to 6/6, 7.5YR 5/6, 6/6); clay loam to light clay; massive; few to abundant ferruginous nodules; pH 6.0-7.5.

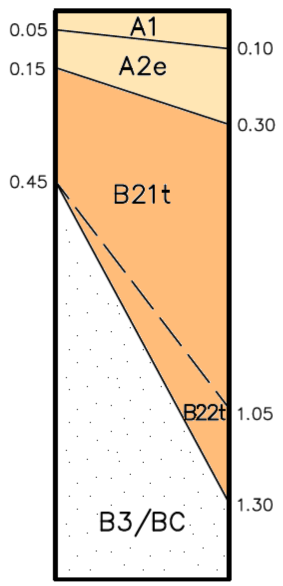
Sites

Distribution One small polygon within the WIN study area, on the eastern edge of the Elliott Formation.

Givelda (Gv)

CONCEPT	Moderately thick, bleached, clay loamy surface over acid to neutral, mottled, brown, strongly sodic clay on moderately weathered fine grained sedimentary rocks.
ASC	**Brown Sodosol**, rarely Yellow or Grey Sodosol
LANDFORM	Hillslopes on rises and low hills. Slopes 1 to 8%
GEOLOGY	Siltstones and fine grained sandstones of the Grahams Creek Formation (JKr), Burrum Coal Measures (Kb), Maryborough Formation (Km), and Brooweena Formation (Rb).
VEGETATION	Tall mid-dense forest of *Eucalyptus moluccana, E. crebra, Corymbia citriodora, E. tereticornis.*
PERMEABILITY	Slowly permeable
DRAINAGE	Imperfectly drained
SURFACE	Mostly hard setting

Depth (m)



HORIZON	**DESCRIPTION**
A1	Black, grey or occasionally brown (10YR 2/1 to 3/2, 3/3, 4/2, 4/3); sandy clay loam to clay loam (frequently silty); massive; pH 5.0-6.5. Clear change to:
A2e	Grey or brown (10YR 4/2, 4/3, 5/3, 5/4, 2.5Y 6/4) with conspicuous bleach; sandy clay loam to clay loam (frequently silty); massive; pH 5.0-6.0. Abrupt or sharp change to:
B21t	Mottled; brown or occasionally yellow or grey (7.5YR 4/4, 5/6, 10YR 4/1 to 4/4, 5/4, 6/8, 2.5Y 4/3, 4/4, 5/4); medium to medium heavy clay; moderate or strong blocky or occasionally lenticular structure; pH 5.5-9.0. Gradual or diffuse change to:
B22t	Frequently present; prominently red mottled, brown or grey (10YR 4/6, 5/3, 5/6, 2.5Y 4/2 to 5/6, 5/2, 6/2); medium to medium heavy clay; moderate or strong blocky or occasionally lenticular structure; pH 5.5-9.0. Gradual or diffuse change to:
B3 / BC	Weathering rock or prominently red mottled grey clay (2.5Y 7/1, 7/2) with common to abundant rock fragments. Alternating layers of mottled grey clay and weathering rock common.

Sites 47, 54, 74, 93, 324, 504, 510, 686, 689, 722, 725

Sampled 94, 486

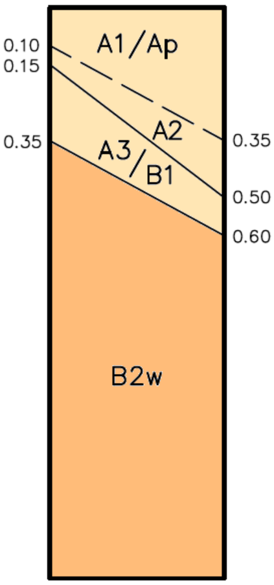
Distribution More common in the western half of the WIN study area.

Notes Rarely red colour (5YR 3/4, 4/4) in B22 horizon. Rarely carbonate nodules or soft segregations in B22 horizon, associated with more alkaline subsoils. Occasionally B3/BC horizon not encountered before 1.50 m.

Gooburrum (Gb)

CONCEPT	Moderately thick to thick, sandy to loamy surface over acid, red clay loam to light medium clay on deeply weathered coarse grained sedimentary rocks.
ASC	**Red Dermosol**
LANDFORM	Hillslopes and hillcrests on rises and low hills. Slopes 1 to 8%
GEOLOGY	Elliott Formation (Te)
VEGETATION	Tall mid-dense forest of *Eucalyptus acmenoides, Corymbia intermedia.* Frequently understorey of *Xanthorrhoea* species. Mostly cleared
PERMEABILITY	Moderately or highly permeable
DRAINAGE	Well-drained
SURFACE	Firm or hard setting. Occasionally very few to few pebbles to cobbles.

Depth (m)



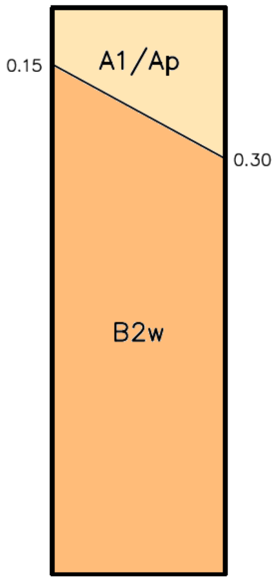
HORIZON	DESCRIPTION
A1 / Ap	Black, brown or red (10YR 2/1 to 3/2, 7.5YR 3/2, 3/3, 5YR 3/2, 4/2); sand to sandy loam; massive; pH 5.0-6.0. Clear change to:
A2	Frequently present; brown, red or black (7.5YR 3/2, 3/3, 3/4, 5YR 4/4, 10YR 5/3); sand to sandy clay loam; massive; pH 5.0-6.0. Clear or gradual change to:
A3 / B1	Red or brown (2.5YR 3/6, 4/8, 5YR 4/3 to 4.6, 5/6, 7.5YR 3/3, 5/4, 5/6); sandy clay loam to clay loam, sandy; massive or weak blocky structure; pH 5.0-6.0. Clear or gradual change to:
B2w	Red (2.5YR 3/6, 4/6, 4/8, 10R 3/4, 3/6, 4/6, 4/8); clay loam, sandy to light medium clay; moderate or strong blocky structure; pH 5.0-6.0.

Sites	113, 128, 241, 246, 285, 448, 610
Distribution	All areas where Elliott Formation geology occurs.

Howes (Hs)

CONCEPT	Acid to neutral, red, strongly structured clay over deeply weathered fine grained sedimentary rocks.
ASC	**Red Ferrosol**
LANDFORM	Plains and hillcrests, upper and mid hillslopes of rises. Slopes 1 to 4%
GEOLOGY	Elliott Formation (Te)
VEGETATION	Tall mid-dense forest of *Corymbia citriodora, C. intermedia, Eucalyptus crebra, C. tessellaris, E. tereticornis*. Mostly cleared. *Acacia* species may invade where not cultivated.
PERMEABILITY	Moderately or highly permeable
DRAINAGE	Well-drained
SURFACE	Firm or hard setting. Frequently very few to few sedimentary pebbles or ironstone nodules.

Depth (m)



HORIZON	DESCRIPTION
A1 / Ap	Red or brown (5YR, 7.5YR 3/3, 3/4, 3/6); light to light medium clay; moderate or strong granular or blocky structure; occasionally few to common ironstone or mudstone pebbles; pH 4.5-7.0. Clear change to:
B2w	Red (5YR, 2.5YR, 10R 3/4 to 4/6, 4/8); light to medium clay; moderate or strong polyhedral or blocky structure; occasionally few to common ironstone pebbles; pH 4.5-7.0.

Sites 153, 155, 172, 389, 396, 417

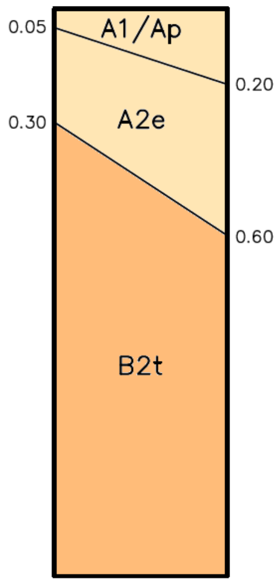
Sampled 173, 418

Distribution All areas where Elliott Formation geology occurs.

Isis (Is)

CONCEPT	Thick, bleached, sandy to loamy surface over acid, mottled, brown or yellow, weakly sodic clay on deeply weathered coarse grained sedimentary rocks.
ASC	**Brown Kurosol**, Yellow Kurosol
LANDFORM	Level plains, hillslopes and hillcrests on gently undulating rises and low hills. Slopes < 3.0%
GEOLOGY	Elliott Formation (Te)
VEGETATION	Tall, mid-dense forest of *Eucalyptus acmenoides, Corymbia intermedia, C. citriodora, E. tereticornis, Lophostemon* species. Frequently with understorey of *Alphitonia excelsa, Melaleuca* species. Mostly cleared.
PERMEABILITY	Moderately permeable
DRAINAGE	Imperfectly drained
SURFACE	Firm or hard setting

Depth (m)



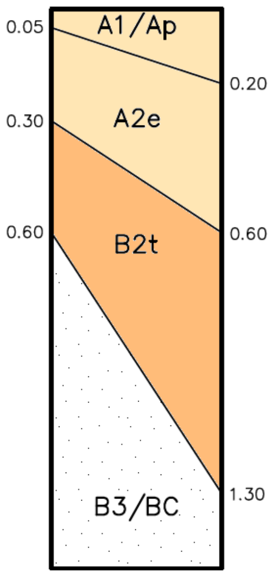
HORIZON	**DESCRIPTION**
A1 / Ap	Grey (7.5YR 4/1 to 5/2, 10YR 4/2, 5/2); sand to sandy loam; massive; pH 5.0-7.5. Clear change to:
A2e	Grey (7.5YR 4/1 to 5/2, 10YR 4/2, 5/2) with conspicuous bleach; sand to sandy loam; massive; few to abundant ironstone or ferruginised sedimenrary pebbles; pH 4.5-5.5. Clear or abrupt change to:
B2t	Mottled; brown or yellow (10YR 4/4, 4/6, 5/3 to 5/8, 6/4 to 6/8, 7/5); light to medium clay (mostly sandy); moderate or strong blocky structure; occasionally few to common ironstone or ferruginised sedimentary pebbles; pH 4.5-5.5.

Sites	148, 261, 270, 294, 681
Distribution	Two polygons within the WIN study area.
Notes	Occasionally A2 horizon is not bleached. The pH range in B2 horizon of *Isis* soil profiles within the WIN study area includes more acid values than described for *Isis* soil profiles in other study areas.

Isis, grey subsoil variant (IsLv)

CONCEPT	Thick, bleached, sandy to loamy surface over acid, mottled, brown or yellow upper B horizon transitioning to grey below 0.6-1.3m, developed on deeply weathered sedimentary rocks.
ASC	**Brown Kurosol**, Yellow Kurosol.
LANDFORM	Level plains, hillslopes and hillcrests on gently undulating rises and low hills. Slopes 2 to 5 %
GEOLOGY	Elliott Formation (Te)
VEGETATION	Tall, mid-dense forest of *Eucalyptus acmenoides*, *Corymbia intermedia*, *C. citriodora, E. tereticornis, Lophostemon* species. Frequently with understorey of *Alphitonia excelsa*, *Melaleuca* species. Mostly cleared.
PERMEABILITY	Slowly permeable
DRAINAGE	Imperfectly drained
SURFACE	Firm or hard setting

Depth (m)



HORIZON	**DESCRIPTION**
A1 / Ap	Grey (7.5YR 4/1 to 5/2, 10YR 4/2, 5/2); sand to sandy loam; massive; pH 5.0-7.5. Clear change to:
A2e	Grey (7.5YR 4/1 to 5/2, 10YR 4/2, 5/2) with conspicuous bleach; sand to sandy loam; massive; few to abundant ironstone or ferruginised sedimentary pebbles; pH 4.5-5.5. Clear or abrupt change to:
B2t	Mottled; brown or yellow (10YR 4/4, 4/6, 5/3 to 5/8, 6/4 to 6/8, 7/5); light to medium clay (mostly sandy); moderate or strong blocky structure; occasionally few to common ironstone or ferruginised sedimentary pebbles; pH 4.5-5.5. Clear or gradual change to:
B3 / BC	Mottled; grey (10YR 5/1, 6/1, 6/2, 2.5Y, 5Y 7/1); medium to medium heavy clay; moderate or strong blocky or occasionally lenticular structure; frequently few to common ferruginised sedimentary pebbles; pH 4.5-5.5.

Sites 23, 25, 123, 140, 159, 345, 406, 407, 409, 424, 659

Sampled 17, 159

Distribution Areas where Elliott Formation geology overlies other sedimentary layers at shallow depths.

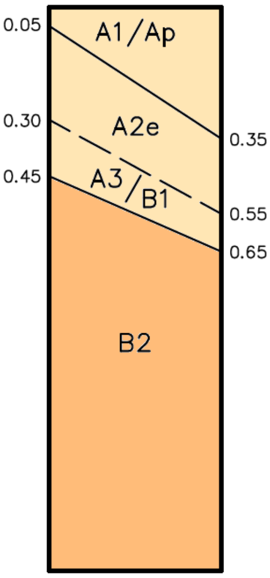
Notes Occasionally A2 horizon not bleached.

This soil variant in the WIN study area is developed on Elliott Formation (Te) geology capping over Burrum Coal Measures (Kb). Occasionally hard sedimentary rock occurs before 1.00 m.

Kepnock (Kp)

CONCEPT	Thick, bleached, clay loamy surface grading to acid, mottled, brown or yellow weakly sodic clay on deeply weathered fine grained sedimentary rocks.
ASC	**Brown Dermosol**, Yellow Dermosol.
LANDFORM	Level plains, hillslopes and hillcrests on gently undulating rises. Slopes 1 to 6%
GEOLOGY	Mudstones, siltstones, fine grained sandstones of the Burrum Coal Measures (Kb), Elliot Formation (Te), Maryborough Formation (Km).
VEGETATION	Tall, mid-dense forest of *Eucalyptus acmenoides, Corymbia citriodora, C. intermedia, E. crebra, Angophora leiocarpa*. Frequently cleared.
PERMEABILITY	Moderately permeable
DRAINAGE	Imperfectly drained
SURFACE	Firm or hard setting

Depth (m)



HORIZON	**DESCRIPTION**
A1 / Ap	Grey or black (10YR 2/2 to 4/2, 5/2, 7.5YR 3/2, 4/1, 4/2); sandy clay loam to clay loam (frequently fine sandy or silty); massive; pH 5.0-6.0. Clear change to:
A2e	As above with conspicuous bleach. Clear or gradual change to:
A3 / B1	Frequently present; mottled; brown or yellow (10YR 4/6, 5/3 to 5/8, 6/4 to 6/6); clay loam to light clay (frequently fine sandy or silty); massive or weak polyhedral or blocky structure; occasionally few to many ferruginous nodules; pH 4.5-6.0. Clear or gradual change to:
B2	Mottled; brown or yellow (7.5YR 4/6, 6/4, 6/6, 7/6, 10YR 4/6, 5/3 to 5/8, 6/4 to 6/6, 2.5Y 5/4); light to medium clay; moderate or strong polyhedral or blocky structure; occasionally few to common ferruginous nodules; pH 4.5-6.5.

Sites 133, 167, 171, 186, 187, 363, 365, 367, 432, 671

Distribution All areas where Kb, Te or Km geology occurs.

Notes Occasionally A2 horizon is not bleached.

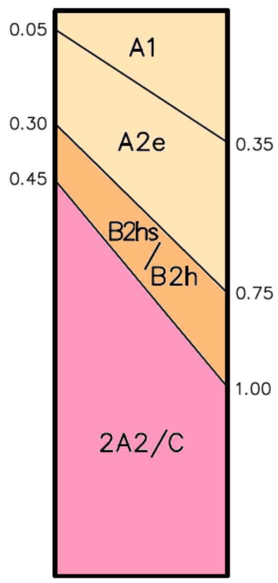
Rarely ASC is a Brown or Yellow Kurosol, associated with soil profiles where A3/B1 horizon is absent.

The pH range in B2 horizon of *Kepnock* soil profiles within the WIN study area includes more acid values than described for *Kepnock* soil profiles in other study areas.

Kinkuna (Kn)

CONCEPT	Acid, bleached, brown, black or grey sand with ortstein or organic pan on deeply weathered coarse-grained sedimentary rocks.
ASC	**Semiaquic Podosol**, Aquic Podosol
LANDFORM	Level plains, swamps and hillslopes on gently undulating rises. Slopes 0.5 to 6%
GEOLOGY	Elliott Formation (Te)
VEGETATION	Isolated to sparse low to tall forest of *Eucalyptus latisinensis, Banksia species*, occasionally with *Syncarpia glomulifera, Allocasuarina* species*, Melaleuca* species*, Xanthorrhoea* species. Heath understorey with *Pteridium esculentum*; frequently tall closed heath shrubs with *Pteridium esculentum*.
PERMEABILITY	Highly permeable
DRAINAGE	Poorly drained
SURFACE	Soft to firm

Depth (m)



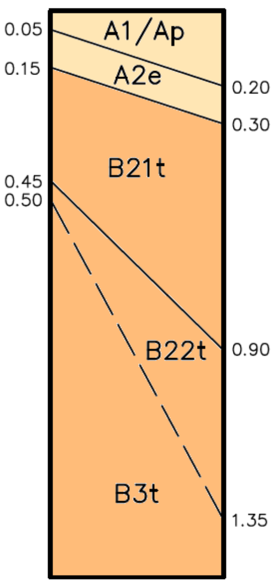
HORIZON	DESCRIPTION
A1	Black or grey (7.5YR, 10YR 2/1 to 5/1); sand to loamy sand; single grain; pH 4.0-6.0. Gradual or diffuse change to:
A2e	As above with conspicuous bleach; pH 4.5-6.0. Clear or abrupt change to:
B2hs / B2h	Brown or black (7.5YR 3/2 to 3/4, 10YR 2/1, 2/2, 3/2 to 3/4, 4/3, 4/4); sand to loamy sand; single grain or massive; ortstein or organic pan (weakly or strongly cemented); pH 4.5-6.0. Clear or diffuse change to:
2A2 / C	Grey (7.5YR 5/2 to 8/2, 6/3, 7/3, 10YR 7/1 to 7/3, 8/2, 8/3); sand to sandy loam; single grain or massive; pH 4.5-6.0.

Sites	12, 13, 24, 42, 193, 237, 250, 251, 277, 287, 352
Distribution	All areas where Elliott Formation geology occurs.
Notes	Water table frequently present below 0.70 m. Rarely a second B2h horizon occurs below the 2A2/C horizon.

Kolan (Ko)

CONCEPT	Moderately thick, bleached, clay loamy surface over strongly acid, mottled, grey, strongly sodic clay on moderately weathered fine grained sedimentary rocks.
ASC	**Grey Kurosol**, occasionally Brown Kurosol
LANDFORM	Hillslopes of rises and low hills. Slopes 1 to 15%
GEOLOGY	Mudstones, siltstones of the Elliott Formation (Te), Burrum Coal Measures (Kb), Maryborough Formation (Km), Grahams Creek Formation (Jkr).
VEGETATION	Tall mid-dense forest of *Corymbia citriodora, Eucalyptus siderophloia, E. moluccana, E. exserta, E. fibrosa. E. moluccana* may be locally dominant.
PERMEABILITY	Slowly permeable
DRAINAGE	Imperfectly drained
SURFACE	Firm or hard setting. Frequently few ironstone nodules.

Depth (m)



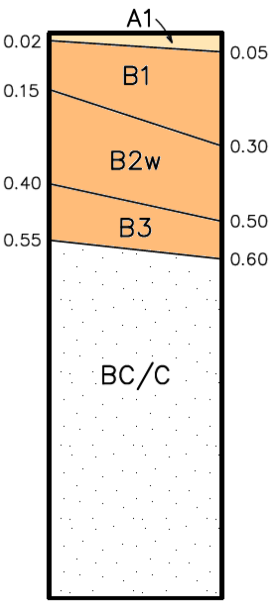
HORIZON	DESCRIPTION
A1 / Ap	Black or grey (10YR 3/1, 3/2, 4/2 to 5/3); loam to clay loam (frequently fine sandy); massive or weak granular or blocky structure; pH 5.0-6.5. Clear change to:
A2e	As above with conspicuous bleach and frequently few to many ferruginous nodules; pH 5.0-6.0. Abrupt or sharp change to:
B21t	Mottled; grey or occasionally brown (10YR 4/2, 5/1, 5/2, 5/3, 5/6, 6/2, 6/3, 6/4); medium to medium heavy clay; strong blocky structure; frequently few to many ferruginous nodules; pH 4.0-5.4. Clear or gradual change to:
B22t	Prominently red mottled; grey or occasionally brown (10YR 5/1 to 6/3, 2.5Y 5/2, 5/4); medium to heavy clay; strong prismatic, blocky or lenticular structure with slickensides; frequently few ferruginous nodules; pH 4.0-5.4. Clear or diffuse change to:
B3t	Where present; prominently red mottled; grey (10YR 5/3, 6/1 to 7/3, 2.5Y 7/2, 7/3); medium to heavy clay; moderate or strong blocky or lenticular structure; fragments of mudstone or siltstone; pH 4.0-5.4.

Sites	57, 101, 105, 106, 108, 158, 160, 282, 326, 375, 377, 381, 385, 386, 394, 399, 413,423, 606, 609, 631, 634, 637, 648, 653, 673, 680 **Sampled** 101, 117 (KoRv 162, 358)
Distribution	All areas where Te, Kb, Km, Jkr geology occurs.
Notes	Similar soil profile with a mottled red (2.5YR 3/4 to 4/6, 5YR 3/4, 4/6) colour in the B horizon have been allocated to *Kolan*, red variant (KoRv). Similar soil profiles that have surface gavels to boulders, rock outcrop or hard or weathering rock by 0.35 m have been allocated to *Kolan*, rocky phase (KoRp). The pH range in B2 horizon of *Kolan* soil profiles within the WIN study area includes more acid values than described for *Kolan* soil profiles in other study areas.

Kowbi (Kb)

CONCEPT	Brown non-cracking clay on basalt.
ASC	**Brown Dermosol**
LANDFORM	Hillslopes and hillcrests on rises and hills. Slopes 8 to 20%
GEOLOGY	Maroondan Basalt (Tbm)
VEGETATION	Mostly cleared, originally *Eucalyptus* species woodland.
PERMEABILITY	Moderately permeable
DRAINAGE	Moderately well or well-drained
SURFACE	Firm

Depth (m)

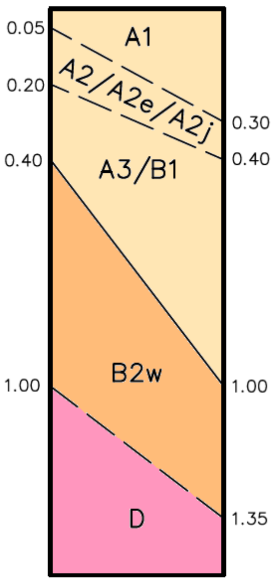


HORIZON	DESCRIPTION
A1	Black (7.5YR 3/2); light to medium clay; strong granular or moderate blocky structure; frequently few basalt gravels; pH 5.5-6.0. Clear or abrupt change to:
B1	Black or brown (7.5YR 3/2, 3/3); medium to heavy clay; moderate or strong blocky structure; frequently few basalt gravels; pH 6.5-7.0. Gradual change to:
B2w	Brown or rarely red or grey (7.5YR 3/3, 4/3, 6/3, 5YR 4/3, 4/8); medium to heavy clay; strong blocky structure; frequently few to common basalt gravels; pH 7.0-7.5. Gradual change to:
B3	Brown (7.5YR 4/3 to 5/4); heavy clay with rock fragments; strong blocky structure; pH 7.0-7.5. Gradual change to:
BC / C	Weathering and hard basalt.
Sites	685
Distribution	Small area of basalt close to the southern boundary of the WIN study area.

Littabella (Lt)

CONCEPT	Acid, brown or red, massive, fine sandy loam to clay loam on local alluvium.
ASC	**Brown Kandosol**, Red Kandosol, Brown-Orthic Tenosol
LANDFORM	Levees, levees and scrolls of local creeks. Slopes < 2%
GEOLOGY	Quaternary alluvium (Qa)
VEGETATION	Mostly cleared, minor dense scrub of *Acacia* species, originally *Eucalyptus* species woodland.
PERMEABILITY	Moderately or highly permeable
DRAINAGE	Well-drained
SURFACE	Firm or hard setting

Depth (m)



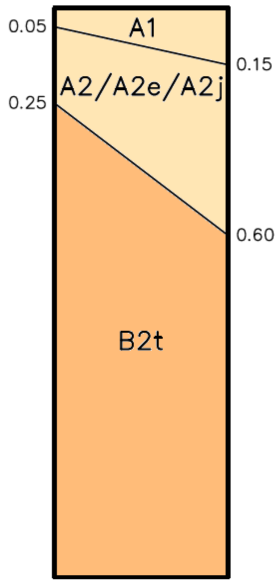
HORIZON	**DESCRIPTION**
A1	Black, grey or brown (10YR 3/2, 3/3, 4/2; 7.5YR 3/2); fine sandy loam to clay loam, fine sandy; massive; pH 5.5-6.5. Clear change to:
A2 / A2e / A2j	Where present; brown (10YR 3/3, 5/3, 2.5Y 5/3, 5/4), frequently with conspicuous or sporadic bleach; fine sandy loam to clay loam, fine sandy; massive; pH 4.5-6.5. Clear change to:
A3 / B1	Where present; brown or red (10YR 5/3, 5/4; 7.5YR 5/4, 5YR 5/4); fine sandy loam to clay loam, fine sandy; massive; pH 4.5-6.5. Clear change to:
B2w	Brown or red (10YR 4/3, 5/3, 5/4; 7.5YR 4/6, 5/3, 5/4; 5YR 4/6, 5/6); fine sandy loam to clay loam, fine sandy; massive or weak blocky structure; pH 4.5-6.5. Clear change to:
D	Where present; brown or grey (10YR 4/3, 5/2 to 5/6); fine sandy loam to fine sandy light clay; massive to strong blocky structure; pH 5.5-6.5.

Sites	134, 175, 178, 180, 271, 679
Distribution	All areas where local alluvium occurs
Notes	Occasionally colour of B horizon is grey (10YR 4/2 to 6/3), ASC Grey Kandosol Occasionally buried soils occur 1.10 m The pH range in B2 horizons of *Littabella* soil profiles within the WIN study area includes more acid values than described for *Littabella* soil profiles in other study areas.

Maroom (Mm)

CONCEPT	Thick, sandy to clay loamy surface over strongly acid to neutral, mottled clay on marine plains.
ASC	**Redoxic Hydrosol**, Extratidal Hydrosol
LANDFORM	Plains and extratidal flats of marine plains, lower edges and swales of beach ridges. Slopes 0.5 to 4%
GEOLOGY	Quaternary coastal deposits (Qhcb, Qpcp, Qhci)
VEGETATION	Tall mid-dense to closed forest of *Corymbia intermedia, Eucalyptus exserta, Angophora* species, *Lophostemon suaveolens, Melaleuca quinquenervia, M. viridiflora, Livistonia australis; Melaleuca* species may dominate in some areas
PERMEABILITY	Slowly permeable
DRAINAGE	Poorly drained
SURFACE	Soft, firm or occasionally loose

Depth (m)



HORIZON	**DESCRIPTION**
A1	Black or grey (7.5YR 2/1, 3/1, 32, 4/2, 10YR 2/2); loamy sand to sandy clay loam; massive; single grain or weak blocky structure; pH 4.5-6.5. Clear or abrupt change to:
A2 / A2e / A2j	Occasionally mottled; brown (10YR, 2.5YR 5/4) frequently with conspicuous or sporadic bleach; loamy sand to sandy clay loam; massive or single grain; pH 4.5-6.5. Abrupt or sharp change to:
B2t	Mottled; grey, brown or black (7.5YR 3/2, 3/3, 4/3, 5/1 to 5/3, 10YR 4/2, 5/2, 5/3, 6/1. 6/2, 2.5Y 4/2); light clay to medium heavy clay (usually sandy); weak, moderate or strong blocky structure; pH 4.5-7.0.

Sites 562, 579, 585, 602

Distribution One small polygon near the mouth of Littabella Creek within the WIN study area. Also scattered soil profiles within the marine plain.

Notes D horizon of grey to brown (10YR 5/2, 5/4, 2.5Y 5/4) sand to sandy clay loam occasionally occurs below 0.55 m. The pH range in B2 horizon of *Maroom* soil profiles within the WIN study area includes more acid values than described for *Maroom* soil profiles in other study areas. *Maroom* soil profiles in the WIN study area are non-saline to at least 1.50 m.

Meadowvale (Md)

CONCEPT Thick, frequently bleached, sandy surface over strongly acid, mottled, yellow or brown, weakly sodic clay on deeply weathered coarse grained sedimentary rocks. Massive or weakly structured upper subsoil; moderately or strongly structured lower subsoil.

ASC **Yellow Dermosol**, Brown Dermosol.

LANDFORM Level plains to hillslopes on undulating rises. Slopes 0.5 to 5%

GEOLOGY Elliott Formation (Te)

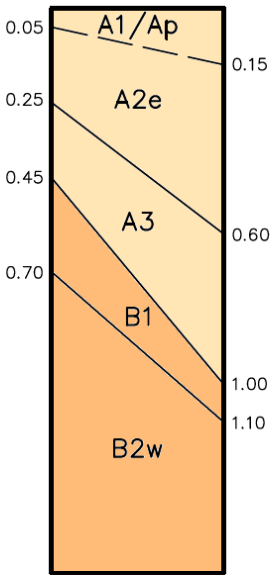
VEGETATION Tall mid-dense forest of *Eucalyptus latisinensis, Corymbia trachyphloia, C. intermedia, E. crebra.* Frequently understorey of *Xanthorrhoea* and occasionally *Melaleuca* species

PERMEABILITY Moderately permeable

DRAINAGE Imperfectly drained

SURFACE Firm or hard setting

Depth (m)



HORIZON	DESCRIPTION
A1 / Ap	Grey or black (7.5YR 3/2, 4/1, 4/2, 5/2, 10 YR 5/1, 5/2); loamy sand to sandy loam; massive; pH 5.0-6.0. Clear or gradual change to:
A2e	As above with conspicuous bleach. Gradual or diffuse change to:
A3	Mottled; yellow or brown (10YR 5/6, 6/4 to 7/6); sandy loam (heavy) to sandy clay loam; massive; pH 5.0-6.0. Gradual or diffuse change to:
B1	Mottled; yellow or brown (10YR 5/3 to 5/6, 6/5 to 7/6, 2.5Y 5/6); fine sandy clay loam to fine sandy light clay; massive or weak blocky structure; frequently common to many ferruginous nodules; occasionally few to common sedimentary gravels; pH 4.0-5.0. Clear to diffuse change to:
B2w	Mottled; yellow or brown (7.5YR 5/6, 10YR 5/6 to 5/8, 6/3 to 6/8, 7/4 to 7/6); light to medium clay (frequently fine sandy); moderate or strong blocky or polyhedral structure; frequently common to many ferruginous nodules; occasionally few to common sedimentary gravels; pH 4.0-5.0.

Sites 36, 46, 60, 125, 129, 139, 141, 182, 183, 188, 205, 330, 338, 354, 690

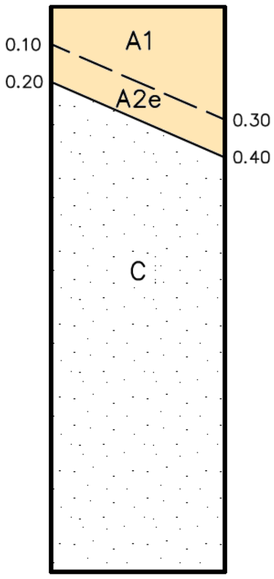
Distribution All areas where Elliott Formation geology occurs.

Notes Grey (10YR 6/1, 6/2) medium to medium heavy clay occasionally occurs below 1.0 m, associated with profiles developed on Elliott Formation (Te) geology capping over Burrum Coal Measures (Kb). The pH range in B2 horizon of *Meadowvale* soil profiles within the WIN study area includes more acid values than described for *Meadowvale* soil profiles in other study areas.

Moolyung (My)

CONCEPT	Moderately thick, bleached sand on acid volcanic rocks.
ASC	**Bleached-Leptic Tenosol**, Leptic Tenosol, Leptic Rudosol
LANDFORM	Hillcrests and hillslopes of rolling rises and rolling low hills. Slopes 5 to 20%
GEOLOGY	Acid volcanics of Grahams Creek Formation (Jkr), Watalgan Granite (Rgwt), *Moolyung* Granodiorite (PRgmy), undifferentiated granite (Rg), Gympie Group (Py/Cg).
VEGETATION	Tall sparse to mid-dense forest of *Corymbia citriodora*, *Eucalyptus crebra, E. tereticornis, E. acmenoides, Angophora leiocarpa, E. exserta, C. intermedia*. Understorey of *Acacia* species.
PERMEABILITY	Highly permeable
DRAINAGE	Rapidly or well-drained
SURFACE	Loose to firm, frequently few to common pebbles to cobbles, occasionally common to abundant rock outcrop.

Depth (m)



HORIZON	**DESCRIPTION**
A1	Black or grey (10YR 2/1, 2/2, 3/1, 3/2, 4/2); coarse sand to coarse sandy loam; single grain or massive; frequently common to abundant coarse gravels to cobbles; pH 5.0-6.0. Clear change to:
A2e	Frequently present; As above with conspicuous bleach. Clear change to:
C	Hard acid volcanic rocks.

Sites 51, 52, 83, 533, 541, 543, 711, 714, 718, 719

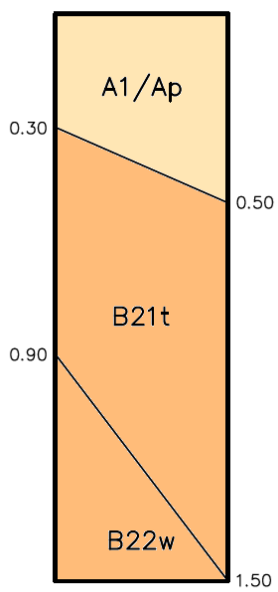
Distribution Western part of the WIN study area.

Notes Rarely coarse sand continues to at least 1.50 m in *Moolyung* soil profiles within the WIN study area. This SPC was developed in the WIN study area to accommodate soil profiles with sandy A horizons overlying acid volcanic rocks. Some profiles allocated to *Gigoon*, sandy variant in other study areas may now fit *Moolyung* SPC.

Moore Park (Mp)

CONCEPT	Acid to neutral, brown or yellow sand on beach ridges.
ASC	**Brown-Orthic Tenosol**
LANDFORM	Beach ridges. Slopes 1 to 4%
GEOLOGY	Quaternary coastal deposits (Qhcb, Qha)
VEGETATION	Tall mid-dense to closed forest of *Corymbia intermedia, C. tessellaris, Angophora leiocarpa.* Understorey of *Banksia, Acacia* and *Grevillea* species*.* Mostly cleared
PERMEABILITY	Highly permeable
DRAINAGE	Rapidly drained
SURFACE	Loose or soft

Depth (m)



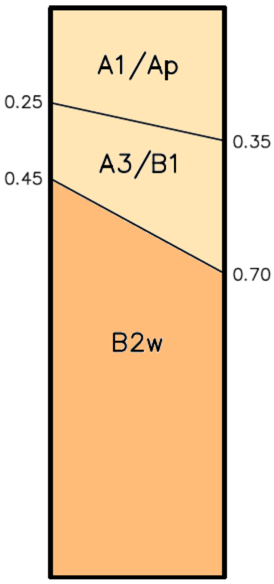
HORIZON	DESCRIPTION
A1 / Ap	Black or brown (7.5YR, 10YR 2/2 to 3/3, 3/4, 3/6, 4/3, 4/4); sand to sandy loam; massive or single grain; pH 5.5- 7.0. Clear change to:
B21w	Occasionally mottled; brown (7.5YR, 10YR 4/4 to 4/6, 5/4 to 5/8); sand to sandy loam; massive or single grain; pH 5.5-7.0. Gradual change to:
B22w	Occasionally mottled; yellow (10YR 6/4 to 6/7, 7/4); sand to sandy loam; massive or single grain; pH 5.5-7.0.

Sites	452, 453, 459, 583
Distribution	All areas where marine geology occurs in the east of the WIN study area.
Notes	Rarely Bs horizon occurs below 1.00 m and ASC is Aeric Podosol. Water table may be present below 1.50 m in lower parts of the beach ridges, depending on time of year and season.

Oakwood (Ok)

CONCEPT	Thick clay loamy to light clay surface over acid to neutral, red, massive to weakly structured clay on deeply weathered fine grained sedimentary rocks.
ASC	**Red Kandosol**
LANDFORM	Level plains and upper hillslopes and hillcrests of rises. Slopes 1 to 4%
GEOLOGY	Elliott Formation (Te), Burrum Coal Measures (Kb)
VEGETATION	Cleared, originally *Eucalyptus* species woodland.
PERMEABILITY	Moderately or highly permeable
DRAINAGE	Well-drained
SURFACE	Hard setting

Depth (m)



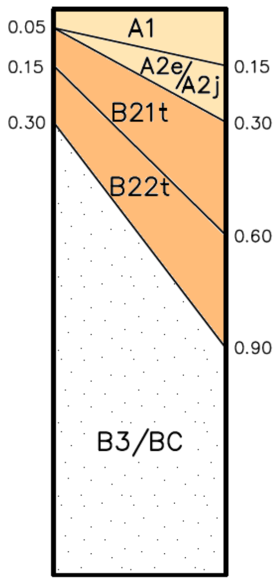
HORIZON	**DESCRIPTION**
A1 / Ap	Brown or black (10YR 2/2, 3/3, 4/2, 5YR 2/2); sandy clay loam to light clay; massive or weak blocky structure; pH 5.5-7.0. Clear change to:
A3 / B1	Brown or red (2.5YR 3/4, 4/8, 5YR 4/4, 4/6, 10YR 4/3); clay loam to light clay; massive or weak blocky structure; very few to few ferruginous nodules; pH 5.5-7.0. Clear change to:
B2w	Red (2.5YR 3/3, 4/6, 4/8, 5/6, 5YR 4/6); light to light medium clay; massive or weak blocky structure; very few to few ferruginous nodules; pH 5.5-7.0.

Sites	311, 364, 470, 564
Distribution	Two small polygons in the centre of the WIN study area.

Owanyilla (Ow)

CONCEPT	Moderately thick, loamy to clay loamy surface over neutral to alkaline, mottled, brown, or grey, strongly sodic clay on moderately weathered andesite.
ASC	**Brown Sodosol**, Grey Sodosol
LANDFORM	Hillslopes, hillcrests on rises. Slopes 1 to 8%
GEOLOGY	Andesites of the Grahams Creek Formation (JKr)
VEGETATION	Tall mid-dense forest of *Corymbia citriodora, Eucalyptus moluccana, E. siderophloia, E. crebra, E. tereticornis, E. tessellaris* and *E. exserta.*
PERMEABILITY	Slowly permeable
DRAINAGE	Imperfectly drained
SURFACE	Hard setting

Depth (m)



HORIZON	DESCRIPTION
A1	Black or grey (7.5YR 3/2, 10YR 4/2); loam, fine sandy to clay loam; massive or weak granular structure; pH 5.5-6.0. Clear change to:
A2e / A2j	As above with conspicuous or sporadic bleach. Abrupt or sharp change to:
B21t	Mottled; brown or grey (10YR 5/2 to 5/4, 7.5YR 4/4); light medium to medium heavy clay; moderate or strong blocky or prismatic structure; frequently few to common ferromanganiferous nodules; pH 5.5-7.0. Gradual or diffuse change to:
B22t	Mottled; brown, grey or occasionally yellow (2.5Y 5/3, 7.5YR 5/2, 10YR 5/3, 5/4, 6/4); medium to heavy clay; moderate or strong lenticular or prismatic structure; frequently few to common ferromanganiferous nodules; pH 5.5-7.0. Gradual or diffuse change to:
B3 / BC	Mottled; brown, grey or occasionally yellow (2.5Y 5/3, 5/4, 7.5YR 5/2, 10YR 5/4, 6/4); medium to heavy clay with rock fragments; moderate blocky structure; pH 6.5-9.0.

Sites 47, 48, 49, 697

Distribution Three polygons in the south and west of the WIN study area.

Peep (Pp)

CONCEPT Moderately thick to thick, bleached, loamy to clay loamy surface over acid to alkaline, mottled, grey or brown, strongly sodic clay on local alluvium.

ASC **Grey Sodosol**, Brown Sodosol, minor Redoxic Hydrosol, Grey or Brown Dermosol, Grey or Brown Kurosol

LANDFORM Valley flats, alluvial plains. Slopes < 2%

GEOLOGY Quaternary alluvium (Qa)

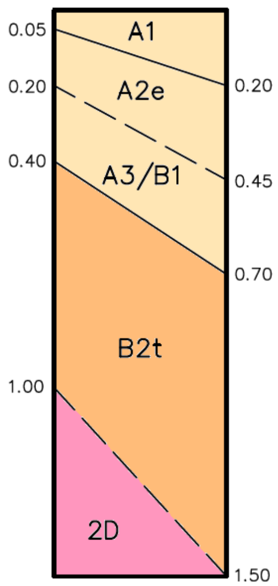
VEGETATION Tall mid-dense to sparse forest of variable species including *Eucalyptus latisinensis* with one or more of *E. exserta, E. moluccana, E. tereticornis, Angophora leiocarpa* or *Corymbia trachyphloia.* Scattered understorey of *Melaleuca* species.

PERMEABILITY Slowly permeable

DRAINAGE Imperfectly drained

SURFACE Firm or hard setting

Depth (m)



HORIZON	DESCRIPTION
A1	Grey or black (7.5YR, 10 YR 3/2, 4/2, 5/2); massive; fine sandy loam to clay loam, fine sandy; pH 5.5-6.0. Clear change to:
A2e	Mottled; grey or yellow (7.5YR, 10 YR 4/2 to 6/2, 6/3) with conspicuous bleach; fine sandy loam to clay loam, fine sandy; massive; very few to few manganiferous nodules; pH 5.5-7.0. Clear or abrupt change to:
A3 / B1	Where present; mottled; grey (7.5YR, 10YR 4/2 to 6/2, 6/3); sandy clay loam to light clay; massive to weak blocky structure; very few to few manganiferous nodules; pH 5.5-7.0. Clear change to:
B2t	Mottled; grey or brown (10YR 4/1 to 5/2, 6/1 to 6/3, 2.5Y 4/4, 5/1 to 5/3); light medium to medium heavy clay; moderate or strong blocky, prismatic or occasionally columnar structure; very few to few manganiferous nodules; pH 5.0 -9.0. Clear change to:
2D	Mottled; grey (10YR 4/2, 5/1,5/2); sandy light clay to light medium clay; few to many *Quartz* or sedimentary pebbles; moderate or strong blocky structure; pH 5.0-9.0.

Sites 33, 78, 81, 85, 118, 130, 231, 232, 244, 359, 400, 405, 429, 433, 474, 487, 498, 523, 536, 544, 554, 571, 635, 672, 678, 702
Sampled 202, 340, 545, 658

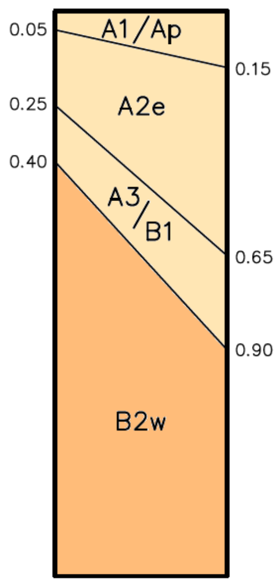
Distribution Occurs on local alluvium associated with creeks and minor streams throughout the WIN study area.

Notes Occasionally very few to few calcareous segregations within alkaline B2 horizon. Occasionally hard manganese pan below 0.60-1.20 m. Where this soil merges with the lower hillslope of rises, low hills or hills, a buried layer of decomposing or hard rock frequently occurs. The pH range in B2 horizon of *Peep* soil profiles within the WIN study area includes a larger range of values than described for *Peep* soil profiles in other study areas.

Quart (Qr)

CONCEPT	Thick, bleached, sandy surface over acid, mottled, yellow or brown, massive, sandy clay loam to sandy clay on deeply weathered coarse grained sedimentary rocks.
ASC	**Yellow Kandosol**, Brown Kandosol
LANDFORM	Mid to upper hillslopes and hillcrests. Slopes 0.5 to 4%
GEOLOGY	Elliott Formation (Te)
VEGETATION	Tall mid-dense forest of *Eucalyptus acmenoides, Corymbia intermedia.* Understorey of *Acacia, Banksia* and *Xanthorrhoea* species. Mostly cleared
PERMEABILITY	Moderately permeable
DRAINAGE	Moderately well-drained
SURFACE	Soft or firm

Depth (m)



HORIZON	**DESCRIPTION**
A1 / Ap	Grey or black (7.5YR, 10YR 3/2, 4/1 to 5/2); loamy sand to sandy loam; massive; pH 5.0-6.0. Clear or gradual change to:
A2e	As above with conspicuous bleach. Diffuse change to:
A3 / B1	Yellow (7.5YR 7/6, 10YR 6/4 to 6/6, 7/4, 7/6); sandy loam to clay loam; massive; pH 4.5-6.0. Diffuse change to:
B2w	Mottled; yellow or brown (7.5YR 5/6, 6/6, 10YR 5/8, 6/5 to 7/6); sandy clay loam to sandy clay; massive to weak blocky structure; frequently few to common ferromanganiferous nodules; pH 5.0-6.5.
Sites	127, 323, 654, 659
Distribution	All areas where Elliott Formation geology occurs.
Notes	The pH range in all horizons of *Quart* soil profiles within the WIN study area includes more acid values than described for *Quart* soil profiles in other study areas.

Robur (Rb)

CONCEPT Very thick, bleached sandy surface over strongly acid to neutral, mottled, grey or rarely gleyed, strongly sodic clay on deeply weathered coarse grained sedimentary rocks.

ASC **Redoxic Hydrosol**

LANDFORM Level plains, valley flats and lower hillslopes of rises. Slopes 0.5 to 4%

GEOLOGY Elliott Formation (Te)

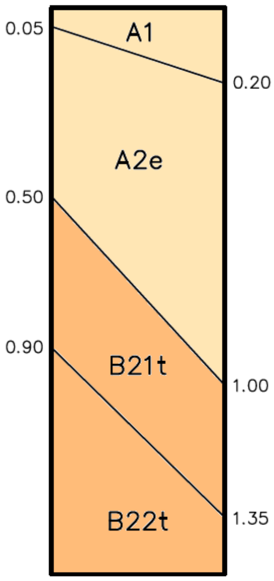
VEGETATION Tall sparse to mid-dense forest of *Eucalyptus latisinensis, Corymbia trachyphloia*, *E, exserta*. Understorey of *Melaleuca viridiflora, Banksia oblongifolia, Banksia Robur* and *Xanthorrhoea johnsonii.*

PERMEABILITY Very slowly or slowly permeable

DRAINAGE Poorly drained

SURFACE Soft to hard setting

Depth (m)



HORIZON	DESCRIPTION
A1	Grey (7.5YR 4/1 to 5/2); loamy sand to sandy loam; massive; pH 5.0-6.0. Clear or gradual change to:
A2e	As above with conspicuous bleach. Abrupt or clear change to:
B21t	Mottled; grey or rarely gley (10YR 4/2, 5/1, 5/2, 6/1 to 6/3, 7/2, 2.5Y, 5Y 5/1, 6/1, N5/0); sandy light to light medium clay; weak or moderate blocky or prismatic structure; frequently very few to common ferromanganiferous nodules; pH 5.0-6.5. Gradual or diffuse change to:
B22t	Mottled; grey or rarely gley (10YR 6/1 to 6/3, 7/1, 7/2, 2.5Y 5/1, 6/1, 7/1, 5Y 6/1, 7/1, 7/2, N5/0); light medium to heavy clay (frequently sandy); strong blocky or prismatic structure; frequently very few to common ferromanganiferous nodules; pH 5.0-8.0.

Sites 7, 190, 197, 204, 212, 217, 248, 265, 288, 321, 328, 347, 355, 428
Sampled 181, 333

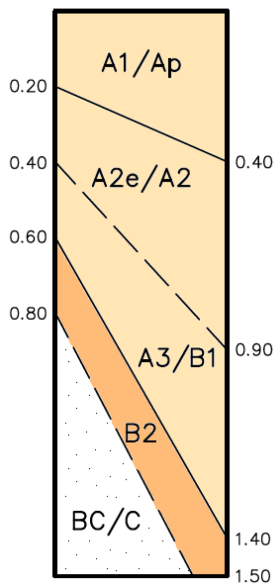
Distribution All areas where Elliott Formation geology occurs.

Notes Within the WIN study area, occasionally some soil profiles that have properties within the *Robur* SPC range have been assessed as imperfectly drained, with the corresponding ASC Grey Kurosol.

Rothchild (Rt)

CONCEPT	Acid, bleached brown or yellow sand on deeply weathered coarse grained sedimentary rocks.
ASC	**Bleached-Orthic Tenosol**, Brown-Orthic Tenosol, Yellow-Orthic Tenosol
LANDFORM	Plains, hillslopes and hillcrests on gently undulating rises. Slopes 1 to 5%
GEOLOGY	Elliott Formation (Te)
VEGETATION	Tall mid-dense forest of *Eucalyptus latisinensis, Corymbia trachyphloia, E. halii, C. intermedia, Angophora leiocarpa.* Understorey of *Acacia* and *Xanthorrhoea* species, *Pteridium esculentum*.
PERMEABILITY	Highly permeable
DRAINAGE	Rapidly or well-drained
SURFACE	Loose to firm

Depth (m)



HORIZON	DESCRIPTION
A1 / Ap	Black or grey (7.5YR 2/2, 3/1, 3/2, 10YR 3/1, 3/2, 4/2); sand to sandy loam; single grain or massive; pH 5.0-7.5. Clear change to:
A2e / A2	Brown or rarely grey (10YR 3/6, 4/3, 4/4, 5/4, 6/2, 6/3); frequently conspicuously bleached; sand to sandy loam; single grain or massive; pH 5.0-6.0. Gradual or diffuse change to:
A3 / B1	Where present; brown or yellow (7.5YR 4/6, 6/4, 10YR 4/6, 5/6, 6/6); loamy sand to sandy loam; single grain or massive; occasionally few quartz pebbles and ferromanganiferous nodules; pH 5.0-6.0. Gradual or diffuse change to:
B2	Brown or yellow (7.5YR 4/6, 6/4, 10YR 5/4 to 6/6, 6/8); loamy sand to sandy loam; massive; frequently common *Quartz* pebbles; occasionally common ferromanganiferous nodules; pH 4.5-6.0. Gradual or diffuse change to:
BC / C	Where present. Weathering and hard sandstone.

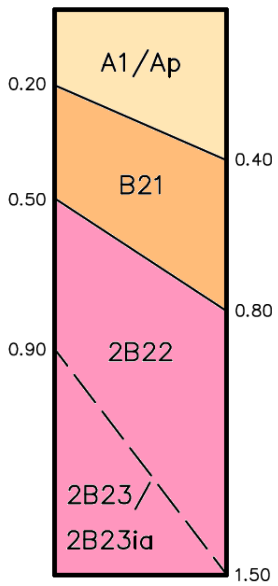
Sites 6, 15, 19, 236, 278, 307, 314, 350, 560, 738

Distribution All areas where Elliott Formation geology occurs.

Sugarmill (Sm)

CONCEPT	Black or grey, clay loam to light clay over strongly acid to neutral, buried, mottled, grey clay. Soil developed from recent alluvium over buried marine sediments.
ASC	**Redoxic Hydrosol**, Black or Grey Dermosol
LANDFORM	Plains, swales, levees, scrolls. Slopes < 2%
GEOLOGY	Quaternary alluvium (Qa) over buried marine sediments.
VEGETATION	Mostly cleared. Frequently regrowth of *Eucalyptus tereticornis, Melaleuca* species.
PERMEABILITY	Slowly permeable
DRAINAGE	Poorly to imperfectly drained
SURFACE	Firm or hard setting

Depth (m)

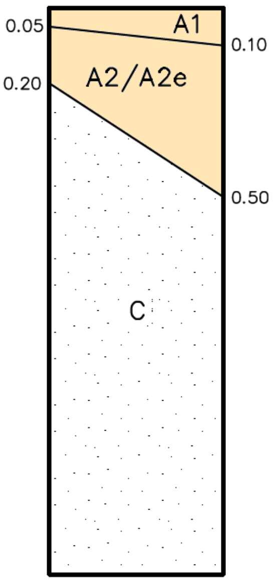


HORIZON	DESCRIPTION
A1 / Ap	Black (7.5YR, 10YR 2/1, 3/2); clay loam to light clay (occasionally silty); moderate or strong granular or blocky structure; pH 4.5-6.0. Clear change to:
B21	Occasionally mottled; black or grey (7.5YR 2/1, 4/1, 4/2, 10YR 2/1 to 3/2, 4/2, 2.5Y 4/1); light to light medium clay; strong blocky or prismatic structure; pH 4.0-7.0. Gradual change to:
2B22	Mottled; grey (7.5YR 4/1, 5/1, 10YR 5/1, 6/1, 6/2, 2.5Y 4/2, 5/1 to 6/2); light to light medium clay; strong blocky or prismatic structure; pH 4.0-6.0. Gradual change to:
2B23 / 2B23ia	Where present; mottled; grey (10YR 2.5Y 4/1, 4/1, 5/2, 6/2); light medium to medium heavy clay; strong blocky structure; frequently very few to few, jarosite soft patches; pH 3.5-5.0.
Sites	244, 263, 272, 274
Distribution	Recent alluvium associated with Littabella Creek and Kolan River and minor occurrence on the Baffle Creek alluvium.
Notes	Colour of B2 horizon is occasionally brown (10YR 4/4, 5/3) within the WIN study area (ASC Brown Dermosol).

Takoko (Tk)

CONCEPT	Acid, bleached loam to clay loam over silicified sedimentary rocks.
ASC	**Bleached-Leptic Tenosol**, Leptic Rudosol
LANDFORM	Hillcrests of Rolling Rises and Rolling Low Hills. Slopes 5 to 20%
GEOLOGY	Maryborough Formation (Km)
VEGETATION	Tall mid-dense forest of *Eucalyptus citriodora, E. acmenoides*, *Corymbia trachyphloia* and *Lophostemon* species.
PERMEABILITY	Moderately permeable
DRAINAGE	Well-drained
SURFACE	Firm, abundant cobbles and stones

Depth (m)

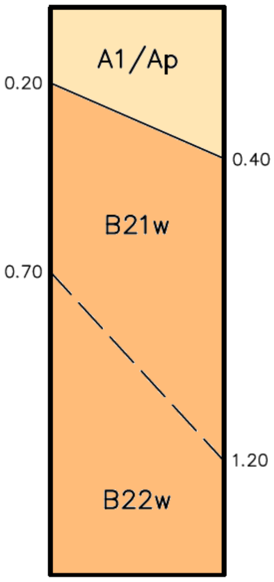


HORIZON	**DESCRIPTION**
A1	Black or grey (10YR 3/1, 3/2, 4/2); sandy loam to clay loam; massive; common to abundant coarse gravels to cobbles; pH 5.0-6.0. Clear change to:
A2e / A2	As above but usually conspicuously bleached. Clear change to:
C	Hard silicified sedimentary rocks.
Sites	111, 361, 397, 421,639, 649, 667, 692, 737
Distribution	All areas where Maryborough Formation geology occurs.

Tantitha (Tt)

CONCEPT	Acid to neutral, red sand on) on beach ridges.
ASC	**Red-Orthic Tenosol**
LANDFORM	Beach ridges. Slopes 1 to 5%
GEOLOGY	Quaternary (Qpa)
VEGETATION	Tall mid-dense to closed forest of *Corymbia intermedia, C. tessellaris, Angophora leiocarpa.* Understorey of *Banksia, Acacia* and *Grevillea* species*.* Mostly cleared.
PERMEABILITY	Highly permeable
DRAINAGE	Rapidly drained
SURFACE	Loose or soft

Depth (m)



HORIZON	**DESCRIPTION**
A1 / Ap	Brown or black (7.5YR, 10YR 3/3, 3/4, 4/2, 4/3, 10YR 2/1, 2/2); sand to sandy loam; massive or single grain; pH 5.5- 7.0. Clear change to:
B21w	Red (5YR 3/3, 4/3 to 4/6, 5/8, 2.5YR 4/6); sand to sandy loam; massive or single grain; pH 5.5- 7.0. Gradual change to:
B22w	Frequently present; brown or yellow (7.5YR, 10YR 4/6, 5/6 to 6/8); sand to sandy loam; massive or single grain; pH 5.5- 7.0.

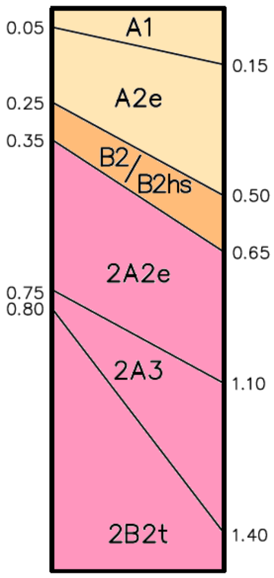
Sites 457, 458, 461, 557, 561

Distribution All areas where older beach ridges occurs in the east of the WIN study area.

Theodolite (Th)

CONCEPT	Acid, bleached, brown sand on deeply weathered course grained sedimentary rocks. Buried layers including bleached sand and moderately structured light to medium clay (usually sandy).
ASC	**Aquic Podosol**, Redoxic Hydrosol
LANDFORM	Level plains. Slopes < 1%
GEOLOGY	Elliott Formation (Te)
VEGETATION	Low to medium sparse to very sparse forest of *Eucalyptus latisinensis*. Understorey of heath, frequently with low mid-dense to dense *Melaleuca nodosa*.
PERMEABILITY	Slowly permeable
DRAINAGE	Poorly drained
SURFACE	Loose, soft or firm (depending on wetness)

Depth (m)



HORIZON	**DESCRIPTION**
A1	Grey (7.5YR 4/1, 5/1, 5/2, 10YR 4/1); sand to sandy loam; single grain; pH 4.0-5.5. Clear or gradual change to:
A2e	As above with conspicuous bleach; pH 4.5-5.5. Clear change to:
B2 / B2hs	Mottled, brown or occasionally red (5YR 3/3, 7.5YR 4/3; 5/3, 5/4); sand to sandy loam; single grain; pH 5.0-6.0. Clear or gradual change to:
2A2e	Frequently mottled, sand to loamy sand with conspicuous bleach; massive or single grain; pH 5.0-6.0. Clear or diffuse change to:
2A3	Mottled, grey or occasionally yellow (7.5YR 7/3, 10YR 6/4, 7/2, 7/4, 8/2, 2.5Y 7/2 to 8/2); sandy loam to sandy clay loam; massive; pH 5.0-6.0. Clear or abrupt change to:
2B2t	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 blocky or prismatic structure; pH 5.0-6.0.

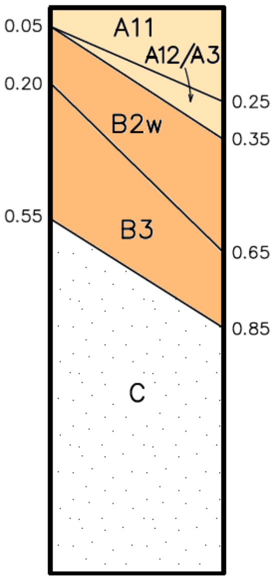
Sites 10, 206, 346

Distribution One polygon in the north east of the WIN study area.

Tiaro (Ta)

CONCEPT	Acid to neutral, black or brown, gravelly clay on andesite.
ASC	**Black Dermosol**, Brown Dermosol
LANDFORM	Hillcrests and hillslopes on gentle to rolling undulating rises and low hills. Slopes 2 to 15%
GEOLOGY	Andesite of the Grahams Creek Formation (JKr)
VEGETATION	Mostly cleared, occasional remnants of vine scrub species.
PERMEABILITY	Moderately permeable
DRAINAGE	Moderately well-drained
SURFACE	Firm. Very few to common cobbles and stones.

Depth (m)



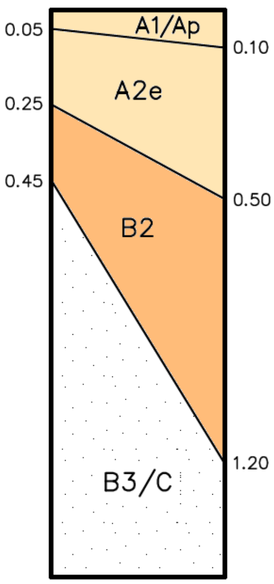
HORIZON	**DESCRIPTION**
A11	Black (10YR 3/1, 3/2, 7.5YR 3/2); clay loam to light clay; strong granular or blocky structure; occasionally few ferruginous nodules; pH 6.0-7.0. Sharp or abrupt change to:
A12 / A3	Black or brown (10YR 3/2, 3/3); light to light medium clay; strong blocky or polyhedral structure; occasionally very few weathered andesite pebbles; frequently few manganiferous or ferromanganiferous nodules; pH 6.0-7.0. Abrupt or clear change to:
B2w	Black or occasionally brown (10YR 3/2, 3/3, 5/4); light medium to medium clay; strong blocky structure; frequently few to common weathered andesite pebbles; frequently few manganiferous nodules or soft segregations; pH 6.0-8.0. Gradual or diffuse change to:
B3	Grey or brown (10YR 4/2, 5/3, 2.5Y 5/2, 6/3); light to medium heavy clay; common weathered andesite pebbles; occasionally few carbonate nodules; pH 7.5-8.0. Gradual or diffuse change to:
C	Weathering and hard andesite.

Sites	82
Distribution	One small polygon in the central west of the WIN study area.

Tirroan (Tr)

CONCEPT	Thick, bleached, sandy surface over strongly acid, mottled, grey, strongly sodic clay on moderately weathered sedimentary rocks.
ASC	**Grey Kurosol**, Brown Kurosol, Grey Sodosol
LANDFORM	Mid to lower hillslopes of rises and low hills. Slopes 0.5 to 10%
GEOLOGY	Burrum Coal Measures (Kb), Graham's Creek Formation (Jkr), Maryborough Formation (Km).
VEGETATION	Tall mid-dense mixed forest including *Eucalyptus latisinensis, Corymbia trachyphloia, E. exserta, C. intermedia, C. citriodora, E. tereticornis, Angophora leiocarpa, E. moluccana.* Understorey includes *Melaleuca, Acacia* and occasionally *Xanthorrhoea* species.
PERMEABILITY	Slowly permeable
DRAINAGE	Imperfectly drained
SURFACE	Hard setting

Depth (m)



HORIZON	**DESCRIPTION**
A1 / Ap	Black or grey (7.5YR 3/2, 4/2, 10YR 3/2); loamy sand to fine sandy loam; massive; pH 5.5-6.0. Clear change to:
A2e	As above with conspicuous bleach. Abrupt or sharp change to:
B2	Mottled; grey or occasionally brown (10YR 4/2, 4/3, 5/1 to 5/4, 6/2); light medium to medium heavy clay; moderate or strong prismatic, blocky or occasionally lenticular structure; pH 5.0-6.0. Clear or gradual change to:
B3 / C	Mottled; grey (7.5YR, 10YR 5/1 to 6/3); light medium to medium heavy clay with sedimentary rock fragments or weathering rock.

Sites 29, 56, 67,146, 208, 301, 303, 325, 356,401, 490, 613, 616, 677

Sampled 37, 73, 119, 149, 209

Distribution All areas where Kb, Jkr or Km geology occurs.

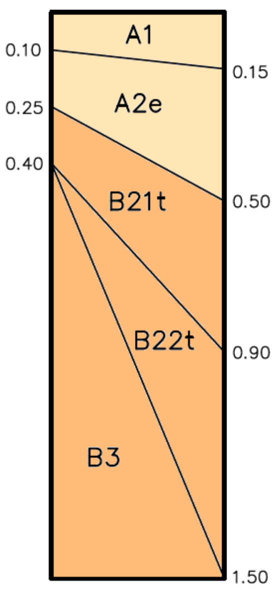
Notes Within the WIN study area, *Tirroan* soil profiles frequently occur close to the boundary between deeply weathered and moderately weathered geology. These soil profiles are developed on colluvium from Elliott Formation (Te) over Burrum Coal Measures Kb) or Graham's Creek Formation (Jkr) sedimentary rocks.

The pH range B2 horizon of *Tirroan* soil profiles within the WIN study area includes more acid values than described for *Tirroan* soil profiles in other study areas.

Turpin (Tp)

CONCEPT	Thick, bleached, sandy surface with maghemite small pebbles over acid, mottled, grey or brown strongly sodic clay on deeply weathered fine grained sedimentary rocks.
ASC	**Grey Kurosol,** Brown Kurosol, Brown Sodosol, Redoxic Hydrosol
LANDFORM	Hillslopes on gently undulating to undulating rises. Slopes 0.5 to 8 %
GEOLOGY	Mudstones, siltstones, fine grained sandstones of the Elliott Formation (Te), Burrum Coal Measures (Kb), Maryborough Formation (Km), Graham's Creek Formation (Jkr).
VEGETATION	Tall mid-dense forest of *Eucalyptus latisinensis, Angophora leiocarpa, Corymbia trachyphloia, C. intermedia, E. exserta, Melaleuca viridiflora.*
PERMEABILITY	Slowly permeable
DRAINAGE	Imperfectly or poorly drained
SURFACE	Firm or hard setting, few to common maghemite small nodules.

Depth (m)



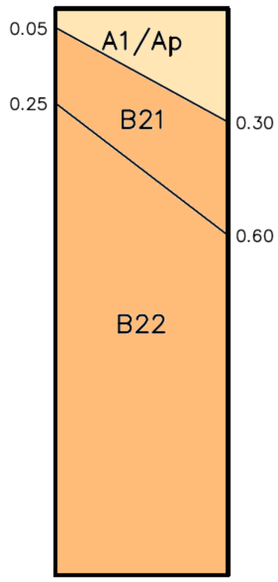
HORIZON	**DESCRIPTION**
A1	Grey or black (7.5YR 3/2, 4/1, 4/2, 5/2); loamy sand to sandy loam; massive; frequently few to common maghemite small nodules; pH 5.5-6.0. Clear or gradual change to:
A2e	As above but mottled with conspicuous bleach. Abrupt change to:
B21t	Mottled, grey or brown (7.5YR 5/2 to 6/3, 10YR 4/1 to 4/4, 5/1, 5/2, 5/3, 6/1 to 7/2); light medium to heavy clay; strong blocky structure; frequently few to many maghemite small nodules; pH 5.0-6.0. Clear or diffuse change to:
B22t	Mottled, grey (10YR 4/1, 5/2, 2.5Y 6/1, 6/4, 5Y 7/1); light medium to heavy clay; strong blocky or lenticular structure, occasionally with slickensides; pH 5.0-6.0. Clear or diffuse change to:
B3	Mottled, grey (7.5YR 5/2, 6/1, 6/2, 10YR 6/1 to 72, 8/2); light medium or heavy clay with rock fragments.

Sites	61, 62, 68, 515, 736, 747
Distribution	All areas where Te, Kb, Km or Jkr geology occurs.
Notes	Soil pH of *Turpin* soil profiles within the WIN study area includes more acid values than described for *Turpin* soil profiles in other study areas. Where this soil is formed on Te cap over Kb geology, the B3 horizon may be formed on the underlying geology.

Walla (Wl)

CONCEPT	Grey cracking clay on alluvial plains.
ASC	**Grey Vertosol**
LANDFORM	Older plains of Quaternary alluvium (Qa)
GEOLOGY	Quaternary alluvium (Qa)
VEGETATION	Mostly cleared, some tall mid-dense forest of *Eucalyptus tereticornis*, *E. moluccana.*
PERMEABILITY	Slowly permeable
DRAINAGE	Imperfectly drained
SURFACE	Weakly cracking, hard setting or poached

Depth (m)



HORIZON	**DESCRIPTION**
A1 / Ap	Grey or black (7.5YR, 10YR 3/2, 4/2); light to medium clay; moderate granular or blocky structure; pH 5.5-6.5. Clear change to:
B21	Mottled, grey (7.5YR 4/2, 10YR 4/2, 4/3, 5/2, 2.5Y 4/2); medium to heavy clay; strong blocky structure; pH 5.0-7.5. Diffuse change to:
B22	Mottled, grey or brown (10YR, 2.5Y 5/1 to 5/3; 2.5Y 6/2); medium to heavy clay; strong lenticular structure with slickensides; pH 5.0-9.0.

Sites 691

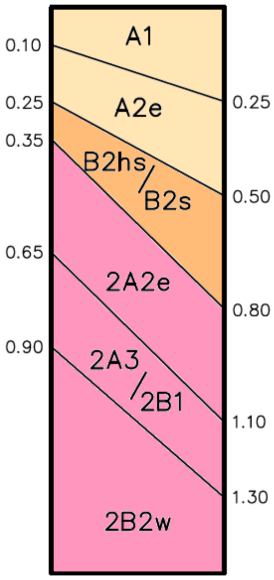
Distribution One polygon associated with alluvium of the Kolan River in the south-west of the WIN study area.

Notes A thin A2 with sporadic bleach frequently occurs in uncultivated *Walla* soil profiles.

Wallum (Wm)

CONCEPT	Acid, bleached brown or yellow sand on deeply weathered coarse grained sedimentary rocks. Buried layers including bleached sand and massive sandy clay loam to sandy light clay.
ASC	**Semiaquic Podosol**, Aquic Podosol, Redoxic Hydrosol
LANDFORM	Level plains. Slopes < 1%
GEOLOGY	Elliott Formation (Te)
VEGETATION	Tall mid-dense to isolated forest of *Eucalyptus latisinensis, E. acmenoides, Corymbia intermedia*. Understorey of heath, *Banksia* and *Xanthorrhoea* species.
PERMEABILITY	Slowly or moderately permeable
DRAINAGE	Poorly drained
SURFACE	Loose or soft (often wet)

Depth (m)



HORIZON	**DESCRIPTION**
A1	Grey or black (7.5YR, 10YR 3/1, 4/1, 5/1); sand to loamy sand; single grain; pH 4.5-5.5. Clear or gradual change to:
A2e	As above with conspicuous bleach. Clear or gradual change to:
B2hs /B2s	Occasionally mottled; brown or yellow (7.5YR 5/3 to 6/4, 10YR 5/3, 7/4,7/6); sand to loamy sand; single grain; pH 5.0-6.0. Clear, gradual or diffuse change to:
2A2e	Conspicuously bleached; sand to loamy sand; single grain; pH 5.0-6.0. Gradual or diffuse change to:
2A3 / 2B1	Mottled; grey or occasionally yellow (10YR 7/1 to 7/4, 8/2 to 8/4); sandy loam to sandy clay loam; massive; occasionally few ferruginous nodules; pH 5.0-6.0. Diffuse change to:
2B2w	Mottled; grey (10YR 7/2, 7/3, 8/2, 8/3, 2.5Y 6/3, 7/1, 8/2); clay loam, sandy to sandy light clay; massive; pH 5.0-6.0.

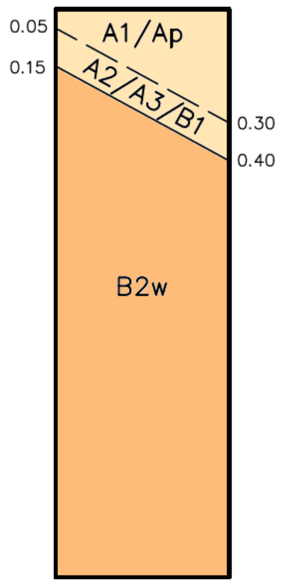
Sites 43

Distribution One polygon within *Littabella* National Park in the WIN study area.

Watalgan (Wt)

CONCEPT	Moderately thick clay loamy to light clay surface over acid, red, non-sodic to weakly sodic clay on deeply weathered fine grained sedimentary rocks.
ASC	**Red Dermosol**
LANDFORM	Level plains to hillslopes and hillcrests of rises and low hills. Slopes 0.5 to 10 %
GEOLOGY	Mudstones, siltstones, fine grained sandstones of the Elliott Formation (Te), Burrum Coal Measures (Kb) and Maryborough Formation (Km).
VEGETATION	Tall mid-dense forest of *Eucalyptus acmenoides*, *E. citriodora, E. siderophloia, E.crebra*. Frequently understorey of *Acacia* species. Mostly cleared.
PERMEABILITY	Moderately permeable
DRAINAGE	Moderately well or well-drained
SURFACE	Firm or hard setting. Frequently few to many ironstone pebbles and ferruginised sedimentary pebbles to cobbles.

Depth (m)



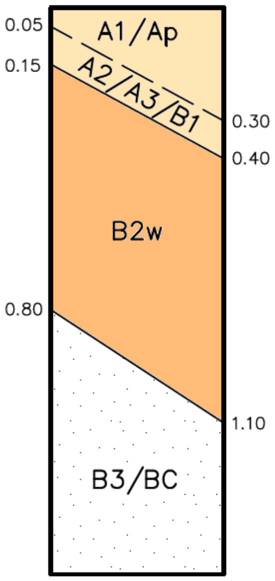
HORIZON	**DESCRIPTION**
A1 / Ap	Black, brown or red (5YR 2/2, 3/2, 3/3; 7.5YR 2/3, 3/3, 4/3, 10YR 3/3, 4/3); clay loam to light clay; weak to strong granular or blocky structure; very few to many ferruginised sedimentary and ironstone pebbles; pH 4.5-6.0. Clear change to:
A2 / A3 / B1	Where present; red or brown (10R 4/4, 2.5YR 3/3 to 4/6, 5YR 3/4, 4/3 to 4/6, 7.5YR 4/4, 4/6); clay loam to light clay; weak or moderate granular or blocky structure; very few to many or occasionally abundant ferruginised sedimentary and ironstone pebbles; pH 4.5-6.0. Clear change to:
B2w	Red (10R 3/6, 4/4 4/6, 2.5YR 3/4, 4/4, 4/6, 4/8); light to medium clay; strong polyhedral or blocky structure; very few to many ferruginised sedimentary and ironstone pebbles; pH 4.5-6.0.

Sites	55, 223, 224, 379, 380, 391, 408, 420, 618, 620, 625, 645, 728
Distribution	All areas where Te, Kb or Km geology occurs.
Notes	Weathering or hard rock (BC or C horizons) occasionally occur below 1.10 m in the *Watalgan* soil profiles within the WIN study area. *Watalgan* soil profiles rarely occur on the Broweena Formation (Rb) geology within the WIN study area. The pH range of *Watalgan* soil profiles within the WIN study area includes more acid values than described for *Watalgan* soil profiles in other study areas.

Watalgan, grey subsoil variant (WtGsv)

CONCEPT	Moderately thick clay loamy to light clay surface over acid, red, non-sodic to weakly sodic clay on deeply weathered fine grained sedimentary rocks. Mottled, grey B3 or BC horizon occurs below 0.80-1.10 m.
ASC	**Red Dermosol**
LANDFORM	Level plains to hillslopes and hillcrests of rises and low hills. Slopes 0.5 to 10 %
GEOLOGY	Mudstones, siltstones, fine grained sandstones of the Elliott Formation (Te), Burrum Coal Measures (Kb) and Maryborough Formation (Km).
VEGETATION	Tall mid-dense forest of *Eucalyptus acmenoides*, *E. citriodora, E. siderophloia, E.crebra, Corymbia* intermedia. Frequently understorey of *Acacia* species*.* Mostly cleared.
PERMEABILITY	Slowly permeable
DRAINAGE	Imperfectly drained
SURFACE	Firm or hard setting, usually few to many ironstone gravels and ferruginised sedimentary pebbles to cobbles.

Depth (m)



HORIZON	**DESCRIPTION**
A1 / Ap	Black, brown or red (5YR 2/2, 3/2, 3/3; 7.5YR 2/3, 3/3, 4/3, 10YR 3/3, 4/3); clay loam to light clay; weak or strong granular or blocky structure; very few to many ferruginised sedimentary and ironstone pebbles; pH 4.5-6.0. Clear change to:
A2 / A3 / B1	Frequently present; red or brown (10R 4/4, 2.5YR 3/3 to 4/6, 5YR 3/4, 4/3 to 4/6, 7.5YR 4/4, 4/6;); clay loam to light clay; weak or moderate granular or blocky structure; very few to many or occasionally abundant ferruginised sedimentary and ironstone pebbles; pH 4.5-6.0. Clear change to:
B2w	Mottled; red (10R 3/6, 4/4 4/6, 2.5YR 3/4, 4/4, 4/6, 4/8); light to medium clay; strong polyhedral or blocky structure; very few to many ferruginised sedimentary and ironstone pebbles; pH 4.5-6.0. Clear change to:
B3 / BC	Mottled; grey (2.5Y 6/1, 6/2, 7/1, 8/1, 8/2; 10YR 4/2, 5/1, 6/1); medium to medium heavy clay; moderate or strong prismatic or blocky structure; few to abundant sedimentary pebbles to cobbles; few to common ironstone pebbles; pH 4.5-6.0.

Sites 38, 115, 227, 366, 384, 404, 628, 670, 721

Sampled 156

Distribution All areas where Te, Kb or Km geology occurs.

Notes *Watalgan*, grey subsoil variant profiles occasionally occur on Elliot Formation (Te) capping over Burrum Coal Measures (Kb) within the WIN study area. Rarely ASC of *Watalgan*, grey subsoil variant profiles is a Red Kurosol within the WIN study area.

Weithew (Wh)

CONCEPT Grey or brown clay soil on local alluvium.

ASC **Grey Dermosol**, Brown Dermosol, Grey Vertosol

LANDFORM Alluvial plains, flood plains. Slopes < 2 %

GEOLOGY Quaternary alluvium (Qa) associated with local creeks

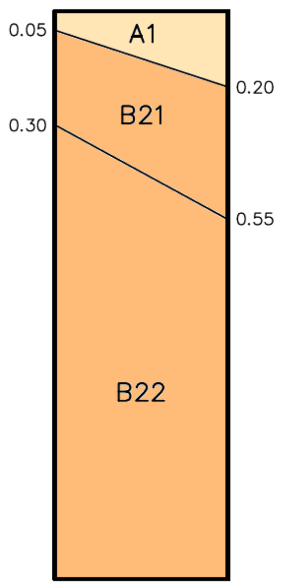
VEGETATION Tall mid-dense forest of *Eucalyptus tereticornis, E. Exserta, E. latisinensis*; understorey of *Acacia species, Alphitonia excelsa* and *Ficus* species, mostly cleared

PERMEABILITY Slowly permeable

DRAINAGE Imperfectly drained

SURFACE Firm or hard setting; weakly cracking

Depth (m)



HORIZON	DESCRIPTION
A1	Black to rarely grey or brown (7.5YR 3/1, 3/2, 10YR 2/1, 3/2, 3/3, 4/3, 5/2); light to light medium clay; moderate or strong blocky or polyhedral structure; pH 5.0-6.0. Clear change to:
B21	Grey or rarely brown (10YR 4/1, 4/2, 4/4, 5/1, 2.5Y 4/1, 5/1 to 5/4); light medium to medium heavy clay; moderate or strong blocky, prismatic or lenticular structure; frequently few manganiferous nodules; pH 5.5-7.5. Clear or gradual change to:
B22	Mottled; grey (10YR 4/1 to 5/2, 2.5Y 4/1, 5/1, 5/2, 6/2); medium to medium heavy clay; strong blocky, prismatic or lenticular structure; frequently few manganiferous nodules; pH 5.5-9.0.

Sites 50, 228, 430, 431, 491, 497, 522, 540

Sampled 84, 225, 531

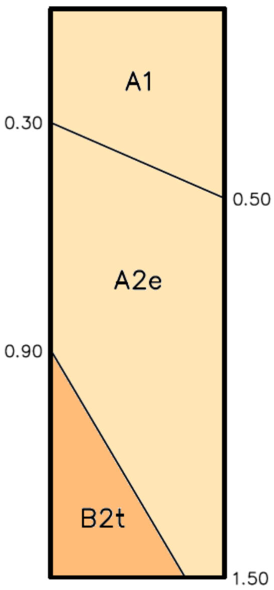
Distribution All areas where local alluvium occurs.

Notes Occasionally calcium carbonate segregations occur in the B22 horizon, associated with alkaline soil profiles. Self-mulching surface of *Weithew* soil profiles was not observed within the WIN study area. Occasionally a sporadically bleached A2 horizon occurs in the *Weithew* soil profiles within the WIN study area. The pH range in B2 horizons of *Weithew* soil profiles within the WIN study area includes more acid values than described for *Weithew* soil profiles in other study areas.

Winfield (Wf)

CONCEPT	Acid to neutral, bleached, mottled grey sand on deeply weathered coarse grained sedimentary rocks.
ASC	**Redoxic Hydrosol, Bleached-Orthic Tenosol**
LANDFORM	Level plains, hillslopes and hillcrests of rises. Slopes < 1 to 9 %
GEOLOGY	Elliott Formation (Te)
VEGETATION	Mid-dense tall forest of *Eucalyptus latisinensis, Corymbia trachyphloia, C. intermedia, Lophostemon* species*.* Understorey frequently includes *Alphitonia excelsa, Melaleuca* and *Acacia* species, *Pteridium esculentum* and rarely *Livistonia australis.* Occasionally invaded by *Lantana camara*. Frequently cleared.
PERMEABILITY	Highly permeable
DRAINAGE	Very poorly to moderately well-drained, depending on landscape position (see notes below).
SURFACE	Loose, soft or firm

Depth (m)



HORIZON	**DESCRIPTION**
A1	Grey or black (7.5YR 3/1, 3/2, 4/2, 10YR 2/1, 2/1, 3/1, 4/1, 5/1); sand to loamy sand; singe grain or massive; pH 5.0-6.0. Clear change to:
A2e	Frequently mottled; grey (10YR 5/1, 6/1 to 7/2) with conspicuous bleach; sand to loamy sand; singe grain or massive; pH 5.0-6.5. Clear change to:
B2t	Frequently mottled; grey (7.5YR 6/3, 10YR 6/2, 7/1, 7/2, 8/3, 2.5Y 7/1, 7/2, 8/1); sand to loamy sand; singe grain or massive; pH 5.0-7.0.

Sites 11, 126, 295, 296, 312, 313, 317, 319, 469, 665.

Sampled 297

Distribution All areas where Elliott Formation geology occurs.

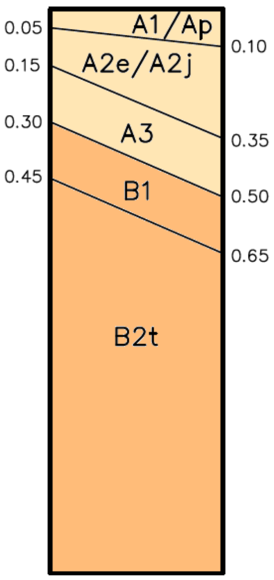
Notes Water table frequently present below 0.50 m, depending on landscape position, time of year and season.

Drainage of *Winfield* soil profiles is dependent on landscape position within the WIN Study area: Poorly or very poorly drained on level plains or lower hillslopes; Imperfectly drained on mid hillslopes; Imperfectly or moderately well-drained on upper hillslopes and hillcrests.

Woolmer (Wr)

CONCEPT	Moderately thick, bleached, loamy surface grading to acid, mottled, yellow or brown, weakly sodic clay on deeply weathered fine grained sedimentary rocks.
ASC	**Yellow Dermosol**, Brown Dermosol
LANDFORM	Level plains to hillslopes on undulating rises. Slopes 1 to 5 %
GEOLOGY	Elliott Formation (Te), Burrum Coal Measures (Kb), Maryborough Formation (Km)
VEGETATION	Tall mid-dense forest of *Eucalyptus latisinensis, Corymbia trachyphloia, C. intermedia.* Frequently understorey of *Acacia* species.
PERMEABILITY	Moderately permeable
DRAINAGE	Imperfectly drained
SURFACE	Firm or hard setting

Depth (m)



HORIZON	DESCRIPTION
A1 / Ap	Grey (7.5YR 4/1, 4/2, 10YR 4/2); sandy loam to loam (frequently fine sandy); massive; pH 5.0-6.0. Clear or gradual change to:
A2e / A2j	As above with conspicuous or occasionally sporadic bleach. Gradual or diffuse change to:
A3	Brown or yellow (7.5YR 5/4, 6/4, 6/5, 10YR 5/3 to 5/6, 6/5); loam fine sandy to sandy clay loam; massive; few to common ferruginous (maghemite) small pebbles; pH 5.0-6.0. Gradual or diffuse change to:
B1	Mottled; yellow or brown (7.5YR 5/5, 6/6, 10YR 5/5, 5/6, 6/6); sandy clay loam to clay loam; massive or weak blocky structure; few to many ferruginous (maghemite) small pebbles; pH 5.0-6.0. Gradual or diffuse change to:
B2t	Mottled; yellow or brown (7.5YR 5/5, 6/6, 10YR 5/4 to 6/6); light to medium clay (frequently fine sandy); moderate or strong polyhedral structure; common to many ferruginous (maghemite) small pebbles; pH 5.0-7.0.

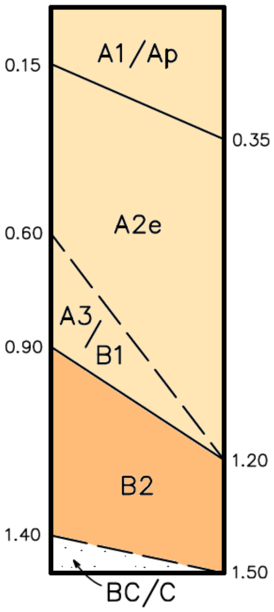
Sites 166

Distribution One small polygon near the centre of the WIN study area.

Yandaran (Yd)

CONCEPT	Very thick, bleached, sandy to loamy surface over acid, mottled, yellow or brown, weakly sodic clay on deeply weathered coarse grained sedimentary rocks.
ASC	**Yellow or Brown Kurosol**, Yellow or Brown Dermosol, Yellow or Brown Chromosol
LANDFORM	Level plains, hillslopes or hillcrests on undulating rises. Slopes generally 1 to 5 %, occasionally up to 10 %
GEOLOGY	Elliott Formation (Te)
VEGETATION	Tall mid-dense forest of *Corymbia clarksoniana*, *C. intermedia; Eucalyptus acmenoides* and *Angophora leiocarpa.* Occasionally with understorey of *Melaleuca* species. Frequently cleared.
PERMEABILITY	Moderately permeable
DRAINAGE	Imperfectly drained
SURFACE	Firm

Depth (m)



HORIZON	**DESCRIPTION**
A1 / Ap	Black (10YR, 2/1 to 3/2); massive; sand to sandy loam; pH 5.0-6.0. Clear change to:
A2e	Yellow or brown (10YR 5/3, 5/4, 6/3 to 6/6); conspicuously bleached; sand to sandy loam; massive; pH 5.0-6.0. Clear change to:
A3 / B1	Frequently present; yellow or brown (10YR 5/6, 6/6, 7.5YR 5/8); sandy clay loam to light clay; massive or weak blocky structure; pH 5.0-6.0. Clear change to:
B2	Mottled; yellow or brown (10YR 5/4 to 6/6, 7/6); sandy light clay to sandy medium clay; moderate or strong blocky or polyhedral structure; few to many ferruginised sandstone pebbles; pH 4.5-6.0. Clear or gradual to
BC / C	Occasionally weathering and hard sandstone.

Sites 3, 28, 121, 143, 191, 196, 200, 201, 219, 220, 222, 230, 242, 258, 259, 260, 276, 308, 329, 373, 374, 426, 427, 434, 454, 559, 605, 611, 675, 693

Sampled 122, 216, 335 **type profile**

Distribution All areas where Elliott Formation geology occurs.

Notes Medium to heavy grey clay may occur below 1.00 m where this soil is formed on Te cap over Kb Geology. This was developed in the WIN study area to accommodate soil profiles with very thick, sandy A horizons, and won't be mapped in previous areas. Some profiles allocated to *Meadowvale* or *Isis* SPC in other study areas may now fit *Yandaran* SPC.

Appendix 2: Variants and Phases used within the WIN study area

Symbol	Variant or Phase	Brief description
Ep	Eroded phase	Significant active erosion.
Lv	Lower subsoil grey variant	A mottled, grey clay layer (usually B3 or BC horizon) occurs that is not within the SPC description. Usually occurs where Elliott formation (Te) geology forms a thin capping over underlying other sedimentary geology.
Pv	Non-sodic variant	Non-sodic soil properties in contrast to the SPC description defined range as sodic.
Shv	Shallow variant	Depth to underlying rock less than the range described within the SPC description.
Sp	Salty phase	Surface salinity recorded at the site.
Sv	Sandy variant	Textures sandier than the range described within the SPC description.
Rp	Rocky phase	Cobble, stone, boulders or rock on the soils surface not within the SPC description, or significantly more than within the SPC description.
Rv	Red variant	B horizon colour redder than normal range for the SPC description.

These symbols indicate soil profiles with similar morphology to an existing soil (as defined by detailed SPC description) but differ in one or more soil or land feature that are not normally associated with that SPC.

Appendix 3: Key for the recognition of the soil profile classes of the WIN study area

MARINE AND BEACH RIDGE PLAINS

A	Soils occur on beach ridges				
	B	Soil has a bleached A2 horizon		*Colvin*	(Cv)
		C	Soils lack bleached A2 horizons		
		D	B2 horizon is red	*Tantitha*	(Tt)
		D	B2 horizon is brown	*Moore Park*	(Mp)
A	Soils occur on plains, swales and tidal flats				
	B	Soil has clay loamy bleached A2 horizon		*Maroom*	(Mm)
	B	Soils lack bleached A2 horizons			
		C	Soil has clay B2 horizons to at least 1.50 m	*Fairymead*	(Fm)
		C	Soil has D horizons of sand to sandy clay loam below 0.65-1.00 m.	*Fairydale*	(Fd)

ALLUVIAL PLAINS OF THE KOLAN RIVERS AND MAJOR CREEKS

A	Soils of the recent alluvia (plains, levees, swales and scrolls)				
	B	Soil has textures of sand to sandy loam throughout		*Barubbra*	(Bb)
	B	Soil contains a number of depositional layers varying in thickness with textures from sandy loam to clay loam		*Burnett*	(Bn)
	B	Soils have A and B2 horizons with textures of clay loam to light clay			
		C	Massive, sandy to sandy clay loam D horizon present below 0.90 to 1.50 m.	*Flagstone*	(Fs)
		C	Massive, sandy to sandy clay loam D horizon present before 0.90 m.	*Gahan*	(Gh)
		C	Soil has mottled grey clay of marine origin below 0.5 to 0.8 m.	*Sugarmill*	(Sm)
A	Soils of the older alluvia of the Burnett and Kolan Rivers				
	B	Soil is a grey cracking clay.		*Walla*	(Wl)
	B	Soils are brown or grey texture contrast soils with sodic B2 horizon.			
		C	A horizon loam to clay loam < 0.45 m thick.	*Auburn*	(Ab)
		C	A horizon loamy sand to sandy loam > 0.45 m thick.	*Crossing*	(Cg)

ALLUVIAL PLAINS OF LOCAL STREAMS

A	Soil has a clay surface (cracking and non-cracking)				*Weithew*	(Wh)
A	Soil is a texture contrast soil with structured, sodic B horizon				*Peep*	(Pp)
A	Soil has a massive or weakly structured brown or red B horizon				*Littabella*	(Lt)

RISES AND PLAINS OF DEEPLY WEATHERED COARSE GRAINED SEDIMENTARY ROCKS

A	B2 horizon is red							
	B	B2 horizon is massive					*Farnsfield*	(Ff)
	B	B2 horizon is structured					*Gooburrum*	(Gb)
A	B2 horizon is yellow to brown							
	B	B2 horizon is massive.						
		C	Texture loamy sand to sandy loam to 1.50 m.				*Rothchild*	(Rt)
		C	B2 horizon texture sandy clay loam to light clay				*Quart*	(Qr)
	B	B2 horizon is structured.						
		C	A horizon > 0.60 m thick; strongly acid B2 horizon				*Yandaran*	(Yd)
		C	A horizon not bleached, clay loam to light clay B2 horizon				*Calavos*	(Ca)
		C	A horizon 0.30-0.60 m thick, B2 horizon light medium to medium clay.					
			D	Massive A3/B1 horizon > 0.2 m thick (Dermosol)			*Meadowvale*	(Md)
			D	A3/B1 horizon absent (Kurosol)			*Isis*	(Is)
			D	Grey B3 or BC horizon below 0.60-1.30 m.			*Isis*, *Grey subsoil variant*	(IsGsv)
A	Upper B2 horizon is grey							
	B	Texture ranges from sand to sandy loam to 1.50 m						
		C	No pan in soil profile before 1.50 m				*Winfield*	(Wf)
		C	Soil profile with a pan at <1.50 m.				*Kinkuna*	(Kn)
		C	Soils have buried horizons below sandy B2 horizon					
			D	Texture of the structured buried horizons is light to medium clay.			*Theodolite*	(Th)
			D	Texture of the massive buried horizons is sandy clay loam to sandy light clay			*Wallum*	(Wm)
	B	Soils have structured clay B2 horizons						
		C	B2 horizons are non-sodic				*Alloway*	(Al)
		C	B2 horizons are sodic				*Robur*	(Rb)

PLAINS, RISES AND LOW HILLS OF THE DEEPLY WEATHERED FINE GRAINED SEDIMENTARY ROCKS

A	Soils with rock fragments throughout				
	B	Soil is < 0.50 m deep and lacks a B2 horizon		*Takoko*	(Tk)
	B	Soil is > 0.50 m deep with medium clay B2 horizon		*Bungadoo*	(Bg)
A	Soils have red B2 horizon				
	B	B2 horizons are massive		*Oakwood*	(Ok)
	B	B2 horizons are structured.			
		C	A horizon texture is clay loam; some gravels throughout	*Watalgan*	(Wt)
		C	A horizon texture is clay; minor gravels throughout.	*Howes*	(Hs)
		C	Grey B3 or BC horizon below 0.80-1.10 m	*Watalgan*, *Grey subsoil variant*	(WtGsv)
A	Soils have yellow or brown B2 horizons				
	B	Soil has clay textured A and B2 horizons		*Cedars*	(Cr)
	B	Soil has massive B2 horizons		*Gillen*	(Gi)
	B	Soils have structured B2 horizons			
		C	Texture of A horizon is fine sandy loam to loam fine sandy	*Woolmer*	(Wr)
		C	Texture of A horizon is clay loamy	*Kepnock*	(Kp)
A	Soils are texture contrast soils with grey to brown Sodic B2 horizons				
	B	Soil has an A horizon of sand to sandy loam		*Turpin*	(Tp)
	B	Soils have A horizon textures ranging from fine sandy loam to clay loam.		*Avondale*	(Av)

RISES AND LOW HILLS OF MODERATELY WEATHERED SEDIMENTARY ROCKS

A	Soil has a light to medium clay A horizon			*Bucca*	(Bc)
A	Soils are texture contrast soils with sodic B2 horizon.				
	B	Texture of A horizon is sandy		*Tirroan*	(Tr)
	B	Texture of A horizon is fine sandy loam to clay loam.			
		C	Soil has abundant rock fragments throughout	*Brooweena*	(Bw)
		C	Soils have few rock fragments in A and B2 horizons		
			D B2 horizon is grey and strongly acid (pH <5.5)	*Kolan*	(Ko)
			D B2 horizon is brown and acid to alkaline (pH > 6.0)	*Givelda*	(Gv)

RISES AND LOW HILLS OF ACID AND INTERMEDIATE VOLCANIC ROCKS

A	Soil profile is sandy throughout	*Moolyung*	(My)
A	Soil is a black clay with rock fragments	*Tiaro*	(Ta)
A	Soil is a texture contrast soil with red or brown non-sodic B2 horizon	*Booyal*	(Bl)

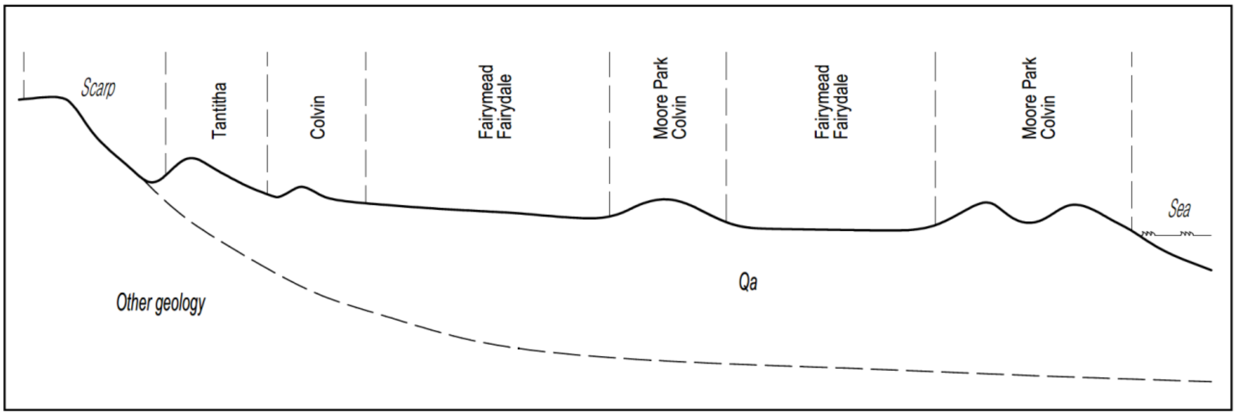
A	Soils are texture contrast with grey or brown sodic B2 horizon			
	B	Soil formed on Andesite of Graham's Creek Formation	*Owanyilla*	(Ow)
	B	A horizon sand to sandy clay loam	*Gigoon*	(Gn)
	B	A horizon sandy clay loam to clay loam	*Doongul*	(Do)

RISES AND LOW HILLS OF BASALT ROCKS

A	Soil has abundant rock fragments on the surface and throughout profile	*Berren*	(Be)
A	Soil has few rock fragments throughout profile	*Kowbi*	(Kb)

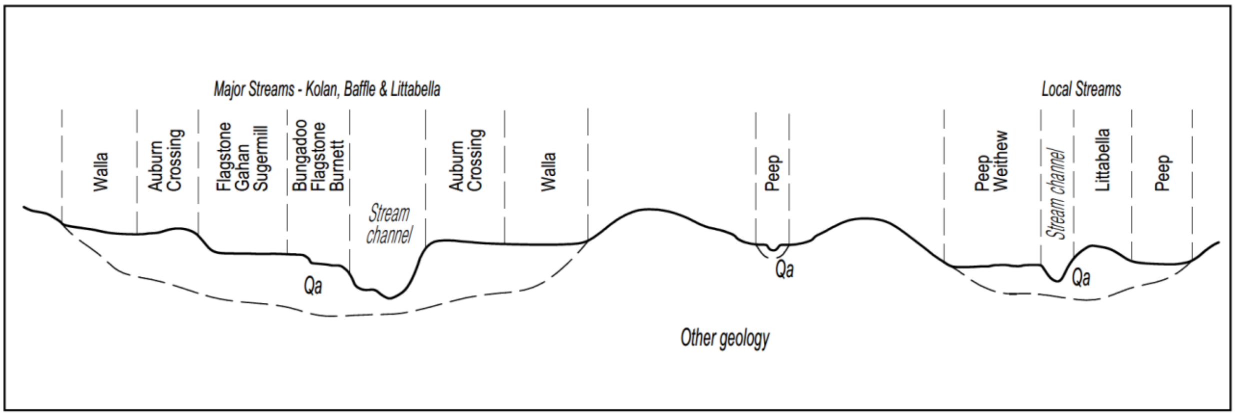
Appendix 4: Diagram cross sections showing idealised relationships between landforms, soils and vegetation, WIN study area

(a) **Beach ridge and marine plains, landform and soils**



Geology reference	Beach ridges	Marine plains	Vegetation
Various Coastal deposits of Qa	Brown or Red Tenosol (*Moore Park*, *Tantitha*)		10–20 m bloodwood, Moreton Bay ash, smooth-barked apple with *Banksia*, *Acacia* and *Grevillea* understorey. Many areas cleared.
	Semi-aquic Podosol (*Colvin*)		10–20 m Moreton Bay ash, bloodwood, blue gum, swamp mahogany, *Livistona* with *Melaleuca* understorey.
		Redoxic, Extratidal Hydrosol (*Maroom*)	10–20 m bloodwood, Queensland peppermint, *Angophora spp*. *Livistona* with *Melaleuca* understorey.
		Redoxic, Extratidal Hydrosol (*Fairymead, Fairydale)*	10–20 m broad leaved paper bark, Moreton Bay ash, blue gum, swamp oak and salt water couch. Salt water couch grassland in some areas.

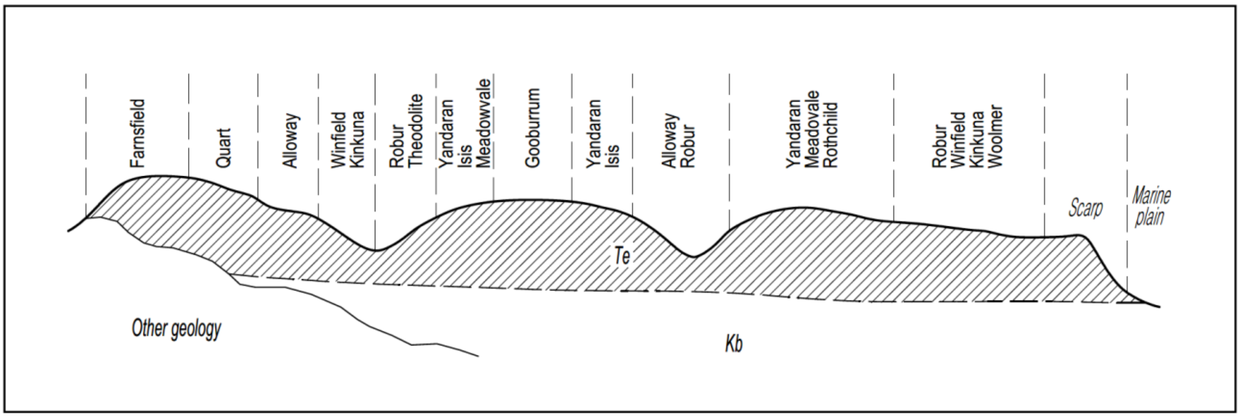
(b) Alluvium, landform and soils



Geology reference	Channel benches, levees, scrolls	Valley flats	Alluvial plains	Vegetation
(Qa) Recent alluvium from Kolan R. and major creeks	Stratic Rudosol or Orthic Tenosol (*Burnett*, *Barubbra*)		Stratic Rudosol or Orthic Tenosol (*Burnett*, *Barubbra*)	10–20 m Moreton Bay ash, blue gum *Lophostemon* spp. with *Acacia spp* understorey.
	Brown and black Dermosol (*Flagstone*, *Gahan*)		Brown and black Dermosol (*Flagstone*, *Gahan*)	Cleared
Qa over marine sediment			Redoxic Hydrosol (*Sugarmill*)	Cleared. May have regrowth of blue gum with *Melaleuca* understorey.
(Qa) Older alluvium of Kolan R.			Brown and grey Sodosol (*Auburn*, *Crossing*)	Cleared. May have regrowth of blue gum, gum-topped box with *Melaleuca* understorey.
			Grey Vertosol (*Walla*)	Cleared. May have regrowth of blue gum, gum-topped box with *Melaleuca* understorey.
(Qa) Local creeks	Grey and brown Sodosol (*Peep*)	Grey and brown Sodosol (*Peep*)	Grey and brown Sodosol (*Peep*)	10–20 m stringybark, gum-topped box, blue gum, bloodwood, Queensland peppermint with *Melaleuca* understorey

Geology reference	Channel benches, levees, scrolls	Valley flats	Alluvial plains	Vegetation
	Brown Kandosol (*Littabella*)			Cleared
(Qa) Local creeks (cont.)			Grey Dermosol or Vertosol (*Weithew*)	10–20 m blue gum, Queensland peppermint, stringybark with understorey of variable species.

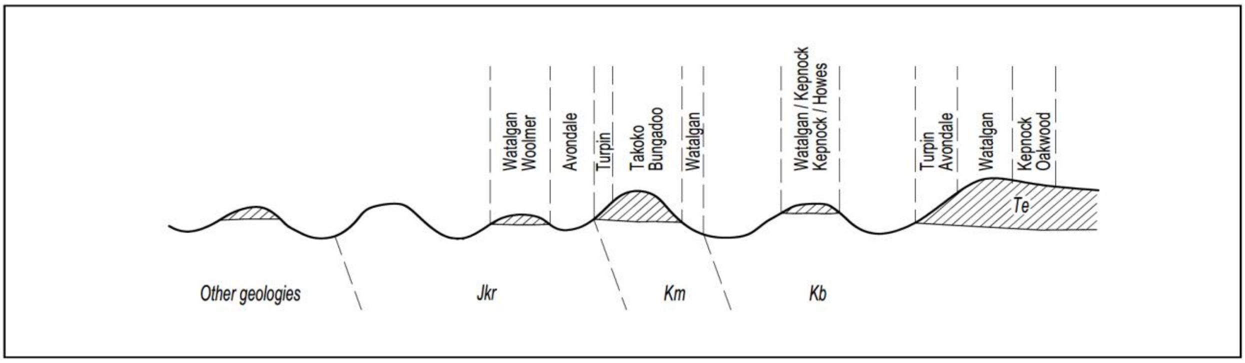
(c) Deeply weathered coarse grained sedimentary rocks, landform and soils



Geology reference	Hillcrests and upper hillslopes	Lower hillslopes	Level plains	Vegetation
Te	Red Kandosol (*Farnsfield*)			10–20 m bloodwood, lemon-scented gum, stringybark. Most areas cleared
	Red, brown and yellow Dermosol (*Gooburrum*, *Calavos*)			10–20 m bloodwood, lemon-scented gum, stringybark, Queensland peppermint, smooth-barked apple with *Acacia* and grass tree understorey. Most areas cleared
	Yellow Kandosol (*Quart*)		Redoxic Hydrosol (*Winfield*)	10–20 m stringybark, bloodwood with *Acacia*, *Banksia* and Grass tree understorey
	Bleached Tenosol (*Winfield*)	Redoxic Hydrosol (*Winfield*)	Redoxic Hydrosol (*Winfield*)	10–20 m stringybark, bloodwood, swamp mahogany with *Melaleuca*, *Acacia* and bracken fern understorey
	Bleached Tenosol (*Rothchild*)	Bleached Tenosol (*Rothchild*)	Bleached Tenosol (*Rothchild*)	10–20 m stringybark, bloodwood, goodwood gum, smooth-barked apple with *Melaleuca*, *Acacia*, Grass tree and bracken fern understorey
	Yellow and brown Dermosol or Kurosol (*Meadowvale*, *Isis*, *Yandaran*)		Yellow and brown Dermosol or Kurosol (*Meadowvale*, *Isis*, *Yandaran*)	10–20 m stringybark, bloodwood, *Lophostemon spp*. with *Acacia*, *Melaleuca* and grass tree understorey

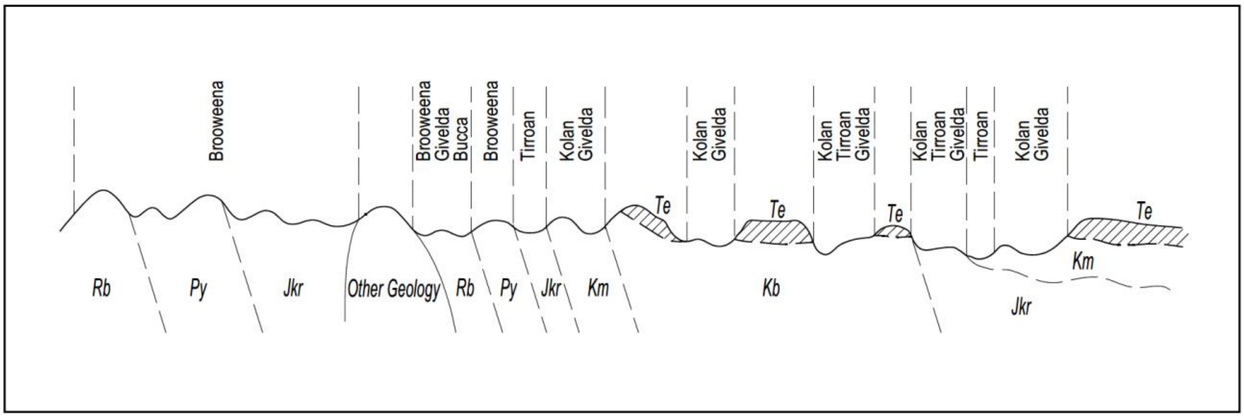
Geology reference	Hillcrests and upper hillslopes	Lower hillslopes	Level plains	Vegetation
Te		Podosol (*Kinkuna*, *Wallum*)	Podosol (*Kinkuna*, *Wallum*)	10–20 m stringybark, bloodwood with bracken fern, heath, grass tree and *Banksia* understorey
		Redoxic Hydrosol (*Alloway*, *Robur*)	Redoxic Hydrosol (*Alloway*, *Robur*)	10–20 m stringybark, bloodwood, Qld peppermint with *Melaleuca* and *Banksia* understorey
			Podosol (*Theodolite*)	Heath with occasional stringybark, *Melaleuca*

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



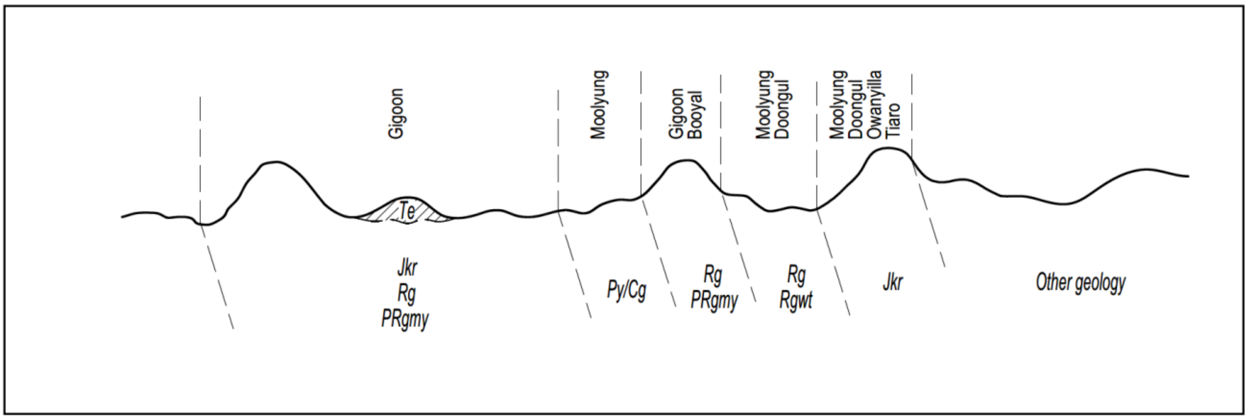
Geology reference	Hillcrests and upper hillslopes	Lower hillslopes	Level plains	Vegetation
Km	Brown and yellow Dermosol or Tenosol with silicified rocks (*Bungadoo, Takoko*)			10–20 m lemon-scented gum, stringybark, bloodwood, *Lophostemon spp.*
Te, Kb, Km,	Red Dermosol (*Watalgan*)		Red Dermosol (*Watalgan*)	10–20 m stringybark lemon-scented gum, ironbark, bloodwood with *Acacia* understorey
Te, Kb	Red Kandosol (*Oakwood*)		Red Kandosol (*Oakwood*)	Cleared
Te, Kb	Brown Dermosol (*Cedars*)		Brown Dermosol (*Cedars*)	Cleared
Kb, Te, Km	Yellow and brown Dermosol (*Kepnock*, *Woolmer*)		Yellow Dermosol (*Kepnock*)	10–20 m stringybark, ironbark, bloodwood, lemon-scented gum usually with *Acacia* understorey
Te	Red Ferrosol (*Howes*)			Cleared
Te, Kb, Jkr, Km		Grey and Brown Kurosol or Hydrosol (*Avondale*, *Turpin*)		10–20 m stringybark, bloodwood, tea tree, smooth-barked apple
Te			Yellow and Brown Kandosol (*Gillen*)	Cleared

(e) Moderately weathered sedimentary rocks, landform and soils



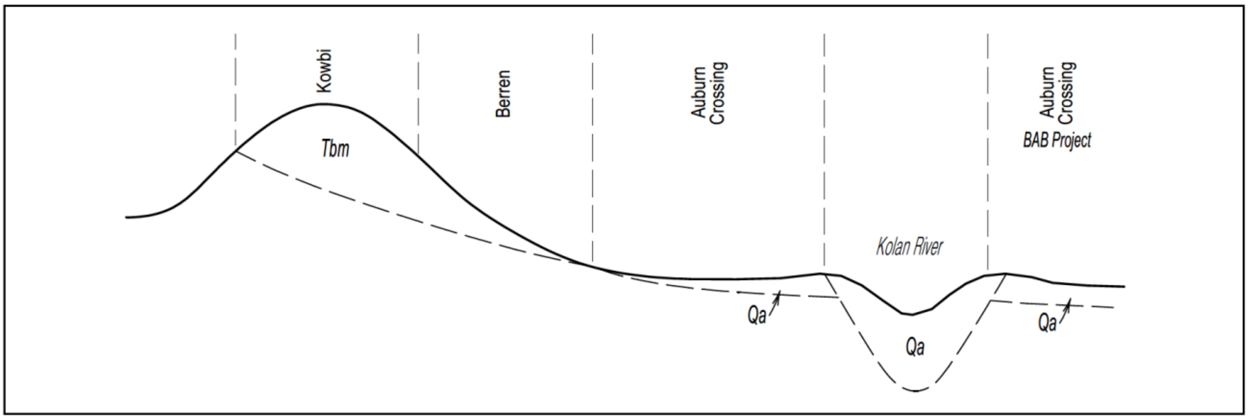
Geology reference	Upper hillslopes	Lower hillslopes	Vegetation
Rb, JKr, Km	Brown Dermosol (*Bucca*)		10–20 m lemon-scented gum, ironbark, gum-topped box, bloodwood
Rb, Jkr, Py	Brown and grey Kurosol or Sodosol (*Brooweena*)		10–20 m lemon-scented gum, ironbark, gum-topped box, Queensland peppermint
Kb, Te, Km, JKr		Grey Kurosol (*Kolan*)	10–20 m lemon-scented gum, ironbark, gum-topped box, Queensland peppermint
Kb, Rb, Jkr, Km		Brown Sodosol (*Givelda*)	10–20 m lemon-scented gum, ironbark, gum-topped box, blue gum
Kb, Jkr, Py		Grey Sodosol (*Tirroan*)	10–20 m lemon-scented gum, bloodwood, ironbark, gum-topped box, smooth-barked apple, Queensland peppermint

(f) Acid and Intermediate volcanic rocks, landform and soils



Geology reference	Upper hillslopes, flats and hillcrests	Lower hillslopes	Vegetation
Rgwt, PRgmy, Rg, Py/Cg, Jkr	Leptic Tenosol or Leptic Rudosol (*Moolyung*)	Leptic Tenosol or Leptic Rudosol (*Moolyung*)	10–20 m lemon-scented gum, ironbark, bloodwood, smooth-barked apple
Rg, Rgwt, PRgmy	Red and brown Chromosol or Dermosol (*Booyal*)		10–20 m ironbark, bloodwood, lemon-scented gum, smooth-barked apple
Rg, Jkr, Rgwt	Grey and brown Sodosol (*Doongul*, *Gigoon*)	Grey and brown Sodosol (*Doongul*, *Gigoon*)	10–20 m ironbark, lemon-scented gum, gum-topped box
JKr Andesite	Brown Sodosol (*Owanyilla*)	Brown Sodosol (*Owanyilla*)	10–20 m lemon-scented gum, ironbark, gum-topped box, Moreton Bay ash, Queensland peppermint
JKr Andesite	Black Dermosol (*Tiaro*)	Black Dermosol (*Tiaro*)	Cleared

(g) Basalt landform and soils



Geology reference	Upper hillslopes	Lower hillslopes	Vegetation
Tbm	Brown Dermosol (*Kowbi*)	Brown Dermosol (*Berren*)	Cleared

Appendix 5: Areas of ASC soil classification within each landform pattern and percentage cleared at time of survey, WIN study area

ASC	Total Area (ha)	Marine and beach ridge plains (ha)	Alluvial plains of the Kolan River and major creeks (ha)	Alluvial plains of local streams (ha)	Plains, rises and low hills on deeply weathered coarse grained sedimentary rocks (ha)	Plains, rises and low hills on deeply weathered fine grained sedimentary rocks (ha)	Plains, rises and low hills on moderately weathered sedimentary rocks (ha)	Rises and low hills on acid and intermediate volcanic rocks (ha)	Rises and low hills on basalt (ha)
Organosols	0								
Podosols	1744	867			877				
Vertosols	54		54						
Hydrosols	5853	2079	347		3427				
Kurosols	17 021				5332	87	11 439	163	
Sodosols	21 078		645	6236			6 045	8152	
Chromosols	475							475	
Ferrosols	154					118			36
Dermosols	5784		129	814	795	1787	1762	481	16
Kandosols	1222			121	1027	74			
Rudusols	2		2						
Tenosols	3340	808	349		712	664		807	
Totals	56 727	3754	1526	1171	12 170	2730	19 246	10 078	52
% of total area cleared	38	42	65	51	31	30	38	46	70

Appendix 6: Chemical results for sampled soil profiles, WIN study area

WIN Site No.	WIN SPC	Sample Depth (m)	Method																			
			S_AQ4_EL			S_AQ4_AA		S_CAT_EQ						* S_EX_ALAC							* S_CIT_RED	
			pH	EC 1:5	EC SE	Cl	NO3-N	Ca	Mg	K	Na	Na corr	Ca:Mg Ratio	Exch Al	Exch Acidity	ECEC	Al sat %	Base Status	ESP	Na+Mg % ECEC	Al	Fe
				dS/m		mg/kg		cmol_c/kg						cmol_c/kg							%	
262	Ab	0.50-0.6	5.2	0.08	0.65	-----	-----	2.31	5.79	0.21	0.68	0.7	0.40	0.76	1.09	9.5	8.0	18.0	7.2	68.1	-----	-----
90	Bw	0.20-0.30	6.3	0.51	3.81	503	<1	<0.14	16.30	0.10	5.09	3.67	<0.01	<0.03	<0.03	20.2	<0.5	33.7	18.2	98.9	-----	-----
289	Bw	0.00-0.10	5.9	0.05		44	< 1	0.67	1.36	0.22	0.43	0.3	0.49	-----	-----	2.6	-----	7.3	11.9	65.2	-----	-----
289	Bw	0.20-0.30	6.2	0.03		21	< 1	0.31	1.08	0.13	0.33	0.3	0.29	-----	-----	1.8	-----	6.1	15.3	75.4	-----	-----
289	Bw	0.30-0.40	6.7	0.11		60	< 1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
289	Bw	0.40-0.50	7.8	0.22		152	< 1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
289	Bw	0.50-0.60	8.3	0.28		209	< 1	<0.60	9.47	0.07	4.87	-----	< 0.06	-----	-----	15.0	-----	25	32.4	95.5	-----	-----
289	Bw	0.60-0.70	9.0	0.34		279	< 1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
279	FfSv	0.00-0.10	6.6	0.04		< 20	4	5.92	0.52	0.30	<0.08	<0.08	11.45	-----	-----	< 6.8	-----	134.8	< 1.1	< 8.8	-----	-----
279	FfSv	0.50-0.60	5.4	0.02		< 20	< 1	0.55	0.12	0.06	<0.08	<0.08	4.51	0.13	0.15	1.0	13.5	< 16.2	< 8.3	< 21	-----	-----

WIN Site No.	WIN SPC	Sample Depth (m)	S_AQ4_EL pH	S_AQ4_EL EC 1:5 (dS/m)	S_AQ4_EL EC SE (dS/m)	S_AQ4_AA Cl (mg/kg)	S_AQ4_AA NO_3^--N (mg/kg)	S_CAT_EQ Ca (cmol_c/kg)	S_CAT_EQ Mg (cmol_c/kg)	S_CAT_EQ K (cmol_c/kg)	S_CAT_EQ Na (cmol_c/kg)	S_CAT_EQ Na corr (cmol_c/kg)	Ca:Mg Ratio	* S_EX_ALAC Exch Al (cmol_c/kg)	* S_EX_ALAC Exch Acidity (cmol_c/kg)	* S_EX_ALAC ECEC (cmol_c/kg)	Al sat %	Base Status	ESP	Na+Mg % ECEC	* S_CIT_RED Al (%)	* S_CIT_RED Fe (%)
279	FfSv	1.10-1.20	5.5	0.02		< 20	< 1	0.62	0.17	0.06	<0.08	<0.08	3.75	-----	-----	< 0.9	-----	< 18.6	-----	-----	-----	-----
254	Gn	0.20-0.30	5.9	0.09	0.80	-----	-----	0.57	11.60	0.18	2.82	2.8	0.05	-----	-----	15.1	-----	33.7	18.7	95.5	-----	-----
256	Gn	0.30-0.50	6.7	0.25	2.08	-----	-----	0.96	12.60	0.13	5.00	5.0	0.08	-----	-----	18.7	-----	37.4	26.7	94.1	-----	-----
94	Gv	0.25-0.40	5.2	0.48	3.58	650	<1	<0.14	12.20	0.06	5.28	3.45	<0.01	1.21	1.57	17.4	7.0	26.4	19.8	89.9	-----	-----
486	Gv	0.00-0.10	4.9	0.08		66	3	0.56	1.71	0.10	0.40	0.2	0.32	0.77	1.18	3.8	20.4	7.3	5.7	56.0	-----	-----
486	Gv	0.20-0.30	6.0	0.05		23	< 1	<0.14	3.99	0.08	0.73	0.7	< 3.5	-----	-----	4.9	-----	14	14.3	95.5	-----	-----
486	Gv	0.30-0.40	6.7	0.09		63	< 1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
486	Gv	0.40-0.50	6.9	0.23		277	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
486	Gv	0.50-0.60	6.6	0.45		627	2	<0.14	9.30	0.12	5.20	3.4	< 0.02	-----	-----	13.0	-----	25.9	26.2	97.7	-----	-----
486	Gv	0.60-0.70	6.5	0.67		975	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
486	Gv	0.70-0.80	6.5	0.79		1189	< 1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

WIN Site No.	WIN SPC	Sample Depth (m)	Method																			
			S_AQ4_EL			S_AQ4_AA		S_CAT_EQ						* S_EX_ALAC							* S_CIT_RED	
			pH	EC 1:5	EC SE	Cl	NO^{3}-N	Ca	Mg	K	Na	Na corr	Ca:Mg Ratio	Exch Al	Exch Acidity	ECEC	Al sat %	Base Status	ESP	Na+Mg % ECEC	Al	Fe
				dS/m		mg/kg		cmol_c/kg						cmol_c/kg							%	
486	Gv	0.80-0.90	6.6	0.85		1260	< 1	<0.14	13.10	0.16	8.76	5.2	-----	-----	-----	18.6	-----	37.2	28.0	98.3	-----	-----
486	Gv	0.90-1.00	6.7	0.91		1350	< 1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
486	Gv	1.00-1.10	6.7	0.95		1420	< 1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
486	Gv	1.10-1.20	6.7	0.97		1440	< 1	<0.14	16.50	0.23	10.70	6.6	-----	-----	-----	23.5	-----	46.9	28.0	98.3	-----	-----
486	Gv	1.20-1.30	6.9	0.97		1450	< 1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
173	Hs	0.30-0.40	5.5	0.05	0.43	<20	<1	3.56	1.78	0.08	<0.08	<0.08	2.00	<0.03	<0.03	< 5.53	<0.5	12.2	< 1.5	< 33.8	0.4	4.7
418	Hs	0.50-0.60	5.7	0.04	0.33	-----	-----	1.20	5.31	0.07	0.19	0.2	0.23	-----	-----	6.7	-----	13.5	2.8	82.1	0.4	8.6
17	IsGsv	0.60-0.70	5.1	0.05	0.41	29	<1	<0.14	5.22	0.04	0.53	0.4	<0.02	0.82	1.05	6.9	11.9	14.6	6.4	82.1	-----	-----
159	IsGsv	0.50-0.60	5.5	0.05	0.43	-----	-----	<0.14	4.92	0.05	0.47	0.5	<0.03	-----	-----	5.5	-----	12.3	8.5	98.0	-----	-----
159	IsGsv	1.20-1.30	4.2	0.10	0.75	-----	-----	<0.14	1.07	0.06	0.40	0.4	<0.13	4.23	4.92	6.3	67.5	2.7	6.3	23.3	-----	-----

WIN Site No.	WIN SPC	Sample Depth (m)	Method																				
			S_AQ4_EL			S_AQ4_AA		S_CAT_EQ					Ca:Mg Ratio	* S_EX_ALAC			Al sat %	Base Status	ESP	Na+Mg % ECEC	* S_CIT_RED	
			pH	EC 1:5	EC SE	Cl	NO3- N	Ca	Mg	K	Na	Na corr		Exch Al	Exch Acidity	ECEC					Al	Fe
				dS/m		mg/kg		cmol_c/kg						cmol_c/kg							%	
101	Ko	0.30-0.45	5.4	0.03	0.25	<20	<1	<0.14	6.93	0.12	0.77	0.8	<0.02	6.76	8.06	17.6	42.2	15.9	4.4	43.8	-----	-----
117	Ko	0.35-0.45	5.0	0.32	2.61	402	<1	1.94	11.30	0.13	5.21	4.07	0.17	9.47	11.40	28.8	34.5	46.5	14.1	53.4	-----	-----
162	KoRv	0.40-0.55	5.1	0.03	0.25	32	<1	<0.14	4.61	0.04	0.22	0.1	<0.03	2.07	2.44	7.4	28.1	9.8	1.8	64.4	-----	-----
358	KoRv	0.80-0.90	4.4	0.06	0.50	-----	-----	<0.14	1.90	0.19	0.51	0.5	<0.07	10.30	12.10	14.4	71.6	5.5	3.5	16.7	-----	-----
202	Pp	0.30-0.50	5.7	0.38	2.84	420	<1	0.91	7.14	0.09	3.89	2.74	0.13	0.1	0.11	11.0	0.9	18.2	24.9	89.8	-----	-----
340	Pp	0.35-0.45	5.7	0.13	1.06	-----	-----	0.34	4.76	0.06	2.06	2.1	0.07	-----	-----	7.2	-----	14.4	28.6	94.7	-----	-----
545	Pp	0.20-0.30	5.1	0.12		142	< 1	<0.14	3.69	0.05	1.55	1.2	<0.04	-----	-----	5.0	-----	10.6	23.0	96.8	-----	-----
545	Pp	1.10-1.20	9.7	0.74		682	< 1	2.16	6.57	0.09	4.51	-----	0.43	-----	-----	13.3	-----	27.8	24.0	83.3	-----	-----

WIN Site No.	WIN SPC	Sample Depth (m)	Method																			
			S_AQ4_EL			S_AQ4_AA		S_CAT_EQ						* S_EX_ALAC							* S_CIT_RED	
			pH	EC 1:5	EC SE	Cl	NO^{3-} N	Ca	Mg	K	Na	Na corr	Ca:Mg Ratio	Exch Al	Exch Acidity	ECEC	Al sat %	Base Status	ESP	Na+Mg % ECEC	Al	Fe
				dS/m		mg/kg		cmol_c/kg						cmol_c/kg							%	
658	Pp	0.00-0.10	5.1	0.12		34	19	1.19	1.32	0.29	0.43	0.318	0.90	0.38	0.64	3.8		8.9	8.5	43.0		
658	Pp	0.50-0.60	8.9	0.26		194	1	0.98	3.26	<0.050	2.03	-----	0.30	-----	-----	6.3	-----	12.6	32.4	84.4	-----	-----
658	Pp	0.80-0.90	8.6	0.28		307	< 1	<0.600	3.32	<0.050	3.24	-----	< 0.18	-----	-----	6.6	-----	14.4	49.4	100.0	-----	-----
658	Pp	1.10-1.20	8.6	0.33		401	< 1	<0.600	3.26	<0.050	3.85	-----	<0.18	-----	-----	7.1	-----	15.5	54.1	100.0	-----	-----
658	Pp	1.40-1.50	8.6	0.52		650	< 1															
181	Rb	0.80-0.90	5.4	0.03	0.25	-----	-----	<0.14	0.79	0.04	0.37	0.4	<0.17	1.94	2.52	3.6	54.3	2.5	10.3	32.2	-----	-----
333	Rb	0.00-0.10	5.2	0.02		< 20	<1	0.44	0.30	0.04	0.10	0.1	-----	0.25	0.37	1.3	20.0	5.9	8.0	32.0	-----	-----
333	Rb	0.20-0.30	5.3	0.01		< 20	<1	<0.14	0.07	<0.03	0.09	0.1	-----			< 0.3	-----	6.8	-----	-----	-----	-----
333	Rb	0.50-0.60	6.9	0.25		287	<1	<0.14	3.03	<0.03	3.33	2.5	-----	-----	-----	5.7	-----	12.6	44.2	97.3	-----	-----
333	Rb	0.60-0.70	7.3	0.41		507	<1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
333	Rb	0.70-0.80	7.6	0.40		499	<1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
333	Rb	0.80-0.90	7.6	0.45		549	<1	<0.60	4.14	0.06	4.56	-----	0.15	-----	-----	9.4	-----	20.8	49.0	93.0	-----	-----
333	Rb	0.90-1.00	7.6	0.57		719	<1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

WIN Site No.	WIN SPC	Sample Depth (m)	Method																			
			S_AQ4_EL			S_AQ4_AA		S_CAT_EQ					Ca:Mg Ratio	* S_EX_ALAC			Al sat %	Base Status	ESP	Na+Mg % ECEC	* S_CIT_RED	
			pH	EC 1:5	EC SE	Cl	NO^{3-}-N	Ca	Mg	K	Na	Na corr		Exch Al	Exch Acidity	ECEC					Al	Fe
				dS/m		mg/kg		cmol_c/kg						cmol_c/kg							%	
333	Rb	1.00-1.10	7.6	0.64		808	<1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
333	Rb	1.10-1.20	7.6	0.68		862	<1	<0.60	5.46	0.06	6.89	-----	0.46	-----	-----	13.0	-----	26.02	53.0	95.0	-----	-----
333	Rb	1.20-1.30	7.5	0.78		992	<1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
333	Rb	1.30-1.40	7.5	0.83		1050	<1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
333	Rb	1.40-1.50	7.5	0.75		930	<1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
37	Tr	0.40-0.55	4.9	0.40	2.98	575	<1	<0.14	6.81	0.12	4.81	3.19	<0.02	5.24	6.31	16.6	31.6	17.1	19.2	60.2	-----	-----
73	Tr	0.37-0.50	5.0	0.02	0.16	26	<1	0.18	5.37	0.19	0.64	0.6	<0.03	9.32	11.40	17.5	53.1	12.3	3.2	33.9	-----	-----
119	Tr	1.15-1.30	5.2	0.08	0.57	-----	-----	0.47	6.81	0.07	1.49	1.5	0.07	2.24	2.95	10.4	21.6	14.7	14.3	79.8	-----	-----
149	Tr	0.40-0.50	6.6	0.39	3.46	387	<1	0.18	3.65	0.11	3.55	2.46	0.05	0.15	0.15	6.6	2.3	14.2	37.6	93.3	-----	-----
209	Tr	0.45-0.60	5.2	0.18	1.34	261	<1	0.38	5.17	0.05	1.82	1.09	0.07	2.03	2.46	9.2	22.2	11.1	11.9	68.4	-----	-----

WIN Site No.	WIN SPC	Sample Depth (m)	Method: S_AQ4_EL pH	S_AQ4_EL $EC_{1:5}$ (dS/m)	S_AQ4_EL EC_{SE} (dS/m)	S_AQ4_AA Cl (mg/kg)	S_AQ4_AA NO^{3-}-N (mg/kg)	S_CAT_EQ Ca (cmol_c/kg)	S_CAT_EQ Mg (cmol_c/kg)	S_CAT_EQ K (cmol_c/kg)	S_CAT_EQ Na (cmol_c/kg)	S_CAT_EQ Na corr (cmol_c/kg)	Ca:Mg Ratio	* S_EX_ALAC Exch Al (cmol_c/kg)	* S_EX_ALAC Exch Acidity (cmol_c/kg)	* S_EX_ALAC ECEC (cmol_c/kg)	Al sat %	Base Status	ESP	Na+Mg % ECEC	* S_CIT_RED Al (%)	* S_CIT_RED Fe (%)
297	Wf	0.00-0.10	5.9	0.03		< 20	6	3.24	0.59	0.09	<0.08	<0.08	5.49	-----	-----	4.0	-----	40	< 2.0	<16.8	-----	-----
297	Wf	0.50-0.60	5.5	0.01		< 20	1	0.18	<0.03	<0.03	<0.08	<0.08	< 6.00	-----	-----	< 0.3	-----	< 6.4	-----	-----	-----	-----
297	Wf	0.80-0.90	5.7	0.02		< 20	<1	<0.14	<0.03	<0.03	<0.08	<0.08	4.66	-----	-----	< 0.3	-----	< 5.6	-----	-----	-----	-----
84	Wh	0.15-0.30	5.0	0.17	1.39	181	<1	0.23	8.05	0.13	1.83	1.32	0.03	3.44	4.27	14.0	24.6	19.2	9.4	66.9	-----	-----
225	Wh	0.40-0.55	5.4	0.11	0.82	-----	-----	0.31	5.84	0.10	2.20	2.2	0.05	3.81	4.58	10.9	34.9	14.0	20.2	73.8	-----	-----
531	Wh	0.50-0.60	8.0	0.11		74	2	0.92	4.92	0.16	2.95	-----	0.19	-----	-----	9.0	-----	14.9	32.9	87.9	-----	-----
531	Wh	0.80-0.90	9.3	0.20		110	2	<0.60	5.44	0.19	5.94	-----	< 0.1	-----	-----	11.6	-----	20.2	51.3	98.3	-----	-----
531	Wh	1.10-1.20	9.7	0.32		99	< 1	0.64	5.27	0.17	5.19	-----	0.12	-----	-----	11.3	-----	18.8	46.0	92.8	-----	-----
156	Wt	0.60-0.70	5.3	0.03	0.25	26	<1	<0.14	2.80	<0.03	0.28	0.2	<0.05	2.23	2.61	5.8	38.6	6.9	3.6	52.1	-----	-----
122	Yd	0.70 -0.85	6.0	0.02	0.18	-----	-----	<0.14	3.54	0.05	0.40	0.4	<0.04	-----	-----	4.1	-----	9.2	9.7	96.0	-----	-----

WIN Site No.	WIN SPC	Sample Depth (m)	Method																			
			S_AQ4_EL			S_AQ4_AA		S_CAT_EQ						* S_EX_ALAC							* S_CIT_RED	
			pH	$EC_{1:5}$	EC_{SE}	Cl	NO^{3}- N	Ca	Mg	K	Na	Na corr	Ca:Mg Ratio	Exch Al	Exch Acidity	ECEC	Al sat %	Base Status	ESP	Na+Mg % ECEC	Al	Fe
				dS/m		mg/kg		cmol_c/kg						cmol_c/kg							%	
216	Yd	0.90-1.10	5.7	0.05	0.44	-----	-----	1.69	2.74	0.29	<0.08	<0.08	0.61	-----	-----	4.8	-----	10.7	< 1.7	< 58.8	-----	-----
335	Yd	0.00-0.10	5.6	0.01		< 20	<1	0.63	0.42	0.06	<0.08	<0.08	1.50	0.25		< 1.4	-----	23.8	< 5.7	< 36	-----	-----
335	Yd	0.50-0.60	5.7	0.01		< 20	<1	<0.14	0.31	<0.03	<0.08	<0.08	-----	-----	-----	< 0.6	-----	-----	-----	-----	-----	-----
335	Yd	0.80-0.90	5.6	0.01		< 20	<1	<0.14	0.26	<0.03	<0.08	<0.08	-----	-----	-----	< 0.5	-----	-----	-----	-----	-----	-----
335	Yd	1.10-1.20	5.3	0.01		< 20	<1	<0.14	0.33	<0.03	<0.08	<0.08	-----	0.47	1.06	1.6	28.7	11.6	4.9	-----	-----	-----
335	Yd	1.40-1.50	5.2	0.03		< 20	<1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Note: All results reported on an air dried basis.

Appendix 7: Chemical results and calculated ratios for sampled soil profiles, WIN, BAB and CBW study areas

SPC	Depth (m) or horizon	pH	EC (dS/m)	Cl mg/kg	Clay (%)	ECEC	Ca	Mg	K	Ca/Mg ratio	ESP% ***
						(m. equiv / 100 g)					
	0-0.10	4.6-5.6	0.03-0.07	<100	6-10	1-4	0.10-2.40	0.20-1.10	0.06-0.16	1.0-2.2	2-8
Alloway (5)	0.50-0.60	4.9-7.2	0.01-0.07	<100	8-29	1-3	0.20-0.31	0.20-1.90	0.01-0.04	0.2-1.2	4-19
	1.10-1.20	5.6-6.3	0.04-0.14	<100	25-44	3-5	0.07-5.0	2.8-4.7	0.01-0.04	<0.1-0.2	5-17
	0-0.10	5.4-5.9	0.04-0.10	<100	7-17	3-11	0.5-6.0	0.80-1.10	0.15-0.46	0.3-5.5	3-4
Auburn (4)	0.50-0.60	5.9-9.1	0.77-0.78	400-1000	31-42	14-21	0.3-6.3	8.70-13.00	0.10-0.50	<0.1-0.5	10-36
	1.10-1.20	8.6		1300	37	17	4.90	10.00	0.20	0.5	40
*Auburn (1) ** *	0.50-0.60	5.2	0.08			9.5	2.31	5.79	0.21	0.4	7.2
	0-0.10	5.2-5.6	0.01-0.03	<100	4-12	1-5	0.20-2.20	0.44-1.70	0.05-0.15	<0.3	5-20
Avondale (5)	0.50-0.60	5.0-5.5	0.05-0.27	<100-800	34-54	5-19	0.10-1.30	2.70-10.40	0.02-0.20	<0.2	16-43
	1.10-1.20	5.0-5.2	0.40	400-800	37	10-23	0.20-1.50	5.50-12.10	0.10	<0.3	43
	0-0.10	4.6	0.09	<100	11	1	0.47	0.57	0.22	0.8	6
Booyal (1)	0.50-0.60	5.9	0.03	<100	46	4	1.20	2.90	0.04	0.4	6
	1.10-1.20	5.9	0.07	<100	51	6	0.80	4.30	0.04	0.2	7
Brooweena (2)	0-0.10	5.9	0.05		13	3	0.67	1.36	0.22	0.5	12
	0.50-0.60	8.3	0.28-0.51	200-5000	65	15-20	<0.60	9.47-16.30	<0.10	<0.1	18-32

	0-0.10	4.7-5.0	0.14	<100	53-70	7-23	1.30-8.00	3.40-5.10	0.30-0.43	0.4-1.6	6-14
Bucca (2)	0.50-0.60	4.4-5.2	0.10	<100	66-70	7-22	0.70-1.20	3.30-3.70	0.10-0.22	<0.4	9-28
	1.10-1.20	4.5-5.4	0.10	<100-500	72-80	20-46	0.47-1.80	7.70-17.00	0.35-0.52	<0.3	13-47
	0-0.10	6.2	0.03	<100	9	5	2.40	1.80	0.33	1.3	3
Burnett (1)	0.50-0.60	6.7	0.01	<100	2	3	2.10	0.90	0.11	2.3	6
	1.10-1.20	7.1	0.01	<100	2	4	2.50	1.00	0.10	2.5	4
	0-0.10	5.6		<100	7	4	2.50	1.00	0.30	2.5	10
Crossing (1)	0.50-0.60	7.7		100	28	13	3.40	6.60	0.15	0.5	20
	1.10-1.20	9.2		<100	17	11	1.40	4.30	0.10	0.3	48
	0-0.10	4.6-4.7	0.12	<100	36-41	10	1.40	1.60	1.20	0.9	6
Fairydale (2)	0.50-0.60	4.1-4.3	0.15-0.20	100-200	38-51	5-10	0.42-1.20	0.47-2.60	0.15-0.43	0.5-0.9	3-16
	1.10-1.20	4.3	0.17	100	16	6	0.22	0.74	0.16	0.3	13
	0-0.10	4.8	0.36	300	48	11	6.30	3.30	0.36	1.9	11
Fairymead (1)	0.50-0.60	4.4	0.36	200	52	7	2.50	2.60	0.24	1.0	30
	1.10-1.20	4.2	0.48	300	45	7	0.41	3.50	0.38	0.1	40
	0-0.10	5.2-6.0	0.02-0.09	<300	4-15	1-7	0.60-4.50	0.25-1.60	0.13-0.63	1.2-3.5	1-5
Farnsfield (7)	0.50-0.60	5.0-6.2	< 0.03	<300	14-40	1-4	0.51-2.50	0.17-1.70	0.02-0.16	0.8-5.9	2-10
	1.10-1.20	5.2-6.2	< 0.06	<800	31-50	3-4	0.36-2.00	1.60-2.10	0.03-0.10	0.2-1.4	3-8

*Farnsfield, sandy variant (1) ** *	0-0.10	6.6	0.04	<100	7	7	5.92	0.52	0.30	11.5	<1.1
	0.50-0.60	5.4	0.02	<100	7	1	0.55	0.12	0.06	4.5	8
	1.10-1.20	5.5	0.02	<100	9	1	0.62	0.17	0.06	3.8	<1
Flagstone (3)	0-0.10	6.7-7.3	0.04-0.11	<100	23-34	15-23	8.80-15.00	4.80-7.30	0.32-0.84	1.7-2.1	3-4
	0.50-0.60	6.7-7.5	0.05-0.12	<100-200	23-36	15-25	9.60-18.00	3.40-7.30	0.15-0.24	2.2-3.9	4
	1.10-1.20	7.6-7.7	0.06-0.01	<100	19-33	13-19	8.30-14.00	4.10-4.20	0.19-0.24	2.0-3.3	4-5
Gigoon (1)	0-0.10	5.8	0.02	<200	5	1	0.64	0.46	0.11	1.4	14
	0.50-0.60	6.9	0.41	4700	33	15	0.01	9.10	0.08	<0.1	36
	0.80-0.90	7.0	0.36	4700	38	17	0.01	10.00	0.11	<0.1	59
*Gigoon (2)** *	Upper B horizon	5.9-6.7	0.09-0.25			15-18	0.57-0.97	11.6-12.6	0.13-0.18	<0.1	18-26
Givelda (2)	0-0.10	6.3-6.4	0.03-0.07	<100	11-17	6	3.10-3.20	2.50-2.70	0.33-0.36	1.2	3
	0.50-0.60	5.2-6.4	0.56-0.72	630-1300	43	22-31	1.30-3.20	12.00-19.00	0.20-0.23	<0.2	28-35
	1.10-1.20	5.0	0.56	800	28	17	0.47	8.80	0.18	0.1	38
*Givelda (2) ** *	0-0.10	4.9	0.08	<100	12	4	0.56	1.71	0.10	0.3	6
	0.50-0.60	5.2-6.6	0.45-0.48	600-700	47	13-17	<0.14	9.30-12.20	0.06-0.12	<0.1	26
	1.10-1.20	6.7	0.97	14400	47	24	<0.14	16.50	0.23	<0.01	28

Gooburrum (4)	0-0.10	5.6-5.9	0.04	<100	8-15	2-4	1.30-2.30	0.60-1.20	0.10-0.25	1.5-3.6	4-8
	0.50-0.60	4.6-5.9	0.04	<100	10-31	1-2	0.14-0.70	0.30-1.20	0.01-0.10	0.2-2.0	6-10
	1.10-1.20	5.5-5.7	0.07	<100	42-65	3-6	0.20-1.80	1.90-2.10	0.01-0.15	<0.1-0.7	4-16
Howes (2)	0-0.10	6.1-6.9	0.10	<100	39-48	12-14	6.20-8.20	3.80-5.50	0.75-1.30	1.5-1.6	2-3
	0.50-0.60	5.7-6.4	0.03	<100	50-60	6-8	2.20-4.00	1.40-3.10	0.14-0.30	1.3-1.6	5
	1.10-1.20	5.0-6.7	0.06	<100	55-58	5	0.30-2.30	1.30-2.60	0.1-0.63	0.2-0.9	6-10
*Howes (2) **	Upper B horizon	5.5-5.7	0.05	<100		6	1.20-3.56	1.78-5.31	0.08	0.2-2.0	<3
Isis (1)	0-0.10	5.8	0.03	<100	7	3	1.4	0.68	0.05	2.1	5
	0.50-0.60	5.9	0.01	<100	10	2	0.73	1	0.02	0.7	12
	1.10-1.20	5.5	0.02	<100	35	4	0.24	2.9	0.02	0.1	10
Kepnock(9)	0-0.10	4.6-6.6	0.02-0.14	<100	6-21	1-5	0.19-3.20	0.20-2.40	0.06-0.43	0.5-2.9	3-7
	0.50-0.60	5.0-5.9	0.02-0.48	<100	6-64	1-8	0.10-1.20	0.26-5.20	0.01-0.06	<0.1-2.3	4-31
	1.10-1.20	4.9-5.9	0.05-0.07	<100	51-58	4-7	0.09-0.80	3.60-5.00	0.03-0.06	<0.1-0.2	7-27

Kinkuna (4)	0-0.10	4.6-6.2	<0.03	<100	1-6	1-3	0.25-0.75	0.50-1.86	0.05-0.12	0.1-2.3	1-9
	0.50-0.60	4.8-6.0	< 0.02	<100	3-5	1	0.03-0.40	0.02-0.40	0.02-0.05	0.2-3.0	3-13
	1.10-1.20	5.1-6.3	0.01	<100	4-9	1	0.04-0.40	0.09-0.46	0.01-0.05	<0.1-2	5-17
Kolan (4)	0-0.10	5.2-6.2	0.03-0.14	<100	6-27	5-9	2.20-2.90	1.90-4.40	0.22-0.48	0.7-1.2	7-12
	0.50-0.60	4.8-5.6	0.26-0.74	300-1000	39-61	15-22	0.10-0.21	7.40-13.00	0.15-0.30	<0.1	19-41
	1.10-1.20	4.9	0.48	600-900	31-63	12-34	0.20-0.27	4.90-18.00	0.13-0.45	<0.1	29-40
*Kolan (1) **	Upper B horizon	5.0-5.4	0.03-0.32	<100-400		17-29	<0.15-1.94	6.93-11.30	0.12-0.13	<0.1-0.2	4.4-14
Kolan, Red Variant (1)	0-0.10	5.8	0.04	100	15	9	3.80	4.40	0.80	0.9	3
	0.50-0.60	5.4	0.46	300	49	18	0.05	11.00	0.31	<0.1	28
	1.10-1.20	4.9	0.48	300	43	23	0.06	13.00	0.31	<0.1	30
*Kolan, Red Variant (2) **	Upper B horizon	5.1	0.03	<100		7	<0.14	4.61	0.04	<0.1	2
	Lower B horizon	4.4	0.06			14	<0.14	1.90	0.51	<0.1	4
Meadowvale (6)	0-0.10	4.8-5.9	0.02-0.05	<100	4-10	1-4	0.18-3.70	0.33-1.50	0.07-0.11	0.3-2.5	2-26
	0.50-0.60	4.6-5.7	< 0.02	<100	4-20	1-3	0.04-0.20	0.20-2.10	0.01-0.10	<0.1-1.0	2-20
	1.10-1.20	4.8-5.9	0.01-0.06	<100	30-60	1-6	0.03-1.80	0.76-5.55	0.02-0.10	<0.1-0.5	5-16

Moore Park (1)	0-0.10	6.2	0.28	200	10	4	2.40	1.30	0.36	1.8	2
	0.50-0.60	8.0	0.10	<100	15	5	3.10	1.30	0.05	2.4	10
	1.10-1.20	7.9	0.08	<100	15	5	1.10	3.10	0.12	0.4	15
Oakwood (6)	0-0.10	5.5-5.9		<100	20-48	5-9	2.90-7.20	1.30-2.10	0.10-0.50	1.7-4.8	2-6
	0.50-0.60	5.0-5.7		<100	29-53	3-5	1.30-3.20	0.90-1.80	0.10-0.33	0.8-2.0	4-10
	1.10-1.20	4.8-6.1		<100	42-68	2-6	0.40-3.50	0.90-2.50	0.10-0.20	0.2-1.4	4-10
Peep (3)	0-0.10	4.8-6.1	0.04-0.07	<100	6-12	2	0.53-2.00	0.97	0.07-0.20	1.1	5-13
	0.50-0.60	5.0-7.4	0.07-0.28	<100-1200	17-35	4-9	0.10-0.34	0.40-8.00	0.01-0.15	0.1-0.9	28-55
	1.10-1.20	4.8-7.4	0.14-0.38	500-1000	25-34	10-14	0.10-0.75	0.90-5.40	0.03-0.20	<0.1-0.8	43-47
*Peep (4) ** *	A horizon	5.1	0.12		13	4	1.19	1.32	0.29	0.9	9
	Upper B horizon	5.1-8.9	0.13-0.38	<100-400	20-39	6-11	0.34-0.98	3.26-7.14	<0.05-0.09	<0.1-0.3	23-32
	Lower B horizon	8.6-9.7	0.33-0.74	400-700	20-45	6-13	<0.06-2.16	3.26-6.57	<0.05-0.09	0.2-0.4	24-54
Quart (6)	0-0.10	5.2-6.3	0.01-0.06	<100	1-12	2	0.88-1.50	0.17-0.77	0.05-0.41	1.4-8.8	2-3
	0.50-0.60	5.1-6.4	0.01-0.03	<100	3-40	1-4	0.25-2.30	0.19-1.90	0.03-0.20	0.8-1.8	3-14
	1.10-1.20	4.8-6.1	0.01-0.06	<100	20-42	2-4	0.48-1.90	0.59-2.30	0.01-0.26	0.5-0.8	2-3

Robur (9)	0-0.10	4.4-6.0	0.01-0.05	<100	1-8	1-2	0.10-0.98	0.20-0.80	0.01-0.08	0.2-1.9	1-14
	0.50-0.60	5.5-6.4	0.01	<100	1-14	1-2	0.03-0.16	0.09-1.40	0.01-0.06	<0.1-1.3	1-15
	1.10-1.20	4.6-6.7	0.03-0.16	<100-200	25-56	4-11	0.04-0.17	3.70-7.90	0.01-0.08	<0.1	9-36
Robur (2) **	0-0.10	5.2-5.3	0.01-0.02	<100	2	1	<0.14-0.44	0.07-0.30	<0.04	<0.1	<1-8
	0.50-0.60	6.9	0.25	300	14	6	<0.14	3.33	<0.03	<0.1	44
	0.80-0.90	5.4-7.6	0.03-0.45	<100-500	23	4-9	<0.60	0.79-4.14	0.04-0.06	<0.1-0.2	10-49
	1.10-1.20	7.6	0.68	900	28	13	<0.60	5.46	0.06	0.1	53
Theodolite (1)	0-0.10	5.4	0.02		5	1	0.06	0.16	0.03	0.4	13
	0.50-0.60	5.3	0.01		4	1	0.04	0.11	0.01	0.4	11
	1.10-1.20	5.1	0.02		31	1	0.04	1.09	0.03	<0.1	19
Tirroan (1)	0-0.10	5.7		<100	10	2	0.50	0.50	0.10	1	10
	0.50-0.60	5.8		<100	6	1	0.20	0.30	0.10	0.7	20
	1.10-1.20	5.6		<100	41	5	0.20	3.90	0.10	<0.1	18
Tirroan (5) **	Upper subsoil	4.9-6.6	0.02-0.40	<100-600		9-18	<0.14-0.38	3.65-6.81	0.05-0.12	<0.1	3.2-38
	Lower subsoil	5.2	0.08			10	0.47	6.81	0.07	<0.1	14
Turpin (3)	0-0.1	5.4-5.7	0.01-0.03	<100	6-7	1-2	0.26-0.96	0.47-1.10	0.05-0.10	0.4-1.5	1-2
	0.5-0.6	5.1-5.4	0.04-0.22	<100	42-49	7-10	0.07-0.25	4.70-4.90	0.08-0.13	<0.1	19-51

Walla (2)	0-0.10	5.4-6.2	0.07-0.09	<100	24-29	11-17	4.70-7.80	5.5-7.6	0.46-1.00	0.9-1.0	3
	0.50-0.60	5.1-5.9	0.25-0.57	<100-730	44-47	18-21	2.90-4.30	9.30-13.00	0.21-0.27	0.2-0.50	14-25
	1.10-1.20	5.5-5.98	0.50-1.21	800-1800	57-58	30-31	3.00-7.70	17.00	0.30-0.38	0.2-0.50	19-32
Watalgan (2)	0-0.10	6.2-.64	0.03-0.04	<100	20-37	10	3.80	5.00	0.23	0.8	3
	0.50-0.60	4.7-6.1	0.02-0.50	<100	55-68	2-5	0.43-0.89	1.20-3.90	0.03-0.13	0.1-0.7	7-10
	1.10-1.20	6.1	0.03	<100	61	4	0.10	3.70	0.03	<0.1	10
Watalgan, Grey subsoil variant (1) **	Lower B horizon	5.3	0.03	<100		6	<0.14	2.80	<0.03	<0.1	3.6
Winfield (1) **	0-0.10	5.9	0.03	<100	4	4	3.24	0.59	0.09	5.5	<2
	0.50-0.60	5.5	0.01	<100	<1	1	0.18	<0.03	<0.03	6.0	8
	0.80-0.90	5.7	0.02	<100	<1	1	<0.14	<0.03	<0.03	4.7	8
Weithew (3) **	A horizon	5.0	0.17	200		14	0.23	8.05	0.13	<0.1	9
	Upper B horizon	5.4-9.0	0.11	<100	41	9-11	0.31-0.92	4.92-5.84	0.10-0.16	<0.1-0.2	20-33
	Lower B horizon	9.3-9.7	0.20-0.32	1000-1100	34	11	0.60	5.27-5.44	0.17-0.19	<0.1	46-51

Woolmer (3)	0-0.10	5.0-6.2	0.02-0.06	<100	7-13	1-3	0.10-2.50	0.23-0.48	0.04-0.22	0.2-0.5	3-9
	0.50-0.60	5.5-5.8	0.03-0.04	<100	23-47	2-5	0.07-0.26	1.90-4.30	0.02-0.05	<0.1	3-8
	1.10-1.20	5.2-5.6	0.04-0.06	<100	56-57	4-5	0.04-0.27	3.50-4.60	0.01-0.05	<0.1	7-9
*Yandaran (3) **	A horizon	5.6-5.7	0.01	<100	4	<1	<0.14	0.30	<0.03	1.5	<5
	B horizon	5.2-6.0	<0.05	100	45	1-5	<0.14-1.70	0.30-3.50	<0.03-0.3	<0.1-1.5	1.7-9.7

Notes

*** The relevence of calculating ESP is questionable as an indicator of dispersion in soils with low pH (or high acidity), very low ECEC, high values of exchangeable aluminium or low clay content. The range of ESP given for *Bucca* SPC in Donnollan *et al.* (1998) includes values that are unlikley to be typical for this soil. Note: All results reported on an air dried basis.

Appendix 8: Estimated effective rooting depth and PAWC of SPCs, WIN study area

SPC	Estimated Rooting Depth (m)	Soil property reducing rooting depth	Estimated PAWC (mm)
Alloway (Al)	> 1.0	Subsoil wetness	63-65
Auburn (Ab)	0.4-0.9	Sodic subsoil	50-85
Avondale (Av)	0.4-0.6	Sodic subsoil	43-55
Barubbra (Bb)	> 1.0	Nil	< 50
Berren (Be)	0.4-0.7	Depth to rock	< 50
Booyal (Bl)	0.6-1.0	Depth to rock	60-100
Brooweena (Bw)	0.3-0.4	Sodic subsoil	< 50
Bucca (Bc)	0.4-0.7	Depth to rock	45-70
Bungadoo (Bg)	0.7-0.9	Depth to rock	< 50
Burnett (Bn)	> 1.0	Nil	< 50
Calavos (Ca)	> 1.0	Nil	63-73
Cedars (Cr)	0.7-1.0	Depth to rock	75-100
Colvin (Cv)	> 1.0	Nil	< 50
Crossing (Cg)	0.3-0.7	Sodic subsoil	< 50
Doongul (Do)	0.3-0.6	Sodic subsoil	40-65
Fairydale (Fd)	0.6-0.8 m	Sodic and extremely acid subsoil with high aluminium levels; subsoil wetness	80-100
Fairymead (Fm)	0.6-0.8 m	Sodic, salty and extremely acid subsoil with high aluminium levels; subsoil wetness	80-120
Farnsfield (Ff)	> 1.0	Nil	69-84
Flagstone (Fs)	> 1.0	Nil	74-92
Gahan (Gh)	> 1.0	Nil	60-75
Gigoon (Gn)	0.3-0.6	Sodic subsoil	35-55
Gillen (Gi)	> 1.0	Nil	55-65
Givelda (Gv)	0.3-0.4	Sodic subsoil	30-55
Gooburrum (Gb)	> 1.0	Nil	60-65
Howes (Hs)	> 1.0	Nil	110-120
Isis (Is)	> 1.0	Nil	57-65
Isis, Grey subsoil variant (IsGsv)	0.6-1.0 m	Sodic subsoil	50-65
Kepnock(Kp)	> 1.0	Nil	74-105
Kinkuna (Kn)	> 1.0	Subsoil wetness	< 50
Kolan (Ko)	0.3-0.4	Sodic and strongly acid subsoil with high aluminium levels	30-55
Kowbi (Kb)	0.4-0.7	Depth to rock	65-100

SPC	Estimated Rooting Depth (m)	Soil property reducing rooting depth	Estimated PAWC (mm)
Littabella (Lt)	> 1.0	Nil	45-80
Maroom (Mm)	0.6-0.8	Sodic subsoil; subsoil wetness	45-65
Meadowvale (Md)	> 1.0	Nil	65-70
Moolyung (My)	0.2-0.4	Depth to rock	< 50
Moore Park (Mp)	> 1.0	Nil	< 50
Oakwood (Ok)	> 1.0	Nil	100-110
Owanyilla (Ow)	0.4	Sodic subsoil	< 50
Peep (Pp)	0.4-0.8	Sodic subsoil	40-65
Quart (Qr)	> 1.0	Nil	54-82
Robur (Rb)	0.5-1.0	Sodic subsoil; subsoil wetness	47-52
Rothchild (Rt)	> 1.0		< 50
Sugarmill (Sm)	0.5-1.0	Sodic subsoil	60-100
Takoko (Tk)	0.2-0.5	Depth to rock	< 50
Tantitha (Tt)	> 1.0		< 50
Theodolite (Th)	> 1.0	Subsoil wetness	< 50
Tiaro (Ta)	0.6-0.9	Depth to rock	60-115
Tirroan (Tr)	0.4-0.6	Sodic subsoil	< 50
Turpin (Tp)	0.4-0.6	Sodic subsoil, subsoil wetness	< 50
Walla (Wl)	0.4-0.9	Sodic and salty subsoil	75-110
Wallum (Wm)	> 1.0		< 50
Watalgan (Wt)	> 1.0		75-148
Watalgan, Grey subsoil variant (WtGsv)	0.8-1.0	Sodic subsoil	75-100
Weithew (Wh)	0.6-0.9	Sodic subsoil	100-125
Winfield (Wf)	> 1.0	Subsoil wetness	< 50
Woolmer (Wr)	> 1.0		73-90
Yandaran (Yd)	> 1.0		45-55

Notes

1. Estimated PAWC to 1.0 m profile depth, unless effective rooting depth is less than 1.0 m.
2. Estimated PAWC from BAB, CBW or MTL reports where data available.
3. Where data not available in these reports, estimated was calculated for WIN soil profiles where chemical data available using the PAWCER equations.
4. For those SPCs where PAWC could not be estimated using data from notes 2 or 3 above, Table A1-2 “Soil texture look up table” from RPI Act Guideline 08/14, 31st July 2015 based on soil texture was used to calculate estimated PAWC.
5. Estimated PAWC does not take into account water used by crop plants from shallow ground water tables or layers that may become seasonally waterlogged for weeks or months.

Appendix 9: Agricultural suitability scheme, WIN study area

The land suitability scheme for the WIN study area is based on the existing Regional Suitability Framework for the Coastal Burnett Area (2013). The existing framework was modified to be consistent with (where possible):

- Published Land Suitability Schemes from other coastal surveys in the region, Bundaberg area (Donnollan *et al.* 1998), Childers area (Wilson 1997), Maryborough-Hervey Bay area (Wilson *et al.* 1999) and Maryborough-Tiaro area (Zund and Brown 2001) as well as other coastal areas such as Calliope and Yeppoon (Ross 1999) and Woongoolba-Rocky Point (Ellis & Wilson 2010).

- Guidelines for Agricultural Land Evaluation in Queensland 2nd Edition (DSITI & DNRM 2015).

- Recent information from industry, based on updated technology, crop varieties and / or grower experience.

Land management options considered in other coastal land suitability schemes are not considered in this scheme where they are no longer important agricultural land uses in the Bundaberg area (for example asparagus). Some dryland (or rainfed) crops are included in this scheme that are not included in other coastal schemes, as they are important land management options in the WIN study area (for example dryland sugarcane). Table 1 and 2 below list the land management options and limitations considered in the WIN land suitability scheme.

For most limitations, all land management options have been listed with a subclass for each limitation value. There are some limitations that only apply to a limited number of land management options, such as furrow irrigation, deep drainage (If) and soil adhesiveness (Pa). For these limitations, only the land management options affected by this limitation are listed with subclasses for each value. All other land management options are grouped together.

A subclass of zero (0) has been used to identify a limitation value for a land management option that is not severe (subclass 4) or extreme (subclass 5), but due to insufficient knowledge or data at the time of survey it could not be determined if the limitation value is negligible (subclass 1), minor (subclass 2) or moderate (subclass 3). The exception was the secondary salinity limitation (Ss) where zero (0) indicated areas likely to be intake rather than discharge areas.

The secondary salinity (Ss) limitation is not considered crop specific but related to land management practices (in developing land for agricultural uses) or environmental effects from agricultural practices. For this limitations, all land management options are grouped together with subclasses dependant on landscape position, soil water regime and whether or not the land management option is irrigated or dryland cropping.

The suitability scheme assesses the suitability of every land management option for each UMA based on the attributes and limitations of individual UMAs. UMA suitability does not considered the impacts on adjacent or nearby UMAs. The reason for this is that off-site impacts from agricultural activities, such as increases in salinity and waterlogging risks are complex and require a detailed understanding of the soil properties, underlying rock, vegetation and there interaction with landuse. The severity of off-site effects from agricultural activities at the property scale can only be determined through more detailed studies.

Secondary salinity is an example where the relationship between adjacent UMAs or recharge and discharge areas was not assessed due to the complex interactions of landscape processes and the scale of the mapping. For example, UMAs in recharge areas were not downgraded for the potential land use impacts on adjacent discharge areas.

An Acid Sulfate Soil (ASS) survey was not undertaken as part of the WIN project. However, some areas where development may intersect ASS were identified during the field work stage. Therefore, acid drainage water hazard from ASS was not considered as a limitation in this scheme. It is recognised that drainage water from ASS can create an environmental and soil degradation hazard and that any development of lands that may contain or will intercept ASS layers will require detailed ASS analyses and management plans under other regulation. Some important notes on ASS in the WIN survey area can be found in Section 6 of the report.

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Table 1 Land management options considered in assessing agricultural land suitability, Miara-Winfield area

Irrigated horticultural crops		Irrigated broadacre crops		Dryland crops
Avocado-microsprinkler irrigated	Lychee-microsprinkler irrigated	Lucerne-spray irrigated	Forage sorghum-spray irrigated	Radiata pine
Banana-microsprinkler irrigated	Macadamia-microsprinkler irrigated	Maize-furrow irrigated	Soybean-furrow irrigated	Pineapple
Fresh beans-spray irrigated	Mango-microsprinkler irrigated	Maize-spray irrigated	Soybean-spray irrigated	Sugarcane
Capsicum-trickle irrigated	Pineapple-spray irrigated	Navy bean-furrow irrigated	Sweet corn-furrow irrigated	
Citrus-microsprinkler irrigated	Potato-spray irrigated	Navy bean-spray irrigated	Sweet corn-spray irrigated	
Cruciferae-trickle irrigated	Strawberry-trickle irrigated	Peanut-furrow irrigated	Sugarcane -furrow irrigated	
Cucurbit-furrow irrigated	Sweet potato-spray irrigated	Peanut-spray irrigated	Sugarcane-spray irrigated	
Cucurbit-spray irrigated	Sweet potato-trickle irrigated			
Ginger-spray irrigated	Tomato-trickle irrigated			
Grapes-trickle irrigated				

Note: Furrow irrigated, spray irrigated, microsprinkler irrigated or dryland production systems for the same crop are assessed as different land management options.

Table 2: Limitations and land use requirements considered in assessing agricultural land suitability, Miara-Winfield area

Land use requirements	Limitations	Soil and land use attributes used to assess each limitation
Frost-free for specific periods	**Cf-Frost**	Frequency, timing and severity of frosts (based on position in landscape); crop tolerance.
Minimal soil loss due to water erosion	**E-Water erosion**	Soil erodibility, land slope, land management option
Minimal impact of damaging floods	**F-Flooding**	Frequency and depth of flooding based on position in landscape and historic flood levels.
Efficient furrow irrigation, minimise deep drainage losses	**If-Furrow irrigation, deep drainage**	Soil infiltration rate, land slope, soil surface texture, subsoil permeability.
Adequate water storage in the soil profile to maintain plant growth	**M-Soil water availability**	PAWC, effective rooting depth, soil infiltration rate, soil surface condition, depth to water table.
Adequate retention of added nutrients	**Nl-Nutrient leaching**	Soil permeability and drainage, laboratory analysis of soil nutrient levels
Soil pH is suitable for plant growth	**Nr-Nutrient balance, soil reaction trend (pH)**	Soil pH
Ability to harvest underground crops	**Pa-Soil adhesiveness**	Soil surface physical condition, texture, structure, clay minerology, profile drainage
Adequate soil depth for plant physical support and root crop harvesting	**Pd-Soil depth to a physical root barrier**	Depth to hard rock or other impermeable layer or chemical barrier
Suitable timing for cultivation	**Pm-Narrow moisture range**	Soil surface (< 0.3m) physical condition, texture, structure
Ease of seedbed preparation and plant establishment, Ease of fruit set (Peanuts)	**Ps-Soil surface condition**	Soil surface physical condition, texture, structure. Gravel content of surface and A horizon
Minimal impact from gravel, stone and rock at the soil surface	**R-Rockiness**	Size (mm) and abundance (%) of coarse fragments on the soil surface and in the A horizon, percentage of rock outcrop, machinery and farmer tolerance of coarse fragments

Land use requirements	Limitations	Soil and land use attributes used to assess each limitation
Favourable levels of soluble salts in the soil profile.	**Sa-Salinity**	Evidence of salinity as indicated by high EC (dS/m), salt crystals or salinity scalds, landscape position and site drainage.
Minimum susceptibility to secondary salinity	**Ss-Secondary salinity**	Soil permeability, drainage and position in the landscape.
Level land surface	**Tm-Microrelief**	Microrelief (gilgai, channel, other) vertical interval, size distribution and density
Safe and efficient use of machinery	**Ts-Slope**	Land slope in relation to machinery safety and efficiency.
Adequate soil aeration	**W-Wetness**	Internal drainage class and soil permeability, effective plant rooting depth and soil morphology (mottles, subsoil colour and texture).
Adequate size of uniform production areas and ability to access them.	**X-Landscape complexity**	Size of production area and access, level of topographic dissection

Cf-Frost

Frosts can kill plants, suppress growth and reduce yield.

Limitation value and subclass determination. Crop tolerance and local experience has been used to determine the incidence and severity of frosts. Seasonal adaptation of crops is not considered (such as frost tolerance of summer crops).

Additional Information

- Generally incidence and severity of frost is determined by position in the landscape. Hill slopes and rises experience fewer and less severe frosts while lower lying flats, creeks and drainage lines may experience regular frosts. Light, moderate and severe frosts are defined in general terms relating to likely effects on the land management options considered in this classification.

Cf-Frost

Limitation		Subclasses for land management options					
Value	**Description**	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**	**Group F**
1	Frost free or occasional light frost (<3 events/yr-hilltops or near coastal areas)	1	1	1	1	1	2
2	Regular light to moderate frosts (= 3 or more events/yr)	1	2	3	3	5	5
3	Regular severe frosts (= 3 or more events/yr)	1	3	4	5	5	5

Cf-Frost

Group A	Group B	Group C	Group D	Group E	Group F
Cruciferae-trickle irrigated	Sugarcane-dryland	Fresh beans-spray irrigated	Strawberry-trickle irrigated	Banana-microsprinkler irrigated	Avocado-microsprinkler irrigated
Grapes-trickle irrigated	Sugarcane-furrow irrigated	Capsicum-trickle irrigated	Ginger-spray irrigated		Macadamia-microsprinkler irrigated
Lucerne-spray irrigated	Sugarcane-spray irrigated	Citrus-microsprinkler irrigated			Mango-microsprinkler irrigated
Maize-furrow irrigated		Cucurbit-furrow irrigated			
Maize-spray irrigated		Cucurbit-spray irrigated			
Navy bean-furrow irrigated		Lychee-microsprinkler irrigated			
Navy bean-spray irrigated		Pineapple-dryland			
Peanut-furrow irrigated		Pineapple-spray irrigated			
Peanut-spray irrigated		Radiata pine			
Potato-spray irrigated		Sweet corn-furrow irrigated			
Forage sorghum -spray irrigated		Sweet corn-spray irrigated			
Soybean-furrow irrigated		Sweet potato-spray irrigated			
Soybean-spray irrigated		Sweet potato-trickle irrigated			
		Tomato-trickle irrigated			

E-Water erosion

Land degradation and long-term productivity decline will occur on unprotected arable land due to excessive soil loss from water erosion.

Limitation value and subclass determination. Slope for a UMA was assessed from slope measurements recorded at sites and from a digital elevation model (DEM). The modal (or most common) slope was determined for each UMA and then categorised according to the suitability scheme.

Qualitative features have been linked to K factor (experimentally determined quantitative measure of soil erodibility) ranges generated by USLE (Universal Soil Loss Equation) (Whischmeier and Smith 1978). Three soil stability categories are recognised in this scheme.

<u>Very stable soils:</u> Strongly structured surface soils high in free iron (Ferrosols). Soil profiles are highly permeable throughout, with K factor usually < 0.02.

<u>Stable soils:</u> Friable surface soils with moderate to strong surface structure or surface soils with a soft, firm or weakly hard setting, medium to coarse sandy surface (sands, sandy loam, sandy clay loam); or surface soils very high in organic matter. Soil profiles are moderately to highly permeable throughout with K factor usually 0.02-0.05.

<u>Unstable soils:</u> Hard setting surface soils with weak to massive surface structure and fine sandy or silty textures (silty loam to fine sandy light clay). Surface horizons are moderately to slowly permeable, usually with low organic matter. Subsoils are slowly to very slowly permeable and usually sodic. Soil profiles have a K factor usually > 0.05.

Additional Information

- Soil loss from water erosion will depend on soil erodibility and land slope for a particular land management option. For each soil type and land management option there is a maximum slope above which soil loss cannot be reduced to acceptable levels by erosion control measures or surface management practices.
- The suitability scheme for forestry and horticultural tree crops assumes land is already cleared with minimal soil disturbance during land preparation for planting. Water erosion subclasses may be higher (or more limiting) for the same value where significant soil disturbance is involved in land preparation and/or adequate erosion protection measures are not implemented during land preparation and early tree growth.
- Horticultural tree and vine crops typically practice grass/cover crop sward management and represent relatively stable land uses depending on soil type. These land management options are considered to have the least risk of water erosion.

- Most other horticultural and broad-acre crops require seedbed preparation on an annual basis. Tillage during summer and autumn to prepare for the winter copping period leaves paddocks exposed and subject to potentially erosive rainfall events. Surface soils are often very loose and paddocks laid out in straight rows. These land management options are considered to have the most risk of water erosion.
- Soil loss from water erosion on alluvial soils can be exacerbated by channel deviation across cultivation areas.
- Appropriately designed and maintained contour banks and waterways can be used to reduce the risk of water erosion in most cropping situations.
- This limitation considers soil loss from furrow irrigation as related to the speed of irrigation water down the furrows, which is largely determined by land slope. In some UMAs the speed of irrigation water down the furrows can be reduced depending on the furrow layout. However, overtopping of the furrows from rainfall events can cause significant water erosion in these instances, which is also considered in this limitation.

E-Water erosion

Limitation		Subclasses for land management options					
Value	**Description**	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**	**Group F**
B0	Unstable soils, non-sloping land	1	1	1	1	1	1
B1	Unstable soils with 0-1% slope	1	0	1	1	0	0
B2	Unstable soils with 1-3% slope	1	3	2	2	4	4
B3	Unstable soils with 3-5% slope	2	4	3	3	5	5
B4	Unstable soils with 5-8% slope	3	5	4	4	5	5
B5	Unstable soils with 8-12% slope	4	5	5	5	5	5
B6	Unstable soils with > 12 % slope	5	5	5	5	5	5

A0	Stable soils, non-sloping land	1	1	1	1	1	1
A1	Stable soils with 0-2% slope	1	0	1	1	0	0
A2	Stable soils with 2-5% slope	1	3	2	2	3	4
A3	Stable soils with 5-8% slope	2	4	3	3	4	5
A4	Stable soils with 8-12% slope	3	5	4	4	5	5
A5	Stable soils with 12-15% slope	3	5	4	5	5	5
A6	Stable soils with 15-20% slope	4	5	5	5	5	5
A7	Stable soils with >20% slope	5	5	5	5	5	5
E0	Very stable soils, non-sloping land	1	1	1	1	1	1
E1	Very stable soils with 0-2% slope	1	1	1	1	0	0
E2	Very stable soils with 2-5% slope	1	2	2	2	3	4
E3	Very stable soils with 5-8% slope	1	3	2	2	4	5
E4	Very stable soils with 8-12% slope	2	4	3	3	5	5
E5	Very stable soils with 12-15% slope	2	5	4	4	5	5
E6	Very stable soils with 15-20% slope	3	5	5	5	5	5
E7	Very stable soils with 20-30% slope	4	5	5	5	5	5
E8	Very stable soils with >30% slope	5	5	5	5	5	5

E-Water erosion

Group A	Group B		Group C	Group D	Group E	Group F
Avocado-microsprinkler irrigated	Capsicum-trickle irrigated	Forage sorghum - spray irrigated	Sugarcane-dryland	Lucerne-spray irrigated	Fresh beans-spray irrigated	Cucurbit-furrow irrigated
Banana-microsprinkler irrigated	Cruciferae-trickle irrigated	Strawberry-trickle irrigated		Sugarcane-spray irrigated	Navy Bean-spray irrigated	Maize-furrow irrigated
Citrus-microsprinkler irrigated	Cucurbit-spray irrigated	Sweet corn-spray irrigated			Peanut-spray irrigated	Navy Bean-furrow irrigated
Grapes-trickle irrigated	Ginger-spray irrigated	Sweet potato-spray irrigated			Potato-spray irrigated	Peanut-furrow irrigated
Lychee-microsprinkler irrigated	Maize-spray irrigated	Sweet potato -trickle irrigated			Soybean-spray irrigated	Sugarcane-furrow irrigated
Macadamia-microsprinkler irrigated	Pineapple-dryland	Tomato-trickle irrigated				Soybean-furrow irrigated
Mango-microsprinkler irrigated	Pineapple-spray irrigated					Sweet corn-furrow irrigated
Radiata Pine						

F-Flooding

The main effects of flooding include yield reduction or plant death caused by anaerobic conditions and/or high water temperature and/or silt deposition during inundation. Other effects include physical removal or damage to the crop by flowing water, floodplain erosion and damage to infrastructure such as irrigation equipment.

Limitation values and subclass determination. Due to the difficulty of assessing the effects of flooding on individual mapping units, landform position in relation to historical flood flows (i.e. flooding frequency) was used to distinguish between suitable and unsuitable land for intolerant crops.

Additional Information

- Sugarcane and many other horticultural and broad acre crops are commonly grown on low-lying areas, despite regular flooding. In such cases, flooding does not detract from the intrinsic value of the land due to some degree of crop tolerance and landholder resilience to the effects of flooding
- Some horticultural tree crops (e.g. citrus, lychees, mangoes) tolerate inundation for periods of about 1 day. This assumes low velocity floodwaters, relatively low silt loads, reasonable water temperatures and rapid internal soil drainage once floodwaters recede.
- Many horticultural crops are grown at the time of the year when the frequency of floods is low (for example over the winter months) and thus avoid most of the flood risk, or are grown on areas that are not flooded. All horticultural crops in Group A below have been allocated a subclass 1 (negligible) under this assumption, to consistent with Bundaberg survey area Donnollan *et al*. (1998).

F-Flooding

Limitation		**Subclasses for land management options**					
Value	**Description**	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**	**Group F**
0	No flooding	1	1	1	1	1	1
1	Flooding less than 1 in 10 years	1	1	0	0	0	0
2	Flooding occurs 1 in 2 to 1 in 10 years	1	1	2	3	3	5
3	Annual flooding	1	2	4	4	5	5

F-Flooding

Group A	Group B	Group C	Group D	Group E	Group F
Capsicum-trickle irrigated	Ginger-spray irrigated	Banana-microsprinkler irrigated	Maize-furrow irrigated	Fresh beans-spray irrigated	Avocado-microsprinkler irrigated
Cruciferae-trickle irrigated		Sweet potato-spray irrigated	Maize-spray irrigated	Lucerne-spray irrigated	Citrus-microsprinkler irrigated
Cucurbit-furrow irrigated		Sweet potato-trickle irrigated	Forage sorghum - spray irrigated	Navy bean-furrow irrigated	Grapes-trickle irrigated
Cucurbit-spray irrigated			Soybean-furrow irrigated	Navy bean-spray irrigated	Lychee-microsprinkler irrigated
Potato-spray irrigated			Soybean-spray irrigated	Peanut-furrow irrigated	Macadamia-microsprinkler irrigated
			Sugarcane-dryland		
Tomato-trickle irrigated			Sugarcane-furrow irrigated	Peanut-spray irrigated	Mango-microsprinkler irrigated
			Sugarcane-spray irrigated	Radiata pine	Pineapple-dryland
			Sweet corn-furrow irrigated	Strawberry-trickle irrigated	Pineapple-spray irrigated
			Sweet corn-spray irrigated		

If-Furrow Irrigation, deep drainage

Irrigation water applied as furrow irrigation must match soil infiltration and permeability as close as possible to minimise deep drainage losses and soil waterlogging. Land slope largely determines the speed of irrigation water down the furrows, which also effects the ability of the water to infiltrate the soil profile. Soil permeability and land slope are the main considerations in determining suitable furrow length. Soil erosion loss as it affected by the speed of irrigation water down the furrows is considered in the water erosion limitation (E).

Limitation values and subclass determination. Limitation values and subclasses are related directly to land slope and soil permeability, which is assessed to 1 m profile depth.

Additional Information

- Direct measurements of soil hydraulic conductivity (permeability) are required to determine subclasses, but this is difficult, time consuming and unavailable for most soils mapped in the Miara-Winfield area. Therefore, indicator attributes for soil permeability such as texture, grade and type of structure, sodicity, pH and depth to salt bulge are assessed to determine soil permeability.
- Furrow irrigation is best suited to land with level slopes and slowly to very slowly permeable soils, such as most Vertosols, Sodosols and Kurosols.
- This limitation considers soil properties that affect furrow irrigation efficiency, and as such is not crop specific but irrigation method specific. It does not apply to other irrigation methods or to dryland crops.

If-Furrow infiltration, deep drainage

Limitation		Subclasses for all furrow irrigated crops
Value	Description	
VP	Very slowly permeable subsoils on level plains (< 2 %).	3
VU	Very slowly permeable subsoils on undulating ground (> 2 %)	5
SP	Slowly permeable subsoils on level plains (< 2%)	3
SU	Slowly permeable subsoils on undulating ground (> 2 %).	5
MP	Moderately permeable subsoils on level plains	5
MU	Moderately permeable subsoils on undulating ground	5
HP	Highly permeable subsoils on level plains	5
HU	Highly permeable subsoils on undulating ground	5

M-Soil water availability

Plant yield can be severely affected by periods of water stress, particularly during critical growth periods. This limitation assumes adequate irrigation water is available in terms of quantity and quality for the land management options considered in this assessment, except for dryland crops which assume no irrigation water is available.

Limitation value and subclass determination. Plant available water capacity (PAWC) is a measure of the amount of water in a soil available to plants over the effective rooting depth (defined below). For irrigated crops, soil water availability values are based on PAWC and its effect on the frequency of irrigation required to optimise crop growth. However, for dryland crops, the soil water availability values define the PAWC ranges where crop production is successful for most years in this area.

This limitation is not applied to micro-sprinkler or trickle irrigation systems where small amounts of water are added frequently.

Generally, soil texture, structure and clay mineralogy over the effective rooting depth are important attributes determining PAWC. For soil profiles with few to abundant coarse fragments, the estimated soil PAWC is adjusted as necessary to account for the reduced volume of soil available to store moisture.

PAWC is estimated to the effective rooting depth. Effective Rooting Depth (ERD) is determined by:

a) Crop growth characteristics.

- Shallow rooted crops-PAWC estimated to 0.5 m only (unless ERD is reduced by physical or chemical properties before this depth)
- Moderately deep rooted crops-PAWC estimated to 1.0 m only (unless ERD is reduced by physical or chemical properties before this depth)
- Deeper rooted crops-PAWC estimated to 1.5m (unless ERD is reduced by physical or chemical properties before this depth)

b) Soil physical and/or chemical properties. Depth to (unless this is below the crop growth characteristics):

- Hard pan or rock or other physical restrictive layer; or
- High salinity ($EC_{1:5}$ > 1 dsm^{-1}); or
- High sodicity (Exch. Na > 6 % and ECEC > 5 meq/100 g); or
- High aluminium (Exch. Al > 50 % of ECEC); or
- Magnesium dominated clays (Ca:Mg ratio < 0.1 and ECEC > 5 meq/100 g); or
- Very low subsoil Ca levels (Exch. Ca < 0.1 cmol_c/kg, or below the limit of detection for the analysis method used by the Laboratory).

Note: that the shallower of any one or more of these soil properties (closest to the surface) determines the ERD for each SPC and UMA.

Additional Information

Some areas and SPCs with high water tables have been identified during this survey. For these areas and SPCs, the PAWC calculations have been adjusted to take into account the water that the crop may extract from the water table, provided that it does not have high salinity or sodicity or low pH that prevents crop uptake, the crop growth characteristics allow access, and the soil profile does not have physical or chemical properties limiting the crop roots from accessing the water table. The depth and extent of the water table in these areas was not mapped in detail during this survey due to scale issues, nor was seasonal variations or the water quality, except where direct measurements were made during the survey field work. Therefore, the PAWC adjustments to account for the presence of a water table are general in nature.

PAWC is the main determination of the frequency of irrigation required to maintain optimum plant growth and yield:

>100 mm	= 15 days
75 to 100 mm	= 12 to 15 days
50 to 75 mm	= 8 to 12 days
<50 mm	= less than 8 days

The relationship between PAWC and irrigation frequency is a guide only.

Irrigation frequency is also affected by seasonal and daily rainfall and evaporation rates (6-7 mm/day in summer) and the amount of water, 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. Crop growth stage also influences irrigation frequency as does the irrigation method and equipment used. Pivot irrigation is considered suitable for broadacre crops with PAWC between 35-50 mm.

M-Soil water availability

Limitation		Subclasses for land management options					
Value	**Description**	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**	**Group F**
1	> 150 mm PAWC	1	1	1	1	1	2
2	125-150 mm PAWC	1	1	1	1	1	2
3	100-125 mm PAWC	1	1	1	1	2	2
4	75-100 mm PAWC	1	1	1	2	3	2
5	50-75 mm PAWC	1	2	2	3	4	2
6	< 50 mm PAWC	1	3	4	4	5	3

PAWC is estimated to 1 m depth, or less if adverse soil physical and/or chemical properties (as defined above) occur at less than 1m depth, with subclasses adjusted for shallow rooted or deeper rooted crops as necessary.

M-Soil water availability

Group A	Group B	Group C	Group D	Group E	Group F
Avocado-microsprinkler irrigated	Ginger-spray irrigated	Lucerne-spray irrigated	Sugarcane-furrow irrigated	Sugarcane-dryland	Fresh beans-spray irrigated
Banana-microsprinkler irrigated	Pineapple-spray irrigated	Maize-furrow irrigated	Sugarcane-spray irrigated		Cucurbit-furrow irrigated
Capsicum-trickle irrigated	Radiata pine	Maize-spray irrigated	Sweet potato-spray irrigated		Cucurbit-spray irrigated
Citrus-microsprinkler irrigated		Peanut-furrow irrigated			Navy bean-furrow irrigated
Cruciferae-trickle irrigated		Peanut-spray irrigated			Navy bean-spray irrigated
Grapes-trickle irrigated		Pineapple-dryland			Potato-spray irrigated
Lychee-microsprinkler irrigated		Forage sorghum (forage)-spray irrigated			
Macadamia-microsprinkler irrigated		Soybean-furrow irrigated			
Mango-microsprinkler irrigated		Soybean-spray irrigated			
Strawberry-trickle irrigated					
Sweet potato-trickle irrigated					
Tomato-trickle irrigated					

Nl-Nutrient leaching

Crop growth may be reduced on low fertility soils which also have the potential to leach added mineral nutrients. These soils usually have low nutrient retention capacity.

Limitation value and subclass determination. Soil permeability and site drainage are used to estimate the potential for nutrient leaching in the soil profile.

Additional Information

- Soils with high permeability to depths greater than the crop effective rooting depth will have a high leaching potential. Increased fertiliser management, such as split dressings which may include small dressings on a regular basis, will be required on such soils for adequate plant growth and to minimise losses to the environment. This will require more management, and therefore more production cost, for adequate crop growth compared to soils with a minimal leaching potential.
- Horticulture crops that are microsprinkler irrigated are less affected by this limitation, as small amount of plant nutrients can be applied on a regular basis using fertigation.

Nl-Nutrient leaching

Limitation		Subclasses for all microsprinkler irrigated crops	Subclasses for all other land management options
Value	Description		
Nl1	All soils with moderate to very slow permeability before 1.50 m depth.	1	1
Nl2	All soils with high permeability and poor to very poor drainage.	1	1
Nl3	All soils with high permeability and imperfect to rapid drainage.	1	2

Nr-Nutrient balance-soil reaction trend (pH)

Crop growth may be reduced on acid soils due to some plant nutrients being present in chemical forms that are unavailable to plants. Solubility of some common elements such as aluminium and manganese is pH dependant, and these may be present in toxic levels in strongly acid soils that are toxic to some plants. Other plant nutrients, such as phosphorus, may become limiting to plant growth in strongly alkaline soils.

Limitation value and subclass determination. Soil pH to 0.60 m profile depth.

Additional Information

- Some plants are more tolerant to growing on acid soils than other plants, notably sugarcane and many silviculture trees.
- Avocados, macadamias and pineapples are more suited to acid soils (pH < 6.0 to 0.60 m) as phytophthora (soil-borne fungus disease) is less prevalent at this pH than at higher soil pH.
- For most other crops, the addition of surface lime is required on a regular basis to correct and maintain the soil pH of acid soils, and to change the plant availability of some plant nutrients. This will require more management and therefore more production cost, for adequate crop growth compared to soils with a neutral pH level.

Nr-Nutrient balance

Limitation		Subclasses for Land Management Options			
Value	**Description**	**Group A**	**Group B**	**Group C**	**All other Land Management Options**
Nr1	All soils with pH to 0.60 m less than 5.0	1	1	2	2
Nr2	All soils with pH to 0.60 m between 5.0 and 6.0	1	1	1	1
Nr3	All soils with pH to 0.60 m greater than 6.0	4	1	2	1

Group A	Group B	Group C
Pineapple (dryland or irrigated)	Sugarcane (dryland or irrigated) Radiata pine	Avocado-microsprinkler irrigated Macadamia-microsprinkler irrigated

Pa-Soil adhesiveness

Adhesive soils may affect the recoverability (i.e. cause harvest and post-harvest difficulties) and condition of root crops (i.e. quality of subsurface harvest material). Recovery and quality of fruit harvested very close to the soil surface (such as strawberries) may also be adversely affected on adhesive soils.

Limitation value and subclass determination. This limitation is only considered for crops where the underground tubers or fruits close to the soil surface are harvested, such as ginger, peanuts, potato, Sweet potato and strawberries. In general, the degree of adhesiveness increases as clay content and/or consistency increase and the degree of pedality (or structure) decreases. Most massive surface clay loam soils or poorly to imperfectly drained soils with clay texture surfaces are adhesive to varying degrees.

Limitation		Soil properties affecting adhesiveness			
Value	**Description**	**Texture and Structure**	**Surface Consistence (dry)**	**Surface Condition**	**Drainage to 0.50 m**
0	Not adhesive	Strongly structured surface soils high in free iron (Ferrosols) Sand to sandy loam surface, single grained or massive, low in organic matter	Loose to firm	Loose, soft or firm	All drainage classes
1	Slightly adhesive soils	Moderately to strongly structured sandy loam to clay loam surface	Weak to very firm	Firm or hard setting	Well or moderately-well drained
2	Moderately adhesive soils	Massive to weakly structured silty or fine sandy textured surface; Non-sodic clay to 0.30 m. (within plough zone)	Firm to very firm	Firm or hard setting	Well or moderately-well drained
3	Strongly adhesive soils	Sticky and/or sodic clay within 0.30 m of the surface	Very firm to very strong	Firm, hard setting or self-mulching	Very poorly to imperfectly drained

Additional Information

- Peanut crops ideally require friable soils to enable harvesting machinery to easily lift and remove the nuts from the soil.
- Adhesive soils may be subject to compaction and declining structural stability.

Soil germination and seedling development problems associated with adverse conditions of the surface soil such as hard setting, coarse aggregates and crusting are considered in the soil surface condition limitation (Ps).

Pa-Soil adhesiveness

Limitation		Suitability subclasses for land management options			
Value	**Description**	**Group A**	**Group B**	**Group C**	**All other land management options**
0	No restriction	1	1	1	1
1	Slightly adhesive soils	1	1	2	1
2	Moderately adhesive soils	1	2	3	1
3	Strongly adhesive soils	2	3	4	1

Group A	Group B	Group C
Strawberry-trickle irrigated	Ginger-spray irrigated Potato-spray irrigated Sweet potato-spray irrigated	Peanut-furrow irrigated Peanut-spray irrigated

Pd-Soil depth

Shallow soils limit root proliferation and anchorage. Plants may dislodge or become uprooted during strong winds.

Limitation value and subclass determination. Consultation with relevant industry professionals, and local landholder experience.

Additional Information

- All crops require an adequate depth of soil for physical support of the aerial portion of the plant. Requirements for physical support will increase with crops that have large canopies e.g. tree crops. Uprooting of trees is particularly a problem on shallow, wet soils during windy conditions.
- Some horticultural crops (e.g. tomatoes) are normally trellised and lodging due to shallow soil depth is not considered an issue.
- Soil depth is equivalent to Effective Rooting Depth. How this is determined is outlined in the Water Availability (M) Limitation.

Pd-Soil depth

Limitation		Subclasses for land management options			
Value	**Description**	**Group A**	**Group B**	**Group C**	**All other land management options**
1	Soil depth >1.0 m	1	1	1	1
2	Soil depth 0.6-1.0 m	1	2	2	1
3	Soil depth 0.4-0.6 m	1	3	4	1
4	Soil depth 0.3-0.4 m	2	4	5	1
5	Soil depth <0.3 m	5	5	5	1

Group A	Group B	Group C
Sugarcane-dryland Sugarcane-furrow irrigated Sugarcane-spray irrigated	Avocado-microsprinkler irrigated Banana-microsprinkler irrigated Citrus-microsprinkler irrigated Lychee-microsprinkler irrigated Macadamia-microsprinkler irrigated Mango-microsprinkler irrigated	Radiata pine

Pm-Narrow moisture range

This limitation considers the ease and timeliness with which a soil may be cultivated. Successful soil tillage depends largely on the inherent characteristics of the surface soil as it dries following a wetting cycle, and the length of time during which the moisture range of the surface material is appropriate for mechanical disturbance. The time period following rainfall or irrigation during which a soil is capable of being successfully cultivated to achieve favourable seedbed conditions (i.e. adequate depth of ploughed layer and favourable tilth) is known as the tillage window.

Limitation value and subclass determination. Some soils have a short tillage window while other soils may be cultivated at any time. Such differences relate directly to the inherent morphological properties of the surface soil including texture, structure, sand fraction, clay mineralogy and sub-surface cation chemistry (e.g. soil sodicity to 0.3m). How easily a soil works up and the length of the tillage window become particularly important for crops where land preparation is required to fit a distinct cropping cycle, such as strictly defined planting times. Typically, a short tillage window is only an issue for crops that require machinery access on a regular basis for normal agricultural practices (such as cultivation, spraying for weeds, pests or diseases or mechanical harvesting).

Local landholder and industry experience is a valuable guide to difficulties associated with successfully farming certain soils in the district that may have short tillage windows, and landholder tolerance of these difficulties. Soils with moderate moisture range include most Sodosols, Kurosols and grey Dermosols with clay loamy, silty or clayey surfaces (ASC terminology). Soils with narrow moisture range include most Vertosols and some very poorly to poorly drained soils such as Hydrosols.

Pm-Narrow moisture range

Limitation		Subclasses for land management options	
Value	Description	Group A	All other management options
0	No restriction	1	1
1	Moderate moisture range	1	2
2	Narrow moisture range	1	3

Group A	
Avocado-microsprinkler irrigated	Lychee-microsprinkler irrigated
Banana-microsprinkler irrigated	Macadamia-microsprinkler irrigated
Citrus-microsprinkler irrigated	Mango-microsprinkler irrigated
Grapes-trickle irrigated	Radiata pine

Ps-Soil surface condition

Problems with successful germination and seedling development during crop establishment can be associated with adverse physical conditions in the surface soil, such as hard setting behaviour, coarse aggregates and crusting. These problems can reduce crop yields. Specialised management inputs or practices may be required to successfully manage crop production on these soils. Mechanical harvesting of some crops, such as macadamias, can be adversely affected on loose soil surfaces.

Limitation value and subclass determination. Plant tolerance limits and requirements in relation to germination emergence, seedling establishment or harvesting are matched with soil properties and supported by agronomic experience and industry recommendations.

Additional Information

- Crops planted from seed are most affected by this limitation, as are pulse crops where seedling emergence is critical to crop establishment. Horticultural crops planted as seedlings or vegetative material (e.g. tree crops, pineapple, sugarcane) are least affected.
- Adverse soil surface conditions can affect the ability of peanuts to push their pegs into the ground and can reduce seedling emergence of pulse or legume crops (such as soybeans).
- A loose soil surface (for example some sands) presents an extreme limitation for mechanical harvesting (vacuum and finger rake) of macadamia nuts.

Ps-Surface condition

Limitation		Subclasses for land management options					
Value	Description	Group A	Group B	Group C	Group D	Group E	Group F
0	No restriction to germination, seedling emergence or harvesting-usually at least weakly structured surface with less than 20 % fine sand or silt. -	1	1	1	1	1	1
1	Hard setting, massive soils with loamy to clay loamy surface textures (ASC terminology) & dry firm to very firm consistency	1	1	1	2	1	2
2	Hard setting, massive soils with fine sandy loam, fine sandy clay loam, clay loam fine sandy or any silty textures & dry very firm to strong consistency	1	2	2	3	1	3
3	Surface crusts present	1	1	2	2	0	3
4	Large soil aggregate size on surface (>20 mm)	1	2	3	2	1	4
5	Loose soil surface (usually singe grain sands or self-mulching cracking clays)	1	1	1	1	5	1

Ps-Surface condition

Group A	Group B	Group C	Group D	Group E	Group F
Avocado-microsprinkler irrigated	Sugarcane-dryland	Capsicum-trickle irrigated	Potato-spray irrigated	Macadamia-microsprinkler irrigated	Fresh beans-spray irrigated
Banana-microsprinkler irrigated	Sugarcane-furrow irrigated	Cruciferae-trickle irrigated	Sweet potato-spray irrigated		Lucerne-spray irrigated
Citrus-microsprinkler irrigated	Sugarcane-spray irrigated	Cucurbit-furrow irrigated			Navy bean-furrow irrigated
Grapes-trickle irrigated	Ginger-spray irrigated	Cucurbit-spray irrigated			Navy bean-spray irrigated
Lychee-microsprinkler irrigated		Maize-furrow irrigated			Peanut-furrow irrigated
Mango-microsprinkler irrigated		Maize-spray irrigated			Peanut-spray irrigated
Radiata pine		Pineapple-dryland			Soybean-furrow irrigated
		Pineapple-spray irrigated			Soybean-spray irrigated
		Sorghum (forage)-furrow irrigated			
		Sorghum (forage)-spray irrigated			
		Strawberry-trickle irrigated			
		Sweet corn-furrow irrigated			
		Sweet corn-spray irrigated			
		Tomato-trickle irrigated			

R-Rockiness

Coarse fragments (pebbles, gravels, cobbles, stones and boulders) and rock in the plough zone can damage and/or interfere with the efficient use of agricultural machinery, during planting, cultivation and harvesting of crops such as sugarcane, soybean, root crops, macadamia and some other horticultural crops.

Limitation value and subclass determination. Assessment of rockiness is based on the size, abundance and distribution of coarse fragments on the soil surface and in the soil profile, and the proportion of rock outcrop within a UMA. The volume of coarse fragments within the soil profile is extremely variable and difficult to estimate for most UMAs. Therefore an average of the abundance and size of surface and profile coarse fragments for each UMA was estimated from site data and then categorised according to the suitability scheme. The limitation increases with the increase in size and/or abundance encountered. Limitation classes were determined by way of industry consultation, particularly relating to landholder / machinery operator tolerances (which are implicitly related to profitability and technological capability).

Additional Information

- Coarse fragments are particles >2 mm and are not continuous with underlying bedrock. Rock is identified as being continuous with bedrock.
- In some areas extensive stone picking operations have occurred in previous years to clear soils for cropping purposes. However, rock picking may be necessary on an infrequent basis in areas with cobbles or larger coarse fragments.
- In general, horticultural and broad acre crops which require several cultivations annually and have low harvest heights (Fresh beans navy beans and soybean) have a low tolerance to rock or coarse fragments; root crops (potatoes, peanuts) are very sensitive; and horticultural tree crops can tolerate considerable amounts. Gravel-sized coarse fragments (20-60 mm) cause significant problems for macadamias due to similarity in size with nuts (on the ground post-shaking).
- Rock or surface coarse fragments can cause significant problems with mechanical harvesting of sugarcane as this can damage equipment and cause major problems with the milling process.
- Coarse fragments can damage and cause increased maintenance requirements of agricultural machinery.
- Effect of coarse fragments and rock in limiting plant available water capacity (PAWC) is considered in the water availability (M) limitation, while depth to hard rock as it effects plant anchorage is considered in the soil depth (Pd) limitation.

R-Rockiness

Limitation		Subclasses for land management options							
Value	**Description**	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**	**Group F**	**Group G**	**Group H**
R0	Course fragments < 6 mm in size or no surface rock	1	1	1	1	1	1	1	1
P1	<2% medium pebbles 6-20 mm	1	1	1	1	1	1	2	2
P2	2-10% medium pebbles 6-20 mm	1	2	1	1	1	2	3	3
P3	10-20% medium pebbles 6-20 mm	1	3	2	1	2	3	4	4
P4	20-50% medium pebbles 6-20 mm	1	4	3	2	3	4	5	5
P5	> 50 % medium pebbles 6-20 mm	3	5	4	3	4	5	5	5
G1	<2% coarse gravel 20-60 mm	1	3	1	1	1	2	1	3
G2	2-10% coarse gravel 20-60 mm	1	4	1	1	2	3	2	4
G3	10-20% coarse gravel 20-60 mm	2	5	2	2	3	4	3	5
G4	20-50% coarse gravel 20-60 mm	3	5	3	3	4	5	4	5
G5	> 50 % coarse gravel 20-60 mm	4	5	4	4	5	5	5	5
C1	<2% cobbles 60-200 mm	1	2	1	1	2	3	4	4
C2	2-10% cobbles 60-200 mm	1	3	2	2	3	4	5	5
C3	10-20% cobbles 60-200 mm	2	4	3	3	4	5	5	5
C4	20-50% cobbles 60-200 mm	3	5	4	4	5	5	5	5
C5	> 50% cobbles 60-200 mm	5	5	5	5	5	5	5	5

S1	<2% stones 200-600 mm	1	3	2	2	3	4	4	5
S2	2-10% stones 200-600 mm	2	4	3	3	4	5	5	5
S3	10-20% stones 200-600 mm	3	4	4	4	5	5	5	5
S4	20-50% stones 200-600 mm	4	5	5	5	5	5	5	5
S5	> 50 stones 200-600 mm	5	5	5	5	5	5	5	5
B1	<2% boulders > 600 mm	2	3	3	3	4	5	5	5
B2	2-10% boulders > 600 mm	3	4	4	4	5	5	5	5
B3	10-20% boulders > 600 mm	4	5	5	5	5	5	5	5
B4	20-50% boulders > 600 mm	5	5	5	5	5	5	5	5
B5	> 50 % boulders > 600 mm	5	5	5	5	5	5	5	5
R1	Rock slab covering <2% of UMA	2	3	3	3	4	5	5	5
R2	Rock slab covering 2-10% of UMA	3	4	4	4	5	5	5	5
R3	Rock slab covering 10-20% of UMA	4	5	5	5	5	5	5	5
R4	Rock slab covering 20-50% of UMA	5	5	5	5	5	5	5	5
R5	Rock slab covering > 505 of UMA	5	5	5	5	5	5	5	5

R-Rockiness

Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H
Avocado-microsprinkler irrigated	Macadamia-microsprinkler irrigated	Banana-microsprinkler irrigated	Pineapple-dryland	Maize-furrow irrigated	Capsicum-trickle irrigated	Strawberry-trickle irrigated	Fresh beans-spray irrigated
Citrus-microsprinkler irrigated			Pineapple-spray irrigated	Maize-spray irrigated	Cruciferae-trickle irrigated		Potato-spray irrigated
Grapes-trickle irrigated			Radiata pine	Forage sorghum Spray Irrigated	Cucurbit-furrow irrigated		Sweet potato-spray irrigated
Lychee-microsprinkler irrigated				Sugarcane-dryland	Cucurbit-spray irrigated		Sweet potato-trickle irrigated
Mango-microsprinkler irrigated				Sugarcane-spray irrigated	Ginger-spray irrigated		Navy bean-furrow irrigated
				Sugarcane-furrow irrigated	Lucerne-spray irrigated		Navy bean-spray irrigated
				Sweet corn Furrow Irrigated	Soybean-furrow irrigated		Peanut-furrow irrigated
				Sweet corn Spray Irrigated	Soybean-spray irrigated		Peanut-spray irrigated
					Tomato-trickle irrigated		

Sa-Salinity

High soluble salts at the surface can severely limit plant establishment and plant growth.

Limitation value and subclass determination. Subclass determination is based on the evidence of surface salinity within a polygon at the time of survey as indicated by high surface EC (dS/m), salt crystals or salinity scalds.

Additional Information

- Nil.

Sa-Salinity

Limitation		Subclasses for all land management options
Value	**Description**	
0	No existing salinity	1
1	Existing salinity	5

Ss-Secondary salinity

Deep drainage losses from permeable soils, usually higher in the landscape, may cause secondary salinity downslope.

Limitation value and subclass determination. Site drainage, soil permeability to 1 metre profile depth, and position in the landscape are used to determine areas of high recharge potential, and the effect that deep drainage may have on water tables downslope. The development of shallow groundwater (and subsequent surface expression in discharge areas) may occur on lower hillslopes, flats, plains and drainage depressions where drainage is restricted (e.g. heavy textured, slowly permeable soils, and lack of incised drainage). Drainage class, permeability (see Furrow Infiltration, deep drainage limitation (If) for how this was estimated for each UMA) and position in the landscape determine the likelihood of secondary salinisation developing.

To determine the limitation value of an UMA, first determine site drainage and soil permeability to determine wetness code and then landscape position (landform element). The limitation value and subclasses for land management options can then be read directly from the matrix on the next page. For example, an imperfectly drained soil with slow permeability to 1 metre profile depth will have a wetness code of 3S. If this soil is mapped in a lower slope position, the UMA will have an Ss limitation value of 3SL, with subclasses of 3 for all dryland and 4 for all irrigated crops.

Additional Information

- Intake or recharge areas are those where there is a downward component to groundwater flow near the soil surface and tend to occur upslope and on convex topography often with shallow or permeable soils over fractured rock. If this downward flow of water is not managed appropriately it may result in groundwater outflow (discharge or seepage) areas. 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.
- Secondary salinity is an example where the relationship between adjacent UMAs or recharge and discharge areas was not assessed due to the complex interactions of landscape processes and the scale of the mapping. UMAs in recharge areas were not downgraded for the potential land use impacts on adjacent discharge areas.
- Some combinations of site drainage, soil permeability and landscape position do not commonly exist in the field, for example poorly or very poorly drained sites on hillcrests or upper hillslopes. These are indicated by a “-“ in the table below.
- The landscape positions and soil permeability drainage combinations where recharge is likely are not assessed in this suitability scheme. Other suitability classification schemes for local projects within the Coastal *Burnett* have assessed this as a limitation for cropping.

Ss Secondary salinity

Soil Water Regime			Landform Element and Subclasses for Mangement Options							
Wetness Code	Site drainage	Soil Permeability to 1 metre profile depth	Upper Hillsope or Hillcrest (U)		Mid or Lower Hillsope (L)		Drainage depression (D)		Plain or Flat (P)	
			All Dryland crops	All Irrigated crops	All Dryland crops	All Irrigated crops	All Dryland crops	All Irrigated crops	All Dryland crops	All Irrigated crops
6H	6 Rapidly drained	H Highly Permeable	0	0	0	0	-	-	1	1
6M	6 Rapidly drained	M Moderately Permeable	0	0	0	0	-	-	1	1
5H	5 Well drained	H Highly Permeable	0	0	0	0	-	-	1	1
5M	5 Well drained	M Moderately Permeable	0	0	0	0	-	-	1	1
4H	4 Moderately well-drained	H Highly Permeable	0	0	1	2	-	-	1	1
4M	4 Moderately well-drained	M Moderately Permeable	0	0	1	2	-	-	1	1
4S	4 Moderately well-drained	S Slowly Permeable	0	0	2	3	-	-	1	2
4V	4 Moderately well-drained	V Very slowly Permeable	0	0	2	3	-	-	1	2
3H	3 Imperfectly drained	H Highly Permeable	0	0	1	2	4	5	1	1
3M	3 Imperfectly drained	M Moderately Permeable	0	1	2	3	4	5	1	2

3S	3 Imperfectly drained	S Slowly Permeable	0	2	3	4	4	5	2	3
3V	3 Imperfectly drained	V Very slowly Permeable	-	-	4	5	4	5	3	3
2H	2 Poorly drained	H Highly Permeable	-	-	2	3	4	5	1	2
2M	2 Poorly drained	M Moderately Permeable	-	-	3	4	4	5	2	3
2S	2 Poorly drained	S Slowly Permeable	-	-	4	5	4	5	3	4
2V	2 Poorly drained	V Very slowly Permeable	-	-	5	5	4	5	4	4
1H	1 Very poorly drained	H Highly Permeable	-	-	4	4	5	5	3	3
1M	1 Very poorly drained	M Moderately Permeable	-	-	4	4	5	5	3	3
1S	1 Very poorly drained	S Slowly Permeable	-	-	4	4	5	5	3	3
1V	1 Very poorly drained	V Very slowly Permeable	-	-	4	4	5	5	3	3

Tm-Microrelief

Uneven ground surface (e.g. gilgai) can cause uneven and lower productivity due to irregular water distribution (e.g. ponding in depressions), irregular cultivation and impeded trafficability.

Limitation value and subclass determination. The vertical interval of microrelief typically dictates the amount of levelling required and/or the potential for reduced productivity. Therefore the vertical interval is used to determine the severity of the limitation. Limitation subclass was determined by land resource surveys, consultation with relevant industry professionals and local landholder experience.

Additional Information

- Microrelief includes: gilgai, channels, melon holes, swamp hummock, rills and small gullies.
- Effects associated with the presence of microrelief such as temporary waterlogging and poor surface condition are covered in the wetness (W) and soil surface condition (Ps) limitations respectively.

Tm-Microrelief

Limitation		Subclasses for all land management options
Value	Description	
0	No surface microrelief	1
1	Microrelief with a vertical interval <0.3m	3
2	Microrelief with a vertical interval 0.3-0.5m	4
3	Microrelief with a vertical interval >0.5m	5

Ts-Topography

The safety and/or efficiency of farm vehicle/machinery operation is affected by steep gradients, specifically rolling and side-slip hazards, and erosion control layouts on land with significant variability in the degree and direction of slopes (e.g. complex slopes); which is particularly important with row crops where final layouts on such lands would necessitate impractical short rows and sharp curves.

Limitation value and subclass determination: Steepness of slope is considered regarding the upper machinery slope limit in relation to safety and efficiency of farm machinery operations. Variation in slope is considered in this limitation in relation to safe machinery operation over short row lengths or inability of trailing implements to effectively negotiate curves less than 30 m radius.

Additional Information

- A suitability subclass of three (3) has been applied in areas where tillage and modified erosion control structures have to be applied in lieu of conventional erosional control structures. Note: Historical land suitability classification schemes for local projects may have used a suitability subclass of zero (0) instead.

Ts-Topography

Limitation		Subclasses for and management options	
Value	**Description**	**Group A**	**All other land management options**
0	Slope 0-15%,	1	1
1	Slope 15-20%,	2	4
2	Slope 20-30%	4	5
3	Slope >30%	5	5
C	Complex slopes 0-15%	1	3

Group A		
Avocado-microsprinkler irrigated Banana-microsprinkler irrigated Citrus-microsprinkler irrigated Grapes-trickle irrigated	Lychee-microsprinkler irrigated Macadamia-microsprinkler irrigated	Mango-microsprinkler irrigated Radiata pine

Wetness-(W1, W2, W3)

Some crop plants are more sensitive to soil wetness problems than others. Many soil-borne diseases and pathogens are more prolific in excessively wet soils, and pose an increased risk to plant health and yield potential. Some crop plants are more susceptible to diseases, pathogens and insects when they are stressed due to growing on excessively wet soils. Advances in plant breeding may help in reducing crop tolerances to soil wetness and associated diseases and pathogens, but this can't be taken into account in this assessment.

Some horticultural tree crops may grow on soils subject to excessive soil wetness, but their potential yields will be reduced due to associated disease and pathogen problems. This limitation considers not only the growth of these crops, but the risks and management inputs required to achieve sustainable production levels on excessively wet soils.

Limitation value and subclass determination. Soil permeability, site drainage and crop tolerance are assessed to determine Wetness subclasses. Texture, grade and type of structure, colour, mottles, segregations and impermeable layers are indicators of soil wetness. Slope and topographic position are indicators of site drainage. Limitation subclasses have been determined by way of consultation with industry experts and local growers, crop tolerance information and the effects of delays in machinery operation.

Wetness is assessed for land management options based on the rooting depth of the crop being grown. To account for this, wetness is considered as 3 separate limitations for each UMA, W1 for most broad acre crops and radiata pine, W2 for most horticultural crops (other than trees) and W3 for most horticultural tree crops

Grower experience with macadamia production in the Bundaberg area on red soils that are rapidly to moderately-well drained and moderately to highly permeable has shown that nut production may be reduced due to excessive tree vegetative growth (commonly known as abnormal vegetative growth syndrome or AVG). Similarly, Macadamias have been successfully grown on some imperfectly drained soils previously thought to be marginal or unsuitable due to excessive soil wetness. Macadamia suitability has been modified in the WIN study area to account for this grower experience.

Additional Information

- Imperfectly, poorly or very poorly drained soils significantly affect plant growth for many crops and are usually the soils where mounding is important. Mounding is a standard management practice for tree crops.
- The most limiting layer within the soil profile to the depth indicated (1.00 m for W1, 0.50 m for W2 and 1.50 m for W3) determines the subclass. For example, if a soil profile has an imperfectly drained and slowly permeable layer at 0.30 m, this layer becomes the most limiting layer for assessing the W1, W2 and W3 limitation. A second example is a soil profile that is moderately-well drained and moderately permeable to 1.2 m, but slowly permeable and imperfectly drained below this depth. This soil will have subclasses of 3 for trickle irrigated grapes (W1), 1 for sugarcane (dryland, furrow or spray irrigated) (W2) and 5 for microsprinkler irrigated avocado (W3).
- For very shallow, shallow, moderately deep and deep soils (NCST, 2009) the most limiting soil layer is assessed for the W1, W2 and W3 limitation, regardless of soil depth (depth to underlying rock, which is considered in other limitations). For example, soils such as *Broweena*, with underlying rock at 0.3-0.75m, a value for W1, W2 and W3 is assessed on the imperfectly drained and slowly permeable subsoil layer. Any effect underlying rock may have on soil permeability or drainage is not considered in this limitation, but included in other limitations.

Wetness to 1m-W1

Limitation		Subclasses for land management options			
Value	**Description**	**Group A**	**Group B**	**Group C**	**Group D**
6H	The upper 1m of the soil is rapidly drained/highly permeable	1	1	2	1
6M	The upper 1m of the soil is rapidly drained/moderately permeable	1	1	1	1
5H	The upper 1m of the soil is well drained/highly permeable	1	1	1	1
5M	The upper 1m of the soil is well drained/moderately permeable	1	1	2	2
4H	The upper 1m of the soil is moderately well drained/highly permeable	1	1	2	2
4M	The upper 1m of the soil is moderately well drained/moderately permeable	1	2	3	3
4S	The upper 1m of the soil is moderately well drained/slowly permeable	2	3	4	4
4V	The upper 1m of the soil is moderately well drained/very slowly permeable	2	3	4	4
3H	The upper 1m of the soil is imperfectly drained/highly permeable	2	2	3	3
3M	The upper 1m of the soil is imperfectly drained/moderately permeable	2	3	4	4
3S	The upper 1m of the soil is imperfectly drained/slowly permeable	3	4	5	5
3V	The upper 1m of the soil is imperfectly drained/very slowly permeable	4	4	5	5
2H	The upper 1m of the soil is poorly drained/highly permeable	3	5	5	5
2M	The upper 1m of the soil is poorly drained/moderately permeable	3	5	5	5
2S	The upper 1m of the soil is poorly drained/slowly permeable	4	5	5	5
2V	The upper 1m of the soil is poorly drained/very slowly permeable	5	5	5	5
1H	The upper 1m of the soil is very poorly drained/highly permeable	5	5	5	5

1M	The upper 1m of the soil is very poorly drained/moderately permeable	5	5	5	5
1S	The upper 1m of the soil is very poorly drained/slowly permeable	5	5	5	5
1V	The upper 1m of the soil is very poorly drained/very slowly permeable	5	5	5	5

Group A	Group B		Group C	Group D
Radiata pine	Maize-furrow irrigated	Soybean-furrow irrigated	Grapes-trickle irrigated	Lucerne-spray irrigated
	Maize-spray irrigated	Soybean-spray irrigated		
	Forage sorghum (forage)-spray irrigated	Sweet corn-furrow irrigated		
		Sweet corn-spray irrigated		

Wetness to 0.5m – W2

Limitation		Subclasses for land management options				
Value	**Description**	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**
6H	The upper 0.5m of the soil is rapidly drained/highly permeable	1	1	1	1	1
6M	The upper 0.5m of the soil is rapidly drained/moderately permeable	1	1	1	1	1
5H	The upper 0.5m of the soil is well drained/highly permeable	1	1	1	1	1
5M	The upper 0.5m of the soil is well drained/moderately permeable	1	1	1	2	2
4H	The upper 0.5m of the soil is moderately well drained/highly permeable	1	1	1	2	3
4M	The upper 0.5m of the soil is moderately well drained/moderately permeable	1	2	2	3	4
4S	The upper 0.5m of the soil is moderately well drained/slowly permeable	2	2	3	4	5
4V	The upper 0.5m of the soil is moderately well drained/very slowly permeable	2	2	3	4	4
3H	The upper 0.5m of the soil is imperfectly drained/highly permeable	2	2	2	3	4
3M	The upper 0.5m of the soil is imperfectly drained/moderately permeable	2	2	3	4	4
3S	The upper 0.5m of the soil is imperfectly drained/slowly permeable	3	3	4	5	5
3V	The upper 0.5m of the soil is imperfectly drained/very slowly permeable	3	3	5	5	5
2H	The upper 0.5m of the soil is poorly drained/highly permeable	3	4	5	5	5
2M	The upper 0.5m of the soil is poorly drained/moderately permeable	3	4	5	5	5
2S	The upper 0.5m of the soil is poorly drained/slowly permeable	4	5	5	5	5
2V	The upper 0.5m of the soil is poorly drained/very slowly permeable	4	5	5	5	5

1H	The upper 0.5m of the soil is very poorly drained/highly permeable	4	5	5	5	5
1M	The upper 0.5m of the soil is very poorly drained/moderately permeable	4	5	5	5	5
1S	The upper 0.5m of the soil is very poorly drained/slowly permeable	5	5	5	5	5
1V	The upper 0.5m of the soil is very poorly drained/very slowly permeable	5	5	5	5	5

Group A	Group B	Group C		Group D	Group E
Sugarcane-dryland	Banana-microsprinkler irrigated	Capsicum-trickle irrigated	Pineapple-spray irrigated	Fresh beans-spray irrigated	Ginger
Sugarcane-furrow Irrigated		Cruciferae-trickle irrigated	Potato-spray irrigated	Navy bean-furrow irrigated	
Sugarcane-spray irrigated		Cucurbit-furrow irrigated	Strawberry-trickle irrigated	Navy bean-spray irrigated	
		Cucurbit-spray irrigated	Sweet potato-spray irrigated	Peanut-furrow irrigated	
		Pineapple-dryland	Tomato-trickle irrigated	Peanut-spray irrigated	

Wetness to 1.5m - W3

Limitation		Subclasses for land management options				
Value	**Description**	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**
6H	The upper 1.5m of the soil is rapidly drained/highly permeable	1	1	1	3	1
6M	The upper 1.5m of the soil is rapidly drained/moderately permeable	1	1	1	3	2
5H	The upper 1.5m of the soil is well drained/highly permeable	1	1	1	3	2
5M	The upper 1.5m of the soil is well drained/moderately permeable	1	1	2	3	3
5S	The upper 1.5m of the soil is well drained/slowly permeable	2	1	3	2	4
4H	The upper 1.5m of the soil is moderately well drained/highly permeable	1	1	3	3	4
4M	The upper 1.5m of the soil is moderately well drained/moderately permeable	1	2	3	3	4
4S	The upper 1.5m of the soil is moderately well drained/slowly permeable	2	3	4	4	5
4V	The upper 1.5m of the soil is moderately well drained/very slowly permeable	2	3	4	4	5
3H	The upper 1.5m of the soil is imperfectly drained/highly permeable	2	2	4	3	5
3M	The upper 1.5m of the soil is imperfectly drained/moderately permeable	2	3	4	3	5
3S	The upper 1.5m of the soil is imperfectly drained/slowly permeable	3	4	5	4	5
3V	The upper 1.5m of the soil is imperfectly drained/very slowly permeable	3	4	5	5	5
2H	The upper 1.5m of the soil is poorly drained/highly permeable	3	3	5	5	5
2M	The upper 1.5m of the soil is poorly drained/moderately permeable	3	4	5	5	5
2S	The upper 1.5m of the soil is poorly drained/slowly permeable	4	5	5	5	5

2V	The upper 1.5m of the soil is poorly drained/very slowly permeable	4	5	5	5	5
1H	The upper 1.5m of the soil is very poorly drained/highly permeable	5	5	5	5	5
1M	The upper 1.5m of the soil is very poorly drained/moderately permeable	5	5	5	5	5
1S	The upper 1.5m of the soil is very poorly drained/slowly permeable	5	5	5	5	5
1V	The upper 1.5m of the soil is very poorly drained/very slowly permeable	5	5	5	5	5

Group A	Group B	Group C	Group D	Group E
Lychee-microsprinkler irrigated	Mango-microsprinkler irrigated	Citrus-microsprinkler irrigated	Macadamia-microsprinkler irrigated	Avocado-microsprinkler irrigated

X-Landscape complexity

An area of suitable land may be too small to justify its use as an isolated production area for a particular land management option.

Limitation value and subclass determination. Minimum production areas for each land use are determined by industry experts and grower experience.

Additional Information

- Small areas of suitable land has most effect on broad acre crops that require large paddock sizes for efficiency (e.g., sugarcane, forage crops, commercial timber). Surveyed lot size is not considered, nor is the distance of a UMA from adequate existing or planned infrastructure, markets or processing facility, as in the case of sugarcane or other land management options where the off-farm product needs to be processed before sale. However, the distance to adjoining irrigation and/or other infrastructure is important, for example, if greater than 0.5 km, suitability is downgraded.
- When the area of suitable land is less than a minimum production area, the area of any contiguous suitable adjacent land is also included in the assessment of the minimum production area.
- The ability to supply irrigation water to a small area surrounded by marginal or unsuitable land is also considered in this limitation. For example, small areas of suitable soil located in isolation on a hillcrest above unsuitable land are downgraded in this scheme.
- Narrow areas of contiguous suitable land have been downgraded as an adequate row length and paddock design for land management options considered in this scheme may be difficult to achieve.
- Minimum production area is based on the minimum area of land which is practical to be used for a land management option. It may be based on implicit economic criteria, such as economies of scale in terms of agricultural production, but it is not related to an ‘economic production unit’ or a ‘living area”.

X-Landscape complexity

Limitation		Subclasses for land management options						
Value	**Description**	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**	**Group F**	**Group G**
0	Minimum practical production area >10 ha	1	1	1	1	1	1	1
1	Minimum practical production area 5-10 ha	1	1	1	1	1	1	4
2	Minimum practical production area 2.5-5 ha	1	1	1	2	3	4	5
3	Minimum practical production area 1.5-2.5 ha or areas 100 to 200 m wide.	1	2	2	3	4	5	5
4	Minimum practical production area <1.5 ha or areas less than 100 m wide.	4	3	4	4	5	5	5

X-Landscape complexity

Group A	Group B	Group C	Group D	Group E	Group F	Group G
Fresh beans-spray irrigated	Avocado-microsprinkler irrigated	Banana-microsprinkler irrigated	Cucurbit-furrow irrigated	Lucerne-spray irrigated	Radiata pine	Maize-furrow irrigated
Capsicum-trickle irrigated	Citrus-microsprinkler irrigated	Ginger-spray irrigated	Cucurbit-spray irrigated	Sugarcane-dryland		Maize-spray irrigated
Cruciferae-trickle irrigated	Grapes-trickle irrigated		Potato-spray irrigated	Sugarcane-furrow irrigated		Navy bean-furrow irrigated
Sweet corn-furrow irrigated	Lychee-microsprinkler irrigated			Sugarcane-spray irrigated		Navy bean-spray irrigated
Sweet corn-spray irrigated	Macadamia-microsprinkler irrigated					Peanut-furrow irrigated
Sweet potato-spray irrigated	Mango-microsprinkler irrigated					Peanut-spray irrigated
Tomato-trickle irrigated	Pineapple-dryland					Forage sorghum -spray irrigated
	Pineapple-spray irrigated					Soybean-furrow irrigated
	Strawberry-trickle irrigated					Soybean-spray irrigated

Appendix 10: Major soil limitations and management remarks for soil management groups in the WIN study area

Soil groups	Major limitations	Management remarks
Tenosols and Podosols with sandy profiles on beach ridges of the Beach ridge plains		
Colvin (Cv) *Moore Park (Mp)* *Tantitha (Tt)*	• Low PAWC • Low fertility and nutrient retention capacity • *Colvin* and occasionally *Moore Park* may be poorly drained at depth on lower hillslopes of the beach ridges	These soils are generally suitable for low volume irrigation of most horticultural crops. High management inputs are required and some options to consider to improve production and sustainability include: • Irrigating with frequent light irrigations using low volume irrigation techniques due to low PAWC and to minimise deep drainage losses • Incorporating crop residues to increase organic matter levels and improve water holding capacity and nutrient retention ability • Splitting fertiliser applications or applying slow release fertilisers to minimise deep drainage losses • Perched water tables may occur on the lower hillslopes of the beach ridges during prolonged wet periods which may affect susceptible crops

Hydrosols of the Marine Plains with sandy surface or recent alluvium over marine plains		
Maroom (Mm) *Sugarmill (Sm)*	• Low lying areas with low slopes, which may be susceptible to flooding • Surface seeps and secondary salinization may occur in some areas due to shallow depth to water tables • Poorly to very poorly drained subsoils • Acid sulfate soil properties in *Sugarmill* soils	These soils are generally suitable for sugarcane and horticultural and broad acre crops tolerant of excessive soil wetness and acid sulfate soil properties. Furrow irrigation is generally suitable on these soils. High management inputs are required to achieve acceptable and sustainable yields and to protect the environment. Some management options to consider to improve production and sustainability include: • Planning operations to reduce access problems during wet periods • Avoiding exposure or mixing of acid sulfate soil layers (*Sugarmill* only) • Applying lime to increase soil pH and nutrient availability • Laser levelling to produce surface gradients that allow efficient run-off of excess water and minimise soil waterlogging

*Hydrosols of the Marine Plains with predominately clay surfaces ***		
Fairydale (Fd) *Fairymead (Fm)*	• Low lying areas with low slopes, which may be susceptible to flooding • Surface seeps and secondary salinization may occur in some areas due to shallow depth to water tables • Poorly to very poorly drained • Acid sulfate soil properties	These soils have been assessed as generally marginal for sugarcane and broad acre crops tolerant of excessive wetness and acid sulfate soil properties (see note at the end of the table). High management inputs are required to achieve acceptable and sustainable yields and to protect the environment. Some management options to consider to improve production and sustainability include: • Planning operations to reduce access problems during wet periods • Appropriate soil investigation to understand the depth and severity of actual acid sulfate soil and potential acid sulfate soil (PASS). • Avoiding lowering the water table or intercepting acid sulfate soil layers to minimise acid leakage into drains. Constructing shallow drains in preference to deep drains • Avoid exposure or mixing of acid sulfate soil layers • Applying lime to increase soil pH and nutrient availability • Laser levelling to produce surface gradients that allow efficient run-off of excess water and minimise soil waterlogging (ensuring PASS is not disturbed).

Tenosols and Rudosols on recent alluvial plains of the Kolan River and major creeks.		
Barubbra (Bb) *Burnett (Bn)*	• *Low PAWC* • *Low fertility and nutrient retention capacity* • *Flooding of some areas* • *Soil complexity and variability*	*These soils are generally suitable for low volume irrigation of sugarcane and most horticultural crops. High management inputs are required and some options to consider to improve production and sustainability include:* • Irrigating with frequent light irrigations using low volume irrigation techniques due to low PAWC and to minimise deep drainage losses • Incorporating crop residues to increase organic matter levels and improve water holding capacity and nutrient retention ability • Using split fertiliser applications or applying slow release fertilisers to minimise deep drainage losses • Growing flood tolerant crops in flood prone areas • Adjust management strategies where possible to account for soil variability

Dermosols and Hydrosols on recent alluvial plains of the Kolan River and major creeks.		
Flagstone (Fs) *Gahan (Gh)*	• Flooding in some areas	These soils are suitable for irrigation of sugarcane and most horticulture and broad acre crops. The management options that may be considered to improve production and sustainability include: • Irrigating *Gahan* more frequently as PAWC is reduced due to the presence of sandy layers in the profile • Growing flood tolerant crops in flood prone areas

Sodosols on alluvial plains of the Kolan River, major creeks and local streams		
Auburn (Ab) *Crossing (Cg)* *Peep (Pp)*	• Rooting depth limited by high sodicity and salt levels in the subsoil • Low PAWC • Hard setting surfaces • Poor internal drainage • Low nutrient retention capacity in topsoil • Flooding of some areas of *Peep*	These soils are generally suitable for irrigated sugarcane and lychees. Management options that need to be considered to improve productivity and sustainability include: • Irrigating more effectively with frequent irrigations as depth of water penetration limited by high sodicity and salt levels • Deep ripping combined with gypsum to improve water penetration and therefore PAWC. However, any translocation of salt or sodium below the root zone and potentially off-site must be monitored and appropriate management strategies implemented. • Avoiding mixing subsoil with surface soil to minimise adverse impacts on seedling emergence and crop establishment • Incorporating crop residues to increase organic matter levels and nutrient retention ability and reduce problems with seedling emergence and crop establishment • Avoid growing lychees in flood prone areas of *Peep*

Vertosols and Grey Dermosols with clayey textures on alluvial plains of the Kolan River, major creeks and local streams		
• *Walla* (*Wl*) • *Weithew* (*Wh*)	• Surface crusting may occur • Gilgai may occur on undeveloped land • Low gradients • Flooding may occur • High subsoil salinity in *Walla* soil • Usually poorly drained at depth • Narrow moisture range for access and cultural activities • Strongly adhesive • Susceptible to secondary salinisation	These soils are generally suitable for irrigated sugarcane, horticultural and broad acre crops tolerant of seasonal wetness. They are generally suitable for furrow irrigation. Some management options that need to be considered to increase productivity and sustainability include: • Planning operations to reduce access problems during wet periods • Cultivating these soils at optimum soil moisture content to avoid smearing if too wet and producing clods when dry • Using short irrigation duration times as water entry is rapid when cracks are open but very slow when cracks close • Deep ripping combined with gypsum to improve water penetration and therefore PAWC. However, any translocation of salt or sodium below the root zone and potentially off-site must be monitored and appropriate management strategies implemented. • Avoiding mixing subsoil with surface soil to minimise adverse impacts on seedling emergence and crop establishment • Incorporating crop residues to increase organic matter levels and reduce problems with seedling emergence and crop establishment • Laser levelling to produce surface gradients that allow efficient run-off of excess water and minimise soil waterlogging • Installing interceptor drains where needed to minimise water table rises and secondary salinization

Kandosols on alluvial plains of local streams		
Littabella (Lt)	• *Surface crusting may occur* • *Low PAWC for soil profiles with sandy surfaces* • *Soil complexity* and variability	This soil is suitable for irrigated sugarcane and most horticultural crops. It occurs in small areas in association with other soils, and is not suitable for broad acre crops. Some management options that need to be considered to increase productivity and sustainability include: • Incorporating crop residues to increase organic matter levels, water holding capacity and nutrient retention ability and reduce problems with seedling emergence and crop establishment • Irrigating more effectively with frequent light irrigations using low volume irrigation techniques to minimise deep drainage losses • Using split fertiliser applications or applying slow release fertilisers to minimise deep drainage losses • Adjust management strategies where possible to account for soil variability

Podosols on plains, drainage depressions and lower hillslopes of rises and low hills on sedimentary rocks		
Kinkuna (Kn) *Theodolite (Th)* *Wallum (Wm)*	• *Low PAWC* • *Low fertility and nutrient retention capacity* • *Often strongly acid with high aluminium levels* • *Excessive wetness and often shallow water tables* • *Secondary salinization may occur in some localities* • *Soil complexity*	These soils are suitable for irrigated sugarcane and horticultural crops tolerant to excessive wetness and strongly acid soils, often with high aluminium. Some management options that need to be considered to increase productivity and sustainability include: • Incorporating crop residues to increase organic matter levels, water holding capacity and nutrient retention ability and reduce problems with seedling emergence and crop establishment • Irrigating more effectively with frequent light irrigations using low volume irrigation techniques • Using split fertiliser applications or applying slow release fertilisers to minimise deep drainage losses • Adjusting management strategies where possible to account for soil variability

<table>
<tr><th colspan="3">Red Kandosols, Dermosols and Ferrosols on plains, hillcrests and mid to upper hillslopes of rises and low hills on sedimentary rocks</th></tr>
<tr><td>Farnsfield (Ff)
Gooburrum (Gb)
Howes (Hs)
Oakwood (Ok)
Watalgan (Wt)</td><td>• Permeable soils occurring in groundwater recharge areas
• Initially low fertility
• Susceptible to erosion on hillslopes
• Hard setting surfaces
• Moderately to strongly adhesive (Howes)
• Some Watalgan profiles overlying grey clay layer with slow permeability below 1.0 m</td><td>These soils are generally suitable for sugarcane and most irrigated horticultural and broad acre crops. However; in some localities they may be unsuitable due to lack of contiguous areas. Some management options that may be considered to improve production and sustainability include:
• Using spray and trickle irrigation methods to reduce losses to deep drainage and minimise secondary salinisation downslope
• Using erosion control measures on sloping land
• Avoiding cultivation on slopes greater than 8%
• Cultivating these soils at optimum soil moisture content to avoid smearing if too wet and producing clods when dry (particularly Howes)
• Incorporating crop residues to increase organic matter levels and nutrient retention ability and reduce problems with seedling emergence and crop establishment
• Avoiding tree crops susceptible to subsoil wetness on soil profiles with grey clay layer at depth</td></tr>
</table>

<table>
<tr><th colspan="3">Yellow and Brown Dermosols, Kandosols and Tenosols with sandy surfaces on plains, hillcrests and mid to upper hillslopes of rises and low hills on sedimentary rocks</th></tr>
<tr><td>Calavos (Ca)
Meadowvale (Md)
Quart (Qr)
Rothchild (Rt)</td><td>• Low to moderate PAWC
• Susceptible to erosion on slopes
• Initially low fertility
• Low nutrient retention capacity</td><td>Generally these soils are suitable for irrigation of sugarcane and most horticultural and broad acre crops tolerant of seasonal wetness in the subsoil. Some management options that may be considered to improve production and sustainability include:
• Using erosion control measures on sloping land
• Avoiding cultivation on hillslopes greater than 8%
• Irrigating more effectively with frequent light irrigations using low volume irrigation techniques
• Incorporating crop residues to increase organic matter levels and nutrient retention ability and reduce problems with seedling emergence and crop establishment</td></tr>
</table>

Yellow and Brown Dermosols and Kandosols with loamy surfaces on plains, hillcrests and mid to upper hillslopes of rises and low hills on sedimentary rocks		
Bucca (Bc) *Cedars (Cr)* *Gillen (Gi)* *Kepnock(Kp)* *Woolmer (Wr)*	• Susceptible to erosion on hillslopes • Initially low fertility • Hard setting surfaces • Surface gravels to cobbles (*Bucca* soil) • Profile may contain up to 50% iron nodules or sandstone gravels which reduces PAWC significantly	Generally these soils are suitable for irrigation of sugarcane and most horticultural and broad acre crops tolerant of seasonal wetness in the subsoil. *Bucca* soil is not suitable for crops where surface gravels or cobles affect harvesting. Some management options to consider to improve production and sustainability include: • Using erosion control measures on sloping lands. • Avoiding cultivation on hillslopes greater than 8%. • Incorporating crop residues to increase organic matter levels and reduce problems with seedling emergence and crop establishment • Rock picking may be required (*Bucca*) • Soils with large amounts of iron nodules or sandstone gravels may need more frequent irrigation than soils with less iron nodules or sandstone gravels. *Bucca* may have low PAWC due to shallow soil profiles

Hydrosols on plains, drainage depressions and lower hillslopes of rises and low hills on sedimentary rocks		
Alloway (Al) *Robur (Rb)* *Winfield (Wf)*	• Occur in discharge areas likely to be subject to secondary salinization • May be waterlogged for several months • Low PAWC of the surface layers • Initially low fertility and nutrient retention capacity • Susceptible to erosion on hillslopes	These soils are generally marginal or unsuitable for most irrigated or dryland crops. *Winfield* may be suitable for irrigation depending on its slope positon and site drainage. Some management options to consider to improve production and sustainability include: • Planning operations to reduce access problems during wet periods • Constructing interception drains above discharge areas to reduce effects of waterlogging and salinisation • Irrigating more effectively with frequent light irrigations using low volume irrigation techniques • Incorporating crop residues to increase organic matter levels, improve water holding capacity and nutrient retention ability and reduce problems with seedling emergence and crop establishment • Splitting fertiliser applications or applying slow release fertilisers to minimise deep drainage losses • Using erosion control measures on sloping lands • Avoiding cultivation on hillslopes greater than 3%

Yellow and Brown Kurosols or Sodosols with sandy surfaces on plains, hillcrests and mid to upper hillslopes of rises and low hills on sedimentary rocks		
Isis (Is) *Yandaran (Yd)*	• Low PAWC of the sandy surface horizons • Susceptible to erosion on hillslopes • Initially low fertility and nutrient retention in the sandy surface horizons • Some profiles overlying grey clay layer with slow permeability below 1.0m	Generally these soils are suitable for irrigation of sugarcane and most horticultural and broad acre crops tolerant of seasonal wetness in the subsoil. Some management options to consider to improve production and sustainability include: • Using erosion control measures on sloping land • Avoiding cultivation on hillslopes greater than 8% • Irrigating more effectively with frequent light irrigations using low volume irrigation techniques • Incorporating crop residues to increase organic matter levels, improve water holding capacity and nutrient retention ability and reduce problems with seedling emergence and crop establishment

Grey Kurosols or Sodosols with loamy surfaces on plains and mid to lower hillslopes of rises and low hills on sedimentary rocks		
Avondale (Av) *Brooweena (Bw)* *Givelda (Gv)* *Kolan (Ko)* *Turpin (Tp)* *Tirroan (Tr)*	• Rooting depth limited by high sodicity and salt levels at shallow depths • Shallow soil depth limits PAWC in some profiles (particularly *Brooweena* and *Tirroan*) • Surface gravels (*Brooweena*, *Turpin* and *Tirroan*) • Low PAWC • Hard setting surfaces • Poor internal drainage • Low fertility and nutrient retention capacity in topsoil • Often strongly acid with high aluminium in the subsoil	These soils are generally suitable for irrigated sugarcane and lychees. High management inputs are required to achieve acceptable yields. Management options that need to be considered to improve productivity and sustainability include: • Irrigating more effectively with frequent light irrigations as depth of water penetration limited by high sodicity and salt levels • Deep ripping combined with gypsum to improve water penetration and therefore PAWC in soils that are not shallow or rocky. However, any translocation of salt or sodium below the root zone and potentially off-site must be monitored and appropriate management strategies implemented. • Avoiding mixing subsoil with surface soil to minimise impacts on seedling emergence and crop establishment • Incorporating crop residues to increase organic matter levels, improve water holding capacity and nutrient retention ability and reduce problems with seedling emergence and crop establishment • Avoiding cultivation or ground disturbance on hillslopes greater than 3%

Rocky Tenosols, Rudosols and Dermosols on hillcrests and upper hillslopes of rises and low hills on sedimentary rocks		
Bungadoo (Bg) *Takoko (Tk)*	• Low PAWC • Common to abundant surface and profile rock • Low fertility and nutrient retention capacity • Shallow soils • Hillslopes up to 20%	This soil is unsuitable for all irrigated and dryland crops considered and improved pastures. It is suitable for grazing of sparse native species. Some management options that may be considered to improve production of native pastures and sustainability include: • Avoiding cultivation and ground disturbance to minimise erosion potential. • Applying light applications of fertiliser where safe access is possible

Red and Brown Dermosols and Chromosols on rises and low hills on acid and intermediate volcanic rocks		
Booyal (Bl) *Tiaro (Ta)*	• Permeable soils occurring in groundwater recharge areas • Initially low fertility • Susceptible to erosion on hillslopes • Hard setting surfaces	Generally suitable for most irrigated horticultural and broad acre crops. However, some localities the may be unsuitable for broad acre crops due to lack of contiguous areas. Some management options that may be considered to improve production and sustainability include: • Using spray and trickle irrigation methods to reduce losses to deep drainage and minimise secondary salinisation downslope • Using erosion control measures on sloping land • Avoiding cultivation on hillslopes greater than 8% • Incorporating crop residues to increase organic matter levels, improve nutrient retention and reduce problems with seedling emergence and crop establishment

Grey and Brown Sodosols and Kurosols on rises and low hills on acid and intermediate volcanic rocks		
Doongul (Do) *Gigoon (Gn)* *Owanyilla (Ow)*	• Rooting depth limited by high sodicity and salt levels at shallow depths. • Shallow soil depth limits PAWC in some profiles • Surface rock • Low PAWC • Hard setting surfaces • Poor internal drainage • Low fertility and nutrient retention capacity in topsoil • Often strongly acid with high aluminium in the subsoil	These soils are generally suitable for irrigated sugarcane and lychees. High management inputs are required to achieve acceptable yields. Management options that need to be considered to improve productivity and sustainability include: • Irrigating more effectively with frequent light irrigations as depth of water penetration limited by high sodicity and salt levels • Deep ripping combined with gypsum to improve water penetration and therefore PAWC in soils that are not shallow or rocky. However, any translocation of salt or sodium below the root zone and potentially off-site must be monitored and appropriate management strategies implemented. • Avoiding mixing subsoil with surface soil to minimise adverse impacts on seedling emergence and crop establishment • Rock picking may be required in some localities • Incorporating crop residues to increase organic matter levels and reduce problems with seedling emergence and crop establishment • Avoid cultivation or ground disturbance on hillslopes greater than 3%

Sandy Tenosols on rises and low hills on acid volcanic rocks		
Moolyung (My)	• Low PAWC • Common to abundant rock • Low fertility and low nutrient retention • Variable soil depth to underlying rock • Hillslopes up to 20%	This soil is unsuitable for all irrigated and dryland crops considered and improved pastures. It is suitable for grazing of sparse native species. Some management options that may be considered to improve production of native pastures and sustainability include: • Avoiding cultivation and ground disturbance to minimise erosion potential • Applying light applications of fertiliser, particularly phosphorous, where safe access is possible

Brown and Black Dermosols and Ferrosols on Basalt rocks		
Berren (Be) _Kowbi (Kb)_	• Stone and rock may be present on surface • Variable soil depth to underlying rock • Narrow moisture range for access and agricultural activities • Strongly adhesive • Hillslopes up to 20 or 30%	These soils are generally suitable for sugarcane and most irrigated horticultural crops. Some management options that may be considered to improve production and sustainability include: • Stone picking where necessary, practical and safe to do so • Using erosion control measures on sloping land • Avoiding cultivation on hillslopes greater than 8% • Cultivating these soils at optimum soil moisture to avoid smearing if too wet and producing clods when dry

Note:

** Sugarcane has been successfully grown on this soil where drainage has been implemented in the past. It has been generally assessed as suitable for sugarcane in the BAB survey as the areas of these soils were growing sugarcane with drainage already constructed. However, suitability assessment in this survey has been assessed as marginal to unsuitable due to excessive wetness and the environmental risks associated with constructed drainage works.

Appendix 11: Project validation

Validation of the WIN project was undertaken to assess the accuracy of mapping and polygon attribution. This was achieved through a two day field validation exercise where soil surveyors unfamiliar with the project were given random sites to make field observations. Observations consisted of detailed soil descriptions which were then used to validate WIN mapping and polygon attributes.

A total of 34 sites were used for validation: WIN 850-868, 950-964.

Validation sites were deemed valid if:

- the validation site had a soil profile class (SPC) matching one of the entities assigned to the polygon in which it was located or a polygon within 100m
- the area likely occupied by the validation site SPC was large enough to meet minimum mapping area requirements e.g. at 1:50 000 scale area must be greater than or equal to 4 hectares
- field texture of the A1 and B21 horizon, of the validation site fell within the texture range of the A1 and B21 horizon of at least one of the SPC entities assigned to the polygon in which the validation site was located
- whole profile permeability and drainage at the validation site fell within the range of at least one of the SPC entities assigned to the polygon in which the validation site was located
- validation site A1 and B21 horizon field pH fell within the range of pH’s for the A1 and B21 horizon of at least one of the SPC entities assigned to the polygon in which the validation site was located
- soil depth at the validation site fell within the range of soil depths attributed to the SPC entities assigned to the polygon in which the validation site was located.

The following are the results of the validation process.

Table 7 Results of validation

Validation parameter	% of validation sites correlated with WIN mapping
SPC	74
Field texture-A	91
Field texture-B	92
Permeability	93
Drainage	96
pH-A	67
pH-B	86
Soil depth	79