QO91007

PROJECT REPORT

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Auburn River irrigation suitability study

P.R. Wilson and P. Sorby
Land Resources Branch

Queensland Department
of Primary Industries

Queensland Government Technical Report

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Queensland Department of Primary Industries
Brisbane 1991

ISSN 0727-6281

Agdex 524/567

This publication was prepared for Queensland Department of Primary Industries officers. It may be distributed to other interested individuals.

Queensland Department of Primary Industries
GPO Box 46
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* Not included in report, accessed through the Director, Land Resources Branch, Queensland Department of Primary Industries.

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1. INTRODUCTION

The Water Resources Commission requested the Land Resources Branch of the Queensland Department of Primary Industries carry out an assessment of soils suitable for irrigation of different crops riparian to the Auburn and Burnett rivers near Mundubbera.

Currently there are ten licenses on the Auburn River irrigating 204 hectares, and a further five licenses being supplied approximately 1000 megalitres each from the Jones Weir, Mundubbera. The Jones Weir operates on water releases from the Worumba Dam, north-west of Eidsvold. Citrus are fully irrigated where as other irrigated crops rely predominantly on rainfall with supplementary irrigation in dry periods.

The survey area covers an area five kilometres either side of the Burnett and Auburn Rivers from Mundubbera to a possible dam site approximately 18 km upstream from where the Auburn River meets the Burnett River. The study area consists of 28 712 ha as shown in Figure 1.

The aims of this investigation are to:

1. Provide a soils map at 1:50 000 scale of the study area.

2. Identify areas suitable for irrigation and supply a crop suitability map.

3. Identify possible management problems that may occur under irrigation and identify salinity hazards.

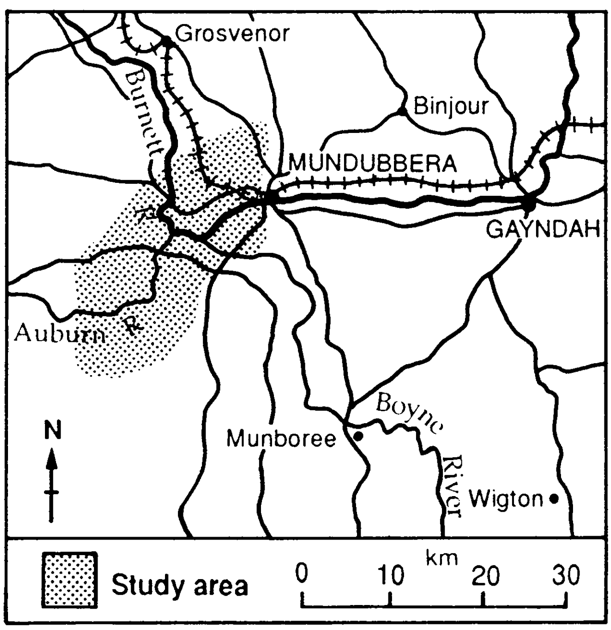

Figure 1. Locality plan

2. LANDFORM

The landform of the study area includes:

. Rises, low hills and hills
. Alluvial fans
. Alluvial plains

A total of 23 soils (see Appendix III) have been identified and relevant soils are included in the description of the landform.

2.1 Rises, low hills and hills

Soil types: Beeron, Boynewood, Hawkwood, Lacon, O'Bil Bil, Toondoon, Washpool.

These landforms have very low to high relief (about 15 to 150 m) with very gently inclined to steep slopes (about 2 to 40%) and fixed stream channels. The geology comprises siltstone, mudstone, conglomerate, shale, sandstone and andesite. The occurrence of the soils is associated with rock type and position in the landscape.

The moderately inclined to steep slopes (>10%) have been mapped as hills and occur mainly in the northern, western and southern parts. The soils are generally very shallow (<0.3 m) and rocky, and have not been described in detail.

The gently undulating to undulating slopes (<10%) occur over a majority of the northern and eastern parts. The upper slopes generally have shallow gravelly soils while lower slopes are generally deep and stone free. Some sheet wash occurs from soils on upper slopes.

2.2 Alluvial fans

Soil types: Chessborough, Evergreen, Glenrock, Pearlinga, Shurback, Wivenhoe.

This landform is very gently to gently inclined (<10%) with very local relief (<30 m). The fans have developed from the wash of material from the hills and deposited at the base of these hills by stream flow or sheet wash. The alluvial fans in the southern and western parts of the study area have coalesced to form a continuous apron fronting the hills. Slopes are generally concave with 4 to 6% on upper slopes and level on lower slopes.

Soil variation is associated with position in the landscape. Well drained soils occur on the upper slopes. The lower slopes show several deposition phases and overlie or abut grey and brown clays.

The relict river deposits on hill tops have been included in this landform because of similarity in soil types and elevation. Fine quartz gravel is usually associated with these soils east of the Boyne River while soils west of the Boyne River are generally gravel free.

2.3 Alluvial plains

Soil types: Auburn, Burnett, Boyne, Coonambula, Derra, Durong, Flagstone, Grindstone, Nail, Riverleigh.

This landform comprises relict alluvia and recent alluvia. The relict alluvia occurs as level plains elevated above the recent alluvia and are often incised by the rivers and creeks. Texture contrast soils and clay soils predominate.

The recent alluvia comprises narrow channel benches and terraces along the Auburn, Burnett and Boyne Rivers, and narrow plains along creeks flowing into the rivers. Relict levees occur on the terraces. The channel benches and edges of the relict levees have layered sandy to loamy alluvial soils. Soils become heavier textured on the back slopes of the terraces. The plains along the creeks are dominated by texture contrast soils.

3. SOILS

3.1 Introduction

Soils of the study area have been previously mapped and described at low intensity scale by de Mooy *et al.* (1977), Isbell *et al.* (1967) and Kent (in preparation).

In this study, 23 soils, 3 variants and 4 phases (Map 1, Appendix III) have been identified, together with three miscellaneous units. Table 1 lists the major distinguishing attributes, landscape and geology for each soil.

Table 1. Soil type, major distinguishing attributes, Great Soil Group, landform and geology

Soil type	Major distinguishing attributes	Great Soil Group	Landform	Geology
Auburn	0.05 to 0.2 m grey-brown, dark or brown A1/Ap horizon over conspicuously bleached A2 horizon to 0.15 to 0.35 m over alkaline, brown, yellow-brown or grey-brown, light medium clay to heavy clay B2 horizon to 1.5 m.	Solodic soil	Alluvial plains	Cainozoic alluvia
Auburn red variant	As above. B2 horizon to 0.6 to 1.3 m over alkaline, red-brown or brown, medium clay to heavy clay D horizon to 1.5 m.			
Beeron	0.05 to 0.2 m dark or grey-brown clay loam, clay loam sandy to sandy clay loam A1/Ap horizon over conspicuously bleached A2 horizon to 0.15 to 0.35 m over alkaline, yellow-brown, brown or yellow, medium clay to heavy clay B2 horizon to 0.5 to 1.5 m over weathered rock.	Solodic soil	Slopes of rises, low hills and hills	Carboniferous Caswell Creek Group and Crana Beds, Triassic Cynthia Beds
Beeron rocky phase	As above with >20% rock fragments			
Beeron eroded phase	As above, severely eroded			
Boyne	0.1 to 0.25 m brown or red-brown sandy loam to clay loam A1/Ap horizons frequently over paler A2 horizons to 0.2 to 0.5 m over neutral to alkaline, red or red-brown, light clay to medium clay to 1.5 m.	Red-brown earth	Terraces	Quaternary alluvia
Boynewood	0.03 to 0.1 m brown or dark clay loam to light medium clay A1 horizon over neutral, red-brown, red, or brown, light medium clay to heavy clay B2 horizon to 0.3 to 0.75 m over weathered rock.	Prairie soil	Upper slopes of rises, low hills and hills	Carboniferous Caswell Creek Group and Crana Beds, Devonian andesite
Boynewood rocky phase	As above with >20% rock fragments			
Burnett	0.15 to 0.40 m brown or dark sandy loam to sandy clay loam A1 horizon over neutral, brown or dark, layered sandy loam to light clay subsoils to 1.5 m.	Alluvial soil	Channel benches, terraces	Quaternary alluvia

Table 1 continued.

Soil type	Major distinguishing attributes	Great Soil Group	Landform	Geology
Chessborough	0.1 to 0.25 m red-brown or brown sandy clay loam, clay loam, clay loam sandy A1/Ap horizon over acid to neutral, red-brown, clay loam to light clay B2 horizon to 0.35 to 0.7 m over acid to alkaline, mottled, yellow-brown or yellow, light clay to medium clay 2B horizon to 1.5 m.	Red earth	Alluvial fans	Cainozoic alluvia
Coonambula	0.10 to 0.15 m dark or grey-brown clay loam to clay loam sandy A1 horizon over conspicuously bleached A2 horizon to 0.2 to 0.4 m over neutral to alkaline, brown, grey-brown, yellow-brown or grey, medium clay to medium heavy clay B2 horizon to 1.5 m.	Solodic soil	Alluvial plains along creeks	Quaternary alluvia
Derra	0.03 to 0.05 m brown, grey-brown or dark light clay to medium clay A11 horizon over neutral to alkaline, grey-brown, brown or grey, medium clay to heavy clay B2 horizon to 1.5 m. Melonhole gilgai, vertical interval 0.4 to 1 m.	Grey clay, brown clay	Alluvial plains	Cainozoic alluvia
Durong	0.02 to 0.05 m grey-brown or dark light clay to medium clay A11 horizon over neutral to alkaline, grey-brown, grey, yellow-brown or brown, medium heavy clay to heavy clay B2 horizon to 1.5 m. Normal gilgai, vertical interval 0.1 to 0.3 m.	Grey clay	Alluvial plains	Cainozoic alluvia
Evergreen	0.05 to 0.1 m grey-brown or dark loamy sand to sandy loam A1 horizon frequently over paler A2 horizon to 0.2 to 0.7 m over acid, red-brown or brown, sand to loamy sand B2 horizon to 0.6 to 1.05 m over acid, red, light sandy clay loam to sandy clay loam 2B horizon to 1.5 m.	(Rudimentary) podzol, (red) earthy sand	Alluvial fans	Jurassic Evergreen Formation
Flagstone	0.1 to 0.35 m dark sandy clay loam, clay loam to light clay A1/Ap horizon over neutral to alkaline, dark or brown, clay loam fine sandy to medium clay B horizon to 1.5 m.	Prairie soil, brown earth	Terraces	Quaternary alluvia
Glenrock	0.05 to 0.2 m red-brown or red sandy clay loam, clay loam, clay loam sandy A1/Ap horizon over acid to neutral, red, clay loam to light clay B2 horizon to 1.5 m.	Red earth	Alluvial fans and crests of low hills and rises	Cainozoic alluvia

Table 1 continued.

Soil type	Major distinguishing attributes	Great Soil Group	Landform	Geology
Glenrock structured variant	0.15 to 0.25 m red clay loam, light clay to light medium clay Ap horizon over acid to neutral, red, light medium clay to medium clay B2 horizon.	No suitable group, intergrades to krasnozem, euchrozem		
Glenrock grey variant	Grey-brown sandy loam A horizon over grey, sandy clay loam B horizons.	Grey earth		
Glenrock shallow phase	0.15 m red-brown clay loam to clay loam sandy Ap horizon over acid to neutral, red-brown, clay loam sandy to light medium clay B2 horizon to 0.4 to 0.65 m over rock.	Red earth		
Grindstone	0.05 m brown silty clay to light medium clay A1 horizon over bleached A2 horizon to 0.13 m over grey medium heavy clay to 1.5 m.	(Bleached) grey clay	Alluvial plains	Quaternary alluvia
Hawkwood	0.1 to 0.15 m brown or grey-brown sandy loam, fine sandy loam to clay loam A1 horizon over conspicuously bleached A2 horizon to 0.25 to 0.4 m over acid to neutral, mottled, yellow, yellow-brown or red-brown, medium clay to medium heavy clay B2 horizon to 0.5 to 1.2 m over weathered rock.	Solodic soil, soloth	Slopes of rises and low hills	Jurassic Evergreen Formation
Lacon	0.03 to 0.06 m dark, brown or grey-brown light to medium clay A11 horizon over neutral to alkaline, brown, dark, grey-brown or grey, medium clay to heavy clay B21 horizon to 0.5 to 1.1 m over alkaline, brown or yellow-brown, medium clay to heavy clay B22 horizon to 0.8 to 1.5 m over weathered rock.	Brown clay, black earth, grey clay	Lower slopes of rises, low hills and hills	Carboniferous Caswell Creek Group and Crana Beds, Triassic Cynthia Beds, Devonian andesite
Nail	0.05 to 0.1 m brown or dark light clay to light medium clay A11 horizon over neutral to alkaline, brown or red-brown, medium clay to heavy clay B2 horizon to 1.5 m.	Brown clay, red clay	Alluvial plains, rises	Cainozoic alluvia
O'Bil Bil	0.1 to 0.2 m brown or dark light clay to light medium clay A1/Ap horizon over neutral, frequently mottled, brown or red-brown, light medium clay to medium heavy clay B21 horizon to 0.2 to 0.55 m over neutral to alkaline, frequently mottled, yellow-brown or brown, light medium clay to medium heavy clay B22 horizon to 0.4 to 0.7 m over rock fragments.	No suitable group, affinities with prairie soil	Slopes of rises and low hills	Triassic Cynthia Beds

Table 1 continued.

Soil type	Major distinguishing attributes	Great Soil Group	Landform	Geology
Pearlinga	0.05 to 0.15 m grey-brown or dark loamy sand to light sandy clay loam A1 horizon over conspicuously bleached A2 horizon to 0.4 to 0.7 m over acid to alkaline, mottled, yellow-brown, grey, brown or grey-brown, sandy clay to medium clay B2 horizon to 1.5 m.	Solodic soil, solodized solonetz, soloth	Alluvial fans	Jurassic Evergreen Formation
Riverleigh	0.1 to 0.25 m dark or brown clay loam fine sandy to silt clay loam A1/Ap horizon over bleached A2 horizon to 0.25 to 0.6 m over neutral to alkaline, brown, grey-brown or dark, light medium clay to medium heavy clay B2 horizon to 1.5 m.	Solodic soil	Backslope of terraces	Quaternary alluvia
Shurback	0.15 to 0.2 m grey-brown clay loam Ap horizon over conspicuously bleached A2 horizon to 0.4 to 0.6 m over neutral to alkaline, mottled, yellow or yellow-brown, medium clay to heavy clay B2 horizon to 1.5 m.	Solodic soil	Alluvial fans	Cainozoic alluvia
Toondoon	0.05 to 0.2 m brown or dark clay loam A1/Ap horizon over conspicuously bleached A2 horizon to 0.25 to 0.45 m over neutral to alkaline, frequently mottled, dark grey-brown or brown medium clay to heavy clay B2 horizon to 0.65 to 1 m over weathered rock.	Solodic soil	Slopes of rises	Jurassic Evergreen Formation
Washpool	0.05 to 0.2 m grey-brown or dark fine gravelly loam sand to sandy clay loam A1 horizon over conspicuously bleached A2 horizon to 0.25 to 0.45 m over neutral to alkaline, frequently mottled, yellow-brown or yellow, light medium clay to heavy clay B2 horizon to 0.6 to 1 m over weathered rock.	Solodic soil	Slopes of low hills	Carboniferous Caswell Creek Group
Wivenhoe	0.1 to 0.15 m dark or grey-brown loam fine sandy, sandy clay loam, clay loam to clay loam sandy A1 horizon over paler A2 horizon to 0.2 to 0.35 m over neutral, mottled, brown, yellow-brown or yellow, light clay to medium clay B2 horizon to 0.7 to 0.9 m.	No suitable group, affinities with solodic soil	Alluvial fans and slopes of rises and low hills	Cainozoic alluvia

3.2 Soil survey methodology

An initial reconnaissance involving ground observations and aerial photo interpretation (api) was carried out to ascertain soil type and soil/landform complexity.

Mapping was done at medium intensity (1:50 000) by free survey (Reid 1988). Greater densities of sites were recorded on the more productive land types or where landform complexity necessitated it. Medium intensity survey is recommended for general feasibility studies and for the selection of areas for more intensive surveys (Reid 1988).

Soil boundaries were checked with a combination of ground observations and api. Traverses were used in less productive land types.

A soils reference was prepared midsurvey from soil descriptions. The reference was adjusted as the survey proceeded. Soils were grouped by landform and geology. A total of 521 sites were described and entered on computer files (Appendix I). Fifteen soil sites from fourteen soil types were sampled for chemical analysis.

Mapping units were delineated onto 1:25 000 scale air photographs then transferred onto a cadastral base. Mapping units are associations, that is, contain several soil types. Each occurrence of a mapping unit is termed a unique map area (UMA). The mapping units and constituent UMAs are named after the dominant soil type. Data on soils, landform and geology were recorded on computer file for each UMA.

3.3 Description of the soils

3.3.1 Soils of the recent alluvial plains

This group of soils is associated with the channel benches and terraces of the Auburn, Burnett and Boyne Rivers and the alluvial plains of creeks flowing into the rivers. The sediments associated with the rivers are derived from a wide range of rock types from within and outside the study area while the creek alluvia are derived from a limited range of rock types from within the study area.

A sandy to loamy layered alluvial soil (Burnett soil) occurs on the channel benches and relict levees on the terraces. Sediments become heavier textured (Flagstone soil) further from the river with a dark texture contrast soil (Riverleigh soil) occurring in the terrace depressions. A bleached texture contrast soil (Coonambula soil) is dominant along the creeks.

3.3.2 Soils of the relict alluvial plains

This group of soils is associated with alluvial plains elevated above the recent alluvia. Grey and brown clays (Derra, Durong, Nail soils) and a bleached texture contrast soil (Auburn soil) predominate in an area between the Boyne and Auburn Rivers. A red gradational or texture contrast soil (Boyne soil) occurs along the edges of the elevated plains. All soils are sodic to strongly sodic and neutral to alkaline at depth. Fine gravel of various origins occur in the soil profile.

3.3.3 Soils of the alluvial fans and relict river deposits

The upper slopes of the alluvial fans in the south have a deep red earth (Glenrock soil). Relict (Tertiary) river deposits occur on hill tops and overlie a range of geological beds. The deep red earth on these river deposits is similar to the red earth of the alluvial fans. Fine quartz gravel usually occurs in the soil east of the Boyne River while other areas are gravel free. A small area of deep well drained sandy soil (Evergreen soil) has developed in a run-on area west of the Auburn River. This sandy soil shows several phases of deposition and has developed from duricrusted sandstone.

The mid to lower slopes of the alluvial fans and relict river deposits have soils which show several phases of deposition and overlie or abut grey and brown clays of the relict alluvial plains. The mid slopes have a shallow (<0.7 m) red earth (Chessborough soil) overlying a mottled yellow clay. The lower slopes have a gradational yellow soil (Wivenhoe soil) and bleached texture contrast soils (Pearlinga, Shurback soils).

3.3.4 Soils of the rises and low hills on sedimentary rocks and andesite

This group of soils has formed *in situ* on the Jurassic Evergreen Formation (labile to sublabile sandstone, siltstone and shale), the Triassic Cynthia Beds (boulder conglomerate, arenite and siltstone), the Carboniferous Caswell Creek Group and Crana Beds (arenite, siltstone and mudstone), and minor undifferentiated Devonian andesite.

Crests typically have shallow gravelly soils. The red or brown prairie soil (Boynewood soil) occurs on the upper slopes of the Carboniferous sediments and Devonian andesite while the prairie soil (O'Bil Bil soil) with cobble (rock fragments 0.06 to 0.2 m) is restricted to the upper slopes of Triassic Cynthia conglomerate beds.

The lower slopes of the Carboniferous and Triassic sediments have deeper gravel free clay soils (Lacon soil) or bleached texture contrast soils (Beeron, Washpool soils). The Washpool soil has sheet wash material deposited on the surface from relict river deposits on upper slopes. The slopes of the Jurassic Evergreen Formation have bleached texture contrast soils (Hawkwood, Toondoon soils).

3.4 Chemical and physical attributes

Fifteen representative soil profiles from 14 soil types were sampled and analysed in the laboratory. These sampled soils represent the most extensive and/or productive soils in the study area. A strongly gilgaied soil (Derra soil) was sampled on the mound and in the depression. The morphological and analytical data for the representative soil profiles are listed in Appendix IV.

Profiles were sampled at 0 to 0.1 m, 0.2 to 0.3 m, 0.5 to 0.6 m, 0.8 to 0.9 m, 1.1 to 1.2 m and 1.4 to 1.5 m. Eight to ten surface samples were taken at each site and bulked. Analytical methods used and general interpretations of the results are outlined by Rayment and Bruce (1984).

3.4.1 Surface fertility

Table 2 presents the soil fertility ratings of the surface 0 to 0.1 m.

Table 2. Soil fertility ratings* for surface 0 to 0.1 m (bulked sample)

Soil	Site No.	Acid P	Bicarb P	Organic Carbon	Total N	Total P	Total K	Total S	Trace elements Zn	Cu	Mn	Replaceable K	C/N ratio
Beeron	S1	VL	VL	M	L	H	M	M	M	M	M	H	12
Auburn	S2	VL	VL	M	L	M	L	M	M	H	H	H	14
Boynewood	S3	VL	VL	M	M	M	M	M	M	M	H	H	11
Derra Mound	S4a	L	L	L	M	M	M	M	L	M	M	H	8
Derra Depression	S4b	M	H	M	M	H	M	M	M	M	M	VH	10
Durong	S5	VL	VL	M	M	M	M	M	L	M	M	VH	11
Burnett	S6	VH	VH	L	L	H	H	M	M	M	M	H	10
Boyne	S7	L	VL	L	L	M	M	L	L	M	M	M	14
Flagstone	S8	VH	H	H	H	VH	H	M	H	M	M	H	13
Wivenhoe	S9	VL	VL	M	L	M	VL	L	M	L	M	M	23
Glenrock	S10	VL	VL	L	L	M	VL	M	L	M	M	M	15
O'Bil Bil	S11	H	M	H	M	H	H	M	M	M	H	H	16
Chessborough	S12	L	VL	L	L	H	L	M	M	M	M	H	13
Coonambula	S13	L	VL	M	L	M	M	M	M	M	H	H	15
Lacon	S14	VL	VL	M	M	M	M	M	M	M	H	H	14

VL - Very Low L - Low M - Moderate H - High VH - Very High

* Ratings are those of Rayment and Bruce (1984)

Acid and bicarbonate extractable phosphorus in the 0 to 0.1 m samples are low to very low in all soils except the Burnett, Flagstone, O'Bil Bil and Derra soils. The Burnett (acid P 252 ppm, bicarb P 43 ppm) and Flagstone soils (acid P 389 ppm, bicarb P 72 ppm) have formed on relatively recent alluvial plains. The O'Bil Bil prairie soil (acid P 63 ppm, bicarb P 31 ppm) has developed on Triassic conglomerate and supports dry vine scrub vegetation. The Derra grey and brown clay (acid P 31 ppm, bicarb P 41 ppm) developed an old alluvia supports brigalow scrub. All other soils support eucalypt vegetation.

Organic carbon levels for all soils range from low (0.8%) to high (3.7%). Levels are generally low in light textured soils but are dependant upon the vegetation type. The more open eucalypt woodlands with sparse ground layer vegetation have the lower organic carbon values.

The total nitrogen values for the surface samples follow a similar trend to vegetation cover and organic carbon. For example, the brigalow clay (Derra soil) and the prairie soil (Flagstone soil) with very dense grass cover have the higher total nitrogen values of 0.24% and 0.27% respectively. The lighter textured soils (Burnett, Boyne, Wivenhoe, Glenrock soils) with open eucalypt vegetation have the lowest total nitrogen of 0.07% to 0.08%.

Carbon/nitrogen ratios range from 8 to 23. An average of 13 indicates a net mineralisation of nitrogen. Those soils with higher ratios (>15) are Wivenhoe and O'Bil Bil.

Total phosphorus for all soils ranges from moderate (0.023%) to very high (0.12%). The total potassium levels are extremely variable, ranging from very low (0.076%) to high (1.46%). Variation is probably due to parent material and/or relative age. For example, the soils on recent alluvia (Burnett, Flagstone soils) have high values (1.45% to 1.46%) while the soils on the relict river deposits (Wivenhoe, Glenrock, Chessborough soils) have very low to low values (0.076% to 0.426%).

Zinc levels are low in the grey clays (Derra, Durong soils 0.5 to 0.6 ppm) the red brown earth (Boyne soils 0.4 ppm) and the red earth (Glenrock soil 0.5 ppm). Copper levels are low (0.3 ppm) in the Wivenhoe soil. Adequate levels of manganese and iron occur in all sampled soils.

Replaceable potassium ranges from moderate (0.26 meq%) to high (1.7 meq%) values and little or no response from potassium fertilizer is likely.

3.4.2 Soil pH

Surface 0 to 0.1 m soil pH for most soils range from slightly acid to neutral. The grey clays (Derra, Durong soils) have slightly alkaline surfaces.

The moderately well drained to well drained soils (Boynewood, Burnett, Boyne, Flagstone, Glenrock soils) are acid to mildly alkaline at depth. The red earth (Glenrock soil) becomes strongly acid at 1.2 metres. All texture contrast and clay soils have alkaline to strongly alkaline subsoils.

3.4.3 Chloride and sodicity

Sodicity is the ratio of exchangeable sodium and cation exchange capacity (CEC) expressed as a percentage (ESP). Sodicity of the sampled profiles is shown in table 3.

All surface samples are non-sodic. Soils with strongly sodic subsoils have alkaline to strongly alkaline subsoils while non-sodic subsoils (Boynewood, Burnett, Flagstone, Glenrock, O'Bil Bil soils) correspond to acid to mildly alkaline subsoils. Baker (1983) showed that for similar soils in the Burdekin, strongly alkaline pH's are associated with sodic to strongly sodic subsoils.

Table 3. Profile Sodicity (ESP) *

	DEPTH				
Soil	0 to 0.1 m	0.2 to 0.3 m	0.5 to 0.6 m	0.8 to 0.9 m	1.1 to 1.2 m
Beeron	1 non-sodic	13 sodic	25 strongly sodic	30 strongly sodic	- -
Auburn	1 non-sodic	9 sodic	15 strongly sodic	22 strongly sodic	24 strongly sodic
Boynewood	1 non-sodic	1 non-sodic	1 non-sodic	2 non-sodic	- -
Derra mound	3 non-sodic	14 sodic	23 strongly sodic	28 strongly sodic	29 strongly sodic
Derra depression	1 non-sodic	3 non-sodic	10 sodic	21 strongly sodic	26 strongly sodic
Durong	2 non-sodic	6 sodic	11 sodic	14 sodic	14 strongly sodic
Burnett	1 non-sodic	1 non-sodic	1 non-sodic	2 non-sodic	2 non-sodic
Boyne	1 non-sodic	1 non-sodic	1 non-sodic	1 non-sodic	2 non-sodic
Flagstone	<1 non-sodic	1 non-sodic	1 non-sodic	1 non-sodic	1 non-sodic
Wivenhoe	1 non-sodic	1 non-sodic	15 strongly sodic	20 strongly sodic	24 strongly sodic
Glenrock	1 non-sodic	5 non-sodic	4 non-sodic	4 non-sodic	- -
O'Bil Bil	1 non-sodic	2 non-sodic	3 non-sodic	- -	- -
Chessborough	1 non-sodic	2 non-sodic	19 strongly sodic	15 strongly sodic	9 sodic
Coonambula	2 non-sodic	11 sodic	18 strongly sodic	18 strongly sodic	18 strongly sodic
Lacon	1 non-sodic	7 sodic	16 strongly sodic	20 strongly sodic	20 strongly sodic

* Ratings from Northcote and Skene (1972)

Soils on upper slopes are usually better drained than soils on lower slopes and a relation between sodicity and landscape position has been detected. For example, the red and brown non-sodic prairie soil (Boynewood soil ESP = 2) occurs on upper slopes on sedimentary rocks while a strongly sodic brown clay, black earth and grey clay (Lacon soil ESP = 20) and a solodic soil (Beeron soil ESP = 30) occur on lower slopes. Another example, the non-sodic red earth on fans and relict river deposits (Glenrock soil ESP = 4) occurs on upper slopes while soils on lower slopes (Chessborough ESP = 15, Wivenhoe soils ESP = 24) are sodic to strongly sodic at depth. The increase in sodicity in the Chessborough soil from ESP = 2 at 0.3 m to ESP = 19 at 0.6 m and decrease in sodicity to ESP = 9 at 1.2 m confirms that this soil has had several phases of deposition (see section 3.3.3). This soil consists of a shallow (<0.6 m) red earth overlying a mottled yellow clay which overlies a mottled gray clay.

The non-sodic more permeable soils on upper slopes act as intake areas while the strongly sodic less permeable soils on lower slopes could act as discharge areas with possible development of salinity problems (see section 4.3.8).

Chloride values (Table 4) show similar trends to ESP. All soils have very low values (<0.008%) at the surface. All non-sodic soils (Boynewood, Burnett, Boyne, Flagstone, Glenrock, O'Bil Bil soils) have very low levels (<0.01%) of chloride. The remaining strongly sodic subsoils (except Chessborough soil) show a peak in chloride levels at or shallower than 1.5 m. For example, the Beeron and Coonambula solodic soils and the Derra (mound) and Lacon clay soils show a peak in Chloride at 0.6 m. The Auburn solodic soil and Durong clay soil show a peak in chloride at 0.9 m. The Wivenhoe soil has peak chloride at 1.2 m. The chloride profiles have been used as an indication of the depth of wetting in a soil and rooting depth (see sections 4.3.2, 4.3.10).

Table 4. Chloride levels (%) and ratings *

Soil	DEPTH 0 to 0.1 m		0.2 to 0.3 m		0.5 to 0.6 m		0.8 to 0.9 m		1.1 to 1.2 m		1.4 to 1.5 m	
Beeron	.001	VL	.015	VL	.074	M	.069	M	-	-	-	-
Auburn	.002	VL	.014	VL	.068	M	.106	H	.098	M	.109	M
Boynewood	.001	VL	.001	VL	.001	VL	.001	VL	-	-	-	-
Derra mound	.001	VL	.020	VL	.103	H	.116	H	.115	H	.113	H
Derra depression	.001	VL	.001	VL	.001	VL	.024	VL	.059	M	.075	M
Durong	.003	VL	.007	VL	.073	M	.101	H	.101	H	.100	H
Burnett	.008	VL	.002	VL	.001	VL	.001	VL	.001	VL	.001	VL
Boyne	.001	VL	.001	VL	.002	VL	.002	VL	.002	VL	.004	VL
Flagstone	.003	VL	.003	VL	.001	VL	.001	VL	.001	VL	.002	VL
Wivenhoe	.001	VL	.001	VL	.037	L	.053	M	.065	M	.065	M
Glenrock	.002	VL	.002	VL	.008	VL	.012	VL	-	-	-	-
O'Bil Bil	.001	VL	.001	VL	.001	VL	-	-	-	-	-	-
Chessborough	.001	VL	.001	VL	.001	VL	.001	VL	.001	VL	.003	VL
Coonambula	.002	VL	.022	VL	.077	M	.074	M	.074	M	.076	M
Lacon	.022	VL	.013	VL	.095	M	.097	M	.088	M	.068	M

* Ratings are those of Shaw and Yule (1978)

3.4.4 Cation exchange capacity (CEC) and clay activity ratio

CEC was determined by summation of exchangeable cations; calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K) as described by Rayment and Bruce (1984). The range of CEC is shown in table 5.

Table 5. CEC (meq/100g) and clay activity ratio (CEC/Clay)

Depth:	0 to 0.1 m		0.2 to 0.3 m		0.5 to 0.6 m		0.8 to 0.9 m		1.1 to 1.2 m	
Soil	CEC	CEC/ clay	CEC	CEC/ clay	CEC	CEC/ clay	CEC	CEC/ clay	CEC	CEC/ clay
Beeron	17	.81	27	.43	27	.45	22	.49	-	-
Auburn	13	.50	16	.30	19	.30	18	.30	19	.30
Boynewood	23	.70	21	.50	28	.40	24	.40	-	-
Derra mound	25	.50	24	.46	25	.47	24	.44	23	.46
Derra depression	35	.69	26	.54	25	.52	21	.48	21	.47
Durong	36	.69	35	.65	33	.63	36	.62	37	.60
Burnett	10	1.25	9	.90	8	.80	7	1.00	10	.70
Boyne	7	.58	5	.38	9	.27	12	.26	12	.32
Flagstone	25	1.04	30	.94	31	.82	31	.89	24	.73
Wivenhoe	7	.80	4	.50	12	1.30	12	.24	14	.28
Glenrock	7	.58	2	.13	5	.08	5	.08	-	-
O'Bil Bil	18	.53	27	.57	28	.62	-	-	-	-
Chessborough	8	.32	4	.17	5	.14	6	.17	6	.16
Coonambula	21	.68	25	.56	30	.55	24	.51	23	.46
Lacon	30	.83	22	.46	29	.42	28	.42	28	.41

CEC varies considerably over the suite of Auburn River soils but is related to clay percentage, clay type and organic matter. Surface soil CEC is affected markedly by organic matter levels. For example, in non-clay soils where the percent clay remains constant from the surface to 0.3 m (Burnett, Boyne, Wivenhoe, Glenrock, Chessborough soils), CEC decreases. CEC increases as clay percentage increases and this is evident in all profiles below the surface. For example, the increase from 48% clay at 0.3 m to 69% clay at 0.6 m in the Lacon soil corresponds to an increase in CEC from 22 meq/100g to 29 meq/100g. In the texture contrast and cracking clay soils, CEC increases with corresponding increase in exchangeable cations, particularly sodium and magnesium.

The types and proportions of clay minerals in a soil have a strong bearing on soil structure, water holding capacity, swelling and cracking characteristics and the ability to hold nutrients. No determination of clay minerals are available for the study area but, using CEC/clay ratios, attempts are made to indicate soils which are dominated by a particular clay mineral.

The clay activity ratios (CAR meq. per g clay) are shown in Table 5. Surface layers should be ignored because organic matter can dramatically effect CEC. CAR for all soils varies from 0.08 to 1.3. Soils of the alluvial fans and relict river deposits (Glenrock, Chessborough, Wivenhoe soils) have low clay activity ratios in the subsoil of 0.08 to 0.24, indicating a high proportion of kaolinitic type clay. CAR increases in soils from the upper slope to lower slope (Glenrock soil to Chessborough soil to Wivenhoe soil) corresponding to an increase in exchangeable cations, particularly sodium and magnesium and slightly higher pH values.

The soils on the recent alluvial plains (Burnett, Flagstone soils) have higher activity ratios (0.7 to >1) than the soils developed on the relict alluvial plans (Auburn, Derra, Durong, Boyne soils CAR 0.3 to 0.65). This may reflect a weathering process or a contribution of sediments from different origins. These higher activity ratios indicate a contribution from the expanding lattice minerals such as smectite. Lenticular structure and slickensides (due to the movement of peds against one another) have been observed in the soils with clay textures and higher activity ratios.

The prairie soil (Boynewood soil), brown clay, black earth and grey clay (Lacon soil) and the solodic soil (Beeron soil) developed on siltstones and mudstones all have similar subsoil activity ratios (CAR 0.4 to 0.49). These activity ratios indicate a contribution from smectite. The sampled Beeron and Lacon soil profiles had lenticular structure. The deeper (>0.5 m) Boynewood soil often has lenticular structure at depth and grades into the Lacon soil.

3.4.5 Plant available water

Plant available water capacity (PAWC) is a measure of the volume of water between field capacity and wilting point to a crops rooting depth.

PAWC has been calculated from the laboratory measurement of water held at -1500kPa pressure using the relationship described by Shaw and Yule (1978). PAWC is calculated to a depth of 0.9 m only or to the depth to rock or depth of maximum chlorides if shallower than 0.9 m (see section 3.4.3). PAWC has been used to predict irrigation frequency for a dry season maize crop with a rooting depth of 0.9 m (see section 4.3.2). Table 6 lists the predicted PAWC for each sampled soil. Note that calculations are not reliable when -1500kPa pressure measurements are less than 10% (Shaw, personal communication). Therefore, predicted PAWC for Burnett, Boyne, Wivenhoe, Glenrock and Chessborough soils may be overestimated.

In the remaining clay and solodic soils, predicted PAWC is governed largely by rooting depth. However, in the limitation on water availability (section 4.3.2), infiltrating characteristics have also been considered. Soils with low infiltration rates (such as the hardsetting texture contrast Beeron, Auburn, Wivenhoe, Coonambula soils) require long periods of irrigation to wet up the profile or a higher irrigation frequency. This places the soil at a greater risk of waterlogging if heavy rain falls after irrigation. This is of greater significance on soils with low slope and during the summer months where the rainfall pattern is one of heavy falls of short duration (Fitzpatrick 1967). The management problems associated with these slowly permeable soils are discussed in section 4.3.2 and 4.3.10. Clay soil profiles are recharged by water flowing down cracks.

The strongly gilgaied (melon hole) grey clay (Derra soil) shows dramatic differences in predicted PAWC between the mound and depression. This is a reflection of the shallower depth of maximum chloride on the mound. Uneven crop production will result if subsoil on the mound is exposed on levelling (see section 4.3.6).

Table 6. Predicted plant available water capacity (PAWC) for the sampled soils

Soil	Predicted rooting depth (m)	Predicted PAWC * (mm)
Beeron	0.6	98
Auburn	0.9	127
Boynewood	0.9	132
Derra mound	0.6	96
Derra depression	>0.9	125
Durong	0.9	130
Burnett	>0.9	103
Boyne	>0.9	118
Flagstone	>0.9	125
Wivenhoe	>0.9	112
Glenrock	>0.9	120
O'Bil Bil	0.6	96
Chessborough	>0.9	123
Coonambula	0.6	96
Lacon	0.6	98

* Based on relationship of Shaw and Yule (1978)

4. LAND USE

4.1 Current land use

In the 1986/87 financial year the gross value for rural production in the Mundubbera shire was 29.6 million dollars (Australian Bureau of Statistics 1987). The citrus industry was the largest earner followed by the cattle industry.

4.1.1 Horticulture

The soils of alluvial origin along the Auburn, Boyne and Burnett Rivers of the study area are the major citrus producing soils of the Mundubbera Shire. Minor areas of red earths on hills and rises also produce citrus, grapes, avocados, mangoes and small crops.

Within the study area approximately 1200 ha of citrus produce 25 000 tonne of fruit annually and of these 60% are Mandarins (John Owen-Turner personal communication). Orchards use either spray, microsprinkle or trickle irrigation. Spray irrigation is used to restrict frost damage in the lower landscape.

Grapes are another important horticultural crop. An estimated 630 tonnes are produced from 140 hectares of vines (4.5 tonne/ha) (John Owen-Turner personal communication). Vines are grown on well drained red earths and on shallow clays on sediments. These shallow soils are normally mounded to aid drainage and root anchorage.

Minor areas of avocados, mangoes, melons (100 ha), vegetable crops and crucifer species are also grown. Areas vary from year to year. Avocado and mango orchards are restricted to the frost free areas with well drained soils. Mounding is required where soil depth is restricted. Some small crops are considered as opportunity crops and are grown to coincide with higher out-of-season prices. There is a potential for other crops like low chill stone fruit once markets have been identified.

4.1.2 Field and grain crops

The main crops grown in the Mundubbera shire are wheat (522 ha), maize (581 ha), barley (178 ha), sorghum (1827 ha), peanuts (539 ha), lucerne (239 ha) and fodder crops (1946 ha) (Australian Bureau of Statistics 1987).

Most cropping in the study area is on the brown clays, black earths and grey clays and prairie soils. Minor areas of texture contrast soils are also planted but yields are low and substantial applications of fertilizer are necessary.

Sorghum is mainly a rainfed crop but some has been grown with supplementary irrigation from a centre pivot operation. The stubble is grazed and the land left fallow for the following summer.

Peanuts in the study area are restricted to the lighter textured well drained soils.

Fodder crops such as the sweet sorghums and oats are grown for fattening stores, for dairy herds and carrying stock over the winter months. A wider range of soils are used, including grey clays and shallow sloping texture contrast soils. Erosion control is important on the latter soils as they are very prone to erosion. Graziers usually only crop the texture contrast soils once in three to five years and sow them to improved pastures in the intervening years.

Irrigated lucerne (204 ha total licensed irrigation) is mainly grown on the alluvial and prairie soils on the Burnett and Auburn River terraces. Lucerne is mainly strip grazed on dairy farms and baled on other farms. The lighter textured alluvial soil requires more frequent irrigation. Root rots and compaction from grazing are problems on the clay soils.

Wheat and barley are grown on the alluvial grey and brown clays and the brown clays on sediments. Wet winter seasons may result in plant nitrogen deficiency in shallow or poorly drained soils.

Maize is grown on lighter clay soils compared to sorghum. Stubble provides stock feed and the mulch helps to retain moisture content and protect the surface from erosion during summer storms.

Minor areas (90 ha) of legume grain such as soybeans, cowpeas and navybeans are grown in the district.

All the crops, except lucerne, are rainfed crops and are grown mainly on the clay soils with higher plant available water capacity.

4.1.3 Beef and Dairying

Livestock disposals in the Mundubbera shire in 1987/88 totalled approximately $7 million (Australian Bureau of Statistics 1988). A total of 127 holdings carry 57 000 stock.

A majority of the study area has been sown to Rhodes grass pastures. The clay soils on sediments and alluvia, and some of the texture contrast soils have been sown to improved pastures. Some of the more productive soils of alluvial origin, including prairie soils and red-brown earths, are used for seed production, baled for hay or grazed.

Native pastures on the steeper, dissected country on the northern, southern and western parts of the study area are used for grazing. Stocking rates are 1 beast to 8 ha or less.

Dairy cattle numbers in the Mundubbera shire number at approximately 3500 (Australian Bureau of Statistics 1988) with the majority of dairy farms situated on the alluvial plain of the Burnett River. The dairy farms in the study area rely on small areas of irrigated pastures. These are strip grazed utilising electric fences. Winter oats or forage sorghums are often sown on the gently undulating to undulating hills and used for weaners and dry cows, and as a supplement to the irrigated pastures.

4.2 Land suitability methodology

A total of 412 unique map areas (UMAs) have been delineated. The significant limitations to production were identified for each UMA. The severity of each limitation was assessed on a 1 to 5 scale (Appendix IV). The suitability classes and relevant limitations to production of the various crops were recorded on the UMA record file.

The UMAs have been individually assessed for their relative suitability for growing avocado, citrus, mango, pecan, low chill stone fruits, grapes, winter grains such as wheat and barley, summer grains such as maize and sorghum, safflower, sunflower, navybean, mungbean, chickpea, peanut, potato, vegetables, cruciferae such as broccoli and cauliflower, cucurbits such as melons, pumpkins and rockmelons, asparagus and improved pastures using the land suitability classification scheme described in Appendix V. Each UMA was also assessed for suitability for furrow irrigation.

The explanation of codes for the UMA record file are described in Appendix VI. The UMA record file (Appendix VII) consists of 3 record types. Record type 1 contains location data and land resources inventory. Record 2 and 3 contain the land suitability assessment of the various crops. Record 3 also contains the UMA area.

The information on the computer files can be accessed through the Director, Land Resources Branch, Department of Primary Industries.

4.3 Limitations to agriculture

Irrigated agriculture within the study area will be affected by the following limitations:

Climate
Water availability
Wetness
Soil depth
Rockiness
Microrelief
Soil physical condition
Secondary salinisation
Water erosion
Furrow infiltration

The limitations affect crop production through influences on crop growth, machinery operations and land degradation.

4.3.1 Climate

Climatic limitations, except frosts, do not vary significantly over the study area and climate will simply determine potential crops.

Plants vary in their tolerance to frosts. Frosts can suppress growth, kill plants or reduce yield (through damage to flowers or fruits) of sensitive crops. Generally, the incidence and severity of frosts in the study area is influenced by position in the landscape. Hill tops receive fewer and less severe frosts and are suitable for sensitive crops such as avocados and mangoes. The low lying channel benches and depressions in the terraces along the rivers can receive a large number (>20) of severe frosts per year. These severely affected areas limit the suitable crops to deciduous plants such as pecans, low chill stone fruits, grapes, and adaptable small crops and field crops.

Local experience and variation in landform were used to determine the suitability subclasses for the various crops. Seasonal adaptation of crops is not considered, for example, frost tolerance of summer crops.

4.3.2 Water availability

Water availability refers to the limitation placed on crop yield by a restriction on soil water supply. For irrigated land, a reduced soil water storage capacity means more frequent irrigation is needed to obtain optimum yields.

The effective rooting depth is needed for assessment of water availability. If no chemical or physically restrictive layer occurs, effective rooting depth is taken as the depth to which approximately 90% of plant roots will extract water. For example, tree crops 1 to 1.5 m, grapes and small crops 0.5 m, grain crops 0.9 m. The effective rooting depth is reduced by restrictive layers which are indicated by rock, consistence, pH, electrical conductivity, sodicity and segregations.

Plant available water capacity (PAWC) provides the best estimate of a soils storage capacity. PAWC is the difference in volumetive water content between the upper storage limit (approximately field capacity) and the lower storage limit (approximately wilting point) summed for each layer within the rooting depth. Based on predictions and measurements by Shaw and Yule (1978) and Gardner and Coughlan (1982) all cracking clay soils have a PAWC >100 mm. Duplex soils which are strongly sodic (ESP >14) and have a salt bulge at 0.6 to 1 m, have a PAWC of 75 to 100 mm, but duplex soils which are strongly sodic at 0.5 to 0.6 m have a PAWC of 50 to 75 mm. Taking these predicted PAWC values into account, soils in the study area have been grouped depending on texture and structure to effective rooting depth. Assessment of PAWC for a wide range of soils in the study area is required.

Subclass determination is based on frequency of irrigation required for soils. Soils with higher PAWC require less frequent irrigations. The days between irrigation is based on predictions by Gardner and Coughlan (1982) for a dry season maize crop during grain filling. They also showed that on sodic texture contrast soils, complete recharge of the rooting depth is incomplete due to the impermeable subsoil and the long periods of irrigation necessary to recharge the soil. If longer irrigated periods occur, waterlogging may be expected. Therefore, predicted PAWC in Table 6 should be interpreted with care.

Based on predictions, all cracking clay soils (Derra, Durong, Grindstone, Lacon, Nail soils) and other structured medium to heavy textured soils (Flagstone, Riverleigh soils) have a PAWC >100 mm. The prairie soils (Boynewood, O'Bil Bil soils) have variable PAWC depending on soil depth.

The solodic soils (Auburn, Coonambula, Shurback, Toondoon, Wivenhoe soils) with a massive medium textured surface over a structured subsoil with a rooting depth of 0.6 to 1 m, the red earths (Glenrock, Chessborough soils) and red-brown earth (Boyne soil) have an estimated PAWC of 75 to 100 mm.

The solodic soils (Beeron, Hawkwood soils) with a medium textured surface over a strongly sodic subsoil or rock at <0.6 m have a estimated PAWC of 50 to 75 mm.

The solodic soils (Pearlinga, Washpool soils) with a light textured surface, and sandy soils (Evergreen soil) have a low estimated PAWC.

Although irrigation frequency has been used to determine suitability subclasses, irrigation method has been taken into account. Field and grain crops and some small crops are usually flood or overhead irrigated. The soils with low PAWC will require more frequent irrigation and therefore greater labour and effort. Tree crops, grapes and some small crops use microsprinklers or drip irrigation where small amounts of water are applied frequently. These systems require little effort and labour and therefore, subclass limits do not apply.

4.3.3 Wetness

The wetness limitation takes into account the adverse effects of excess water on production through the reduction in crop growth and quality, restrictions on machinery use and the need for reclamation works.

Drainage classes (McDonald *et al.* 1984) are assessed and takes into account all aspects of internal and external drainage in the existing state. The attributes used to indicate internal drainage include colour, mottles, segregations and impermeable layers. Red or brown whole colours indicate well drained soils while mottled grey soils with segregations, such as manganiferous nodules, indicate imperfect drainage. Slope and topographic position are used to assess the ease of disposal of excess water. Soil permeability, indicated by texture, pedality, grade of structure, segregations, pH, ESP, affects the supply to and removal of soil water from the root zone. Permeability has been used in the subclass determinations to assess, in relative terms, the spacing of drains. The soils have been placed into the various drainage and permeability categories in the existing state and recorded on the UMA record file.

Due to the extended irrigation times in the slowly permeable soils (solodic soils, clays) to wet up the root profile, short term waterlogging will be expected, especially for flood irrigation where long furrow lengths are desirable for ease of management.

Crop sensitivity to wetness is the overriding criteria for determining suitability. The suitability subclasses also take into account the depth requirements for the various crops. For example, avocados require a well drained soil to 1.5 m for optimum production while small crops require a well drained soil to 0.5 m.

4.3.4 Soil depth

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

The effective rooting depth is determined by the depth of soil to rock, hardpan or other impermeable layers (see wetness limitation). Subclasses are based on consultation.

4.3.5 Rockiness

Rock fragments (includes gravel, cobble) within the plough depth will interfere with the use of, and possibly cause damage to, agricultural machinery. The volume of rock fragments within the soil is extremely variable and difficult to estimate for a UMA. Tolerance levels also vary among farmers and for different agricultural enterprises.

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

The size and amount of rock fragments, as defined by McDonald *et al.* (1984), were used to determine the suitability subclasses. The limitation increases with the increase in size and/or amount encountered. Rock fragments are consistently a problem on the O'Bil Bil soil and the upper slopes of the Beeron (Beeron rocky phase) and Boynewood (Boynewood rock phase) soils. Erosion control measures should be implemented on sloping soils to reduce the concentration of rock fragments at the surface.

4.3.6 Microrelief

Gilgai microrelief will affect the efficiency of furrow irrigation, and the depressions will pond water causing uneven crop productivity. Microrelief should not cause commercial crop production problems provided that adequate irrigation layout and levelling can be maintained. Gilgai vertical interval relates to the amount of levelling required. Large gilgai (melonholes) require excessive levelling resulting in exposure of the strongly sodic saline subsoils on the mounds. This will again result in uneven crop production.

The grey and brown clays with brigalow scrub (Derra soil) have large melonhole gilgai with a depth up to 1.5 m and up to 15 to 20 m between mounds. The Durong soil (grey clay) associated with the Derra soil has typically small gilgai with a depth of 0.1 to 0.3 m and 5 to 10 m between mounds. The sloping brown clays and black earths (Lacon soil) frequently have linear gilgai with a depth of 0.1 to 0.3 m and up to 5 m between mounds.

Local opinion and consultation on the ability to level the gilgai has been used to determine the subclasses.

4.3.7 Soil physical condition

The limitation is applied to soils where soil properties influence seedbed preparation, plant establishment and the harvest of root crops. The soil physical condition of a soil is subdivided into properties such as surface condition, moisture range for working and adhesive soils.

Surface condition will affect seedling emergence and establishment, and root crop development through hardsetting surfaces, crusting or coarse structure. Adverse surface condition affects fruiting of peanuts. Favourable conditions are more critical for this crop during fruiting than for seedling establishment as only minimal amendments may be used under a mature crop. Surface condition may be managed for most crops by maintaining moist surface conditions but increased irrigation frequently may be required. Emergence and establishment of broad leaf plants are generally more severely affected than the other crops. Small crops are usually pregerminated and seedlings transplanted into the field.

Hardsetting surfaces are evident to varying degrees in all solodic soils with medium textured surfaces (Auburn, Beeron, Coonambula, Hawkwood, Shurback, Toondoon, Wivenhoe soils), red earths (Glenrock, Chessborough soils) and the red-brown earth (Boyne soil). Crusting is evident in all the clay soils (Derra, Durong, Grindstone, Lacon, Nail soils) and prairie soils (Boynewood, O'Bil Bil soils). Coarse aggregates in the surface affects seed germination by reducing soil to seed contact area, particularly for small seeded crops and some legume crops. This problem is evident in the grey clays (Derra, Durong soils).

It is desirable that a soil can be cultivated over a wide range of moisture levels to give some flexibility to the timing of operations. Soils with moisture contents above that range are too wet to cultivate, and cultivation of the soil at moisture contents below that range gives a coarse seed bed. The effects are more pronounced for land uses where timing of operations are critical to achieve favourable markets. The clay soils (Derra, Durong, Grindstone, Lacon, Nail soils) have a narrow range of water content when they can be tilled effectively. The hardsetting texture contrast soils (Auburn, Beeron, Coonambula, Hawkwood, Shurback, Toondoon, Wivenhoe soils) and prairie soils (Boynewood, O'Bil Bil soils) have a narrow to moderate moisture range for cultivation.

Adhesive soils affect the recoverability and condition of root crops. Root crops ideally require friable soils, so harvest machinery can easily lift and remove the crop from the soil. The majority of the massive surfaced soils and clay soils are adhesive to varying degrees.

4.3.8 Secondary salinisation

Changes in hydrology caused by clearing and irrigation may change the salinity of the soil profile. Secondary salinisation is a serious threat to the viability of the irrigation area.

Studies in the Burdekin (Gardner and Coughlan 1982) have shown that surface salinisation occurs at the interface of permeable and slowly permeable soils. Drainage water below the root zone of the permeable soils (intake areas) moves downslope and raises the watertable where restricted permeability is encountered (contact areas). Provided the watertable remains close to the surface (within about 1 m) evaporation will concentrate salts at the surface by capillary flow. The severity of surface salinisation will depend on the period of time that watertables are maintained close to the surface. Root zone salinisation may also result.

Preliminary results from the Red Farm area indicate that seepage water at contact areas has a similar salinity to the water applied in irrigation on upper slopes (Shaw personal communication). This indicates that the underlying geology and the soils are contributing little to the salt levels. Intensive investigations are required on a range of soils and landscapes.

Management should involve careful monitoring of the quantity and quality of irrigation water applied to intake areas. The soils acting as intact areas are well drained permeable red earths (Glenrock soil) and are valuable horticultural soils. The contact areas are usually solodic soils (Chessborough, Pearlinga, Washpool, Wivenhoe soils). If the intake areas are cleared and continue to be used for irrigated cropping, a larger number of seepage areas and more extensive salinisation will be expected. The retention of native trees and/or construction of drains may lower the watertables and reduce salinisation. The effectiveness of drains depends on the permeability of the subsoils.

The effect of widespread irrigation on regional watertables is unknown. Initially, irrigation will leach salts to lower in the profile in soils with moderate to high salt levels. The amount of leaching will depend on the amount of deep drainage. The long term affect on watertables requires investigation. Electromagnetic induction (EM) measurements of various soils and landscapes show high salt levels in the strongly sodic, slowly permeable soils such as the solodic soils and clays.

Water quality varies according to the source. Table 7 shows the range and average electrical conductivity (EC) of water in the Boyne River at Derra, the Mundubbera weir and the Auburn River at Glenwood above the proposed dam site. The range of sodium adsorption ratios (SAR) is also included. Water salinity ranges from high in the Boyne River to medium in the Auburn and Burnett Rivers. SAR values are low.

EC measurements indicate that the water is suitable for all crops except very low salt tolerant crops (Gill 1984). The SAR levels indicate few problems except for sodium sensitive crops. These recommendations are based on the likely effect of water when used for irrigation and should be used as guidelines only. Precise standards are virtually impossible to set, since the conditions of use must be taken into account and will modify the effects of the water. Factors which must be considered include;

- type of crops to be irrigated
- soil type
- climate and season
- irrigation method
- management of irrigation and drainage

The standards of these interacting factors are beyond the capability of this study. Shaw *et al.* (1987) discuss these factors in detail.

Table 7. Electrical conductivity (EC) and sodium adsorption ratio (SAR) of water in the Auburn, Burnett and Boyne Rivers

	Auburn R. (June 1971 to Dec 1988)		Burnett R. (May 1976 to Nov 1988)		Boyne R. (Aug 1985 to Sept 1988)	
	EC (dS/m)	SAR	EC (dS/m)	SAR	EC (dS/m)	SAR
Range	0.1 to 1.1	0.4 to 3.3	0.13 to 1.16	1.4 to 2.6	0.76 to 1.25	2.7 to 3.3
Average	0.47		0.7		1.0	

Source: Water Resources Commission (unpublished data).

4.3.9 Water erosion

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

Soil erosion by flowing water is determined by climatic factors such as amount, distribution and intensity of rainfall, landform such as gradient and slope length, soil erodibility and management practices such as maintaining surface trash.

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

The well drained permeable red earths, and red and brown prairie soils have an upper slope limit of 8% for arable agriculture. The highly erodible texture contrast soils have an arable slope limit of 1%.

Where furrow irrigation is used, water flow in furrows on too steep a gradient can cause soil erosion. Gradient of the furrow can be decreased by adjusting the furrow direction at an angle to the slope. Over topping of furrows especially those with excessive side slopes can initiate rill erosion. Soil type and slope in combination with furrow infiltration have been used to determine suitability of a UMA for furrow irrigation.

4.3.10 Furrow infiltration

Irrigation type (flood, spray) and design (furrow length, slope) should be tailored to the permeability attributes of each soil. For furrow irrigation, long furrow lengths and application times are inappropriate for soils where a significant deep drainage component is likely to occur, especially at the headditch end. Furrow irrigation is suitable only on low sloping land (see section 4.3.9) and slowly permeable clays (Durong, Grindstone, Lacon, Nail soils) and solodic soils with medium textured surfaces (Auburn, Coonambula soils).

Spray, microsprinklers or drip irrigation should be used on permeable and sloping soils.

4.4 Preferred land use

The agricultural suitability map (map 2) identifies the areas suitable (classes 1, 2 and 3) for the various land uses. Table 8 summarises the total area of each suitability class for each soil mapping unit and each crop.

The alluvial soil (Burnett soil), the prairie soil on terraces (Flagstone soil), the red-brown earth on relict alluvia (Boyne soil) and the red earth (Glenrock soil) are the soils suitable for the widest range of crops. These soils presently grow a majority of the district tree crops, small crops and field and grain crops. The clay soils (Durong, Lacon, Nail soils) and the red and brown prairie soil (Boynewood soil) are soils which are suitable for a wide range of field and grain crops.

Suitability for furrow irrigation was determined on soil and slope attributes only. Crop suitability and furrow irrigation suitability are combined to determine if a crop is suitable for furrow irrigation in a particular area. This is shown in Table 8 where the Auburn soil mapping unit has 1335 ha suitable for furrow irrigation. However, only 946 ha are suitable for furrow irrigating vegetables, cruciferae, cucurbits, asparagus, potato, sunflower, soybean and summer and winter grains.

It is desirable that land suitable for the wider range of uses be maintained in a productive state. The horticultural industry, particularly citrus, will be the likely main user of increased allocation of irrigation water. The suitable soils adjacent to the rivers will be the main development areas.

Table 8. Area (ha) of suitability classes for each soil mapping unit and crop

Soil mapping unit	Suit class	Avo	Citrus	Mango	Pecan	Stone fruit	Grape	Vege Crucif Cucur Aspar	Potato	Peanut	Saff.	Sunf.	Navy.	Mung.	Chick.	Lucern	Soy.	Summer grain	Winter grain	Past.	Furr.* Irrig.
Auburn	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1236
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	63	946	946	0	0	946	0	0	0	0	946	946	946	1252	
	4	0	82	0	82	82	1037	325	290	1022	1022	290	1022	1022	1022	1037	290	325	325	82	35
	5	1335	1253	1335	1253	1253	234	64	99	313	313	99	313	313	313	298	99	64	64	0	64
Auburn red variant	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	96	0	0	0	0	0	0	0	0	0	0	0	0	102	0
	4	0	275	0	275	275	203	24	24	24	0	24	24	0	0	0	24	24	24	197	24
	5	299	24	299	24	24	0	275	275	275	299	275	275	299	299	299	275	275	275	0	275
Burnett	1	0	0	0	23	23	132	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	538	538	445	0	0	448	429	448	0	429	429	535	448	554	554	554	0
	3	0	542	0	23	23	7	561	561	121	140	121	561	140	140	35	121	16	16	16	0
	4	0	42	0	0	0	0	23	23	14	14	14	23	14	14	14	14	14	14	14	7
	5	584	0	584	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	577
Beeron	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1764	
	4	0	0	0	0	0	2249	21	7	0	0	7	0	0	0	14	7	21	21	485	14
	5	2823	2823	2823	2823	2823	573	2801	2816	2823	2823	2816	2823	2823	2823	2808	2816	2801	2801	566	2801
Beeron eroded phase	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Beeron rocky phase	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	8	0
	4	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
	5	17	17	8	17	17	3	17	17	17	17	17	17	17	17	17	17	17	17	3	17

* Areas for suitability classes 1, 2 and 3 are combined.

Table 8 continued.

Soil mapping unit	Suit class	Avo	Citrus	Mango	Pecan	Stone fruit	Grape	Vege Crucif Cucur Aspar	Potato	Peanut	Saff.	Sunf.	Navy.	Mung.	Chick.	Lucern	Soy.	Summer grain	Winter grain	Past.	Furr.* Irrig.
Boynewood	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	124	102	0	0	0	0	0	0	0	52	0	102	102	780	0
	3	0	770	0	770	770	656	678	102	102	102	102	102	102	102	718	102	668	668	0	0
	4	0	0	0	0	0	0	0	678	678	668	678	678	668	668	0	678	10	10	0	102
	5	780	10	780	10	10	0	0	0	0	10	0	0	10	10	10	0	0	0	0	678
Boynewood rocky phase	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	28	0	0	0	0	0	0	0	0	0	0	0	0	28	0
	3	0	0	0	0	0	518	0	0	0	8	8	0	0	0	0	0	36	0	587	0
	4	0	546	23	546	546	127	36	0	0	67	109	0	36	0	36	36	81	36	58	39
	5	763	217	740	217	217	90	726	763	763	688	645	763	726	763	726	726	645	726	90	724
Boyne	1	0	0	0	0	0	183	0	0	0	0	0	0	0	0	0	0	7	7	7	149
	2	0	0	0	27	27	643	7	7	261	261	261	7	261	261	613	149	786	647	647	
	3	0	715	0	688	688	117	872	849	634	634	634	849	634	634	305	746	126	265	265	
	4	0	177	0	177	177	0	65	88	48	48	48	88	48	48	25	48	25	25	25	668
	5	943	52	943	52	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	127
Chess-borough	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	49	383	0
	3	0	0	0	0	0	58	49	49	49	49	49	49	49	49	49	49	0	0	9	0
	4	8	57	8	57	57	341	341	341	341	341	341	341	341	341	341	341	341	341	0	341
	5	392	342	392	342	342	0	9	9	9	9	9	9	9	9	9	9	9	9	0	58
Coonambula	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	981
	2	0	0	0	0	0	84	0	0	0	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	0	718	718	0	0	718	0	0	0	0	718	718	718	738	
	4	0	0	13	0	0	994	360	263	981	965	263	981	965	965	1049	263	360	360	340	97
	5	1078	1078	1064	1078	1078	0	0	97	97	113	97	97	113	113	29	97	0	0	0	0
Durong	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1162
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	694	
	3	0	0	0	0	0	0	1327	1311	0	0	1273	0	0	0	0	1273	1289	1289	648	
	4	0	0	0	0	0	1454	121	138	1434	1304	176	1434	1304	1304	1304	176	159	159	127	290
	5	1468	1468	1468	1468	1468	14	20	20	34	164	20	34	164	164	164	20	20	20	0	16

Table 8 continued.

Soil mapping unit	Suit class	Avo	Citrus	Mango	Pecan	Stone fruit	Grape	Vege Crucif Cucur Aspar	Potato	Peanut	Saff.	Sunf.	Navy.	Mung.	Chick.	Lucern	Soy.	Summer grain	Winter grain	Past.	Furr.* Irrig.
Derra	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1501
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	4	0	0	0	0	0	97	97	97	97	51	97	97	51	51	51	97	97	97	97	0
	5	1501	1501	1501	1501	1501	1404	1404	1404	1404	1450	1404	1404	1450	1450	1450	1404	1404	1404	1404	0
Evergreen	1	0	221	0	221	221	221	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	221	0	221	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	221	221	221	221	221	221	221	221	221	221	221	221	221	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	221
Flagstone	1	0	0	0	0	0	125	0	0	0	0	246	0	0	0	0	246	568	568	375	0
	2	0	0	0	513	513	554	583	573	661	661	420	573	661	661	670	420	107	107	304	0
	3	0	549	0	167	167	0	96	102	15	15	9	102	15	15	9	9	4	4	0	0
	4	0	130	0	0	0	0	0	4	4	4	4	4	4	4	0	4	0	0	0	71
	5	679	0	679	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	609
Glenrock	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	643	643	643	643	678	0	0	64	64	64	0	64	64	637	64	637	637	678	0
	3	643	18	54	18	18	18	678	637	572	572	572	637	572	572	6	572	42	42	18	0
	4	18	36	0	36	36	0	18	42	42	42	42	42	42	42	54	42	18	18	0	0
	5	36	0	0	0	0	0	0	18	18	18	18	18	18	18	0	18	0	0	0	696
Glenrock grey variant	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0
	4	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16
Glenrock shallow phase	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	59	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	62	62	62	62	62	0	62	0	0	59	59	0	59	0	62	59	62	62	62	0
	5	0	0	0	0	0	0	0	62	62	3	3	62	3	62	0	3	0	0	0	62

Table 8 continued.

Soil mapping unit	Suit class	Avo	Citrus	Mango	Pecan	Stone fruit	Grape	Vege Crucif Cucur Aspar	Potato	Peanut	Saff.	Sunf.	Navy.	Mung.	Chick.	Lucern	Soy.	Summer grain	Winter grain	Past.	Furr.* Irrig.
Glenrock structured variant	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	4	4	4	4	54	0	0	0	0	0	0	0	0	0	0	0	0	39	0
	3	34	29	29	29	29	29	54	0	0	0	0	0	0	0	54	0	54	54	45	0
	4	0	0	50	0	0	0	29	54	54	54	54	54	54	54	29	54	29	29	0	0
	5	50	50	0	50	50	0	0	29	29	29	29	29	29	29	0	29	0	0	0	84
Grindstone	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	127
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	127	
	4	0	0	0	0	0	0	127	127	0	0	127	0	0	0	0	127	127	127	0	0
	5	127	127	127	127	127	127	0	0	127	127	0	127	127	127	127	0	0	0	0	0
Hills	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	6779	6779	6779	6779	6779	6779	6779	6779	6779	6779	6779	6779	6779	6779	6779	6779	6779	6779	6779	6779
Hawkwood	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	276	0
	4	0	130	1705	130	130	1736	0	0	0	0	0	0	0	0	0	0	0	0	1750	0
	5	2488	2359	783	2359	2359	753	2488	2488	2488	2488	2488	2488	2488	2488	2488	2488	2488	2488	462	2488
Lacon	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	181
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	395	
	3	0	0	0	0	0	19	401	331	0	12	263	19	12	12	12	263	328	328	238	
	4	0	205	165	205	205	463	232	302	482	331	370	463	331	331	331	370	305	305	0	372
	5	633	427	467	427	427	150	0	0	150	290	0	150	290	290	290	0	0	0	0	80
Nail	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	97
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	369	
	3	0	0	0	0	0	314	361	361	0	246	246	246	246	246	246	246	246	246	68	
	4	0	323	0	323	323	123	77	9	369	9	123	123	9	9	77	123	191	191	0	272
	5	437	114	437	114	114	0	0	68	68	182	68	68	182	182	114	68	0	0	0	68

Table 8 continued.

Soil mapping unit	Suit class	Avo	Citrus	Mango	Pecan	Stone fruit	Grape	Vege Crucif Cucur Aspar	Potato	Peanut	Saff.	Sunf.	Navy.	Mung.	Chick.	Lucern	Soy.	Summer grain	Winter grain	Past.	Furr.* Irrig.
O'Bil Bil	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	269	0
	3	0	0	262	0	0	269	0	0	0	0	0	0	0	0	0	0	0	0	321	0
	4	0	269	321	269	269	0	321	0	0	269	269	0	0	0	0	0	590	321	0	137
	5	590	321	7	321	321	321	269	590	590	321	321	590	590	590	590	590	0	269	0	453
Pearlinga	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	151	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	151	0	0	166	0	0	0	0	0	0	0	0	151	0	181	181	181	0
	4	0	151	0	151	151	55	372	372	372	181	372	372	181	181	29	372	192	192	192	34
	5	372	221	221	221	221	0	0	0	0	192	0	0	192	192	192	0	0	0	0	338
Riverleigh	1	0	0	0	0	0	9	0	0	0	0	72	0	0	0	0	72	72	72	95	0
	2	0	0	0	9	9	133	142	142	143	81	71	118	81	81	81	71	71	71	71	0
	3	0	9	0	114	114	24	25	25	24	62	0	48	62	62	62	0	0	0	0	0
	4	0	133	0	19	19	0	0	0	0	0	24	0	0	0	0	24	24	24	0	166
	5	166	24	166	24	24	0	0	0	0	24	0	0	24	24	24	0	0	0	0	0
Stream channels	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	1729	1729	1729	1729	1729	1729	1729	1729	1729	1729	1729	1729	1729	1729	1729	1729	1729	1729	1729	1729
Shurback	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	109
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	3	0	0	0	0	0	0	109	109	0	0	109	0	0	0	0	109	109	109	155	
	4	0	0	0	0	0	155	0	0	109	109	0	109	109	109	109	0	0	0	0	0
	5	155	155	155	155	155	0	47	47	47	47	47	47	47	47	47	47	47	47	0	47
Toondoon	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	226	0	0	0	0	0	0	0	0	0	0	0	0	39	0
	4	0	0	25	0	0	143	39	0	0	0	0	0	0	0	39	0	39	39	330	39
	5	417	417	393	417	417	49	379	417	417	417	417	417	417	417	379	417	379	379	49	379

Table 8 continued.

Soil mapping unit	Suit class	Avo	Citrus	Mango	Pecan	Stone fruit	Grape	Vege Crucif Cucur Aspar	Potato	Peanut	Saff.	Sunf.	Navy.	Mung.	Chick.	Lucern	Soy.	Summer grain	Winter grain	Past.	Furr.* Irrig.
Urban	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	174	174	174	174	174	174	174	174	174	174	174	174	174	174	174	174	174	174	174	174
Washpool	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	324	0	0	0	0	0	0	0	0	0	0	0	0	364	0
	5	391	391	391	391	391	67	391	391	391	391	391	391	391	391	391	391	391	391	26	391
Wivenhoe	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	415	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	92	68	92	92	483	483	438	438	438	438	438	438	438	483	438	483	483	44	346
	5	483	390	415	390	390	0	0	44	44	44	44	44	44	44	0	44	0	0	0	137
Total	1	0	221	0	243	243	670	0	0	0	0	317	0	0	0	0	317	646	646	508	5548
	2	221	647	868	1734	1734	2954	833	722	1578	1497	1265	698	1497	1497	2587	1153	2306	2167	5633	
	3	676	2633	496	1809	1809	2597	6875	6099	1517	1840	5050	2614	1832	1832	1648	5154	4762	4864	6873	
	4	103	2727	2464	2440	2440	9998	3409	3533	6745	6212	4165	6529	5913	5818	5321	3823	3753	3439	4392	3054
	5	27712	22486	24884	22486	22486	12492	17596	18359	18872	19163	17914	18872	19471	19566	19156	18264	17245	17596	9403	20110

5. CONCLUSIONS

The Water Resources Commission requested the Land Resources Branch of the Queensland Department of Primary Industries undertake a 1:50 000 soil survey and land suitability assessment for irrigated crops in an area 5 km either side of the Auburn and Burnett Rivers from Mundubbera to a proposed dam site 18 km up the Auburn River.

The proposed dam will supply irrigation water to the study area with excess water being released down the Burnett River. The current land uses in the study area are dominated by tree crops (predominantly citrus), grapes, improved pastures for seed production and grazing, maize and sorghum grain crops. The horticultural industries utilise the majority of the existing available water. An increase in water allocations has the potential to increase production of all agriculture, particularly horticultural crops.

This report describes and catalogues the land resources of 28 712 ha of land. The resources are described in terms of geology, landform and soils. A total of 23 soils were identified and mapped (Map 1).

The lands were assessed in terms of land suitability for growing avocado, citrus, mango, pecan, low chill stone fruits, grapes, winter grains, summer grains, safflower, sunflower, navybean, mungbean, chickpea, lucerne, soybean, peanut, potato, vegetables, cruciferae, cucurbits, asparagus and improved pastures. Each of the 412 unique map areas (UMAs) were individually assessed for their suitability for growing the crops. A total of 897 ha is suitable (class 1, 2 and 3 land) for avocado, 3500 ha for citrus, 1364 ha for mango, 3786 ha for pecan and low chill stone fruits, 6222 ha for grapes, 7678 ha for winter grains, 7714 ha for summer grains, 3337 ha for safflower, 6633 ha for sunflower, 3312 ha for navybean, 3329 ha for mungbean and chickpea, 4236 ha for lucerne, 6625 ha for soybean, 3095 ha for peanut, 6821 ha for potato, 7707 ha for vegetables, cruciferae, cucurbits and asparagus, 13 014 ha for improved pastures. A total of 5548 ha is suitable for furrow irrigation. However, no account was taken on the availability of the land.

All land considered marginal/currently unsuitable (class 4) for any agricultural use is of dubious benefit due to the high costs of and/or unreliable production, or land degradation. Future changes in technology may prove these lands to be suitable.

The significant limitations to production were identified and assessed for each UMA. The limitations assessed were climate, water availability, wetness, soil depth, rockiness, microrelief, soil physical condition, secondary salinisation, water erosion and furrow infiltration.

The report identifies the areas of land suitable for irrigated agricultural development and the management needs of these lands. The guidelines are aimed at promoting sustained or improved productivity while avoiding degradation of the land resources.

The resource data can be rapidly reassessed for the suitability of new crops or where changing technology alters suitability. The system of recording resource and suitability data is compatible with the computer aided drafting system whereby data can be printed in map or overlay form.

The information in the report will be useful to industry groups, land holders, local authorities and government departments who have a commitment to maintain the land in a highly productive state.

A number of constraints on agriculture need to be addressed for any development of the area. These include:

- A detailed cost benefit study is required.
- The possibility of salinisation requires detailed investigation of the effects of irrigation and watertables on a range of soils and landforms.
- Maintenance of native vegetation where secondary salinisation may result and investigation of the feasibility of drains in these areas to lower watertables.
- The long term effects of irrigation on regional watertables is unknown.
- Further information is required on the factors which will modify the efficiency of irrigation. These factors include the type of crops, soil types, climate and season, irrigation method, management of irrigation and drainage. This information will determine the most suitable irrigation method and management for the different soils and crops while limiting the effects of salinity.
- Generally, the size of existing farms is small (260 ha) resulting in small areas of uniform soil types on a farm.

6. ACKNOWLEDGEMENTS

The authors wish to thank:

- Messrs S. O'Donnell, I. Partridge, J. Owen-Turner, J. Chapman, G. Robbins for crop suitability information.

- Miss Cassandra Hill for typing the report.

- Mr M. Carrol for drafting of the maps.

- Mr K. Rosenthal and Mrs C. Fisher for filing and sorting data on computer files.

- Mr D.E. Baker for editorial comment on soil chemistry.

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APPENDIX II

CONVENTIONS USED IN THE DESCRIPTION OF THE MORPHOLOGY AND LANDFORM OF THE SOIL TYPES

A **soil type** is a three dimensional soil body of group of soil bodies, such that any profile within the body(s) has a similar number and arrangement of major horizons whose attributes, primarily morphological, are within a defined range. All profiles within the unit have similar parent materials.

The soil type may be at varying levels of generalisation depending primarily on the scale of the survey and density of ground observations.

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

Principle Profile Form (PPF) as defined by Northcote (1979) are listed in order of frequency of occurrence. A "p" after the PPF denotes ploughed.

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

Microrelief as in McDonald *et al.* (1984).

Landform as in McDonald *et al.* (1984).

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

Horizons as in McDonald *et al.* (1984).

Textures are field textures as in McDonald *et al.* (1984)

Structure as in McDonald *et al.* (1984)

Segregations as in McDonald *et al.* (1984)

Boundaries in the soil profile diagram are:

__________ clear to abrupt

-------------- gradual to diffuse

Boundary type as in McDonald *et al.* (1984)

Frequency of occurrence

Frequently = >30% of occasions

Occasionally = <30% of occasions

Surface condition as in McDonald *et al.* (1984)

Colour codes (moist) are those of Oyama and Takehara (1967) while colour nomenclature is based on the Value/Chroma rating system of Northcote (1979) and utilising the following table:

Value/Chroma 2a = 4/1, 4/2 to 6/1, 6/2

Value/Chroma 2b = 5/3, 5/4 to 6/3, 6/4

Value/Chroma Rating	1	2a	2b	4	5
Hue					
10R	dark	red-grey	red-brown	red	red
2.5YR	dark	grey-brown	red-brown	red	red
5YR	dark	grey-brown	brown	red-brown	red-brown
7.5YR	dark	grey-brown	brown	yellow-brown	brown
10YR	dark	grey	yellow-brown	yellow	brown
2.5Y	dark	grey	yellow-grey	yellow	olive-brown
5Y	dark	grey	yellow-grey	yellow	olive

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APPENDIX III

DESCRIPTION OF THE SOIL TYPES

Soil type: Auburn

Concept: Alkaline texture contrast soil on relict alluvial plains

Great soil group: Solodic soil

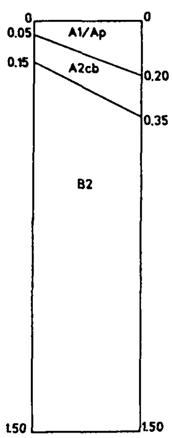
Principle profile form: Dy2.43, Dy3.43, Db1.43

Substrate material: Cainozoic alluvia

Landform: Alluvial plain

Surface condition: Hardsetting

Microrelief: Nil



A1/Ap: Grey-brown, dark or brown (7.5YR 3/2, 4/2, 4/3); clay loam to clay loam sandy, occasionally sandy loam; massive or moderate to weak <5 mm granular. Field pH 6.5 to 7.0. Clear to abrupt change to -

A2cb: Brown or grey-brown (7.5YR 5/2, 5/3, 5/4, 6/2, 6/3); clay loam to clay loam sandy, occasionally sandy loam; massive; occasionally <10% manganiferous nodules <6 mm; conspicuously bleached. Field pH 6.5 to 8.5. Abrupt change to -

B2: Frequently mottled, especially upper part of B2; Brown, yellow-brown or grey-brown (7.5YR 4/2, 4/3, 4/4, 5/2, 5/3, 5/4, 5/5, 6/3, 10YR 4/3, 5/2, 5/3, 5/4, 6/3, 6/4, 6/5) frequently becoming paler at depth; light medium clay to heavy clay; strong 5 to 20 mm angular blocky or lenticular; frequently <10% manganiferous nodules and calcareous concretions <6 mm. Field pH 8.5 to 9.5.

pH >8.5 at 0.4 to 0.8 m

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

D: Red-brown or brown (5YR 4/4, 4/6, 5/6, 7.5YR 4/6, 10YR 4/6); medium to heavy clay; strong 5 to 20 m angular blocky; <10% manganiferous nodules, soft segregations and/or calcareous concretions <6 mm. pH 8.5 to 9.5.

Soil type: Beeron

Concept: Alkaline texture contrast soil with a clay loam surface developed on siltstones and mudstones

Great soil group: Solodic soil

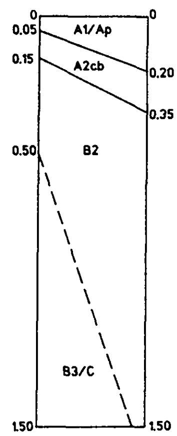
Principle profile form: Dy3.43, Dy2.43, Db1.43, Dy3.13p, Db1.13p

Substrate material: Siltstones and mudstones of the Carboniferous Caswell Creek Group and Crana Beds, Triassic Cynthia Beds

Landform: Slopes of rises, low hills and hills. Slope 1 to 10%.

Surface condition: Hardsetting

Microrelief: Nil



A1/Ap: Dark or grey-brown, occasionally brown (7.5YR 3/2, 3/3, 4/2, 4/3, 10YR 3/2); clay loam, clay loam sandy to sandy clay loam; massive or weak to moderate <5 mm granular. Field pH 6.0 to 7.0. Clear to gradual change to -

A2cb: Brown, grey-brown, grey or yellow-brown (7.5YR 5/2, 5/3, 5/4, 6/3, 10YR 5/2, 6/3, 6/4); clay loam, clay loam sandy to sandy clay loam; massive; occasionally <10% manganiferous nodules <6 mm; conspicuously bleached. Field pH 6.5 to 7.5. Abrupt to sharp change to -

B2: Frequently mottled; yellow-brown, brown, yellow or occasionally grey-brown (7.5YR 4/2, 10YR 4/3, 4/4, 5/3, 5/4, 5/6, 6/4); medium to heavy clay; moderate to strong 5 to 20 mm angular blocky or occasionally lenticular; frequently <10% manganiferous or ferromanganiferous nodules and/or calcareous concretions <6 mm. Field pH 7.5 to 9.5. Gradual to diffuse change to -

B3/C: as above with rock fragments or rock. Field pH 8.0 to 9.5.

pH > 8.5 at 0.3 to 0.6 m if no rock at 0.6 m

Beeron rocky phase
As above with >20% rock fragments. B2 horizon to 0.45 m over C horizon.

Beeron eroded phase
As above. Severely eroded.

Soil type: Boyne

Concept: Brown massive surface over red structured clay on alluvia

Great soil group: Red-brown earth

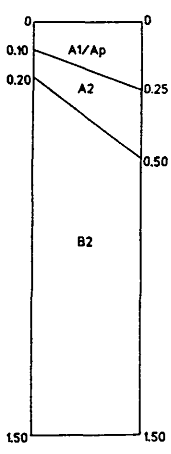
Principle profile form: Gn3.12, Dr2.23, Dr2.13, Dr2.12, Dr3.12, Dr2.22, Dr2.33

Substrate material: Cainozoic alluvia

Landform: Terraces

Surface condition: Hardsetting

Microrelief: Nil



A1/Ap: Brown, red-brown or occasionally dark (5YR, 7.5YR 3/2, 3/3, 3/4, 4/3, 4/4); sandy loam to clay loam; massive. Field pH 6.0 to 7.5. Clear to gradual change to -

A2: Frequently occurs; red-brown or brown (5YR 4/3, 4/4, 4/6, 7.5YR 4/4, 5/4); sandy loam to clay loam; massive; occasionally bleached. Field pH 6.0 to 8.0. Clear to gradual change to -

A3/B1: Occasionally occurs; red or red-brown (2.5YR, 5YR 4/4, 4/6); sandy clay loam, clay loam, clay loam sandy, light clay; massive to moderate <5 mm subangular block. Clear to gradual change to -

B2: Red or red-brown (2.5YR 3/6, 4/6, 5YR 3/6, 4/4, 4/6); light clay to medium clay; moderate to strong 2 to 10 mm, occasionally 20 mm, subangular or angular blocky; frequently <10% manganiferous nodules <6 mm. Field pH 7.0 to 9.0.

Soil type: Boynewood

Concept: Red or brown noncracking clay developed on siltstones, mudstones and andesite

Great soil group: Prairie soil

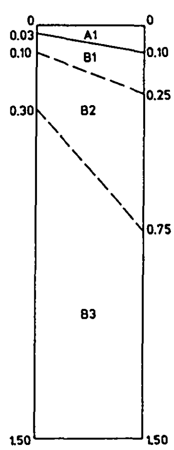
Principle profile form: Uf6.31, Uf6.34, Gn3.12

Substrate material: Siltstone, mudstone and andesite of the Carboniferous Caswell Creek Group and Crana Beds, Devonian andesite

Landform: Upper slopes of rises, low hills and hills. Slopes 1 to 8%

Surface condition: Crusting, firm

Microrelief: Nil



A1: Brown or dark (5YR 3/2, 3/3, 7.5YR 3/2, 3/3, 3/4, 4/3, 4/4, 10YR 3/2, 3/3); clay loam, light clay to light medium clay; strong <5 mm granular. Field pH 6.5 to 7.5. Clear to gradual change to -

B1: Red-brown or brown (5YR 3/3, 3/4, 4/3, 4/4, 7.5YR 3/3, 3/4, 4/4); light clay to medium clay; strong 2 to 10 mm subangular blocky. Field pH 7.0 to 8.0. Gradual to diffuse change to -

B2: Red-brown, red or brown (2.5YR 4/6, 5YR 3/6, 4/4, 4/6, 4/8, 7.5YR 4/4, 4/6); light medium to heavy clay; strong 2 to 10 mm subangular blocky frequently becoming lenticular in lower B2. Field pH 7.0 to 8.5. Gradual to diffuse change to -

B3: Red-brown, brown or yellow-brown (5YR 4/4, 4/6, 5/8, 7.5YR 4/4, 5/6, 10YR 4/4, 6/4); light clay to medium heavy clay; strong 2 to 10 mm subangular block; >2% rock fragments. Field pH 7.0 to 9.0.

Boynewood rocky phase
As above with >20% rock fragments.

Soil type: Burnett

Concept: Brown layered soil of alluvial origin

Great soil group: Alluvial soil

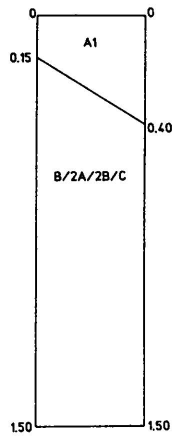
Principle profile form: Um1.43, Um5.52

Substrate material: Quaternary alluvia

Landform: Terraces and channel benches

Surface condition: Firm or soft or loose or hardsetting

Microrelief: Nil



A1: Brown or dark (7.5YR 3/2, 3/3, 3/4, 4/2, 4/3, 10YR 3/2, 3/3, 3/4); sandy loam to loam fine sandy and sandy clay loam; massive to moderate 2 to 10 mm granular. Field pH 6.0 to 7.5. Clear to diffuse change to -

B/2A/2B/C: Brown, dark or occasionally red-brown (5YR 4/4, 7.5YR 3/2, 3/4, 4/3, 4/4, 4/6, 5/4, 5/6, 10YR 2/3, 3/3, 3/4, 4/6); layered sandy loam to light clay; massive to moderate 2 to 10 mm subangular blocky. Clear to diffuse changes between layers. Field pH 6.5 to 8.0.

Soil type: Chessborough

Concept: Red-brown soil over mottled yellow clay on alluvial fans

Great soil group: Red earth

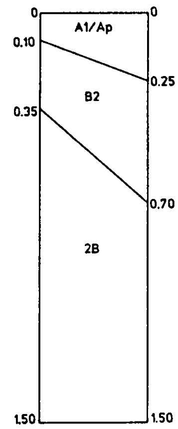
Principle profile form: Um5.52, Gn2.12, Gn2.11

Substrate material: Cainozoic alluvia

Landform: Alluvial fans. Slope 0 to 3%

Surface condition: Hardsetting

Microrelief: Nil



A1/Ap: Red-brown or brown (5YR 3/3, 3/4, 4/3, 7.5YR 3/2, 3/3); sandy clay loam, clay loam to clay loam sandy; massive. Field pH 6.0 to 7.0. Clear to gradual change to -

B2: Red-brown (5YR 3/6, 4/4, 4/6, 4/8); clay loam to light clay; massive to weak 2 to 5 mm subangular block. Field pH 5.5 to 7.0. Clear to gradual change to -

2B: Mottled; yellow-brown, yellow or red-brown (5YR 5/6, 7.5YR 5/5, 5/6, 10YR 5/6, 5/8, 6/6); light clay to medium clay; moderate to strong 2 to 10 mm subangular blocky; < 10% ferromanganiferous or manganiferous nodules <6 mm. Field pH 5.5 to 9.0.

Soil type: Coonambula

Concept: Alkaline texture contrast soil along creeks

Great soil group: Solodic soil

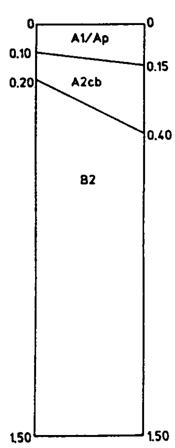
Principle profile form: Dy2.43, Dy2.42, Dy3.43, Db1.42, Dy3.42, Db2.42

Substrate material: Quaternary alluvia

Landform: Alluvial plains

Surface condition: Hardsetting

Microrelief: Nil



A1/Ap: Dark or grey-brown (7.5YR 3/2, 4/2); clay loam to clay loam sandy; massive to moderate <5 mm granular. Field pH 6.0 to 7.0. Clear to gradual change to -

A2cb: Grey-brown or brown (7.5YR 5/2, 5/3, 5/4); clay loam to clay loam sandy; massive; conspicuously bleached. Field pH 6.0 to 7.0. Sharp to abrupt change to -

B2: Brown, grey-brown, yellow-brown or grey (7.5YR 4/2, 4/3, 4/4, 5/2, 5/3, 5/4, 6/3, 10YR 4/2, 5/2, 5/3, 5/4, 6/3, 6/4); medium clay to medium heavy clay; strong 5 to 20 mm angular blocky; frequently manganiferous or calcareous nodules. Field pH 7.0 to 9.0.

Soil type: Derra

Concept: Strongly gilgaied (melonhole) grey or brown clay on relict alluvial plains

Great soil group: Grey clay, brown clay

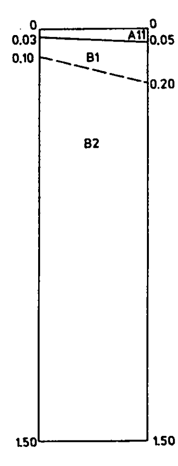
Principle profile form: Ug5.24, Ug5.35, Ug5.34, Ug5.25

Substrate material: Cainozoic alluvia

Landform: Alluvial plains

Surface condition: Cracking, self mulching, crusting

Microrelief: Type: Melonhole gilgai
Vertical interval: 0.4 to 1.0 m
Horizontal interval: 10 to 20 m



A11: Brown, grey-brown or dark (7.5YR 3/2, 3/3, 4/2, 4/3, 4/4, 10YR 3/3, 4/2); light clay to medium clay; moderate to strong <5 mm granular or subangular blocky. Field pH 6.0 to 8.0. Clear to abrupt change to -

B1: Brown or grey-brown (7.5YR 3/3, 4/2, 4/3, 4/4); light medium to medium heavy clay; strong 2 to 10 mm subangular blocky; occasionally <2% manganiferous nodules <6 mm. Field pH 6.5 to 8.3. Mainly gradual change to -

B2: Occasionally mottled; grey-brown, brown or grey (7.5YR 4/2, 4/3, 4/4, 5/2, 5/3, 5/4, 6/2, 10YR 4/3, 4/4, 5/3, 5/4) frequently becoming paler at depth; medium to heavy clay; strong <5 mm lenticular or subangular blocky; frequently <10% calcareous concretions <6 mm. Field pH 7.0 to 9.5.

Soil type: Durong

Concept: Grey clay on relict alluvial plains

Great soil group: Grey clay

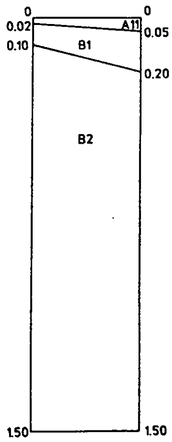
Principle profile form: Ug5.24, Ug5.16, Ug5.35

Substrate material: Cainozoic alluvia

Landform: Alluvial plains

Surface condition: Cracking, self mulching, crusting

Microrelief: Frequently gilgaied
Type: Normal gilgai
Vertical interval: <0.3 m
Horizontal interval: 5 to 10 m



A11: Grey-brown, dark or occasionally brown (7.5YR 3/1, 3/2, 3/3, 4/1, 4/2, 10YR 3/2, 4/2); light to medium clay; strong <5 mm granular or subangular blocky. Field pH 6.5 to 8.5. Clear to abrupt change to -

B1: Grey-brown, dark or occasionally brown (7.5YR 3/1, 4/1, 4/2, 4/3, 10YR 3/2, 4/2); medium to medium heavy clay; strong <10 mm subangular blocky; frequently <10% manganiferous nodules <6 mm. Field pH 7.0 to 8.5. Clear to gradual change to -

B2: Grey-brown, grey, yellow-brown or brown (7.5YR, 10YR 4/1, 4/2, 4/3, 5/2, 5/3); frequently becoming mottled and paler (7.5YR 5/3, 10YR 5/3, 5/4, 6/3, 6/4) at depth; medium heavy to heavy clay; strong <5 mm lenticular or subangular blocky; frequently <10% calcareous nodules <6 mm. Field pH 8.0 to 9.5.

pH >8.5 at 0.4 to 1 m

A majority of sites pH 9.0 at 0.6 to 1 m

Soil type: Flagstone

Concept: Dark or brown structured clay loam to clay developed on alluvia

Great soil group: Prairie soil, brown earth

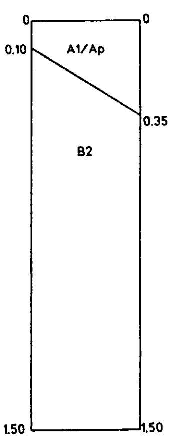
Principle profile form: Uf6.32, Um6.32, Dd1.13, Um6.31, Db1.13, Dd1.12

Substrate material: Quaternary alluvia

Landform: Terraces

Surface condition: Firm or hardsetting

Microrelief: Nil



A1/Ap: Dark or occasionally brown (5YR 3/2, 7.5YR 3/1, 3/2, 10YR 2/2, 2/3, 3/2, 3/3); sandy clay loam, clay loam to light clay; massive to strong 2 to 5 mm granular. Field pH 6.0 to 8.0. Clear to gradual change to -

B2: Dark or brown (7.5YR 3/2, 3/3, 3/4, 4/2, 4/3, 4/4, 10YR 2/2, 2/3, 3/2, 3/3, 3/4); clay loam fine sandy to medium clay; medium to strong 5 to 10 mm subangular blocky. Field pH 7.0 to 8.5.

Soil type: Evergreen

Concept: Red sand

Great soil group: (Rudimentary) podzol, (red) earthy sand

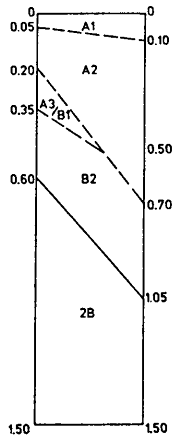
Principle profile form: Uc2.21, Uc4.21, Uc5.22

Substrate material: Duricrusted sandstone of the Jurassic Evergreen Formation

Landform: Alluvial fans. Slope 1 to 4%

Surface condition: Loose

Microrelief: Nil



A1: Grey-brown or dark (5YR 3/2, 4/2, 7.5YR 4/2); loamy sand to sandy loam; single grain. Field pH 5.8 to 6.0. Clear to gradual change to -

A2: Frequently occurs; brown or red-brown (5YR 4/3, 7.5YR 4/3, 6/4); sand to loamy sand; single grain; occasionally conspicuously bleached. Field pH 5.8 to 6.0. Gradual change to -

A3/B1: Frequently occurs; red-brown (5YR 4/4, 5/4, 5/6); loamy sand; single grain or massive. Field pH 5.8 to 6.0. Diffuse change to -

B2: Red-brown or brown (5YR 5/6, 5/8, 6/4); sand to loamy sand; single grain or massive. Field pH 5.8 to 6.0. Abrupt to gradual change to -

2B: Red (2.5YR, 5YR 4/8); light sandy clay loam to sandy clay loam; massive. Field pH 5.8.

Soil type: Glenrock

Concept: Red, massive, gradational to uniform soil

Great soil group: Red earth

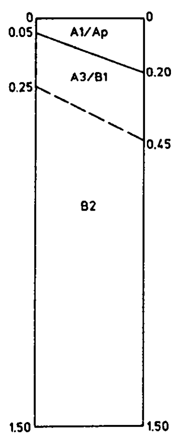
Principle profile form: Gn2.12, Gn2.11, Um5.52

Substrate material: Cainozoic alluvia

Landform: Alluvial fans, and crests of rises and low hills. Slopes 1 to 6%

Surface condition: Hardsetting

Microrelief: Nil



A1/Ap: Red-brown or red (2.5YR 3/3, 3/4, 4/4, 5YR 3/3, 3/6, 7.5YR 3/3); sandy clay loam, clay loam, clay loam sandy; massive to weak 2 to 5 mm granular. Field pH 6.0 to 7.5. Clear change to -

A3/B1: Frequently occurs; red (2.5YR 3/4, 3/6, 4/4, 4/6, 5YR 3/6); clay loam to light clay; massive. Field pH 5.5 to 7.0. Diffuse to gradual change to -

B2: Red (10YR 3/6, 2.5YR 3/6, 4/6, 4/8); clay loam to light clay; massive to weak 2 to 5 mm polyhedral or subangular blocky; occasionally <10% ferromanganiferous nodules <6 mm. Field pH 5.5 to 7.5.

Glenrock structured variant
Principle Profile Form: Uf6.31, Gn3.11, Gn3.12

Ap: 0.15 to 0.25 m; red or red-brown (2.5YR 3/3, 5YR 3/4, 4/4); light clay to light medium clay; weak to strong granular. Clear change to -

B2: Red (2.5YR 3/6, 4/6); light medium to medium clay; moderate to strong polyhedral or subangular blocky, pH 5.5 to 7.5.

Glenrock grey variant
Shallow (<0.6 m) grey earth on lower slopes. Grey-brown sandy loam A horizon over grey sandy clay loam B horizon. Soils overlie ironstone.

Glenrock shallow phase
Principle Profile Form: Gn2.11, Um5.51

Ap: 0.15 m; red-brown (5YR 3/3); clay loam to clay loam sandy; massive. Clear change to -

B2: 0.4 to 0.65 m; red-brown (5YR 3/6, 4/6); clay loam sandy to light medium clay; massive to weak 2 to 5 mm polyhedral; pH 6.0 to 7.0. Diffuse to clear change to -

B3: 0.6 to 0.75 m; red-brown (5YR 4/6, 5/6); clay loam sandy to light clay; massive; rock fragments. Clear change to -

C: Yellow-brown or grey (10YR 6/1, 6/4); rock.

Soil type: Grindstone

Concept: Bleached grey clay

Great soil group: (Bleached) grey clay

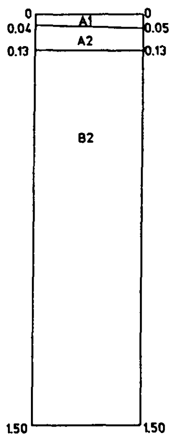
Principle profile form: Ug3.2

Substrate material: Quaternary alluvia

Landform: Drainage depression in alluvial plains

Surface condition: Cracking

Microrelief: 'Nil



A1: Brown (7.5YR 3/4, 10YR 2/3); silty clay to light medium clay; massive to subangular blocky. Field pH 6.0 to 6.5.

A2: Brown or grey (7.5YR 4/3, 2.5YR 4/1); light medium clay; massive to subangular blocky; sporadically bleached. Field pH 6.0 to 6.5.

B2: Grey (10YR 4/2, 5/3); medium heavy clay; strong lenticular to angular blocky; <10% manganiferous concretions or soft segregations, and calcareous concretions <6 mm. Field pH 8.0 to 9.0.

Soil type: Hawkwood

Concept: Mottled, neutral to alkaline texture contrast soil developed on siltstones and sandstones

Great soil group: Solodic soil, soloth

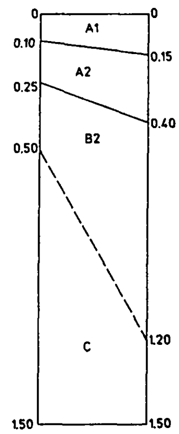
Principle profile form: Dy3.42, Dy3.41, Dr3.42, Dr3.41

Substrate material: Siltstones and sandstone of the Jurassic Evergreen Formation

Landform: Slopes of rises and low hills. Slopes 0 to 8%

Surface condition: Hardsetting

Microrelief: Nil



A1: Brown or grey-brown (5YR, 7.5YR 4/2, 4/3); sandy loam, fine sandy loam to clay loam; massive. Field pH 5.5 to 6.5. Clear to gradual change to -

A2: Grey-brown or brown (7.5YR 5/4, 6/2, 6/3); sandy loam, fine sandy loam to clay loam; massive; conspicuously bleached. Field pH 5.5 to 6.0. Abrupt change to -

B2: Mottled; yellow, yellow-brown or red-brown (5YR 4/6, 7.5YR 5/6, 10YR 5/6, 6/3); medium to medium heavy clay; strong 5 to 20 mm angular blocky. Field pH 6.0 to 8.0. Gradual to diffuse change to -

C: Weathered rock.

Soil type: Lacon

Concept: Brown, black and grey clay soils developed on siltstones, mudstones and andesite

Great soil group: Brown clay, black earth, grey clay

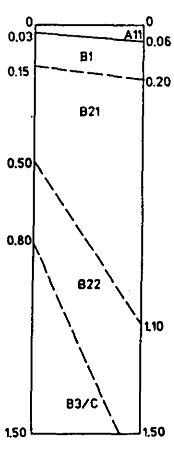
Principle profile form: Ug5.32, Ug5.34, Ug5.13, Ug5.22, Ug5.14, Ug5.15, Ug5.16

Substrate material: Siltstones, mudstones, and andesite of the Carboniferous Caswell Creek Group and Crana Beds, Triassic Cynthia Beds, Devonian andesite

Landform: Lower slopes of rises, low hills and hills. Slopes 0.5 to 6%

Surface condition: Cracking, self mulching, crusting

Microrelief: Frequently occurs
Type: Linear gilgai
Verticle interval: 0.1 to 0.15 m
Horizontal interval: 5 to 10 m



A11: Dark, brown or grey-brown (7.5YR 2/2, 3/1, 3/2, 3/3, 4/2, 4/3, 10YR 3/2, 3/3, 4/3); light clay to medium clay; strong <5 mm granular. Field pH 6.5 to 9.0. Clear change to -

B1: Dark or brown (7.5YR 3/1, 4/1, 4/3, 10YR 3/2, 4/3); light medium to medium clay; strong 2 to 10 mm subangular blocky. Field pH 7.0 to 9.0. Gradual to diffuse change to -

B21: Brown, dark, grey-brown or grey (7.5YR 3/1, 3/4, 4/1, 4/3, 4/4, 10YR 3/1, 3/2, 4/2, 4/3, 4/4); medium to heavy clay; strong <5 mm lenticular; frequently <10% manganiferous nodules <6 mm. Field pH 7.5 to 9.5. Diffuse change to -

B22: Brown or yellow-brown (7.5YR 4/6, 5/4, 5/6, 10YR 4/4, 4/6, 5/3, 5/4, 5/5); medium to heavy clay; strong <5 mm lenticular; frequently <10% manganiferous nodules and calcareous concretions <6 mm. Field pH 8.5 to 9.5. Diffuse change to -

B3/C: As above with rock fragments or rock. Field pH 8.5 to 9.5.

Soil type: Nail

Concept: Brown cracking clay on relict alluvial plains

Great soil group; Brown clay, red clay

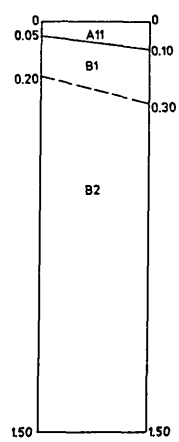
Principle profile form: Ug5.34, Ug5.38

Substrate material: Cainozoic alluvia

Landform: Alluvial plains, rises

Surface condition: Seasonally cracking, crusting

Microrelief: Nil



A11: Brown, dark or occasionally red-brown (5YR 3/2, 3/3, 7.5YR 3/2, 3/3, 3/4, 10YR 3/3); light clay to light medium clay; strong <5 mm granular. Field pH 6.5 to 8.0. Clear change to -

B1: Brown or red-brown (5YR 3/3, 4/3, 4/4, 7.5YR 3/3, 10YR 3/4); light to medium clay; strong 2 to 5 mm subangular blocky. Field pH 7.0 to 8.5. Diffuse change to -

B2: Brown or red-brown (5YR, 7.5YR, 10YR 4/4, 4/6); light medium clay to heavy clay; strong 2 to 10 mm lenticular or subangular blocky; frequently <10% manganiferous nodules and calcarious concretions <6 mm. Field pH 7.0 to 9.0.

Soil type: O'Bil Bil

Concept: Noncracking clay soil with cobble (0.06 to 0.2 m) on the surface developed on conglomerate

Great soil group: No suitable group, affinities with prairie soil

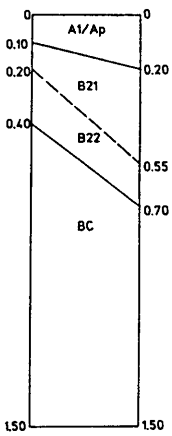
Principle profile form: Uf6.4, Uf6.31

Substrate material: Boulder conglomerate of the Triassic Cynthia Beds

Landform: Slopes of rises and low hills. Slopes 0 to 12%

Surface condition: Hardsetting

Microrelief: Nil



A1/Ap: Brown or dark (7.5YR 3/2, 3/3, 3/4, 4/3, 10YR 3/2, 3/3); light clay to light medium clay; moderate to strong 2 to 5 mm granular; 2 to 20% 0.06 to 0.2 m cobble. Field pH 6.0 to 7.5. Clear change to -

B21: Frequently mottled; brown or red-brown (5YR 3/4, 3/6, 4/4, 4/6, 7.5YR 4/3, 4/4, 10YR 3/3, 3/4, 4/3, 4/4); light medium clay to medium heavy clay; strong 2 to 10 mm subangular to angular blocky. Field pH 7.0 to 8.5. Gradual to diffuse change to -

B22: Frequently mottled; yellow-brown, brown or occasionally yellow (7.5YR 5/4, 5/6, 6/5, 10YR 4/6, 5/4, 5/6, 6/4); light medium clay to medium heavy clay; strong angular blocky occasionally lenticular. Field pH 7.5 to 9.0.

BC: Clay with rock fragments. Field pH 8.0 to 9.0.

Soil type: Pearlinga

Concept: Sandy surfaced texture contrast soil developed on alluvial fans

Great soil group: Solodic soil, solodized solonetz, soloth

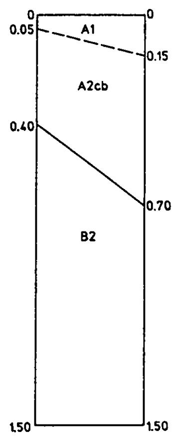
Principle profile form: Dy5.42, Dy5.43, Dy5.41, Dy3.42, Dy3.41

Substrate material: Sandstone of the Jurassic Evergreen Formation

Landform: Alluvial fans. Slopes 1 to 4%

Surface condition: Loose or hardsetting

Microrelief: Nil



A1: Grey-brown or dark (7.5YR 3/2, 4/2); loamy sand to light sandy clay loam; massive. Field pH 6.0 to 6.5. Gradual to clear change to -

A2cb: Grey-brown or brown (7.5YR 5/2, 5/3, 6/2, 6/3, 7/2, 7/3); loamy sand to light sandy clay loam; massive; conspicuously bleached. Field pH 5.5. to 7.5. Abrupt to sharp change to -

B2: Mottled; yellow-brown, grey, brown, grey-brown or occasionally yellow (7.5YR 5/2, 6/2, 6/3, 10YR 5/5, 6/2, 6/3, 6/4); sandy clay to medium clay; moderate to strong 10 to 50 mm angular blocky, prismatic or columnar; frequently <20% manganiferous nodules <20 mm. Field pH 5.5 to 8.5.

Soil type: Riverleigh

Concept: Texture contrast soil with a bleached A2 horizon over a dark or brown clay subsoil or terraces

Great soil group: Solodic soil

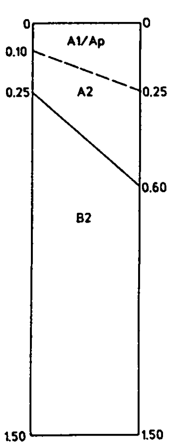
Principle profile form: Db1.32, Dy2.32, Dy2.42, Dd1.33, Db1.33

Substrate material: Quaternary alluvia

Landform: Back slope of terraces

Surface condition: Hardsetting

Microrelief: Nil



A1/Ap: Dark or brown (5YR 3/1, 3/2, 7.5YR 3/2, 3/3, 3/4, 4/3, 10YR 3/2, 3/3); clay loam fine sandy to silty clay loam; massive to moderate 2 to 10 mm granular. Field pH 6.0 to 7.5. Gradual to diffuse change to -

A2: Brown or grey-brown (7.5YR 4/2, 4/3, 4/4, 5/2, 5/3); clay loam fine sandy to silty clay loam; massive to weak 5 to 10 mm subangular blocky; sporadically to conspicuously bleached. Field pH 6.5 to 8.0. Clear to abrupt change to -

B2: Brown, grey-brown, dark or occasionally red-brown (5YR 4/4, 7.5YR 3/3, 4/2, 4/3, 4/4, 10YR 3/2, 3/3, 4/4); light medium to medium heavy clay; strong 5 to 20 mm angular blocky or prismatic; frequently <10% manganiferous nodules <6 mm. Field pH 7.0 to 8.5.

Soil type: Shurback

Concept: Texture contrast soil with clay loam surface and numerous nodules in lower A2 horizon developed on alluvial fans

Great soil group: Solodic soil

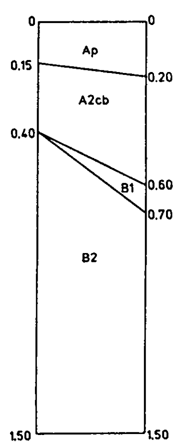
Principle profile form: Dy3.42, Gn3.06

Substrate material: Cainozoic alluvia

Landform: Alluvial fans. Slopes 0 to 3%

Surface condition: Hardsetting

Microrelief: Nil



Ap: Grey-brown (5YR, 7.5YR 4/2); clay loam; massive. Field pH 6.0 to 7.0. Clear change to -

A2cb: Brown or grey-brown (7.5YR 5/3, 6/2); clay loam; massive; 10 to 20% manganiferous nodules 6 to 20 mm; conspicuously bleached. Field pH 7.0 to 8.0. Clear change to -

B1: Frequently occurs; yellow-brown or brown (7.5YR 5/3, 10YR 5/4); light clay; moderate 2 to 5 mm subangular blocky; <20% manganiferous nodules 2 to 20 mm. Field pH 7.5 to 8.5. Clear to diffuse change to -

B2: Mottled; yellow or yellow-brown (10YR 5/4, 5/5, 6/4); medium to heavy clay; strong angular blocky or prismatic. Field pH 7.5 to 9.0.

Soil type: Toondoon

Concept: Texture contrast soil with clay loam surface over a dark grey-brown or brown clay subsoil developed on siltstones

Great soil group: Solodic soil

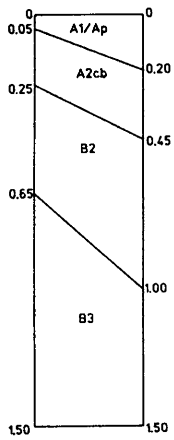
Principle profile form: Dy3.43, Dy3.42, Dy2.42, Db1.43

Substrate material: Siltstones of the Jurassic Evergreen Formation

Landform: Slopes of rises. Slopes 2 to 6%

Surface condition: Hardsetting

Microrelief: Nil



A1/Ap: Brown or dark (7.5YR 3/2, 3/3, 3/4, 10YR 2/3); clay loam; massive. Field pH 6.0 to 6.5. Clear change to -

A2cb: Brown or grey-brown (5YR 5/3, 7.5YR 4/2, 5/2, 5/3, 6/3); clay loam; massive; conspicuously bleached. Field pH 6.5 to 7.0. Abrupt change to -

B2: Frequently mottled; grey-brown or brown (7.5YR 4/2, 4/3, 10YR 4/3) frequently becoming paler at depth; medium to heavy clay; strong 5 to 20 mm angular blocky; <20% manganiferous nodules <6 mm. Field pH 6.5 to 8.5. Clear to gradual change to -

B3: Grey, yellow-brown or grey-brown (7.5YR 6/2, 10YR 6/2, 6/4); medium to heavy clay; moderate to strong 5 to 20 mm angular blocky; rock fragments. Field pH 8.0 to 8.5.

Soil type: Washpool

Concept: Texture contrast soil with fine gravelly loamy sand to sandy clay loam surface over clay developed on mudstone

Great soil group: Solodic soil

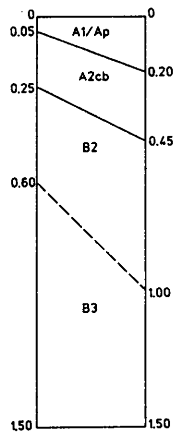
Principle profile form: Dy3.42, Dy3.43, Dy2.43

Substrate material: Cainozoic alluvia over siltstones and mudstones of the Carboniferous Caswell Creek Group

Landform: Slopes of low hills

Surface condition: Hardsetting

Microrelief: Nil



A1/Ap: Grey-brown or dark (7.5YR 3/2, 4/2); fine gravelly loamy sand to sandy clay loam; massive. Field pH 6.0 to 7.0. Clear change to -

A2cb: Yellow-brown, grey-brown or brown (7.5YR 5/2, 5/3, 6/3, 10YR 5/3); fine gravelly loamy sand to sandy clay loam; massive; conspicuously bleached. Field pH 6.0 to 7.0. Abrupt to sharp change to -

B2: Frequently mottled; yellow-brown or yellow (10YR 5/3, 5/4, 5/6, 6/4); light medium clay to heavy clay; strong 5 to 20 mm angular blocky; frequently <10% manganiferous nodules <6 mm. Field pH 7.0 to 9.0. Gradual change to -

B3: Yellow (10YR 5/6); gravelly light medium clay to medium heavy clay; moderate to strong angular blocky; rock fragments. Field pH 7.0 to 9.0.

Soil type: Wivenhoe

Concept: Yellow structured gradational soil developed on relict alluvia

Great soil group: No suitable group, affinities with solodic soil

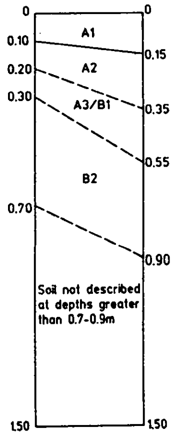
Principle profile form: Gn3.75, Gn3.82, Gn3.72p

Substrate material: Cainozoic alluvia

Landform: Alluvial fans and slopes of rises and low hills. Slopes 1 to 6%

Surface condition: Hardsetting

Microrelief: Nil



A1: Dark or grey-brown (5YR, 7.5YR 3/2, 4/2); loam fine sandy, sandy clay loam, clay loam, clay loam sandy; massive to moderate 2 to 5 mm granular. Field pH 6.0 to 7.5. Clear change to -

A2: Brown or red-brown (5YR 4/3, 7.5YR 4/3, 5/3, 5/4); loam fine sandy, sandy clay loam, clay loam, clay loam sandy; massive. Field pH 6.0 to 8.0. Gradual to diffuse change to -

A3/B1: Brown, yellow-brown or yellow (7.5YR 4/4, 5/4, 5/6, 10YR 5/4, 5/6, 6/4); clay loam, clay loam sandy to light clay, sandy clay; massive to weak 2 to 5 mm subangular blocky. Field pH 6.0 to 8.0. Gradual to diffuse change to -

B2: Mottled; yellow (10YR 5/6, 5/8, 6/5); light clay to medium clay; moderate to strong 2 to 5 mm subangular blocky; <10% manganiferous nodules <6 mm. Field pH 6.5 to 8.5.

APPENDIX IV

MORPHOLOGICAL AND ANALYTICAL DATA FOR REPRESENTATIVE SOIL PROFILES

SOIL TYPE: Beeron
SITE NO: S1
A.M.G. REFERENCE: 325 800 mE 7 161 800 mN ZONE 56

GREAT SOIL GROUP: Solodic soil
PRINCIPAL PROFILE FORM: Dy3.43
SOIL TAXONOMY UNIT: Typic Natrustalf
FAO UNESCO UNIT: Ochric Solonetz

SUBSTRATE MATERIAL:
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:

SLOPE: 4 %
LANDFORM ELEMENT TYPE: Simple slope
LANDFORM PATTERN TYPE: Undulating rises

VEGETATION
STRUCTURAL FORM:
DOMINANT SPECIES

ANNUAL RAINFALL:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Hard setting

HORIZON	DEPTH	DESCRIPTION
A1	0 to .07 m	Greyish brown (7.5YR4/2); clay loam; massive; moist; moderately firm; few medium ferromanganiferous nodules. Clear to-
A2cb	.07 to .21 m	Light brownish grey (7.5YR7/2), dry conspicuously bleached; clay loam; massive; moderately moist; moderately firm; common medium ferromanganiferous nodules. Sharp to-
B21	.21 to .30 m	Dull yellowish brown (10YR5/4); common fine distinct brown mottles; heavy clay; strong 5-10mm angular blocky; moist; very firm; common medium ferromanganiferous nodules. Clear to-
B22	.30 to .45 m	Dull yellowish brown (10YR5/4); common fine distinct brown mottles; heavy clay; strong 5-10mm lenticular; moist; very firm; common medium ferromanganiferous nodules. Diffuse to-
B23	.45 to .75 m	Dull yellowish brown (10YR5/4); heavy clay; strong 10-20mm lenticular; moist; moderately strong; few medium ferromanganiferous nodules. Clear to-
B3	.75 to .83 m	Bright yellowish brown (10YR6/6); medium clay; many medium pebbles, angular mudstone; moderate 5-10mm angular blocky; moist; very firm.

Depth	1:5 Soil/Water			Particle Size				Exch. Cations					Total Elements			Moistures			Disp.Ratio		Exch	Exch	ECEC	pH
	pH	EC	Cl	CS	FS	S	C	CEC	Ca	Mg	Na	K	P	K	S	ADM	33*	1500*	R1	R2	Al	Acid		CaCl2
metres		dS/m	%	%				m.eq/100g					%			%					m.eq/100g			
	@ 40C		@105C	@ 105C				@ 105C					@ 80C			@ 105C			@ 40C		@ 105C			@ 40C
0.10	6.0	.03	.001	40	20	21	21	17	3.7	3.6	.13	.54	.051	.732	.029	1.3		9	.67					
0.20	6.7	.02	.001													1.0								
0.30	7.7	.13	.015	13	11	12	63	28	3.6	16	3.7	.21	.016	.930	.012	2.7		21	.80					
0.60	8.9	.75	.076	9	14	15	60	28	4.1	17	7.2	.18	.012	.894	.015	2.7		19	.92					
0.85	9.2	.73	.071	24	14	17	45	23	3.8	14	6.8	.15	.009	1.54	.014	2.4		15	.74					

Depth	Org.C	Tot.N	Extr. P		HCl	CaCl2 Extr		DTPA-extr.					Extractable			P		Alternative Cations				
	(W&B)		Acid	Bicarb.	K	K	P	Fe	Mn	Cu	Zn	B	SO4S	NO3N	NH4N	Buff Cap	Equil	CEC	Ca	Mg	Na	K
metres	%	%	mg/kg		meq%	mg/kg		mg/kg					mg/kg				ug/L	m.eq/100g				
	@ 105C	@ 105C	@ 105C		@105C	@ 105C		@ 105C					@ 105C			@ 40C		@ 105C				
0.10	1.7	.14	7	5	.51			66	56	1.2	1.2											

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: Leach pH 8.5 Alc. M NH4Cl (pre-wash)
CEC methods: Alc. M NH4Cl; Ca/KNO3 displacement
Alternative cation method:
Alternative CEC method:
ECEC METHOD:

SOIL TYPE: Auburn
SITE NO: S2
A.M.G. REFERENCE: 322 500 mE 7 158 100 mN ZONE 56

GREAT SOIL GROUP: Solodic soil
PRINCIPAL PROFILE FORM: Dy2.43
SOIL TAXONOMY UNIT: Typic Natrustalf
FAO UNESCO UNIT: Ochric Solonetz

SUBSTRATE MATERIAL:
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:

SLOPE: 0 %
LANDFORM ELEMENT TYPE: Plain
LANDFORM PATTERN TYPE: Level plain

VEGETATION
STRUCTURAL FORM:
DOMINANT SPECIES

ANNUAL RAINFALL:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Hard setting

HORIZON	DEPTH	DESCRIPTION
A1	0 to .08 m	Greyish brown (7.5YR4/2); clay loam; massive; moderately moist; moderately firm. Clear to-
A2cb	.08 to .20 m	Dull brown (7.5YR6/3), dry conspicuously bleached; clay loam; massive; moderately moist; moderately firm; very few medium manganiferous nodules. Sharp to-
B21	.20 to .35 m	Dull brown (7.5YR5/3); common fine distinct yellow mottles; medium clay; strong 5-10mm angular blocky; moderately moist; very firm; very few medium manganiferous nodules. Gradual to-
B22	.35 to .80 m	Dull yellowish brown (10YR5/3); medium heavy clay; strong 5-10mm lenticular; moderately moist; moderately strong; very few medium manganiferous nodules. Diffuse to-
B23	.80 to 1.30 m	Dull yellowish orange (10YR6/3); heavy clay; strong 10-20mm lenticular; moderately moist; moderately strong; few medium carbonate nodules. Diffuse to-
B24	1.30 to 1.60 m	Dull yellowish orange (10YR6/3); common fine faint brown mottles; heavy clay; strong 5-10mm angular blocky; moderately moist; moderately strong; common coarse carbonate nodules.

Depth	1:5 Soil/Water			Particle Size				Exch. Cations					Total Elements			Moistures			Disp.Ratio		Exch	Exch	ECEC	pH
	pH	EC	Cl	CS	FS	S	C	CEC	Ca	Mg	Na	K	P	K	S	ADM	33*	1500*	R1	R2	Al	Acid		CaCl2
metres		dS/m	%	%				m.eq/100g					%			%					m.eq/100g			
	@ 40C		@105C	@ 105C				@ 105C					@ 80C			@ 105C			@ 40C		@ 105C			@ 40C
0.10	6.5	.03	.002	20	26	27	28	13	5.4	2.1	.12	.58	.033	.447	.021	1.2		8	.61					
0.30	7.7	.12	.014	14	16	19	50	16	5.7	6.6	1.4	.39	.017	.543	.012	1.7		14	.79					
0.60	8.4	.47	.069	8	12	20	59	19	6.2	9.8	3.0	.37	.015	.590	.016	2.0		15	.86					
0.90	8.8	.77	.108	15	11	18	58	18	5.4	9.8	4.1	.38	.014	.626	.016	1.6		16	.95					
1.20	8.8	.85	.100	7	13	19	59	19	5.3	9.9	4.6	.38	.014	.670	.016	1.8								
1.50	8.7	.90	.111																					

Depth	Org.C	Tot.N	Extr. P		HCl	CaCl2 Extr		DTPA-extr.					Extractable			P		Alternative Cations				
	(W&B)		Acid	Bicarb.	K	K	P	Fe	Mn	Cu	Zn	B	SO4S	NO3N	NH4N	Buff Cap	Equil	CEC	Ca	Mg	Na	K
metres	%	%	mg/kg		meq%	mg/kg		mg/kg					mg/kg				ug/L	m.eq/100g				
	@ 105C	@ 105C	@ 105C		@105C	@ 105C		@ 105C					@ 105C			@ 40C		@ 105C				
0.10	1.7	.12	7	4	.53			50	63	1.0	0.8											

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: Leach pH 8.5 Alc. M NH4Cl (pre-wash)
CEC methods: Alc. M NH4Cl; Ca/KNO3 displacement
Alternative cation method:
Alternative CEC method:
ECEC METHOD:

SOIL TYPE: Boynewood
SITE NO: S3
A.M.G. REFERENCE: 324 550 mE 7 163 300 mN ZONE 56

GREAT SOIL GROUP: Prairie soil
PRINCIPAL PROFILE FORM: Uf6.31
SOIL TAXONOMY UNIT: Haplustalf
FAO UNESCO UNIT: Brunic Luvisol

SUBSTRATE MATERIAL: Mudstone
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:

SLOPE: 4.5 %
LANDFORM ELEMENT TYPE: Hillslope
LANDFORM PATTERN TYPE: Low hills

VEGETATION
STRUCTURAL FORM:
DOMINANT SPECIES: Eucalyptus melanophloia

ANNUAL RAINFALL:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Hard setting, periodic cracking

HORIZON	DEPTH	DESCRIPTION
A1	0 to .10 m	Dark brown (7.5YR3/3); light medium clay; strong 2-5mm granular parting to moderate 2-5mm subangular blocky; moist;. Gradual to-
B21	.10 to .30 m	Dark brown (7.5YR3/4); light medium clay; strong 5-10mm subangular blocky; moderately moist;; very few fine ferruginous concretions, very few fine manganiferous concretions. Gradual to-
B22	.30 to .60 m	Reddish brown (2.5YR4/6); medium heavy clay; very few small pebbles, subrounded mudstone; strong 5-10mm angular blocky parting to moderate 10-20mm lenticular; moderately moist;; very few fine ferruginous concretions, very few fine manganiferous concretions. Gradual to-
B23	.60 to .72 m	Reddish brown (5YR4/6); medium heavy clay; few medium pebbles, subrounded mudstone; strong 10-20mm lenticular; dry;; very few fine ferruginous concretions, very few fine manganiferous concretions. Clear to-
BC	.72 to .78 m	Reddish brown (5YR4/6); many medium pebbles, angular mudstone; dry;.

Depth	1:5 Soil/Water			Particle Size				Exch. Cations					Total Elements			Moistures			Disp.Ratio		Exch	Exch	ECEC	pH
	pH	EC	Cl	CS	FS	S	C	CEC	Ca	Mg	Na	K	P	K	S	ADM	33*	1500*	R1	R2	Al	Acid		CaCl2
metres		dS/m	%	%				m.eq/100g					%			%					m.eq/100g			
	@ 40C		@105C	@ 105C				@ 105C					@ 80C			@ 105C			@ 40C		@ 105C			@ 40C
B 0.10	6.9	.05	.001																					
0.10	7.2	.06	.001	18	30	20	32	24	16	2.8	.12	.96	.042	.613	.033	2.3		15	.34					
0.30	7.2	.03	.001	14	26	17	45	21	14	2.5	.14	.41	.024	.553	.018	2.0		16	.40					
0.60	7.9	.04	.001	6	12	11	73	29	23	3.7	.41	.24	.012	.480	.012	3.3		25	.34					
0.80	8.1	.05	.001	19	16	11	54	25	23	3.9	.48	.15	.014	.433	.009	2.3		19	.48					

Depth	Org.C	Tot.N	Extr. P		HCl	CaCl2 Extr		DTPA-extr.					Extractable			P		Alternative Cations				
	(W&B)		Acid	Bicarb.	K	K	P	Fe	Mn	Cu	Zn	B	SO4S	NO3N	NH4N	Buff Cap	Equil	CEC	Ca	Mg	Na	K
metres	%	%	mg/kg		meq%	mg/kg		mg/kg					mg/kg				ug/L	m.eq/100g				
	@ 105C	@ 105C	@ 105C		@105C	@ 105C		@ 105C					@ 105C			@ 40C		@ 105C				
B 0.10	1.9	.17	8	8	.93			37	62	1.4	1.2											

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: Leach pH 8.5 Alc. M NH4Cl (pre-wash)
CEC methods: Alc. M NH4Cl; Ca/KNO3 displacement
Alternative cation method:
Alternative CEC method:
ECEC METHOD:

SOIL TYPE: Derra
SITE NO: S4A
A.M.G. REFERENCE: 318 800 mE 7 158 500 mN ZONE 56

GREAT SOIL GROUP: Grey clay
PRINCIPAL PROFILE FORM: Ug5.24
SOIL TAXONOMY UNIT: Typic Chromustert
FAO UNESCO UNIT: Chromovertisol

TYPE OF MICRORELIEF: Normal gilgai
VERTICAL INTERVAL: .80 m
HORIZONTAL INTERVAL: 15 m
COMPONENT OF MICRORELIEF SAMPLED: Mound

SUBSTRATE MATERIAL:
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:

SLOPE: 5 %
LANDFORM ELEMENT TYPE: Plain
LANDFORM PATTERN TYPE: Stagnant alluvial plain

VEGETATION
STRUCTURAL FORM:
DOMINANT SPECIES: Acacia harpophylla

ANNUAL RAINFALL:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Periodic cracking, surface crust

HORIZON	DEPTH	DESCRIPTION
A1	0 to .05 m	Dark brown (10YR3/4) moist; light clay; strong 2-5mm subangular blocky; moist; moderately firm; few medium carbonate concretions.
B21k	.05 to .70 m	Dull yellowish brown (10YR5/4) moist; medium heavy clay; strong 10-20mm lenticular; moderately moist; moderately strong; common medium carbonate concretions, few medium manganiferous concretions.
B22	.70 to 1.63 m	Dull yellowish orange (10YR6/4) moist; medium heavy clay; strong 10-20mm lenticular; moderately moist; very strong; very few fine manganiferous concretions, very few fine ferruginous concretions.

Depth	1:5 Soil/Water			Particle Size				Exch. Cations					Total Elements			Moistures			Disp.Ratio		Exch	Exch	ECEC	pH
	pH	EC	Cl	CS	FS	S	C	CEC	Ca	Mg	Na	K	P	K	S	ADM	33*	1500*	R1	R2	Al	Acid		CaCl2
metres		dS/m	%	%				m.eq/100g					%			%					m.eq/100g			
	@ 40C		@105C	@ 105C				@ 105C					@ 80C			@ 105C			@ 40C		@ 105C			@ 40C
B 0.10	8.1	.14	.001																					
0.10	8.6	.14	.001	14	22	14	50	26	18	8.0	.73	.61	.031	.547	.030	2.4		15	.47					
0.30	9.0	.38	.020	14	21	15	52	25	11	11	3.4	.22	.018	.523	.024	2.5		16	.77					
0.60	8.8	1.0	.106	12	22	17	53	26	8.0	13	5.8	.26	.017	.544	.041	2.5		16	.84					
0.90	8.7	1.1	.119	11	21	15	54	25	6.5	13	7.0	.27	.014	.551	.041	2.4		16	.94					
1.20	8.6	1.1	.118	13	22	17	49	24	5.3	12	6.9	.28	.013	.554	.037	2.5								
1.50	8.6	1.0	.116																					

Depth	Org.C	Tot.N	Extr. P		HCl	CaCl2 Extr		DTPA-extr.					Extractable			P		Alternative Cations				
	(W&B)		Acid	Bicarb.	K	K	P	Fe	Mn	Cu	Zn	B	SO4S	NO3N	NH4N	Buff	Equil	CEC	Ca	Mg	Na	K
metres	%	%	mg/kg		meq%	mg/kg		mg/kg					mg/kg			Cap	ug/L	m.eq/100g				
	@ 105C	@ 105C	@ 105C		@105C	@ 105C		@ 105C					@ 105C			@ 40C		@ 105C				
B 0.10	1.5	.18	20	10	.98			17	13	1.1	0.6											

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: Leach pH 8.5 Alc. M NH4Cl (pre-wash)
CEC methods: Alc. M NH4Cl; Ca/KNO3 displacement
Alternative cation method:
Alternative CEC method:
ECEC METHOD:

SOIL TYPE: Derra
SITE NO: S4B
A.M.G. REFERENCE: 323 080 mE 7 161 800 mN ZONE 56

GREAT SOIL GROUP: Grey clay
PRINCIPAL PROFILE FORM: Ug5.25
SOIL TAXONOMY UNIT: Typic Chromustert
FAO UNESCO UNIT: Chromovertisol

TYPE OF MICRORELIEF: Normal gilgai
VERTICAL INTERVAL: .80 m
HORIZONTAL INTERVAL: 15 m
COMPONENT OF MICRORELIEF SAMPLED: Depression

SUBSTRATE MATERIAL:
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:

SLOPE:
LANDFORM ELEMENT TYPE: Plain
LANDFORM PATTERN TYPE: Stagnant alluvial plain

VEGETATION
STRUCTURAL FORM:
DOMINANT SPECIES

ANNUAL RAINFALL:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY:

HORIZON	DEPTH	DESCRIPTION
A1	0 to .15 m	Brownish black (10YR2/2) moist; medium clay; strong subangular blocky; moist; moderately firm.
B21	.15 to .50 m	Greyish yellow-brown (10YR5/2); common medium distinct brown mottles; medium heavy clay; strong angular blocky; moist; very firm; few medium manganiferous concretions.
B22k	.50 to .85 m	Dull yellowish brown (10YR4/3); few medium faint yellow mottles; heavy clay; strong lenticular; moderately moist; very strong; common medium carbonate concretions, few medium manganiferous concretions.
B23	.85 to 1.60 m	Brown (10YR4/4); few medium faint dark mottles, few medium faint yellow mottles; heavy clay; strong lenticular; moderately moist; very strong; few medium carbonate concretions, few medium manganiferous concretions, few medium ferruginous concretions.

Depth metres	1:5 Soil/Water pH @ 40C	EC dS/m @ 40C	Cl % @105C	Particle Size % @ 105C CS	FS	S	C	Exch. Cations m.eq/100g @ 105C CEC	Ca	Mg	Na	K	Total Elements % @ 80C P	K	S	Moistures % @ 105C ADM	33*	1500*	Disp.Ratio @ 40C R1	R2	Exch Al m.eq/100g @ 105C	Exch Acid	ECEC	pH CaCl2 @ 40C
B 0.10	7.4	.17	.001																					
0.10	7.4	.21	.001	12	17	20	51	36	26	4.1	.36	.54	.073	.572	.045	3.0		20	.37					
0.30	8.5	.12	.001	19	22	14	48	27	22	3.9	.79	.28	.030	.481	.013	2.7		16	.56					
0.60	9.0	.21	.001	20	20	12	48	26	15	7.3	2.7	.21	.019	.466	.014	2.7		17	.83					
0.90	9.2	.39	.025	21	23	13	44	22	9.5	7.9	4.4	.17	.019	.486	.022	2.4		16	.91					
1.20	9.0	.68	.060	20	23	13	45	22	8.2	8.5	5.6	.19	.018	.511	.023	2.4								
1.50	9.0	.84	.077																					

Depth metres	Org.C (W&B) % @ 105C	Tot.N % @ 105C	Extr. P mg/kg @ 105C Acid	Bicarb.	HCl K meq% @105C	CaCl2 Extr mg/kg @ 105C K	P	DTPA-extr. mg/kg @ 105C Fe	Mn	Cu	Zn	B	Extractable mg/kg @ 105C SO4S	NO3N	NH4N	P Buff Cap @ 40C	P Equil ug/L	Alternative Cations m.eq/100g @ 105C CEC	Ca	Mg	Na	K
B 0.10	2.4	.25	32	42	1.8			127	28	2.7	1.9											

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: Leach pH 8.5 Alc. M NH4Cl (pre-wash)
CEC methods: Alc. M NH4Cl; Ca/KNO3 displacement
Alternative cation method:
Alternative CEC method:
ECEC METHOD:

SOIL TYPE: Durong
SITE NO: S5
A.M.G. REFERENCE: 323 080 mE 7 161 800 mN ZONE 56

GREAT SOIL GROUP: Grey clay
PRINCIPAL PROFILE FORM: Ug5.24
SOIL TAXONOMY UNIT: Typic Chromustert
FAO UNESCO UNIT: Chromo Vertisol

SUBSTRATE MATERIAL:
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:

SLOPE: 1.5 %
LANDFORM ELEMENT TYPE: Plain
LANDFORM PATTERN TYPE: Stagnant alluvial plain

VEGETATION
STRUCTURAL FORM:
DOMINANT SPECIES: Eucalyptus populnea

ANNUAL RAINFALL:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Periodic cracking, surface crust

HORIZON	DEPTH	DESCRIPTION
A1	0 to .02 m	Brownish black (10YR3/2); medium clay; strong subangular blocky; moderately moist; very firm.
B21	.02 to .30 m	Yellowish grey (2.5Y4/1); medium heavy clay; strong angular blocky; moderately moist; very strong.
B22k	.30 to 1.10 m	Yellowish grey (2.5Y4/1); heavy clay; strong lenticular; moderately moist; very strong; few medium carbonate concretions.
B23	1.10 to 1.53 m	Dark greyish yellow (2.5Y5/2); heavy clay; strong lenticular; moderately moist; very strong; very few fine carbonate concretions.

Depth	1:5 Soil/Water			Particle Size				Exch. Cations					Total Elements			Moistures			Disp.Ratio		Exch	Exch	ECEC	pH
	pH	EC	Cl	CS	FS	S	C	CEC	Ca	Mg	Na	K	P	K	S	ADM	33*	1500*	R1	R2	Al	Acid		CaCl2
metres		dS/m	%	%				m.eq/100g					%			%					m.eq/100g			
	@ 40C		@105C	@ 105C				@ 105C					@ 80C			@ 105C			@ 40C		@ 105C			@ 40C
B 0.10	7.6	.14	.003																					
0.10	7.4	.09	.002	16	14	16	52	37	20	11	.64	.95	.023	.578	.029	3.3		21	.54					
0.30	8.5	.11	.007	13	16	18	54	36	21	13	2.2	.33	.012	.511	.016	3.8		22	.66					
0.60	8.7	.66	.076	14	17	20	52	34	17	14	3.8	.23	.008	.506	.017	3.5		19	.71					
0.90	8.6	.87	.105	9	14	21	58	37	17	17	5.1	.30	.007	.500	.020	4.1		21	.75					
1.20	8.5	.85	.105	8	13	18	62	39	17	18	5.5	.34	.008	.599	.017	4.3								
1.50	8.6	.84	.104																					

Depth	Org.C	Tot.N	Extr. P		HCl	CaCl2 Extr		DTPA-extr.					Extractable			P		Alternative Cations				
	(W&B)		Acid	Bicarb.	K	K	P	Fe	Mn	Cu	Zn	B	SO4S	NO3N	NH4N	Buff Cap	Equil	CEC	Ca	Mg	Na	K
metres	%	%	mg/kg		meq%	mg/kg		mg/kg					mg/kg				ug/L	m.eq/100g				
	@ 105C	@ 105C	@ 105C		@105C	@ 105C		@ 105C					@ 105C			@ 40C		@ 105C				
B 0.10	1.9	.17	8	5	1.2			22	22	1.5	0.5											

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: Leach pH 8.5 Alc. M NH4Cl (pre-wash)
CEC methods: Alc. M NH4Cl; Ca/KNO3 displacement
Alternative cation method:
Alternative CEC method:
ECEC METHOD:

SOIL TYPE: Burnett
SITE NO: S6
A.M.G. REFERENCE: 317 100 mE 7 165 700 mN ZONE 56

GREAT SOIL GROUP: Alluvial soil
PRINCIPAL PROFILE FORM: Um6.42
SOIL TAXONOMY UNIT: Ustifluvent
FAO UNESCO UNIT: Eutric Fluvisol

SUBSTRATE MATERIAL:
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:

SLOPE: 0 %
LANDFORM ELEMENT TYPE: Plain
LANDFORM PATTERN TYPE: Level plain

VEGETATION
STRUCTURAL FORM: Tall woodland
DOMINANT SPECIES: Eucalyptus crebra

ANNUAL RAINFALL:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Soft

HORIZON	DEPTH	DESCRIPTION
A1	0 to .25 m	Brown (7.5YR4/3); loam, fine sandy; weak 5-10mm granular; moderately moist; moderately weak. Gradual to-
A3	.25 to .85 m	Brown (7.5YR4/3); loam, fine sandy; massive; moderately moist; moderately firm. Gradual to-
C	.85 to .95 m	Dull brown (7.5YR5/4); fine sandy loam; massive; moderately moist; moderately firm. Clear to-
D	.95 to 1.30 m	Dull brown (7.5YR5/4); loam, fine sandy; moderate 5-10mm subangular blocky; moderately moist; moderately firm. Diffuse to-
D	1.30 to 1.50 m	Dull brown (7.5YR5/4); fine sandy loam; massive; moderately moist; moderately firm.

Depth	1:5 Soil/Water			Particle Size				Exch. Cations					Total Elements			Moistures			Disp.Ratio		Exch	Exch	ECEC	pH
	pH	EC	Cl	CS	FS	S	C	CEC	Ca	Mg	Na	K	P	K	S	ADM	33*	1500*	R1	R2	Al	Acid		CaCl2
metres		dS/m	%	%				m.eq/100g					%			%					m.eq/100g			
	@ 40C		@105C	@ 105C				@ 105C					@ 80C			@ 105C			@ 40C		@ 105C			@ 40C
0.10	6.4	.16	.008	31	53	8	8	10	4.7	1.5	.05	.88	.078	1.45	.027	0.6		5	.41					
0.30	7.1	.04	.002	27	54	8	10	9	4.9	1.7	.05	.67	.069	1.45	.015	0.6		5	.52					
0.60	7.5	.02	.001	19	62	8	10	8	4.3	2.5	.05	.32	.061	1.41	.011	0.6		5	.62					
0.90	7.5	.02	.001	25	60	5	7	7	3.3	2.3	.11	.18	.058	1.37	.009	0.5		4	.83					
1.20	7.3	.02	.001	16	59	7	14	10	5.0	3.5	.22	.20	.063	1.32	.009	0.8								
1.50	7.4	.02	.001													0.6								

Depth	Org.C	Tot.N	Extr. P		HCl	CaCl2 Extr		DTPA-extr.					Extractable			P		Alternative Cations				
	(W&B)		Acid	Bicarb.	K	K	P	Fe	Mn	Cu	Zn	B	SO4S	NO3N	NH4N	Buff Cap	Equil	CEC	Ca	Mg	Na	K
metres	%	%	mg/kg		meq%	mg/kg		mg/kg					mg/kg				ug/L	m.eq/100g				
	@ 105C	@ 105C	@ 105C		@105C	@ 105C		@ 105C					@ 105C			@ 40C		@ 105C				
0.10	0.8	.08	254	43	1.0			28	16	0.5	1.3											

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: Leach pH 8.5 Alc. M NH4Cl (pre-wash)
CEC methods: Alc. M NH4Cl; Ca/KNO3 displacement
Alternative cation method:
Alternative CEC method:
ECEC METHOD:

SOIL TYPE: Boyne
SITE NO: S7
A.M.G. REFERENCE: 317 200 mE 7 160 850 mN ZONE 56

GREAT SOIL GROUP: Red brown earth
PRINCIPAL PROFILE FORM: Dr2.22
SOIL TAXONOMY UNIT: Typic Paleustalf
FAO UNESCO UNIT: Chromic Luvisol

SUBSTRATE MATERIAL:
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:

SLOPE: 1 %
LANDFORM ELEMENT TYPE: Levee
LANDFORM PATTERN TYPE: Alluvial plain

VEGETATION
STRUCTURAL FORM:
DOMINANT SPECIES: Eucalyptus melanophloia

ANNUAL RAINFALL:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Hard setting

HORIZON	DEPTH	DESCRIPTION
A1	0 to .25 m	Dark reddish brown (5YR3/4); sandy clay loam,fine sandy; massive; moderately moist; very firm.
A2	.25 to .48 m	Dark reddish brown (2.5YR3/4); sandy clay loam,fine sandy; massive; dry; moderately strong.
B21	.48 to 1.00 m	Dark reddish brown (2.5YR3/6); fine sandy medium clay; strong angular blocky parting to strong prismatic; dry; very strong; very few fine manganiferous concretions.
B22	1.00 to 1.60 m	Reddish brown (2.5YR4/6); fine sandy medium heavy clay; strong angular blocky parting to strong prismatic; dry; very strong; very few fine manganiferous concretions.

Depth	1:5 Soil/Water			Particle Size				Exch. Cations					Total Elements			Moistures			Disp.Ratio		Exch	Exch	ECEC	pH
	pH	EC	Cl	CS	FS	S	C	CEC	Ca	Mg	Na	K	P	K	S	ADM	33*	1500*	R1	R2	Al	Acid		CaCl2
metres		dS/m	%	%				m.eq/100g					%			%					m.eq/100g			
	@ 40C		@105C	@ 105C				@ 105C					@ 80C			@ 105C			@ 40C		@ 105C			@ 40C
B 0.10	7.2	.04	.001																					
0.10	7.2	.04	.001	16	61	10	12	7	4.3	1.5	.08	.54	.030	.875	.018	0.5		5	.57					
0.30	7.5	.02	.001	16	61	11	13	5	2.2	1.1	.05	.44	.021	.905	.010	0.4		5	.57					
0.60	7.3	.03	.002	11	47	8	33	9	3.5	2.4	.07	.41	.023	.844	.012	1.0		11	.55					
0.90	7.3	.04	.002	10	35	7	47	12	4.9	4.0	.14	.31	.022	.747	.010	1.4		15	.51					
1.20	7.5	.04	.002	13	39	6	38	12	4.7	4.4	.21	.26	.022	.861	.008	1.4								
1.50	7.5	.04	.004													1.3								

Depth	Org.C	Tot.N	Extr. P		HCl	CaCl2 Extr		DTPA-extr.					Extractable			P		Alternative Cations				
	(W&B)		Acid	Bicarb.	K	K	P	Fe	Mn	Cu	Zn	B	SO4S	NO3N	NH4N	Buff Cap	Equil	CEC	Ca	Mg	Na	K
metres	%	%	mg/kg		meq%	mg/kg		mg/kg					mg/kg				ug/L	m.eq/100g				
	@ 105C	@ 105C	@ 105C		@105C	@ 105C		@ 105C					@ 105C			@ 40C		@ 105C				
B 0.10	1.1	.08	18	9	.45			7	28	0.6	0.4											

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: Leach pH 8.5 Alc. M NH4Cl (pre-wash)
CEC methods: Alc. M NH4Cl; Ca/KNO3 displacement
Alternative cation method:
Alternative CEC method:
ECEC METHOD:

SOIL TYPE: Flagstone
SITE NO: S8
A.M.G. REFERENCE: 318 200 mE 7 166 080 mN ZONE 56

GREAT SOIL GROUP: Prairie soil
PRINCIPAL PROFILE FORM: Dd1.12
SOIL TAXONOMY UNIT: Typic Haplustalf
FAO UNESCO UNIT: Brunic Luvisol

SUBSTRATE MATERIAL:
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:

SLOPE: 2 %
LANDFORM ELEMENT TYPE: Drainage depression
LANDFORM PATTERN TYPE: Alluvial plain

VEGETATION
STRUCTURAL FORM:
DOMINANT SPECIES: Eucalyptus tereticornis, Eucalyptus tessellaris

ANNUAL RAINFALL:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Hard setting

HORIZON	DEPTH	DESCRIPTION
A11	0 to .10 m	Brownish black (10YR3/2); clay loam,fine sandy; massive.
A12	.10 to .23 m	Dark brown (10YR3/3); clay loam,fine sandy; massive; very few medium ferruginous concretions.
B21	.23 to 1.00 m	Brownish black (10YR2/2); light medium clay; strong angular blocky.
B22	1.00 to 1.45 m	Brownish black (10YR3/2); light medium clay; moderate angular blocky.
D	1.45 to 1.77 m	Dark brown (7.5YR3/3); sandy clay loam; massive.

Depth	1:5 Soil/Water			Particle Size				Exch. Cations					Total Elements			Moistures			Disp.Ratio		Exch	Exch	ECEC	pH
	pH	EC	Cl	CS	FS	S	C	CEC	Ca	Mg	Na	K	P	K	S	ADM	33*	1500*	R1	R2	Al	Acid		CaCl2
metres		dS/m	%	%				m.eq/100g					%			%					m.eq/100g			
	@ 40C		@105C	@ 105C				@ 105C					@ 80C			@ 105C			@ 40C		@ 105C			@ 40C
B 0.10	6.1	.10	.002																					
0.10	6.0	.11	.003	4	53	19	24	25	12	5.1	.11	1.4	.120	1.46	.048	1.6		25	.43					
0.30	7.4	.07	.003	1	39	31	32	30	21	8.4	.31	.63	.099	1.28	.030	1.5		17	.50					
0.60	7.4	.05	.001	.9	31	34	38	32	19	8.4	.30	.58	.101	1.28	.022	2.1		18	.48					
0.90	7.2	.05	.001	2	37	30	35	32	19	8.8	.34	.54	.114	1.24	.021	2.1		17	.49					
1.20	7.3	.04	.001	.9	48	24	33	25	15	7.1	.26	.37	.084	1.27	.021	2.1								
1.50	7.5	.03	.001													1.9								

Depth	Org.C	Tot.N	Extr. P		HCl	CaCl2 Extr		DTPA-extr.					Extractable			P		Alternative Cations				
	(W&B)		Acid	Bicarb.	K	K	P	Fe	Mn	Cu	Zn	B	SO4S	NO3N	NH4N	Buff Cap	Equil	CEC	Ca	Mg	Na	K
metres	%	%	mg/kg		meq%	mg/kg		mg/kg					mg/kg				ug/L	m.eq/100g				
	@ 105C	@ 105C	@ 105C		@105C	@ 105C		@ 105C					@ 105C			@ 40C		@ 105C				
B 0.10	3.8	.27	395	73	1.5			128	49	1.9	11											

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: Leach pH 8.5 Alc. M NH4Cl (pre-wash)
Alternative cation method:
ECEC METHOD:
CEC methods: Alc. M NH4Cl; Ca/KNO3 displacement
Alternative CEC method:

SOIL TYPE: Wivenhoe
SITE NO: S9
A.M.G. REFERENCE: 327 200 mE 7 163 180 mN ZONE 56

GREAT SOIL GROUP: Yellow podzolic soil
PRINCIPAL PROFILE FORM: Dy5.41
SOIL TAXONOMY UNIT: Typic Natrustalf
FAO UNESCO UNIT: Chromic Solonetz

SUBSTRATE MATERIAL:
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:

SLOPE: 0.5 %
LANDFORM ELEMENT TYPE: Pediment
LANDFORM PATTERN TYPE: Stagnant alluvial plain

VEGETATION
STRUCTURAL FORM:
DOMINANT SPECIES: Eucalyptus crebra

ANNUAL RAINFALL:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Loose

HORIZON	DEPTH	DESCRIPTION
A1	0 to .18 m	Dark brown (10YR3/3) moist; light sandy clay loam; massive; moderately moist; moderately firm.
A21cb	.18 to .42 m	Light grey (10YR8/1) dry; sandy clay loam; massive; dry; moderately firm.
A22sb	.42 to .50 m	Dull brown (7.5YR5/3) moist, dry sporadically bleached; light sandy clay loam; dry; very firm; continuous moderately cemented densipan; few fine manganiferous nodules.
B21	.50 to 1.20 m	Dull yellowish orange (10YR6/4) moist; common medium faint grey mottles; light medium clay; strong polyhedral parting to moderate subangular blocky; dry; very firm; very few fine manganiferous concretions.
D	1.20 to 1.70 m	Dull yellowish orange (10YR6/4) moist; common medium distinct grey mottles; medium clay; moderate angular blocky; dry; very strong; very few fine manganiferous soft segregations.

Depth metres	1:5 Soil/Water pH @ 40C	EC dS/m @ 40C	Cl % @105C	Particle Size CS % @ 105C	FS	S	C	Exch. Cations CEC m.eq/100g @ 105C	Ca	Mg	Na	K	Total Elements P % @ 80C	K	S	Moistures ADM % @ 105C	33*	1500*	Disp.Ratio R1 @ 40C	R2	Exch Al m.eq/100g @ 105C	Exch Acid	ECEC	pH CaCl2 @ 40C
B 0.10	5.9	.03	.001																					
0.10	5.9	.02	.001	46	34	10	9	7	1.4	1.1	.05	.23	.023	.086	.018	0.5		3	.71					
0.30	5.6	.01	.001	46	36	13	8	4	0.1	0.2	.05	.12	.012	.066	.009	0.1		2	.77					
0.60	7.7	.22	.037	22	19	9	49	12	1.0	7.0	1.8	.09	.015	.190	.010	1.0		15	.78					
0.90	7.9	.31	.054	23	18	8	51	12	0.6	7.0	2.4	.09	.015	.184	.010	1.1		14	.80					
1.20	7.8	.37	.066	21	18	11	50	14	0.5	8.6	3.4	.10	.014	.199	.012	1.3								
1.50	7.2	.38	.066													1.3								

Depth metres	Org.C (W&B) % @ 105C	Tot.N % @ 105C	Extr. P Acid mg/kg @ 105C	Bicarb.	HCl K meq% @105C	CaCl2 Extr K mg/kg @ 105C	P	DTPA-extr. Fe mg/kg @ 105C	Mn	Cu	Zn	B	Extractable SO4S mg/kg @ 105C	NO3N	NH4N	Buff Cap	P Equil ug/L @ 40C	Alternative Cations CEC m.eq/100g @ 105C	Ca	Mg	Na	K
B 0.10	1.6	.07	9	5	.26			49	20	0.3	1.0											

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: Leach pH 8.5 Alc. M NH4Cl (pre-wash)
CEC methods: Alc. M NH4Cl; Ca/KNO3 displacement
Alternative cation method:
Alternative CEC method:
ECEC METHOD:

SOIL TYPE: Glenrock
SITE NO: S10
A.M.G. REFERENCE: 328 000 mE 7 163 500 mN ZONE 56

GREAT SOIL GROUP: Red earth
PRINCIPAL PROFILE FORM: Gn2.12
SOIL TAXONOMY UNIT: Typic Kandiustalf
FAO UNESCO UNIT: Rhodic Luvisol

SUBSTRATE MATERIAL:
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:

SLOPE: 3 %
LANDFORM ELEMENT TYPE: Simple slope
LANDFORM PATTERN TYPE: Gently undulating plains

VEGETATION
STRUCTURAL FORM:
DOMINANT SPECIES

ANNUAL RAINFALL:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Hard setting

HORIZON	DEPTH	DESCRIPTION
A1	0 to .05 m	Dark reddish brown (5YR3/3); sandy clay loam; few small pebbles, subrounded quartz; weak 2-5mm granular; moist; moderately weak. Clear to-
A3	.05 to .25 m	Dull reddish brown (2.5YR4/4); clay loam,sandy; few small pebbles, subrounded quartz; massive; moderately moist; moderately firm. Diffuse to-
B1	.25 to .40 m	Reddish brown (2.5YR4/6); sandy clay; few small pebbles, subrounded quartz; massive; moderately moist; moderately firm. Diffuse to-
B2	.40 to .80 m	Dark red (10R3/6); light clay; few small pebbles, subrounded quartz; weak 2-5mm subangular blocky; moderately moist; moderately firm.

Depth metres	1:5 Soil/Water pH @ 40C	EC dS/m @ 40C	Cl % @105C	Particle Size CS % @ 105C	FS	S	C	Exch. Cations CEC m.eq/100g @ 105C	Ca	Mg	Na	K	Total Elements P % @ 80C	K	S	Moistures ADM % @ 105C	33*	1500*	Disp.Ratio R1 @ 40C	R2	Exch Al m.eq/100g @ 105C	Exch Acid	ECEC	pH CaCl2 @ 40C
0.10	7.2	.06	.002	42	34	14	12	7	5.0	1.8	.05	.36	.028	.076	.022	0.6		5	.52					
0.30	6.3	.03	.002	37	35	13	16	2	1.7	0.5	.10	.07	.018	.057	.012	0.3		4	.59					
0.60	6.1	.07	.008	18	16	5	62	5	2.9	1.9	.19	.03	.030	.128	.012	1.1		15	.13					
0.80	5.1	.09	.012	15	14	5	65	5	2.4	2.1	.19	.05	.031	.133	.016	0.8		16	.08					

Depth metres	Org.C (W&B) % @ 105C	Tot.N % @ 105C	Extr. P Acid mg/kg @ 105C	Bicarb.	HCl K meq% @105C	CaCl2 Extr K mg/kg @ 105C	P	DTPA-extr. Fe mg/kg @ 105C	Mn	Cu	Zn	B	Extractable SO4S mg/kg @ 105C	NO3N	NH4N	P Buff Cap @ 40C	Equil ug/L	Alternative Cations CEC m.eq/100g @ 105C	Ca	Mg	Na	K
0.10	1.2	.08	7	4	.38			7	15	0.8	0.5											

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: Equil. shake pH 7.0 M NH_4Cl
Alternative cation method:
ECEC METHOD: Sum basic cations

CEC methods: Alc. M NH_4Cl; Ca/KNO_3 displacement
Alternative CEC method:

SOIL TYPE: O'Bilbil
SITE NO: S11
A.M.G. REFERENCE: 322 700 mE 7 169 100 mN ZONE 56

GREAT SOIL GROUP: No suitable group
PRINCIPAL PROFILE FORM: Uf6.4
SOIL TAXONOMY UNIT: Argiustoll
FAO UNESCO UNIT: Luvic Phaeozem

SURFACE COARSE FRAGMENTS: Common coarse pebbles, rounded conglomerate

SUBSTRATE MATERIAL: Conglomerate
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:

SLOPE: 5 %
LANDFORM ELEMENT TYPE: Hillcrest
LANDFORM PATTERN TYPE: Low hills

VEGETATION
STRUCTURAL FORM:
DOMINANT SPECIES: Acacia harpophylla

ANNUAL RAINFALL:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Hard setting

HORIZON	DEPTH	DESCRIPTION
A11	0 to .18 m	Dark brown (7.5YR3/3); light clay; strong granular; moist; moderately firm.
A12	.18 to .25 m	Dark brown (7.5YR3/3); light clay; fragments, conglomerate; strong granular; moist; moderately firm; few medium manganiferous concretions, few medium ferruginous concretions.
B21	.25 to .48 m	Brown (7.5YR4/3); common medium distinct grey mottles, few medium faint red mottles; medium heavy clay; strong angular blocky; moist; very firm; few medium manganiferous soft segregations, few medium ferruginous concretions.
BC	.48 to .53 m	Dull brown (7.5YR5/3); medium heavy clay; many coarse pebbles, conglomerate, fragments, conglomerate; strong angular blocky; moist; very firm.
R	to m	Fragments, conglomerate.

Depth metres	1:5 Soil/Water pH @ 40C	EC dS/m @ 40C	Cl % @105C	Particle Size CS % @ 105C	FS	S	C	Exch. Cations CEC m.eq/100g @ 105C	Ca	Mg	Na	K	Total Elements P % @ 80C	K	S	Moistures ADM % @ 105C	33*	1500*	Disp.Ratio R1 @ 40C	R2	Exch Al m.eq/100g @ 105C	Exch Acid	ECEC	pH CaCl2 @ 40C
B 0.10	6.7	.06	.001																					
0.10	6.3	.04	.001	25	25	16	34	18	13	3.8	.13	.84	.079	1.07	.040	1.8		14	.60					
0.30	6.9	.05	.001	26	16	12	47	28	16	10	.62	.47	.030	.892	.020	2.3		18	.71					
0.60	6.7	.10	.001	30	13	15	45	29	15	13	.96	.39	.031	1.18	.063	3.6		17	.66					

Depth metres	Org.C (W&B) % @ 105C	Tot.N % @ 105C	Extr. P Acid mg/kg @ 105C	Bicarb.	HCl K meq% @105C	CaCl2 Extr K mg/kg @ 105C	P	DTPA-extr. Fe mg/kg @ 105C	Mn	Cu	Zn	B	Extractable SO4S mg/kg @ 105C	NO3N	NH4N	Buff Cap	P Equil ug/L @ 40C	Alternative Cations CEC m.eq/100g @ 105C	Ca	Mg	Na	K
B 0.10	2.7	.17	64	32	1.3			44	64	1.0	3.6											

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: Equil. shake pH 7.0 M NH4Cl
Alternative cation method:
ECEC METHOD: Sum basic cations

CEC methods: Alc. M NH4Cl; Ca/KNO3 displacement
Alternative CEC method:

SOIL TYPE: Chessborough
SITE NO: S12
A.M.G. REFERENCE: 320 200 mE 7 153 600 mN ZONE 56

GREAT SOIL GROUP: Red earth
PRINCIPAL PROFILE FORM: Gn2.11
SOIL TAXONOMY UNIT: Kandiustalf
FAO UNESCO UNIT: Ferric Luvisol

SUBSTRATE MATERIAL:
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:

SLOPE: 0 %
LANDFORM ELEMENT TYPE: Fan
LANDFORM PATTERN TYPE: Level plain

VEGETATION
STRUCTURAL FORM:
DOMINANT SPECIES

ANNUAL RAINFALL:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Hard setting

HORIZON	DEPTH	DESCRIPTION
A1	0 to .06 m	Brownish black (7.5YR3/2); clay loam; moderate 2-5mm granular; moist; moderately firm. Clear to-
A3	.06 to .25 m	Dull reddish brown (5YR4/4); clay loam; massive; moist; moderately firm. Gradual to-
B2	.25 to .40 m	Reddish brown (5YR4/6); light clay; massive; moist; moderately firm. Gradual to-
B2	.40 to .60 m	Bright reddish brown (5YR5/6); light clay; massive; moist; moderately firm. Gradual to-
2B?	.60 to .95 m	Bright brown (7.5YR5/6); common medium faint red mottles; light clay; moderate 2-5mm polyhedral; moist; moderately firm; few medium ferromanganiferous nodules. Diffuse to-
2B?	.95 to 1.30 m	Bright brown (7.5YR5/6); common medium faint yellow mottles; light medium clay; moderate 2-5mm subangular blocky; moist; moderately firm; very few medium ferromanganiferous nodules. Diffuse to-
3B	1.30 to 1.60 m	Dull yellowish orange (10YR6/3); common medium distinct yellow mottles; medium clay; strong angular blocky; moist; very firm.

Depth	1:5 Soil/Water			Particle Size				Exch. Cations					Total Elements			Moistures			Disp.Ratio		Exch	Exch	ECEC	pH
	pH	EC	Cl	CS	FS	S	C	CEC	Ca	Mg	Na	K	P	K	S	ADM	33*	1500*	R1	R2	Al	Acid		CaCl2
metres		dS/m	%	%				m.eq/100g					%			%					m.eq/100g			
	@ 40C		@105C	@ 105C				@ 105C					@ 80C			@ 105C			@ 40C		@ 105C			@ 40C
0.10	6.5	.06	.001	30	34	11	25	8	5.8	1.5	.05	.97	.067	.426	.031	0.7		9	.44					
0.30	6.1	.02	.001	32	34	10	24	4	2.4	0.7	.09	.68	.048	.416	.018	0.6		8	.45					
0.60	5.9	.02	.001	26	31	8	35	5	3.0	1.2	.96	.23	.034	.397	.015	0.8		10	.39					
0.90	6.3	.03	.001	23	29	10	36	6	2.5	2.6	.27	.11	.035	.375	.013	0.9		11	.36					
1.20	7.0	.03	.001	25	29	9	38	6	2.1	3.5	.54	.11	.031	.393	.010	1.0								
1.50	7.5	.07	.003													1.5								

Depth	Org.C	Tot.N	Extr. P		HCl	CaCl2 Extr		DTPA-extr.					Extractable			P		Alternative Cations				
	(W&B)		Acid	Bicarb.	K	K	P	Fe	Mn	Cu	Zn	B	SO4S	NO3N	NH4N	Buff Cap	Equil	CEC	Ca	Mg	Na	K
metres	%	%	mg/kg		meq%	mg/kg		mg/kg					mg/kg				ug/L	m.eq/100g				
	@ 105C	@ 105C	@ 105C		@105C	@ 105C		@ 105C					@ 105C			@ 40C		@ 105C				
0.10	1.4	.11	11	6	.84			30	49	1.0	1.8											

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: Equil. shake pH 7.0 M NH4Cl
Alternative cation method:
ECEC METHOD: Sum basic cations

CEC methods: Alc. M NH4Cl; Ca/KNO3 displacement
Alternative CEC method:

SOIL TYPE: Coonambula
SITE NO: S13
A.M.G. REFERENCE: 325 000 mE 7 167 500 mN ZONE 56

GREAT SOIL GROUP: Solodic soil
PRINCIPAL PROFILE FORM: Dy2.43
SOIL TAXONOMY UNIT: Typic Natrustalf
FAO UNESCO UNIT: Ochric Solonetz

SUBSTRATE MATERIAL:
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:

SLOPE:
LANDFORM ELEMENT TYPE: Plain
LANDFORM PATTERN TYPE: Level plain

VEGETATION
STRUCTURAL FORM:
DOMINANT SPECIES

ANNUAL RAINFALL:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Hard setting

HORIZON	DEPTH	DESCRIPTION
A1	0 to .15 m	Brownish black (7.5YR3/2); clay loam; weak 2-5mm granular; moist; moderately firm. Gradual to-
A2cb	.15 to .25 m	Greyish brown (7.5YR5/2), dry conspicuously bleached; clay loam; massive; moderately moist; moderately firm; very few fine manganiferous nodules. Abrupt to-
B21	.25 to .50 m	Brownish grey (10YR4/1); medium clay; strong 10-20mm angular blocky; moderately moist; moderately strong. Diffuse to-
B22	.50 to .70 m	Dull yellowish brown (10YR5/4); medium clay; strong 10-20mm angular blocky; moderately moist; moderately strong. Diffuse to-
B23	.70 to 1.00 m	Greyish yellow-brown (10YR4/2); medium heavy clay; very few medium pebbles, chert; strong 5-10mm angular blocky; moderately moist; moderately strong; very few medium carbonate nodules. Diffuse to-
B24	1.00 to 1.55 m	Dull yellowish brown (10YR5/4); common fine distinct dark mottles; medium heavy clay; strong 5-10mm angular blocky; moderately moist; moderately strong; few medium carbonate nodules.

Depth	1:5 Soil/Water			Particle Size				Exch. Cations					Total Elements			Moistures			Disp.Ratio		Exch	Exch	ECEC	pH
	pH	EC	Cl	CS	FS	S	C	CEC	Ca	Mg	Na	K	P	K	S	ADM	33*	1500*	R1	R2	Al	Acid		CaCl2
metres		dS/m	%	%				m.eq/100g					%			%					m.eq/100g			
	@ 40C		@105C	@ 105C				@ 105C					@ 80C			@ 105C			@ 40C		@ 105C			@ 40C
0.10	6.2	.05	.002	15	21	31	31	21	7.3	4.2	0.4	.88	.037	.938	.026	1.7		13	.68					
0.30	6.0	.18	.023	4	22	29	45	26	8.0	7.7	2.9	.34	.016	.934	.015	2.3		17	.85					
0.60	8.3	.55	.079	3	16	25	55	31	13	13	5.7	.36	.012	.989	.018	3.0		19	.95					
0.90	8.8	.66	.075	8	22	23	47	24	9.8	9.9	4.4	.36	.013	.981	.012	1.7		17	.93					
1.20	8.9	.68	.075	12	23	17	50	23	9.8	9.9	4.3	.39	.012	1.06	.013	1.8								
1.50	8.8	.65	.077													1.7								

Depth	Org.C	Tot.N	Extr. P		HCl	CaCl2 Extr		DTPA-extr.					Extractable			P		Alternative Cations				
	(W&B)		Acid	Bicarb.	K	K	P	Fe	Mn	Cu	Zn	B	SO4S	NO3N	NH4N	Buff	Equil	CEC	Ca	Mg	Na	K
metres	%	%	mg/kg		meq%	mg/kg		mg/kg					mg/kg			Cap	ug/L	m.eq/100g				
	@ 105C	@ 105C	@ 105C		@105C	@ 105C		@ 105C					@ 105C			@ 40C		@ 105C				
0.10	1.9	.13	11	8	.84			88	76	1.1	1.2											

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: Leach pH 8.5 Alc. M NH4Cl (pre-wash)
CEC methods: Alc. M NH4Cl; Ca/KNO3 displacement
Alternative cation method:
Alternative CEC method:
ECEC METHOD:

SOIL TYPE: Lacon
SITE NO: S14
A.M.G. REFERENCE: 323 300 mE 7 162 200 mN ZONE 56

GREAT SOIL GROUP: Brown clay
PRINCIPAL PROFILE FORM: Ug5.34
SOIL TAXONOMY UNIT: Typic Chromustert
FAO UNESCO UNIT: Chromo Vertisol

SUBSTRATE MATERIAL: Mudstone
CONFIDENCE SUBSTRATE IS PARENT MATERIAL:

SLOPE: 3 %
LANDFORM ELEMENT TYPE: Simple slope
LANDFORM PATTERN TYPE: Gently undulating rises

VEGETATION
STRUCTURAL FORM:
DOMINANT SPECIES

ANNUAL RAINFALL:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Self mulching, surface crust

HORIZON	DEPTH	DESCRIPTION
A1	0 to .05 m	Brownish black (7.5YR3/2); light medium clay; strong 2-5mm granular; moist; moderately firm. Abrupt to-
B1	.05 to .25 m	Brown (7.5YR4/3); light medium clay; strong 2-5mm subangular blocky; moist; moderately firm. Gradual to-
B21	.25 to .70 m	Brown (7.5YR4/3); medium heavy clay; strong 2-5mm lenticular; moist; very firm; very few fine manganiferous nodules. Diffuse to-
B22	.70 to 1.60 m	Bright brown (7.5YR5/6); medium heavy clay; strong 2-5mm lenticular; moist; very firm; few medium carbonate nodules.

Depth metres	1:5 Soil/Water pH @ 40C	EC dS/m	Cl % @105C	Particle Size CS % @ 105C	FS	S	C	Exch. Cations CEC m.eq/100g @ 105C	Ca	Mg	Na	K	Total Elements P % @ 80C	K	S	Moistures ADM % @ 105C	33*	1500*	Disp.Ratio R1 @ 40C	R2	Exch Al m.eq/100g @ 105C	Exch Acid	ECEC	pH CaCl2 @ 40C
0.10	6.7	.06	.002	10	26	28	36	31	14	5.4	0.2	.86	.043	.785	.037	2.2		17	.47					
0.30	6.9	.10	.013	11	20	24	48	22	9.5	5.5	1.5	.19	.017	.580	.015	2.1		17	.62					
0.60	8.1	.62	.098	6	12	15	69	30	13	10	4.8	.18	.010	.662	.017	3.1		24	.69					
0.90	8.7	.78	.100	10	11	13	67	29	12	10	5.7	.18	.009	.638	.011	3.0		23	.80					
1.20	8.8	.72	.091	8	12	14	68	29	12	10	5.8	.16	.011	.639	.008	3.0								
1.50	8.8	.67	.069													2.1								

Depth metres	Org.C (W&B) % @ 105C	Tot.N % @ 105C	Extr. P Acid mg/kg @ 105C	Bicarb.	HCl K meq% @105C	CaCl2 Extr K mg/kg @ 105C	P	DTPA-extr. Fe mg/kg @ 105C	Mn	Cu	Zn	B	Extractable SO4S mg/kg @ 105C	NO3N	NH4N	P Buff Cap @ 40C	P Equil ug/L	Alternative Cations CEC m.eq/100g @ 105C	Ca	Mg	Na	K
0.10	2.4	.17	6	7	.83			49	62	2.6	0.9											

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: Leach pH 8.5 Alc. M NH4Cl (pre-wash)
CEC methods: Alc. M NH4Cl; Ca/KNO3 displacement
Alternative cation method:
Alternative CEC method:
ECEC METHOD:

APPENDIX V

LAND SUITABILITY CLASSES

Class definitions

Five land suitability classes have been defined for use in Queensland, with land suitability decreasing progressively from Class 1 to Class 5. Land is classified on the basis of a specified land use which allows optimum production with minimal degradation to the land resource in the long term.

Class 1 — Suitable land with negligible limitations. This is highly productive land requiring only simple management practices to maintain economic production.

Class 2 — Suitable land with minor limitations which either reduce production or require more than the simple management practices* of class 1 land to maintain economic production.

Class 3 — Suitable land with moderate limitations which either further lower production or require more than those management practices of class 2 land to maintain economic production.

Class 4 — Marginal land which is presently considered unsuitable due to severe limitations. The precise effects of these limitations on the proposed land use are unknown. The use of this land is dependent upon either undertaking additional studies to determine its suitability for sustained production or reducing the effects of the limitations(s) to achieve production.

Class 5 — Unsuitable land with extreme limitations that preclude its use.

Land is considered less suitable as the severity of limitations for a land use increase, reflecting either (a) reduced potential for production, and/or (b) increased inputs to achieve an acceptable level of production and/or (c) increased inputs required to prevent land degradation. The first three classes are considered suitable for the specified land use as the benefits from using the land for that land use in the long term should outweigh the inputs required to initiate and maintain production. Decreasing land suitability within a region often reflects the need for increased inputs rather than decreased potential production. Class 4 is considered presently unsuitable and is used for marginal land where it is doubtful that the inputs required to achieve and maintain production outweigh the benefits in the long term. It is also used for land where reducing the effect of a limitation may allow it to be upgraded to a higher suitability class, but additional studies are needed to determine the feasibility of this.

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* Where more than simple management practices are required, this may involve changes in land preparation, irrigation management, the addition of soil ameliorants and the use of additional measures to prevent land degradation.

Class 5 is considered unsuitable, having limitations that in aggregate are so severe that the benefits would not justify the inputs required to initiate and maintain production in the long term. It would require a major change in economics, technology or management expertise before the land could be considered suitable for that land use. Some class 5 lands however, such as escarpments, will always remain unsuitable for agriculture.

APPENDIX VI

LAND SUITABILITY CLASSIFICATION SCHEME FOR IRRIGATED CROPS

CLIMATE (c)

Effect

Frosts suppress growth, kill plants and reduce yield.

Assessment

Incidence and severity of frosts have been used to distinguish affected areas.

Subclass determination

Crop tolerance and local experience.

Soil/land attribute level	Suitability subclass for various crops		
	Avocado Mango	Citrus	All other Crops *
No to light frosts (hill tops) Code: C1	2	1	1
Regular frosts Code: C2	5	3	1
Severe frosts (channel benches, depressions in lower terraces) Code: C3	5	4	1

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

WATER AVAILABILITY (m)

Effect

Plant yield will be decreased by periods of water stress particularly during critical growth periods.

Assessment

PAWC[1] based on predicted values (Gardner and Coughlan 1982, Shaw and Yule 1978). Generally, PAWC relates to soil texture and pedality to effective rooting depth[2].

Subclass determination

PAWC subclass limits relate to irrigation frequency for spray or furrow irrigation only:

1	>100 mm = >10 days
2	75 to 100 mm = 8 to 10 days
3	50 to 75 mm = 5 to 8 days
4	<50 mm = <5 days

Subclass limits do not apply to microsprinkler or drip irrigation systems where small amounts of water are added frequently.

Soil/land attribute level	Suitability subclass for various crops		
	Microsprinkler/drip irrigation, Avocado, Citrus, Mango, Pecan, Stone fruit, Grapes	Veges, Cruciferae, Cucurbits, Asparagus, Potato, Navybean	Safflower, Sunflower, Peanuts, Mungbean, Chickpea, Lucerne, Summer grains, Winter grains, Soybean, Pastures
Structured medium to heavy textured soils Code: M1a to d			
(a) *	1	2	1
(b)	1	2	1
(c)	1	2	2
(d)	1	3	3
Massive uniform and gradational medium texture soils or gradational and duplex soils with massive medium textured A horizons and structured B horizons Codes: M2, 3a to d			
(a)	1	3	2
(b)	1	3	2
(c)	1	3	3
(d)	1	4	4

1 PAWC: Plant available water capacity

2 Effective rooting depth is taken to the depth of optimal water extraction, for example, tree crops 1-1.5 m, grapes and small crops 0.5 m, field crops 0.9 m, or reduced if intercepted by salt bulge or rock.

Duplex soils with light textured A horizons >0.4m Code: M4a to d			
(a)	1	4	3
(b)	1	4	3
(c)	1	4	4
(d)	1	4	4
Uniform sands Code: M5a to d			
(a)	1	4	4
(b)	1	4	4
(c)	1	4	4
(d)	1	4	4

* Effective rooting depth (a) >1 m, (b) 0.6 to 1 m, (c) 0.4 to 0.6 m, (d) <0.4 m

WETNESS (w)

Effect

Waterlogged soils reduce plant growth and delay effective machinery operations.

Assessment

Internal and external drainage are assessed. Indicator attributes of internal drainage include texture, pedality and grade of structure, colour, mottles, segregations and impermeable layers. Slope and topographic position assess external drainage capability. Drainage class[1] and soil permeability[2] (McDonald et al. 1984) are assessed and modified by plant rooting depth requirement.

Subclass Determination

Consultation, crop tolerance information and effects concerning delays in machinery operations.

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1 Drainage class: This accounts for all aspects of internal and external drainage in the existing state. Both are reassessed from the point of view of the ease of drainage to make the final subclass decision. The reassessment considers drainage spacing (permeability) and ease of disposal (external drainage).

Drainage class
1 Very poorly drained
2 Poorly drained
3 Imperfectly drained
4 Moderately well drained
5 Well drained
6 Rapidly drained

2 Permeability
H Highly permeable
M Moderately permeable
S Slowly permeable

Soil/land attribute level	Suitability subclass for various crops						
	(a)Depth req. 0 to 1.5m			(b)Depth req. 0 to 1m		(c)Depth req. 0 to .5m	
	Avocado	Citrus, Pecan, Stone fruit	Mango	Safflower, Mungbean, Chickpea, Lucerne	Sunflower Summer grains, Winter grains, Soybean	Grape, Navybean, Peanuts	Veges, Cruciferae, Cucurbits, Asparagus, Potato
6H	1	1	1	1	1	1	1
6M	2	1	1	1	1	1	1
5H	2	1	1	1	1	1	1
5M	3	2	1	2	1	2	1
5S	4	3	2	3	2	3	2
4H	3	2	1	2	1	2	1
4M	4	3	2	3	2	3	2
4S	5	4	3	4	3	4	3
3H	4	3	2	3	2	3	2
3M	5	4	3	4	3	4	3
3S	5	5	4	5	4	5	4

SOIL DEPTH (d)

Effect

Shallow soils limit root proliferation and anchorage. Plants may be uprooted during strong winds.

Assessment

Effective soil depth: Depth to decomposing rock, pan or impermeable layer.

Subclass determination

Consultation.

Soil/land attribute level	Suitability subclass for various crops	
	Tree crops	All other crops
Effective soil depth		
>1 m Code: D1	1	1
0.6 to 1 m Code: D2	2	1
0.4 to 0.6 m Code: D3	3	1
<0.4 m Code: D4	4	1

ROCKINESS (r)

Effect

Coarse (rock) fragments[1] and rock in the plough zone interfere with the efficient use of, and can damage agricultural machinery. Surface rock interferes with the harvesting of some crops.

Assessment

Size and amount of coarse (rock) fragments in the plough layer are assessed, together with machinery and farmer tolerance.

Subclass

Consultation, particularly related to farmer tolerances which are implicity related to profitability and technological capability.

Soil/land attribute level		Suitability subclass for various crops			
Size	Amount %	All tree crops, Grapes, Pastures	Safflower, Sunflower, Summer grains	Mungbean, Lucerne, Soybean, Winter grains, Veges, Cruciferae, Cucurbits Asparagus	Potato, Peanuts, Navybean, Chickpea
No coarse fragments		1	1	1	1
Code: R0					
20 to 60 mm	<2	1	1	2	3
(Gravel)	2 to 10	1	2	3	4
	10 to 20	1	3	4	5
Codes:	20 to 50	2	4	5	5
G1 to 5	>50	3	5	5	5
60 to 200 mm	<2	1	2	3	4
(Cobble)	2 to 10	1	3	4	5
	10 to 20	2	4	5	5
Codes:	20 to 50	3	5	5	5
C1 to 5	>50	4	5	5	5

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1 By definition (McDonald et al. 1984), coarse fragments are particles greater than 2 mm and not continuous with underlying bedrock. Rock is defined as being continuous with bedrock.

MICRORELIEF (g)

Effect

Uneven crop productivity associated with uneven surface water distribution, for example, water ponded in depressions.

Assessment

Gilgai vertical interval relates to the amount of levelling required. Levelling is required for efficient irrigation and surface drainage.

Subclass determination

Local opinion and consultation.

Soil/land attribute level	Suitability subclass for various crops
	All crops
Vertical interval	
<0.1 m Code: G0	1
0.1 to 0.3 m Code: G1	3
0.3 to 0.6 m Code: G2	4
>0.6 m Code: G3	5

SOIL PHYSICAL CONDITION (p)

Effect

1. Germination and seedling development problems associated with adverse conditions of the soil surface such as hardsetting, crusting and coarse aggregates.

2. Difficulties in achieving favourable tilth with machinery in soils with a narrow moisture range for working.

3. Harvesting difficulties and quality of subsurface harvest material affected by soil adhesiveness.

Assessment

Soil morphological properties such as texture, structure and consistence are evaluated and matched to crop requirements. Local experience indicates problems associated with certain soils.

Subclass determination

1. Plant tolerance limits and requirements in relation to germination and harvesting, and supported by local experience.

2. Local opinion of the severity of the problem of narrow moisture range.

Soil/land attribute level	Suitability subclass for various crops								
	All tree crops, Grapes	Safflower, Sunflower, Navybean, Mungbean, Chickpea, Lucerne	Soybean	Summer grains	Winter grains	Potato	Peanuts	Veges Cruciferae Cucurbits Asparagus	Pastures
No restrictions Code: P0	1	1	1	1	1	1	1	1	1
Slightly adhesive soils Code: P1	1	1	1	1	1	1	2	1	1
Massive hardsetting soils with sandy loam to clay loam textures with dry moderately firm consistence Code: P2	1	2	2	1	1	2	2	1	2
Moderately adhesive soils Code: P3	1	1	1	1	1	2	3	1	1
Crusting Code: P4	1	2	3	1	2	2	2	2	2
Massive hardsetting soils with loam fine sandy to clay loam surface textures with dry very firm consistence Code: P5	1	3	3	2	3	3	3	2	3
Moderate moisture range Code: P6	1	2	2	2	2	2	2	2	1
Strongly adhesive soils Code: P7	1	1	1	1	1	3	4	1	1
Narrow moisture range Code: P8	1	3	3	3	3	3	3	3	2

SECONDARY SALINISATION (s)

Effect

Drainage losses from permeable soils, usually higher in the landscape, may cause secondary salinisation downslope.

Assessment

Intake areas considers soil permeability (McDonald et al. 1984) and position in the landscape, and the affect of deep drainage losses may have on watertables downslope. High watertable may occur at contact areas where heavy textured slowly permeable soils occur.

Subclass determination

Soil permeability and position in the landscape. Hydraulic conductivity and groundwater measurements are required for a wide range of soils and landscapes.

Soil/land attribute level	Suitability subclass for various crops
	All Crops
No restriction Code: S0	1
Highly to moderately permeable soils acting as intact areas and usually higher in the landscape Code: S1	i *
Areas susceptible to development of secondary salinisation due to high watertables (contact areas) Code: S2	4

* Intake areas are not downgraded, the i symbol is used to flag the fact that deep drainage may cause salinisation downslope but does not detract from the value of the land.

EROSION (e)

Effect

Land degradation and long term productivity decline will occur on unprotected arable land because of excessive soil erosion.

Assessment

Soil loss will depend on soil erodibility and land slope for a particular crop and surface management system. For each soil type there is a maximum slope above which soil loss cannot be reduced to acceptable levels by erosion control measures.

Subclass determination

Slope limits are determined in consultation with soil conservation extension and research personnel, and extension and research agronomists. The implications of the subclasses are:

e1	surveyed row direction only required
e2	conventional parallel structures required
e3	e2 measures and some surface management practices[1]
e4 & e5	non-arable land

Soil/land attribute level	Suitability subclass for various crops		
Slope %	Avocado, Citrus, Mango, Pecan, Stone fruit, Grapes, Pastures	Winter grains, Summer grains, Veges, Cruciferae, Cucurbits, Asparagus, Lucerne	Safflower, Sunflower, Navybean, Mungbean, Chickpea, Peanuts, Potato, Soybean
Red earth and other massive soils			
<1	1	1	1
1 to 2	1	1	2
2 to 5	1	2	3
5 to 8	2	3	4
8 to 12	3	4	5
>12	5	5	5
Codes: E1 to 6			
Red and brown prairie soils			
<1	1	1	1
1 to 2	1	1	2
2 to 4	1	2	3
4 to 8	2	3	4
8 to 10	3	4	5
>10	5	5	5
Codes: P1 to 6			
Grey and brown clays			
<1	1	1	1
1 to 2	1	1	2
2 to 4	1	2	3
4 to 6	2	3	4
6 to 8	3	4	5
>8	5	5	5
Codes: C1 to 6			

[1] Surface management practices: A range of options aimed at minimum soil disturbance, combined with the retention of harvest residue material as a surface cover.

Texture contrast soils with fine sandy loam to clay loam surface			
0	1	1	1
0 to 1	2	3	4
1 to 2	2	4	5
2 to 4	3	5	5
4 to 6	4	5	5
>6	5	5	5
Codes: T1 to 6			
Texture contrast soils with loamy sand to sandy loam surface			
0	1	1	1
0 to 2	1	2	3
2 to 4	2	3	4
4 to 6	3	4	5
6 to 8	4	5	5
>8	5	5	5
Code: D1 to 6			

FURROW INFILTRATION (i)

Effect

The amount of water applied must match the infiltration characteristics of the soil to minimise deep drainage and runoff, and to determine the most suitable furrow length. Additional management requirements are associated with short furrows or waterlogging in the upper end of furrows if furrow lengths are too long. Furrow gradient affects soil erosion.

Assessment

Soil permeability and slope are assessed. Indicator attributes of permeability include texture, pedality and grade of structure, sodicity, pH, salt bulge.

Subclass determination

Consultation.

Soil permeability in relation to excessive water loss or additional management requirements. Hydraulic conductivity measurements required.

Slope in relation to excessive soil loss. Furrow irrigation not recommended on slopes >1% for texture contrast soils and 2% for other soils, or slopes >0.5% in the direction of irrigation (across slopes) for texture contrast soils and 1% for other soils. Slope limits need further substantiation for each soil, crop and management system.

Soil/land attribute level	Suitability subclass for various crops
	All crops
(a) Permeability	
Slowly permeable soils which are strongly sodic (ESP>14), strongly alkaline (pH>8.5) or salt bulge at 1 m. Code: I1	suitable
Soils which are sodic (ESP 6 to 14), moderately alkaline (pH7.5 to 8.5), and low in salt at 1 m. Code: I2	4
Permeable soils which are non-sodic (ESP<6), acid to neutral (pH<7.5), low in salts, or sandy textures at 1 m. Code: I3	5
(b) Slope	
Texture contrast soils	
<1%	suitable
1 to 2%	4
>2%	5
Other soils	
<2%	suitable
2 to 4%	4
>4%	5
Codes: see e limitation	