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Land Resource Assessment of the Brisbane Valley, Queensland

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Department of Natural Resources
Queensland

NATIONAL LANDCARE PROGRAM

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This report is intended to provide information only on the subject under review. There are limitations inherent in land resource studies, such as accuracy in relation to map scale and assumptions regarding socio-economic factors for land evaluation. Readers are advised against relying solely on the information contained therein. Before acting on the information conveyed in this report, readers should be satisfied they have received adequate information and advice.

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Map 2	**Soils – Moore Sheet**	DNR Ref. No. 99-BVL-I-P-3233
Map 3	**Land suitability – Esk Sheet**	DNR Ref. No. 99-BVL-I-P-3239
Map 4	**Land suitability – Moore Sheet**	DNR Ref. No. 99-BVL-I-P-3240

SUMMARY

With the assistance of funding from the National Landcare Program over five years, the land resources of a 1374 km^2 portion of the upper Brisbane Valley have been described and documented.

The upper Brisbane Valley (570 300 ha) is essentially the most extensive sub-catchment of the Brisbane River System. Apart from its water harvesting function, the area also supports significant agricultural and pastoral activity. Traditionally, the lands have remained forested or have been used for the grazing of native pastures and dryland farming. However, there is a move toward more intensive (often irrigated) cropping and animal husbandry. The capacity of the land to sustain such changes needs to be considered in terms of the limitations imposed by the soil, topography and climate.

The survey takes in the central portion of the sub-catchment (137 376 ha) corresponding to the Esk and Moore 1:50 000 map sheets. In terms of intensive land use, the most utilised land in the survey area is the alluvium of the Brisbane River and associated watercourses, which accounts for about 50% of the land suitable for intensive development. The lower slopes of the Esk Trough account for about 40% of further land suitable for intensive land use.

Forty seven distinct soil profile classes and ten soil phases have been identified. Each soil profile class is clearly described and detailed morphological and analytical data presented. A total of 1316 unique map areas (UMAs) have been delineated on the basis of topography, vegetation and soil type and these have been mapped at a scale of 1:50 000.

Each UMA has been evaluated for its overall suitability for agriculture and its suitability for each of the following land uses: dryland (rainfed) cropping, irrigated small crops, irrigated pasture, dryland sown pasture and horticultural trees/vines. This survey did not summarise land suitability for specific crops, nor did it evaluate the availability of suitable irrigation water.

A comprehensive UMA database has been established, enabling 85 items of information to be stored for each UMA. Included in the database are items relating to UMA size, spatial location, soils, geology, landform, vegetation, soil attributes such as surface pH and nutrient status, erosion status, woody weed species, limitation class, land suitability class and agricultural land class.

Six maps have been included with the report — *soils*, *suitability for dryland sown pastures*, and *suitability for irrigated agriculture* (three individual maps for each map sheet: Esk and Moore). However, as the UMA data has been integrated with GIS spatial data, maps pertaining to any category of UMA data may be produced.

Twenty nine percent of the total survey area is considered suitable for dryland sown pastures, 30% is suitable for irrigated pasture, 8% is suitable for dryland cropping, 16% is suitable for irrigated cropping, and 23% is suitable for tree and vine crops. Currently, approximately 4% of the land area is developed for cropping and sown pasture. Therefore, based on the inherent qualities of the land, there is considerable capacity to increase the intensity of farming practices and enterprises.

Thirty six percent of the survey area was found to be affected by minor sheet erosion and a further 7% by moderate sheet erosion. 6% of the survey area is affected by gully erosion, mainly in association with sodic subsoils. Compared to adjacent catchments (Lockyer Valley and Bremer River), secondary salinity is not a major problem, with only about ten saline seepages observed.

The relative erodibility of four soil profile classes under pasture was investigated in a rainfall simulator study. The results confirm that soil loss is strongly linked to the quantity of pasture cover and suggest that soil erodibility is influenced by the structure, texture and organic matter content of the surface soil. Land management practices that retain adequate surface cover and minimise any adverse impact on surface soil properties would therefore assist in reducing the loss of valuable surface soil.

1. INTRODUCTION

The upper Brisbane River is the most extensive sub-catchment[1] (570 300 ha) of the Brisbane River system representing 42% of the total catchment. It is also an area of significant agricultural and pastoral activity and acts as a catchment for Wivenhoe Dam — the major water storage for the City of Brisbane and adjacent local authority areas.

The area surveyed and documented in this report is the area covered by the *Esk* and *Moore* 1:50 000 topographic map sheets, covering 137 376 ha or 24% of the upper Brisbane River sub-catchment, generally known as ‘the Brisbane Valley’.

Regional population growth in south-east Queensland is placing increasing pressure on existing agricultural land uses in the Brisbane Valley. There are a number of small to medium sized urban centres in the area, and rural residential development is expanding. These pressures, along with changes to more intensive cropping and grazing land uses have resulted in a demand for more detailed land management recommendations, which, in turn, require greater knowledge of the land resources. Unplanned development has the potential to alienate areas of good quality agricultural land, reducing the viability of both rural communities and rural industries.

This is the first major investigation of soils undertaken in the Brisbane Valley. Until this survey, the land resources of the Brisbane Valley were the least documented of any sub-catchment in the Brisbane River system — with data available at a scale too broad[2] for both regional planning and for use by landholders. The scale of mapping (1:50 000) presented here aims to address the needs of both land users and land administrators.

The Moreton Region Non-urban Land Suitability Survey (QDPI, 1974) documented extensive soil erosion in the Brisbane Valley, caused by either inappropriate land use or unsustainable land use practices. Sustainable land use and appropriate land management in the Brisbane Valley depends on an understanding of its natural resources and the limitations for particular land uses.

The specific objectives of this survey were to:

1. survey and document the land resources of the upper Brisbane Valley area in sufficient detail for subsequent land suitability classification
2. use the land resource inventory as a basis of classifying land suitability for dryland cropping, irrigated agriculture and beef cattle grazing
3. assess the current state of land degradation in the area
4. recommend appropriate agronomic, soil conservation and other land management practices to maintain productivity of the land.

The National Landcare Program, whose support is gratefully acknowledged, largely funded the Brisbane Valley Land Resource Assessment.

[1] see Table 8
[2] see Section 4 for list of references.

2. THE BRISBANE VALLEY AREA

2.1 LOCATION AND SIZE

The *Esk* and *Moore* 1:50 000 map sheets which comprise the survey area cover a large portion of the Brisbane Valley area, north-west of Ipswich (Figure 1). Esk and Toogoolawah are the principal towns in the area. Wivenhoe Dam occupies a section in the south-east corner of the *Esk* sheet. The survey area is situated almost entirely in the upper Brisbane River sub-catchment, but also includes a part of the Stanley River sub-catchment. [See Section 2.6.1 for sub-catchment boundaries.]

The northern and southern boundaries of the survey area are the latitudes 26°45'S and 27°15'S respectively. The longtitudes 152°15'E and 152°30'E represent the western and eastern boundaries respectively. The total area of the two map sheets is 137 376 ha (or 1374 km^2). 118 242 ha (or 86%) of the survey area lies in the Esk Shire (which is 31% of the total area of the shire) with the remainder (19 134 ha) in the Kilcoy Shire (13% of the total area of the shire).

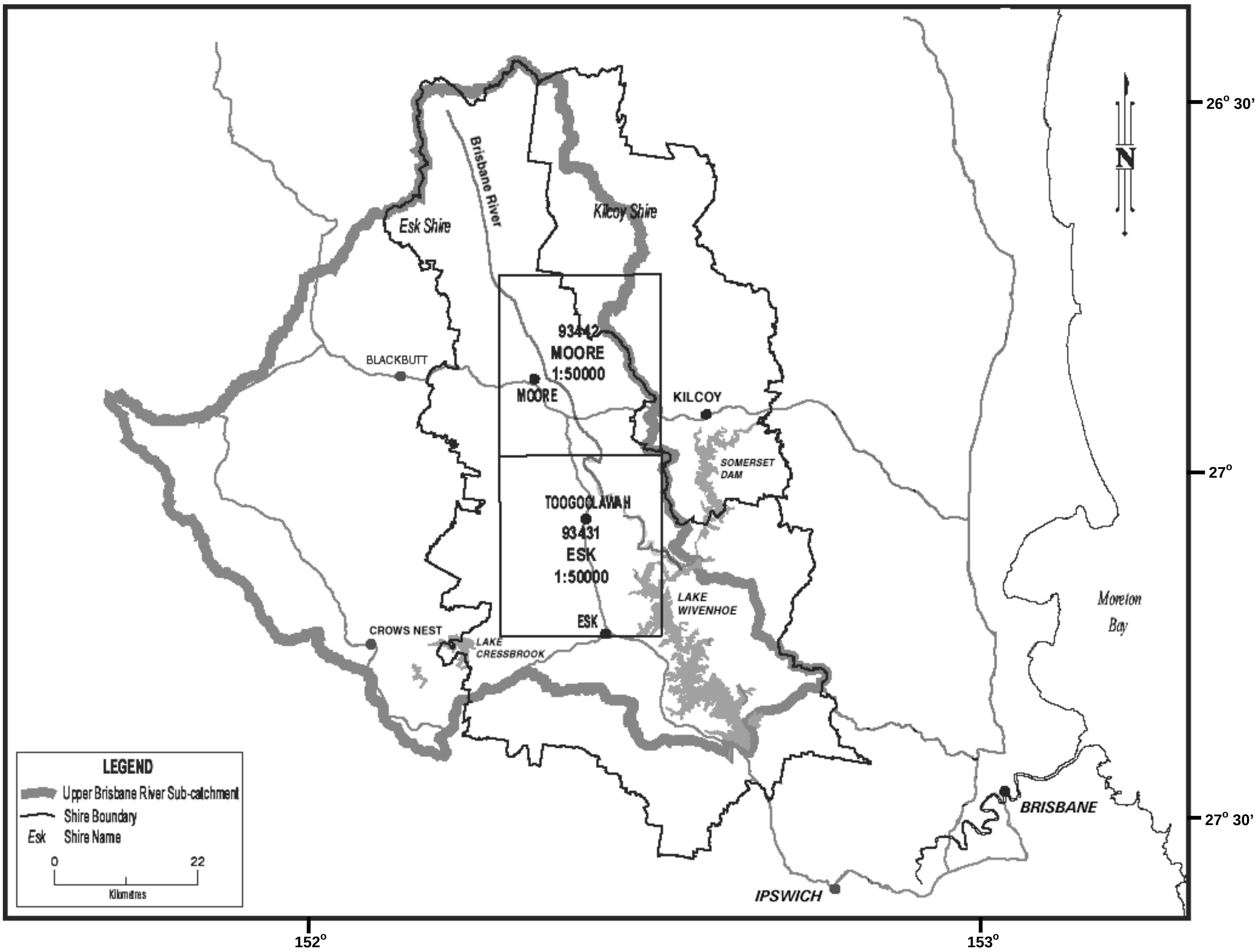


Figure 1 *Location of the Brisbane Valley survey area*

2.2 LAND USE AND POPULATION

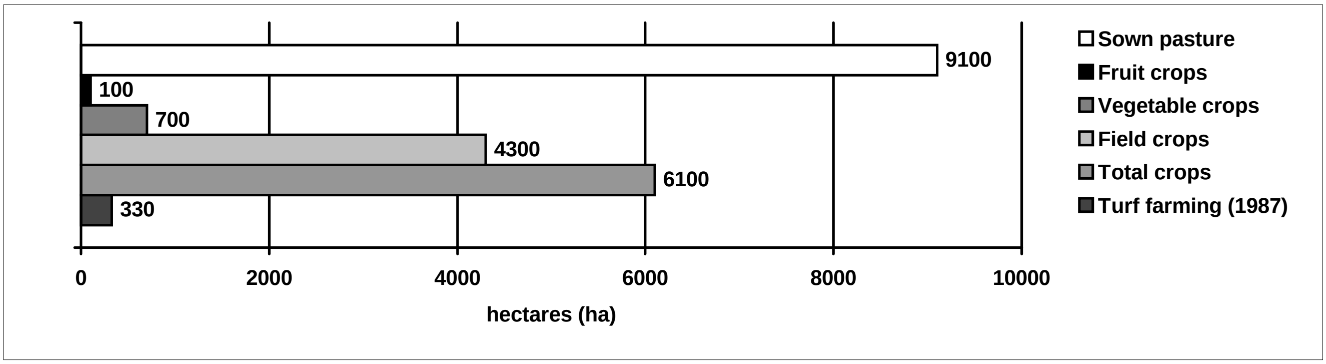
2.2.1 Land use

The Brisbane Valley was one of the first areas settled in Queensland following the introduction of free settlement, when in 1842, D.C. McConnell selected the Cressbrook Run on the Brisbane River near Toogoolawah (Lloyd, 1990). From the 1850's beef cattle began replacing sheep and since then have been the dominant rural industry in the region at least in terms of total area and number of establishments[3]. Dairying, although declining in the number of farms, is still significant, as is the pig industry. Cropping has always been present, but since the 1930's, irrigation has allowed the development of enterprises based on intensive cropping.

The general pattern of agriculture in the area is that the soils on the alluvial flats are intensively cropped and irrigated. This area generally merges with dryland cultivation or improved pastures on adjacent slopes. Above this, on the steeper slopes, grazing of native pastures is the dominant land use. The alluvial flats associated with Cressbrook Creek in the vicinity of Toogoolawah are where most of the intensive cropping is located.

Land tenure and agricultural production statistics have not been compiled for the survey area. As the majority of the survey area lies within the Esk Shire, available statistics for the Esk Shire (Australian Bureau of Statistics 1987 and 1994) are quoted here (Figure 2). It should be noted however, that the southern section of the Esk Shire includes areas of cultivation in the Lockyer Valley (see Figure 1). Thus the statistics are only an approximation of the situation in the survey area.

Commercial agricultural establishments occupy 65% of the Esk Shire. The remainder comprises forestry and water reserves, parks, nature reserves, urban areas and miscellaneous uses. Of the agricultural areas, 94% (in 1993–94) remains as native pasture, with the rest divided between sown pasture (9100 ha) and cropping (6100 ha). Of the cropping areas (in 1993–94), 4300 ha were devoted to fieldcrops, 1700 ha to vegetables and 100 ha to fruit crops (including nuts and grapes). Turf farming is also a significant land use (330 ha in 1986–87). Statistics comparing the area of irrigated cropping versus the area of non-irrigated cropping were not available.



Figures for 1993–94 (Australian Bureau of Statistics, 1995), except for turf farming – Australian Bureau of Statistics 1986–87, quoted in Lloyd (1990).

Figure 2 *Sown pasture and cropping in the Esk Shire*

[3] Depending on the season and prices, cropping produces a greater gross return. In 1986–87, crops grown on 7400 ha produced a return of over $16 million while livestock disposals and livestock products totalled $15 million. Vegetable crops on 2163 ha produced a $12 million return (Esk Shire statistics, Australian Bureau of Statistics 1986–87 quoted in Lloyd, 1990).

Green beans, peas, watermelons, pumpkins and tomatoes are the most widely planted vegetable crops with smaller areas of potatoes, carrots, cabbages, sweet corn and cucumbers. Of the small area utilised for fruit, citrus and avocado are the major plantings.

Figure 3 *Alluvial flats are important for intensive pasture production in the Brisbane Valley (seen here along Emu Creek)*

Field crops include a range of cereals, soybeans, hay and fodder crops. These are often grown in association with grazing enterprises or as rotation crops for disease and weed control in more intensive farming systems. Grain enterprises revolve around summer crops (such as grain sorghum and soybeans) but winter cropping may be profitable in good seasons.

Grazing properties are about equally divided between breeding and fattening. Despite relatively small areas of improved pastures, the region is regarded as 'fair' fattening country (Lloyd, 1990). This is due to the generally favourable rainfall, mild temperatures and the large areas of productive naturalised pastures.

Timber production is a significant industry in the region, with about equal volumes coming from private land and State Forests. The Esk Shire has approximately 86 440 ha of State Forest and timber reserves, making up 23% of the Shire (QDPI, 1973). State Forests located in Kilcoy Shire also form part of the Brisbane Valley survey area. Hoop pine and exotic pines dominate the planting programs in State Forests, but native hardwoods are also included.

Sand and gravel extraction in the upper Brisbane River is emerging as a significant industry of regional importance. The Department of Natural Resources is presently monitoring extraction rates and the impacts of extraction on streams, stream banks and riverine vegetation. It is important that the rates of sand and gravel extraction be sustainable and minimise the risk of bed and bank degradation.

2.2.2 Population

Population estimates for 1986, 1995 and 2011 for the local authority areas in which the Brisbane Valley survey area is situated are shown in Table 1. While the total population is relatively modest, the projected growth is significant. The proximity of the area to the large centres of Ipswich and Brisbane means that there is rising demand for rural residential development, which has the potential to fragment agricultural areas and reduce the viability of agricultural enterprises.

Table 1 ***Population estimates for Esk and Kilcoy Shires***

Local Government Area	1986[a]	1995[b]	projected population for 2011[b]	% increase 1995–2011
Esk	10 760	13 830	19 400	40%
Kilcoy	2 700	3 170	5 100	61%

Source: [a] Department of Housing and Local Government and Planning, 1995
[b] RPAG, 1995

2.3 CLIMATE

2.3.1 Rainfall

Rainfall variability

The climate of the Brisbane Valley area can be broadly described as *humid subtropical* with hot wet summers and mild dry winters. Mean annual rainfall is between 800 mm and 1000 mm for most of the area, but increases to about 1200 mm in the areas of highest elevation in the east and south-west. About 70% of the annual rainfall usually falls in the six months October to March, while about 50% falls in the four 'wet' months December to March. The mean annual rainfall for six stations is shown in Table 2. Esk and Toogoolawah are in the survey area; data from other stations are included for comparison.

Table 2 *Mean annual rainfall and seasonal variation for six stations*

Station	Elevation (m)	Mean Annual Rainfall (mm)	6 months Apr–Sept (% of mean annual)	6 months Oct–Mar (% of mean annual)	4 months Dec–Mar (% of mean annual)
Esk	100	936	32	68	52
Toogoolawah	99	859	30	70	52
Kilcoy	124	966	32	68	53
Somerset Dam	73	1027	32	68	52
Gatton	29	787	31	69	51
Amberley	27	885	30	70	52

Source: Bureau of Meteorology (at least 50 years of data, until 1996)

Both seasonal and annual rainfall are highly variable (Figure 4). This is in part due to the sporadic incidence of rainfall depressions associated with tropical cyclones. In this region, about 30% of annual rainfall may be caused by cyclonic conditions (Co-ordinator General's Department, 1972). Twenty-two cyclones have affected the south Queensland coast over a 50 year period to 1970 (Murphy, 1971). The region is also significantly affected by reversals in global scale circulation patterns — such as *El Niño* effects due to sea temperature variations in the Pacific (Auliciems, 1990).

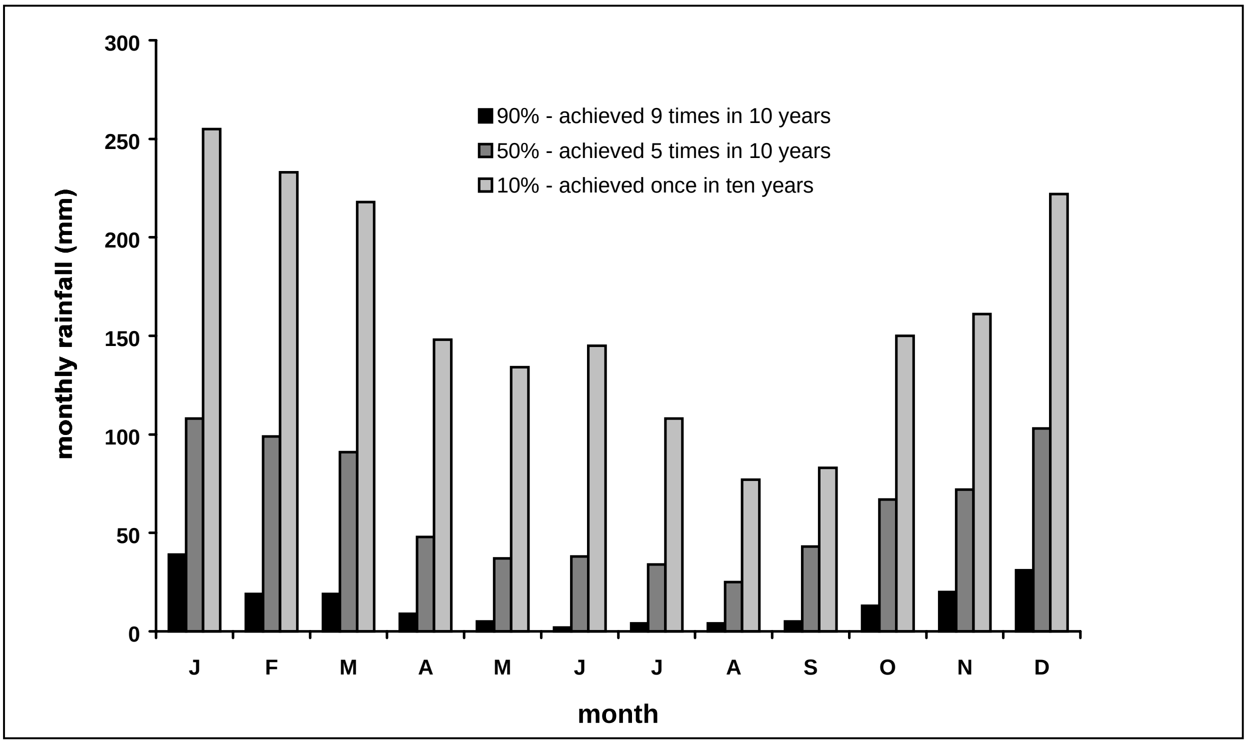


Figure 4 ***Monthly and annual rainfall variability for Esk***

Rainfall intensity

High intensity rainfall increases the potential for soil loss from exposed soil surfaces. The erosivity of rainfall may be quantified using the erosion index (EI_{30}) which is derived from the product of total storm rainfall and the maximum 30-minute intensity of the storm. This index has proved to be highly correlated with soil loss. Rosenthal and White (1980) provide EI_{30} data for Amberley and Kilcoy, and estimates for Esk. These data are shown in Table 3, together with mean monthly rainfall and average number of rain days.

Table 3 *Mean monthly rainfall[1], average number of rain days (≥ 0.1 mm)[a] and average EI_{30}[b] for Esk, Kilcoy and Amberley*

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
ESK (Lat: 27.24° S, Long: 152.42° E)													
Mean rainfall (mm)	134	129	107	68	54	52	46	32	44	72	82	116	936
No. of rain days (mean)	9	9	9	6	5	5	5	4	5	6	7	8	77
Average EI_{30}	70	44	25	8	6	7	6	4	5	15	32	48	270
KILCOY (Lat: 26.95° S, Long: 152.56° E)													
Mean rainfall (mm)	140	137	119	76	61	55	47	31	38	67	79	116	966
No. of rain days (mean)	10	10	10	7	7	6	5	4	5	6	7	8	85
Average EI_{30}	64	87	42	9	7	7	8	3	3	11	19	45	305
AMBERLEY (Lat: 27.63° S, Long: 152.72° E)													
Mean rainfall (mm)	120	127	90	55	47	53	46	31	34	81	78	123	885
No. of rain days (mean)	11	12	12	8	7	6	6	6	6	9	9	10	102
Average EI_{30}	91	52	36	7	5	8	13	8	6	40	51	62	380

Source [a] Bureau of Meteorology (at least 50 years of data, up until 1996)
[b] Rosenthal and White (1980)

These data show that rainfall in the summer months is not only higher, but significantly more intense, raising the potential for soil loss. The annual EI_{30} in this region is higher than for cropping areas to the west (eg. Dalby with 174), but less than areas closer to the coast (eg. Nambour with 864).

Evaporation

The effectiveness of rainfall for plant growth is limited by high evaporation rates. Mean pan evaporation exceeds mean rainfall in most months of the year in sub-coastal south-east Queensland. This reduces the effectiveness of the rainfall, and means that water deficiency is a major limitation to plant growth. Pan evaporation data for Gatton is provided, as it is not available for stations in the survey area. This is compared with mean monthly rainfall in Table 4.

Table 4 *Mean monthly rainfall and pan evaporation for Gatton**

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean rainfall (mm)	114	100	84	51	42	47	41	28	36	67	76	100	787
Mean monthly pan evaporation (mm)	201	170	164	129	99	87	93	118	153	183	195	217	1809

* located approximately 40 km south east of Esk
Source: Bureau of Meteorology (97 years of rainfall and 26 years of evaporation data to 1993)

Drought

Droughts, defined as *severe rainfall deficiencies over a period of at least 12 months*, are a regular occurrence in the area. Twenty droughts (where annual rainfall is less than the driest 10% of years for each period) have been recorded in the Brisbane Valley between 1886 and 1993. Thus, drought can be expected to occur approximately one year in every five. A severe drought has less rainfall than that received in the driest 5% of calendar years. The occurrence of drought in the Brisbane Valley area is shown in Table 5.

Table 5 *Occurrence of drought at Esk, 1886 – 1993*

Drought Period	Duration (months)	Total rainfall (mm)	% of time in severe drought
Nov 1887 to Apr 1889	18	1138	14
Jun 1901 to Feb 1903	21	1062	70
Feb 1911 to Jan 1912	12	592	0
Mar 1915 to Feb 1916	12	583	0
Jan 1918 to Dec 1919	24	1141	38
Dec 1922 to Nov 1923	12	641	0
Apr 1931 to Aug 1932	17	715	17
Nov 1935 to Jul 937	21	1228	0
Jan 1941 to Sep 1942	21	1139	20
Feb 1951 to Sep 1952	20	940	56
Jul 1956 to Mar 1958	21	1126	10
Jan 1960 to Dec 1960	12	619	0
May 1964 to Jun 1965	14	665	0
Feb 1968 to Oct 1969	21	989	70
Oct 1976 to Mar 1978	18	1064	57
Feb 1979 to Dec 1980	23	1081	50
May 1982 to Apr 1983	14	770	0
May 1985 to Nov 1987	31	1547	30
June 1990 to Nov 1991	18	716	100
May 1992 to Dec 1993[4]	20	792	89

Source: Clewett *et al.*, 1994 (*Australian Rainman*)

Flooding

The Bureau of Meteorology (1983) has tabulated details of some 36 major flooding episodes associated with the Brisbane River in the last 140 years. *Local flash flooding* may affect local creek and gully areas, and particularly low-lying roadways. Such flooding generally follows severe thunderstorms and is regarded as inevitable by the Bureau of Meteorology (1983). *Major flash flooding* is associated with more prolonged rain (over 24 hours in duration) associated with more significant synoptic systems (Bureau of Meteorology, 1983). This is most likely to occur from December to April. *Major river flooding* such as in January 1974 (lower Brisbane River) and in February 1999 (upper Brisbane River) is far less frequent, but appears to have occurred in the Brisbane River system at least once in every generation (Auliciems, 1990).

2.3.2 Temperature

Long-term maximum and minimum temperatures (and the observation of frosts) for Somerset Dam and Gatton (both outside the survey area) are shown in Table 6.

Very hot days (maxima ≥ 38°C) occur for only 2 to 4 days each year. The coldest months are June, July and August with an average daily minima of less than 9° for this period. Frosts are most common in these months, but they may also occur in May and September.

2.3.3 Climate and agriculture

The regional climate is well suited to crop and pasture production, livestock production as well as human occupation (Lloyd, 1990).

Rainfall occurrence and reliability are probably the most important climatic factors influencing agricultural production (Faulkner, 1996). Supplementary water for irrigation is essential for intensive cropping such as vegetables. However, significant areas of field crop and sown pasture are grown without irrigation, resulting in production of variable quality and quantity.

[4] This drought continued until October, 1995 (*Long Paddock*, DPI, 1996)

GATTON (Lat: 27.55° S, Long: 152.33° E)													
Mean maximum temperature (°C)	31.1	30.6	29.4	27.2	23.5	21.0	20.4	21.9	24.9	27.4	29.4	30.8	26.5
Mean minimum temperature (°C)	19.5	19.1	17.4	13.9	10.6	7.6	6.0	7.1	9.5	13.2	15.9	18.4	13.2
Days of frost observation: average					1	2	6	4	1				
highest					9	10	27	14	13				
SOMERSET DAM (Lat: 27.12° S, Long: 152.55° E)													
Mean maximum temperature (°C)	30.2	29.8	28.3	26.5	23.0	20.7	19.7	21.6	24.3	27.0	29.4	30.0	25.9
Mean minimum temperature (°C)	19.1	19.2	17.7	15.1	10.7	8.5	6.4	7.6	10.4	13.8	16.5	18.0	13.6
Days of frost observation: average					0	1	3	2					
highest					2	5	10	6					

Source: Bureau of Meteorology. No stations record data in the survey area.

Native pastures reach maximum productivity during summer, which can lead to feed deficiencies for beef cattle in winter and spring. Supplementary irrigation and the production of forage crops can assist in the shortfall, but this is costly. Most winter feeding programs rely on summer-grown hay, silage and grain. Temperate pastures such as white clover and annual ryegrass produce high quality feed from autumn until early summer but require irrigation for good production and persistence (Hawley, 1994). Summer crops are planted when there is sufficient soil moisture and a probability of follow-up rains. Extremely high temperatures, together with low humidity and moisture stress can damage summer grain crops, particularly in their early reproductive stages. There are distinct early and late summer cropping phases to ensure that the stress during the flowering stage is minimised (Faulkner, 1996). Winter cereals grown under dryland conditions are a minor component of cropping systems due to lower rainfall.

On sloping lands, soil erosion potential is high due to periods of high erosion index (EI_{30}) coinciding with the sowing period for summer crops. Maintaining surface cover (including minimum or zero tillage practices) reduces the risk. Appropriate soil conservation measures should be implemented if cultivating sloping ground, and no routine cultivation should be undertaken on slopes >8% for all soil types.

Flooding may be a severe limitation and is generally associated with high value soils on alluvium. Hail associated with storms can severely damage crops as can frost. Planting times for some crops are influenced by the probability of frost occurrence.

Figure 5 *Maintaining surface cover is essential under tree crops on sloping ground (mango plantation west of Toogoolawah)*

2.4 GEOLOGY AND LANDFORM

2.4.1 Geological units and physiography

The survey area is dominated by the Esk Trough — a large Mesozoic basin located between two major Palaeozoic Blocks (the Yarraman Block to the west and the D'Aguilar Block to the east).

The *Esk Trough* is a compressed graben[5]-like feature bounded to the west and east by large faults. It extends over a distance of 270 km from near the Wivenhoe Dam wall to as far north as Gayndah. The maximum width of the trough is 35 km. At its southern end, the trough disappears beneath the overlying sediments of the Moreton Basin (Day *et al.*, 1974).

The Yarraman and D'Aguilar Blocks form the topographic high points of the survey area, although parts of the Esk Trough are also elevated and rugged due to folding and/or faulting. The Mt Esk Rhyolitic Complex dominates the topography in the south of the survey area, in the vicinity of Esk.

Each of the three major structural elements is comprised of several smaller units (including various intrusions). The lithology, landform and age relationships of the geological units in the survey area (including the alluvium) are summarised in Table 7. The distribution of the geological units is illustrated in Figure 6.

Because of their importance in the survey area, the rocks of the Esk Trough, and their stratigraphic relationships, are described in more detail. Three major geological units are present in the Trough: two sedimentary units (*Bryden Formation* and *Esk Formation*) and a volcanic unit (*Neara Volcanics)*.

Esk and Bryden Formations

The Esk Formation has the most extensive distribution of the sedimentary groups, outcropping in the western and southern areas of the Esk Trough. It comprises conglomerates, sandstones and shale. It has a maximum thickness of up to 3000 m in the north, but thins southward, to about 300 m near Esk (Cranfield *et al.*, 1976). A characteristic feature of the Esk sediments is the rapid alteration of sediment type, both laterally and vertically; for example, poorly sorted conglomerate beds grading into medium-grained sandstones (Zimmerman, 1956). This suggests a rapid deposition in a swiftly subsiding basin bordered by highlands, with fluctuating energy levels of the depositing streams (Day *et al.*, 1974). In places, layers of tuff are present in the sedimentary beds, indicating concurrent volcanic activity. The Esk Formation is also extensively intruded by a variety of porphyritic materials (the *Brisbane Valley Porphyrites*). Many small outcrops of porphyry (often with a granitic-like appearance) have been exposed by erosion of the overlying sediments of the Esk Formation. Many of these are not indicated on geological maps. Good examples can be seen at Colinton and at the Yimbun and Ottaba railway cuttings.

The Bryden Formation is similar to the Esk Formation, but outcrops over a smaller area (in the north of the survey area, and small areas to the east and south-east). Comprising the oldest sediments of the Esk Trough, it is generally overlain by other rocks.

Neara Volcanics

The Neara Volcanics outcrop over much of the eastern portion of the Esk Trough. They include a variety of rock types, with one common feature — the andesitic[6] nature of most of their constituents.

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[5] A downthrown, linear, crustal block bordered lengthways by normal faults (Allaby and Allaby, 1990). The term *Esk Trough* (after Jorgenson and Barton, 1966) has been generally adopted in preference to the *Esk Rift*, because the border faults lack continuity.

[6] Andesite is a fine grained, volcanic rock, usually dark grey in colour. It is similar to basalt, but contains a small amount of quartz (< 10%), and is hence termed intermediate. Basalt contains no quartz (and is termed basic). Acid rocks are igneous rocks that contain more than 10% quartz (eg. granite, granodiorite, rhyolite).

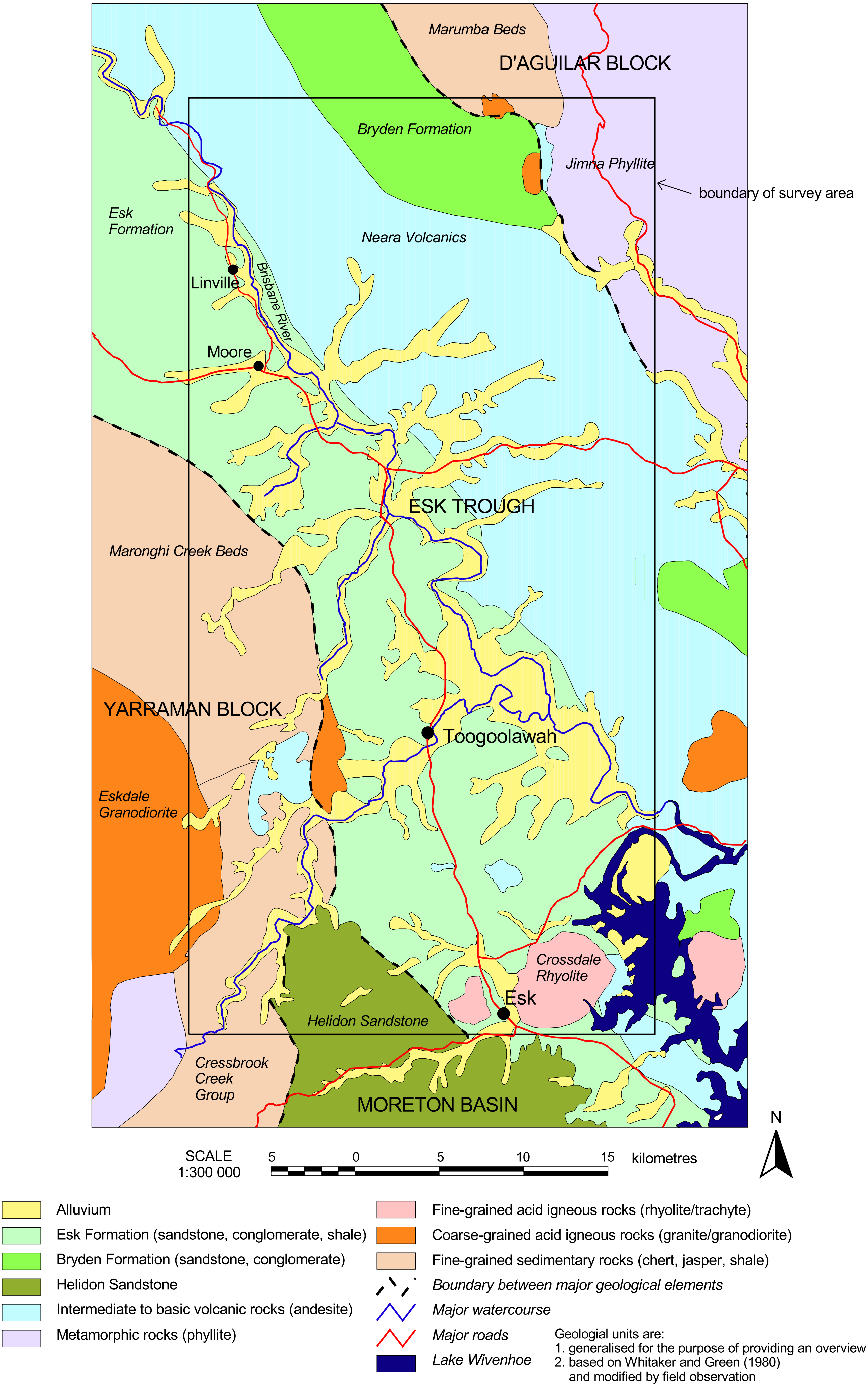


Figure 6 *Map showing geological units in the survey area*

Table 7 *Geological units in the survey area arranged according to major structural elements*

Geological unit and symbol	General geological grouping	Area (ha) in survey area	Landform	Lithology	Age
<u>ALLUVIUM</u>					
Terraces and alluvial plains Qa	Alluvium	22 741	level to gently undulating plains	sand, clay, gravel, unconsolidated material	QUATERNARY
High old river terraces TQa	Alluvium	2 981	undulating plains and rises	gravel, cobble, clay, sands, unconsolidated material	TERTIARY/ QUATERNARY Pliocene-Pleistocene
<u>MORETON BASIN</u>					
Helidon Sandstone RJbh	Coarse-grained sedimentary rocks	3488	rolling rises to steep hills	sandstone, siltstone, minor shale and conglomerate	MESOZOIC Triassic to Jurassic
<u>ESK TROUGH</u>					
Bryden Formation Rtb	Coarse-grained sedimentary rocks	4 751	rolling rises to steep hills	conglomerate, sandstone, shale, minor tuff	MESOZOIC Early to Middle Triassic
Neara Volcanics Rtn	Intermediate to basic volcanic rocks	40 977	rolling rises to steep hills	volcanic conglomerate, andesite, agglomerate, minor mudstones	MESOZOIC Middle Triassic
Esk Formation Rte	Coarse-grained sedimentary rocks	30 417	undulating rises to steep hills	sandstone, conglomerate, mudstone, shale, minor tuff	MESOZOIC Middle Triassic
Crossdale Rhyolite (and undifferentiated trachytes/rhyolites) Rji	Fine-grained acid igneous rocks	2 864	steep hills/mountains	rhyolite	MESOZOIC Triassic to Jurassic
Brisbane Valley Porphyrites Jkib, Rib	Intermediate to basic volcanic rocks	535	steep hills	porphyritic microgranite and microdiorite, rhyolite, minor andesite	MESOZOIC Jurassic to Cretaceous
<u>YARRAMAN BLOCK</u>					
Maronghi Creek Beds DCm	Fine-grained sedimentary rocks	8 844	mountains	chert, jasper, slate, mudstone, metavolcanics	PALAEOZOIC Devonian-Carboniferous
Cressbrook Creek Group Pc	Fine-grained sedimentary rocks	5 519	steep hills to mountains	sandstone, shale, mudstone, chert, rhyolite, andesite, conglomerate	PALAEOZOIC Permian
Eskdale Granodiorite and other granitic intrusions Prge, PR*g*	Coarse-grained acid igneous rocks	2374	rolling to steep hills	granodiorite, granite and other acid intrusives	MESOZOIC Permian to Triassic (intruded into PALAEOZOIC rocks)
Gilla Andesite PRg	Intermediate to basic volcanic rocks	893	steep hills	andesite (intermediate volcanics)	MESOZOIC Permian to Triassic
<u>D'AGUILAR BLOCK</u>					
Jimna Phyllite Cd	Metamorphic rocks	5 643	mountains	phyllite, basic meta-volcanics, greywacke	PALAEOZOIC Carboniferous
Marumba Beds Pm	Fine-grained sedimentary rocks	679	steep hills	mudstone, sandstone, conglomerate, rhyolite	PALAEOZOIC Permian
Undifferentiated Granitic Intrusion Rg	Coarse-grained acid igneous rocks	282	steep hills	granite and other acid intrusives	MESOZOIC Triassic

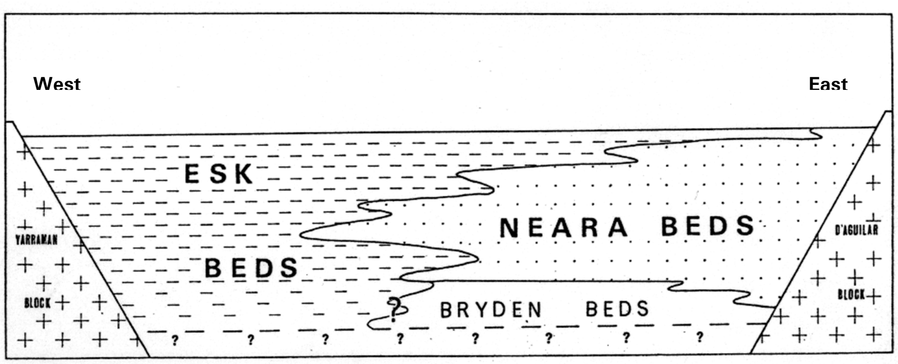
Notes:
1. Names and symbols for geological units are taken from *Moreton Geology, 1:500 000 map* (Whitaker & Green, 1980) except for Jimna Phyllite, which is based on Donchak *et al.* (1995).
2. The general geological grouping has been used to group the soil profile classes (see Table 17).
3. Geological Eras and Sub-eras are capitalised; Periods and Epochs are in lower case.
4. The Cressbrook Creek Group actually forms a small block at the south-eastern margin of the Yarraman Block, but is here considered as part of the Yarraman Block. Similarly, the Marumba Beds, although a separate block, are included with the D'Aguilar Block.
5. Miscellaneous mapping units (stream channels, lake, some urban areas) totalling 4 451 ha were not allocated to geological groups.

Figure 7 *Low hills of rounded topography are a common feature of the Neara Volcanics (D'Aguilar Highway, northeast of Harlin)*

Included in the Neara Volcanics are andesitic flows, andesitic boulder beds and minor tuffs. In addition to andesite, a common rock is volcanic conglomerate, which generally consists of large rounded boulders set in an andesitic flow matrix or angular boulders of various sizes in a tuffaceous matrix; or a combination of both (Hill, 1930). Hill also described a true conglomerate with its matrix consisting of clastic grains. The large occurrence of andesitic boulders and fragments has been suggested by various writers as evidence for rapid deposition in an aqueous environment. This theory is supported by the presence of shale bands. These volcanic beds were probably deposited as lava streams or mud flows (lahars) which filled the valley floors.

The Neara Volcanics appear to have been deposited at about the same time as the sediments of the Esk and Bryden Formations. Porphyritic rocks similar to the Brisbane Valley Porphyrites also intrude them. The Bryden Formation inter-fingers with, and is conformably overlain by the andesitic flows. However, the stratigraphic relationship between the Esk Formation and the Neara Volcanics is ill defined. Generally, the Esk Formation conformably overlies the Neara Volcanics (Day *et al.*, 1974). However, Jell (1969) observed Neara Volcanics overlying the Esk Formation in the Linville area (see Figure 8).

The Brisbane River meanders along the boundary of the Esk Formation and the Neara Volcanics, generally favouring the softer rocks of the Esk Formation. Such structural control of the drainage pattern is typical for this region (Beckmann and Stevens, 1978).



The Esk Trough lies between the Yarraman Block in the west and the D'Aguilar Block in the east. Source: Jell (1969).

Figure 8 *Diagrammatic representation of the rock units of the Esk Trough at the latitude of Linville*

2.4.2 Geological history

Palaeozoic

The Yarraman and D'Aguilar Blocks contain the oldest rocks in the area, which date from the Palaeozoic Era. They were laid down as sands and clays with some basaltic lava flows, being deposited in relatively deep water off the ancient coastline in pre-Permian times. During the Carboniferous Period they were crumpled, folded and partially metamorphosed by the squeezing of crustal plates. These rocks were still at least partially covered by shallow seas in the Permian Period. Further sedimentation took place, followed by further uplift in late Permian to mid-Triassic times. Both blocks are now bordered by Permian strata along the margins of the Esk Trough, having become elevated during early Triassic times. The Maronghi Creek Beds of the Yarraman Block are less metamorphosed than the phyllites of the D'Aguilar Block (Beckmann and Stevens, 1978). Both Palaeozoic Blocks were intruded by granite-type rocks (eg. Eskdale Granodiorite) in the late Permian to early Triassic periods.

Mesozoic

Tectonic displacements in the Palaeozoic rocks (probably strike-slip faulting) caused the subsidence of a large fault block, leading to the formation of the Esk Trough; the largest movements taking place along the West Ipswich and associated faults (O'Brien *et al*., 1990).

The freshly uplifted mountainous areas (of Palaeozoic rocks) became the source areas for the sediments of the Esk Trough. The sediments of the basal Bryden Formation were the first deposits in this rapidly subsiding trough, followed by outpourings of andesitic volcanic debris. Evidence suggests the extrusive volcanic debris originated along the fault along the western margin of the D'Aguilar Block (Reid, 1966). This was followed by the deposition of non-volcanic material (of the Esk Formation) which continued to fill the trough. In contrast to the Palaeozoic sedimentation, which was almost entirely marine, Mesozoic deposition took place in continental freshwater conditions. Conglomerates of the Esk and Bryden Formations contain pebbles, cobbles and boulders of quartzite, jasper and chert consistent with source areas such as the Maronghi Creek Beds, the Jimna Phyllite and the Cressbrook Creek Group. The absence of any material resembling the boulders of the Neara Volcanics indicates these volcanics did not act as source rocks for the Esk Formation (Zimmerman, 1956). The small amounts of volcanic material present in the sediments of the Esk Formation possibly came from the same source that gave rise to the layers of tuff that are also present. The trachyte mass just to the west of Esk has been suggested as a site for the vent that released at least some of the tuffs and igneous flows of the area (Zimmerman, 1956).

Figure 9 *The regional strike of bedding in the Esk Formation is evident in this ridge, located west of Harlin*

It seems likely that at the time of the Triassic deposition, the Esk Trough was a shallow basin being steadily filled, perhaps as it continued to subside, by the rapidly eroding highlands (the absence of graded bedding in the Esk sediments indicates that deep water conditions were unlikely). Shallow water would have led to the concentration of evaporite-rich lakes or swamps which would account for the calcareous nature of the Esk sediments, as well as the formation of the thin coal seams present (Cranfield *et al.*, 1976).

Later in the Mesozoic Era, the Esk Trough strata were folded parallel to the regional strike of the Palaeozoic blocks (due to compressive forces in the basement rocks). Subsequent tensional forces caused marginal fault movements (Reid, 1966).

Development of the Moreton Basin began in the late Triassic, with deposition of conglomerate, followed by finer-grained sediments in the Ipswich area. Sands of the Helidon Sandstone were then formed over a wide area, possibly by braided streams, and deposited unconformably over the sediments of the Esk Formation. A fault in the D'Aguilar Block allowed the trough to drain (as it does today) — to the south east of the survey area.

Further tensional downfaulting of the Esk Trough and the intrusion of the Brisbane Valley Porphyrites followed deposition of the Helidon Sandstones. Hill (1930) postulated that these intrusions have been more prevalent along lines of anti-clinal fracturing. The Mt. Esk Rhyolitic Complex (Crossdale Rhyolite) was extruded over the sediments of the Esk Formation as a series of domes, possibly during the Jurassic Period (West, 1975).

Cainozoic

In the early Tertiary Period, sediments were deposited in small basins developing along the lower Brisbane River between Ipswich and Oxley. Their presence shows that a valley existed close to the present river course and that this area has not been affected by earth movements for the last 65 million years at least (Stevens, 1990).

Basalts erupted from vents in the scarp of the Main Range (and the Blackbutt Range, to the west of the survey area) in the Tertiary Period (more specifically the Miocene Epoch) and cap the western margin of the Brisbane River catchment. It has been suggested (Beckmann and Stevens, 1978) that the western part of the Esk Trough was once covered by basaltic flows, protruding as far as Esk and Toogoolawah. The headward backcutting of all streams produced the radial drainage pattern observed today.

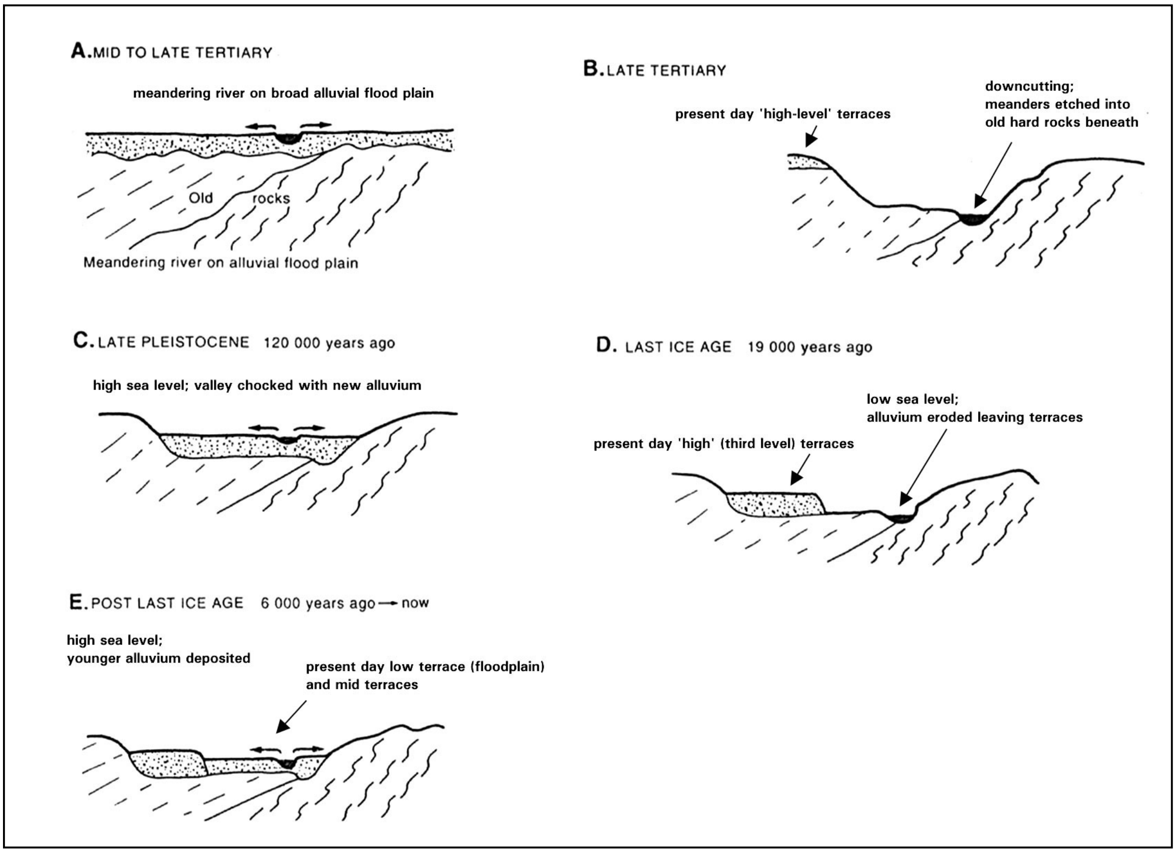
Figure 10 *Rugged terrain in the eastern portion of the Esk Trough in the northeastern part of the survey area*

Tertiary and Quaternary alluvium

The Brisbane River and its tributaries have seen alluvium deposited, removed and deposited again since the late Tertiary. This cyclic pattern is due to marked changes in climate (and hence sea level). Alluvial terraces can be dated (in relation to one another) by using landform and soil features as well as information about past climate change.

In the upper Brisbane Valley, alluvial terraces are generally confined to areas within the Esk Trough. The older Palaeozoic sediments have narrow gullies with only minor terraces or flood plains. Hill (1930) commented about the ‘surprisingly large’ area of alluvium associated with Cressbrook Creek, which is far more extensive than the Brisbane River alluvium in the Toogoolawah area. Three sets of terraces are generally observable along Brisbane River and Cressbrook Creek — referred to as low terrace, middle terrace and high (or upper) terrace. The low terrace is more correctly designated a flood plain because of its relatively frequent inundation. This survey identified a series of high-level terraces (a ‘fourth level’ of terraces) that had not been previously mapped as alluvium.

The progressive development of the Brisbane River Valley is shown in Figure 11. The present course of the river was apparently established as a series of migrating meanders on a broad alluvial plain, at a slightly higher level than the present, late in the Tertiary period (Willmott, 1992). A subsequent fall in sea level saw the river cut down in its plain and into the underlying rocks, entrenching and fixing its meanders between rock banks. Rocky cliffs adjacent to meanders are a prominent feature of the lower Brisbane River (eg. at Kangaroo Point) but can also be seen in the upper Brisbane River (eg. near Harlin). Most of the Tertiary alluvial plain was subsequently eroded away. A later rise in sea level (in the late Pleistocene) caused alluvium to be deposited in the river and associated stream valleys. Another fall in sea level, associated with the last Ice Age (18 to 20 thousand years ago), saw this alluvium eroded, leaving horizontal terraces on the sides of the valleys. As the sea level rose again to present levels, younger alluvium has again been deposited in the entrenched, terraced valley in a series of terraces (see Figure 11). Modern flooding covers many of the lower plains (depositing sediment), but very little deposition occurs on the higher terraces, where deep texture contrast soils have developed.



Adapted from: Willmott, 1992

Figure 11 *Progressive development of the Brisbane River valley*

The third (or 'upper') terrace observed in the survey area probably corresponds to depositions during the last inter-glacial period (late Pleistocene, about 120 000 years ago), when the sea level was higher than it is today (see Figure 11). Similar high terraces are described in south-east Queensland and documented in various reports (Beckmann, 1959; Mew, 1978; Smith *et al.*, 1983; Powell, 1987). These terraces generally consist of fine alluvial sediments and are 20 m to 30 m higher than the existing stream level.

The 'high-level' (fourth level) terraces occur at a higher elevation than the 'upper' terraces, approximately 25 m to 40 m above the current river level and are generally associated with meanders of the Brisbane River (see Figure 12). They are also found along the Cressbrook and Maronghi Creeks at 10 m to 15 m above the current stream level. The high-level terraces identified in the survey area total approximately 3000 ha; however it is possible that with further investigation, this area could be added to.

The high-level terraces range from flat to undulating topography and the soils have a strongly developed texture contrast with mottled subsoils and acid reaction trend. Water-worn coarse gravel and cobble is commonly (but not always) found throughout the soil profile. The presence of this gravel suggests a rapid deposition of alluvial material, which is to be expected if these terraces date from the Tertiary period. However, lateritic products (such as ferruginised gravel) in these sediments are only observed in one or two locations (see Section 4.1.1).

These high-level terraces probably correlate with, but are far more extensive than the gravels documented by Laycock (1964). Laycock described high-level gravel occurrences at a number of localities on the Brisbane River near Esk as a 'thin veneer', probably of Tertiary age. Occurrences of high terrace gravels associated with the Brisbane River (as far upstream as Lake Wivenhoe) have been identified and allocated to the Pliocene Epoch (late Tertiary) or the Pleistocene Epoch (early Quaternary) in recent geological mapping (Cranfield *et al.*, 1981; Whitaker and Green, 1980). Smith *et al.* (1983) describe one of these occurrences at Moggill, on the lower Brisbane River, which is deeply weathered (lateritised) and dissected with steep escarpments occurring along parts of its perimeter. At about 70 m above sea level it is the highest land in the area and 'clearly a remnant of a much more extensive old surface'. Wilson and Sorby (1991) described similar landforms in the Inland Burnett area of south-east Queensland.

Characteristics of the soil type commonly associated with the high-level terraces (**Ottaba** soil profile class) are discussed in Section 4.1.1 and Section 4.3.

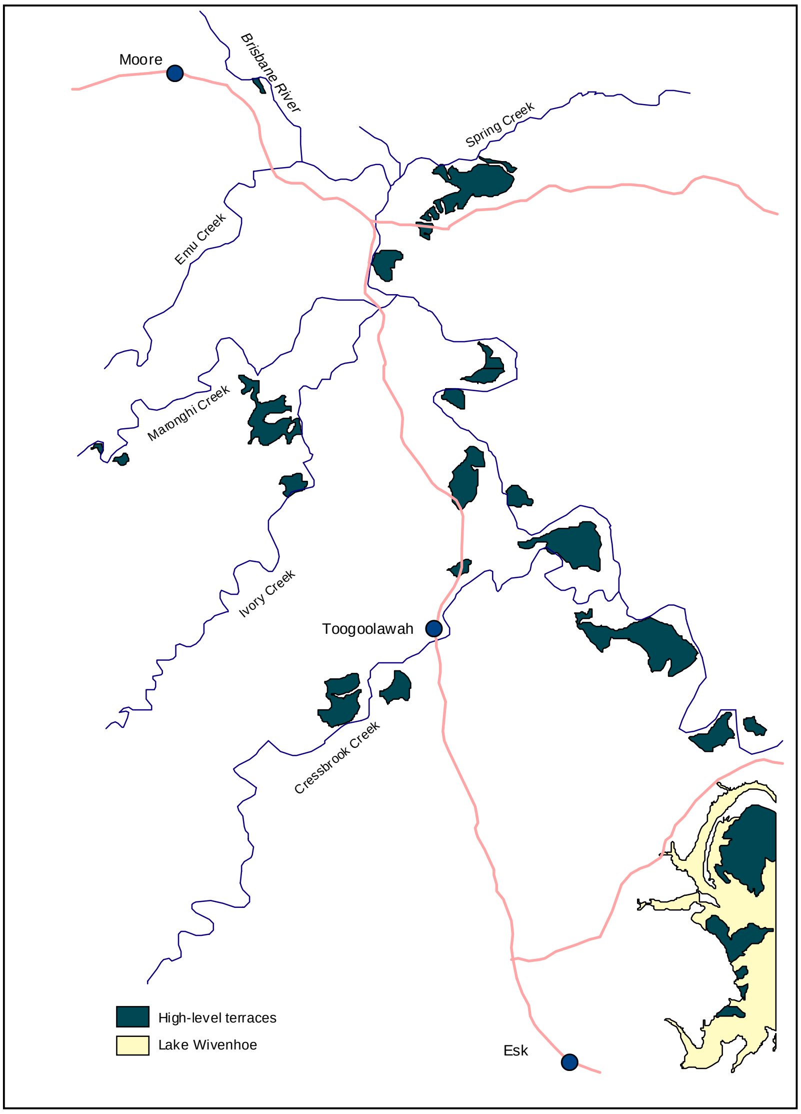


Figure 12 *Occurrence of high-level alluvial terraces in the Brisbane Valley survey area*

Current seismo-tectonic activity

A zone of seismic activity still exists in the Brisbane Valley area, extending into northern New South Wales. Activity is concentrated within several kilometres of the southern end of the eastern fault of the Esk Trough; further north, the activity is up to 10 km to the west of the mapped outcrop of the fault. In 12 years of monitoring, over 200 earthquakes with magnitudes from -2.0 to 4.0[7] have been located in the Wivenhoe Dam area. Of these, 68 have been located with sufficient accuracy to allow correlation between seismicity and geological structure. A north-east dipping structure to at least 10 km depth is indicated, resulting from the crust being compressed horizontally in a northeast-southwest direction (Cuthbertson, 1990).

2.4.3 Geology and soils

In this survey, soil profile classes have been grouped according to substrate or parent material (ie. underlying geology). The general geological groups used to categorise soil profile classes are shown in Table 7. This practice highlights the importance of parent material as a determining factor of soil properties. Detailed soil mapping was not attempted in areas of steep and rugged terrain. Key area data based on geology was used for the extrapolation of soil information for areas mapped as miscellaneous soil units (see accompanying Maps 1 and 2).

Figure 13 *The small settlement of Yednia in the north east of the survey area is surrounded by steep hills of Jimna Phyllite (part of the D'Aguilar Block)*

[7] earthquake magnitudes analogous to 'Richter' scale

2.5 VEGETATION

Grazing, agriculture and residential development have extensively modified the vegetation of the Brisbane Valley. Pre-European-settlement vegetation for the Ipswich 1:250 000 map sheet has been described and mapped by Elsol (1991) and the vegetation for the Nanango 1:100 000 sheet has been mapped by Pedley (Queensland Herbarium, unpublished). Boyland and Durrington (1973) have described the vegetation in the Esk Shire. A concurrent survey by the Department of Environment is mapping both the existing and pre-European vegetation in Esk Shire (Johnson and Lawson, 1997). During the current survey, dominant vegetation species (including trees and grasses) were recorded at all soil description sites, as well as the level of disturbance (degree of clearing). The relationships between vegetation distribution and soil groups are discussed in Section 4.2.

2.5.1 Open forest and woodland communities

Fringing forests

These narrow belts of vegetation are found along the Brisbane River and associated watercourses. They are found in the actual stream channels or on the channel benches, rarely extending beyond the main bank.

Characteristic trees are *Casuarina cunninghamiana* (river she-oak), *Melaleuca bracteata* (black tea tree) and *Callistemon viminalis* (red bottlebrush). A grassy ground cover is often present. The understorey may contain *Cudrania cochinchinensis* (cockspur thorn). Introduced plants are often encountered, including *Salix babylonica* (weeping willow), and problem weeds such as *Gleditsia triacanthos* (honey locust) and *Macfadyena ungis-cati* (cat's claw vine).

Along some creeks, 'scrub' species may also be found; for example *Grevillea robusta* (silky oak), *Melia azedarach* var. *australasica* (white cedar), *Castanospermum australe* (black bean), *Waterhousia floribunda* (weeping lilly pilly), *Mallotus phillipensis*, *Eugenia* spp. (lilly pilly) and *Lophostemon confertus* (scrub box).

Blue gum woodlands

The widespread blue gum flats of the alluvial plains and terraces have been extensively cleared for agriculture. Regular burning by aborigines probably contributed to the original open formation and grassy understorey (Young, 1990). In addition to *Eucalyptus tereticornis* (Queensland blue gum), *Angophora subvelutina* (broad-leaved apple) and *Corymbia tessellaris* (Moreton Bay ash) are also conspicuous. *Lophostemon suaveolens* (swamp mahogany) is also common in wetter areas. *Angophora leiocarpa* (rusty gum) and *Eucalyptus moluccana* (gum topped box) may be found along with blue gum and other species on the higher alluvial terraces. *Eucalyptus melanophloia* (silver-leaved ironbark) and *Eucalyptus crebra* (narrow-leaved ironbark) may also be found in rare instances.

Figure 14 *Queensland blue gum along a creek in the Brisbane Valley*

Grasses include *Bothriochloa bladhii* (forest bluegrass), *Dicanthium sericeum* (Queensland bluegrass), *Bothriochloa decipiens* (pitted bluegrass), *Digitaria didactyla* (blue couch), *Cynodon dactylon* (green couch), *Cymbopogon refractus* (barbwire grass) and *Aristida* spp. (wiregrass). *Heteropogon contortus* (black speargrass) is less common. The introduced paspalum (*Paspalum dilatum*) is commonly found; and legumes and fodder crops are widely grown.

Ironbark open forests and woodlands

These cover by far the largest area of any vegetation type in the survey area, occurring on all geological units and nearly all landforms apart from stream channels and the low and middle alluvial terraces. *Eucalyptus crebra* (narrow leaved ironbark) or *Eucalyptus melanophloia* (silver-leaved ironbark) usually predominate with narrow leaved ironbark being the most common. *Eucalyptus fibrosa* subsp. *fibrosa* (broad leaved ironbark) was recorded occasionally. *Eucalyptus siderophloia* (grey ironbark) was not readily distinguished from *E. crebra*, so if it occurred, it was documented as *E. crebra*.

Other species to occur in the ironbark associations are *Eucalyptus tereticornis*, *Corymbia tessellaris*, *C. intermedia* (pink bloodwood) and occasionally *C. citriodora* (spotted gum). There is no distinct shrubby layer, but scattered shrubs and small trees do occur. These include *Alphitonia excelsa* (red ash), *Exocarpus cupressiformis* (native cherry), *Allocasuarina torulosa* (rose she-oak), *Allocasuarina littoralis* (black she-oak), *Acacia aulacocarpa* (hickory wattle) and *Brachychiton populneus* (kurrajong). In the north, *Xanthorrhoea glauca* (glaucous-leaved grass tree) is locally common. Regular controlled burning used to control weeds and rejuvenate the grasses has a marked effect on the understorey flora. *Lantana camara* is widely distributed.

There is usually a good cover of grasses such as *Bothriochloa decepiens* (pitted bluegrass), *Heteropogon contortus* (black spear grass), *Aristida* spp. (wire grass), *Eragrostis* spp. (love grasses), *Themeda triandra* (kangaroo grass), *Sporobolis creber* (slender rat’s tail grass) and various *Panicum* spp. Native legumes such as *Glycine tabacina* (glycine pea) also occur.

Spotted gum - ironbark open forests

Corymbia citriodora (spotted gum) communities are common in the central to southern parts of the survey area on the Helidon Sandstone and Permian Fine Sediments and also in the north-east on Jimna Phyllite. They are particularly prevalent on the upper slopes and crests of hills and mountains. Rock outcrop and surface rock are common. *Eucalyptus crebra* (narrow-leaved ironbark) is also often present and other associated species may be *Angophora leiocarpa* (rusty gum), *Angophora woodsiana* (smudgee), *Corymbia intermedia*, *Eucalyptus tereticornis* and *Corymbia tessellaris*. In the north-east, on Jimna Phyllite, associated species include *Eucalyptus carnea* (broad-leaved white mahogany), *E. acmenoides* (yellow stringbark), *E. propinqua* (small fruited grey gum). As for the ironbark open forests, the shrub layer is sparse and similar grass species occur.

Gum-topped box open forest

Small areas of *Eucalyptus moluccana* (gum-topped box) open forest occur, particularly in the southern part of the survey area to the west of Esk and Toogoolawah. It is found on undulating rises, hillslopes and colluvium associated with the coarse-grained sedimentary rocks, but may also occur on the fine-grained sedimentary rocks. It is often in pure stands but may occur with *Eucalyptus crebra*, *E. tessellaris*, *E. tereticornis* and *Corymbia citriodora*. *Melaleuca bracteata* (black tea tree) or *Alphitonia excelsa* (red ash) may be present in the understorey.

Queensland peppermint - brown bloodwood open forest

This community of *Eucalyptus exserta* (Queensland peppermint) and *Corymbia trachyphloia* (brown bloodwood) is confined to the rhyolite domes (eg. Mt Esk) in the south of the survey area. Also documented in this association (by Johnson and Lawson, 1997), are *Eucalyptus acmenoides* (yellow stringybark), *E. dura* (gum topped ironbark), *E. fibrosa* subsp. *fibrosa*, (broad leaved ironbark), *Corymbia citriodora* (spotted gum) and *Allocasuarina littoralis*. The lower stratum contains *Grevillea banksii* and *Xanthorrhoea johnsonii*.

2.5.2 Closed forest (softwood scrub)

Areas of closed forest known as 'dry rainforest' or *softwood scrub* have an extensive distribution in the survey area. These communities generally fit into the *Araucarian notophyll/microphyll vine forest* (ANVF/AMVF) of Webb (1959, 1978); however, some areas may be better classified as *semi-evergreen vine thicket* (SEVT). Structurally, rainforest may be defined as closed forest, but it is distinguished from other closed forests by the presence of epiphytes, lianes, root and stem structures and by the absence of annual herbs on the forest floor (Walker and Hopkins, 1990). It often occurs as scattered patches and may be intermixed with sclerophyllous species such as *Eucalyptus spp*. and *Lophostemon confertus*. Young and McDonald (1987) have reviewed the distribution, composition and status of rainforest in southern Queensland.

Araucaria cunninghamii (hoop pine) is generally conspicuous in the closed forest communities of the upper Brisbane Valley area, rising above the more or less continuous canopy. On drier sites, the closed forests have a lower canopy height and hoop pine is absent. A large range of tree species is present; common representatives are *Alectryon connatus*, *Flindersia australis* (crow's ash), *Geijera salicifolia* (scrub wilga), *Dendrocnide photinophylla* (shining-leaved stinging tree), *Erythrina vespertilio* (bat's-wing coral tree) and *Euroschinus falcata* (ribbonwood). Shrub species are common, but ground cover is sparse. Vines (lianes) occur frequently. *Acacia harpophylla* (brigalow) is also found occasionally.

Most scrub communities have been disturbed for timber harvesting and many have been cleared for dairying and other grazing enterprises. Near Kilcoy, hoop-pine plantations have replaced considerable areas of scrub. Comparatively intact communities survive in more remote parts of the survey area and almost 300 ha (ANVF type) is protected in the Cressbrook Nature Reserve. Heavy infestations of *Lantana camara* characterise cleared and disturbed areas.

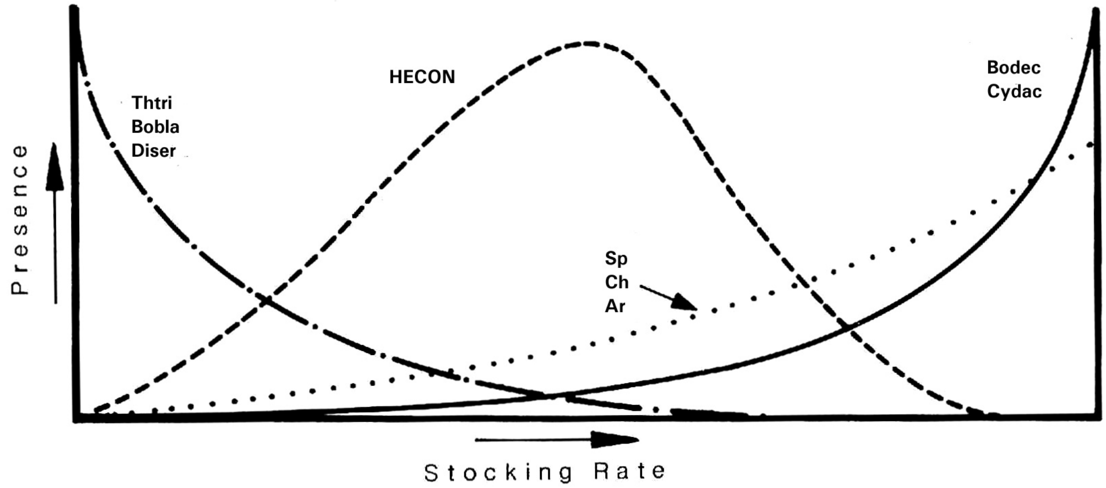
2.5.3 Native pastures

In the woodlands and open forests of the Brisbane Valley, *Heteropogon contortus* (black speargrass) is the most important native pasture species. Observations in the Brisbane Valley support evidence from throughout the 'speargrass belt' of the humid and subhumid zones of Queensland that there are significant changes in botanical composition as grazing pressure increases (see Figure 15). When the region was first settled, *Themeda triandra* (kangaroo grass) was the main species present, but within 20 years of grazing by sheep and cattle, speargrass had started to take over (Partridge, 1993). Now, under continued heavy grazing, speargrass is itself being replaced, usually by less desirable species.

The condition of speargrass pastures can be assessed by recording both the basal area of all plants present and the species composition of the pasture. The presence of *Themeda triandra* and *Bothriochloa bladhii* (forest bluegrass) is a good indicator of conservative rather than excessive stocking rates. Other desirable native pasture species commonly recorded in the survey area were *Dicanthium sericeum* (Queensland bluegrass), *Cymbopogon refractus* (barb-wire grass) and *Hyparrhenia filipendula* (Tambookie grass).

Under excessive stocking rates, the desirable species tend to be replaced by undesirable species such as *Aristida* spp. (wiregrass), *Bothriochloa decipiens* (pitted bluegrass), *Sporobolus creber* or *S. elongatus* (slender rat's-tail grasses), *Eragrostis* spp. (love grass) and *Chloris divaricata* (slender chloris). Greater than 10% basal area of wiregrass indicates degradation of the pasture (Pressland *et al*., 1988).

Both *Cynodon dactylon* (green couch) and the naturalised *Digitaria didactyla* (Queensland blue couch), also replace speargrass under heavy grazing pressure. Couch grass is preferable to wire grass and pitted blue grass because it is palatable and being a creeping grass provides a better ground cover against erosion and weed invasion (Partridge, 1993). On more fertile alluvial and clay soils, naturalised grasses such as paspalum often replace native pasture species.



adapted from Pressland *et al.,* 1988

HECON	= *Heteropogon contortus*	Sp	= *Sprorobolus* spp.
Thtri	= *Themeda triandra*	Ch	= *Chloris* spp.
Bobla	= *Bothriochloa bladhii*	Ar	= *Aristida* spp.
Diser	= *Dicanthium sericeum*	Bodec	= *Bothriochloa decipiens*
		Cydac	= *Cynodon dactylon*

Figure 15 *Suggested effects of stocking rate on the composition of speargrass pastures*

Figure 16 *Degraded pasture country in the Brisbane Valley, off the D'Aguilar highway*

2.6 HYDROLOGY

2.6.1 Surface water

The Brisbane River, together with its four principal tributaries (shown in Table 8), drains a catchment area of approximately 1 356 200 ha (13 562 km^2).

Table 8 *Catchment areas of major tributaries and reaches of the Brisbane River*

Sub-catchment	Downstream limit	Catchment area (ha)	%
Upper Brisbane River	Wivenhoe Dam wall	570 300	42
Stanley River	Brisbane River	132 700	10
Middle Brisbane	Mt Crosby	54 700	4
Lockyer Creek	Brisbane River	297 500	22
Bremer River	Brisbane River	203 000	15
Lower Brisbane	Moreton Bay	98 000	7
Total		1 356 200	100

Source: Department of Environment, 1997

The survey area is situated almost entirely in the upper Brisbane River sub-catchment, but overlaps slightly into the Stanley River sub-catchment. The most important tributaries of the Brisbane and Stanley Rivers in the survey area (from north to south) are: Monsildale Creek, Sheep Station Creek, Oaky Creek, Maronghi Creek, Emu Creek, Gregors Creek, Ivory Creek, Cressbrook Creek and Gallanani Creek.

Surface water flow statistics from selected gauging stations in the upper Brisbane Valley are shown in Table 9. The impact of Cressbrook Dam can be seen by contrasting results from the two Cressbrook Creek stations. Tipton is above the Dam, while Rosentretters Bridge is below the dam, SW of Toogoolawah. Selected water quality data for the same stations are shown in Table 10.

Table 9 *Mean monthly flow (ML) and mean annual flow (ML) at selected stream gauging stations in the upper Brisbane Valley*

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Cressbrook Creek at Tipton, 1/1/1952 - 1/1/1987	7 511	10 077	5 243	2 118	3 199	5 450	2 674	1 124	964	1 363	2 315	3 257	51 255
Cressbrook Creek at Rosentretters Br. 1/1/1986 - 1/1/1998	959	834	914	4 209	4 870	1 742	1 253	566	342	238	387	266	19 728
Emu Creek at Boat Mountain 1/1/1965 - 1/1/1998	5 009	9 022	3 574	4 465	4 614	3 8657	1 518	749	885	1008	2 175	3 407	43 494
Brisbane River at Linville 1/1/1964 - 1/1/1998	19 977	21 498	12 208	13 257	6 706	9 574	9 242	3 045	2 436	2 720	6 173	9 624	101 701
Brisbane River at Gregors Creek 1/1/1962 - 1/1/1998	46 764	44 568	27 487	30 069	19 062	25 584	22 128	6 782	5 721	7 061	13 338	20 434	278 743

The dates shown indicate the period of record.
Source: Department of Natural Resources (unpublished data)

The two major dams located in the Brisbane River catchment – Somerset Dam and Wivenhoe Dam – are used for multiple purposes including water supply, flood control, hydroelectric power generation and recreation. The importance of flood control is illustrated by the fact that 55–60% of the total storage of each dam is allocated to flood control. The other on-stream storages that effect water flowing through the survey area are Cressbrook Dam and Perseverance Dam. Table 11 shows the capacities of the major storages in the Brisbane Valley area.

Table 10 *Analysis results for water sampled at stream gauging stations in the upper Brisbane Valley*

TEST	Cressbrook Creek at Tinton	Cressbrook Creek at Rosentretters Bridge	Emu Creek at Boat Mountain	Brisbane River at Linville	Brisbane River at Gregors Creek
No. of results	58	11	41	98	90
Sodium (ppm)	48	39	91	71	73
Calcium (ppm)	30	28	39	48	49
Magnesium (ppm)	54	19	39	30	32
Chloride (ppm)	24	82	210	168	169
Sulfate (ppm)	122	12	10	12	10
Bicarbonate (ppm)	121	125	188	188	204
Fluoride (ppm)	0.2	0.1	0.2	0.2	0.2
Nitrate (ppm)	0.9	0.4	0.9	1.0	1.0
Hardness as $CaCO_3$ (ppm)	174	125	257	237	253
Alkalinity as $CaCO_3$ (ppm)	100	103	157	158	170
pH	7.8	7.6	8.0	8.0	8.0
EC (µS/cm)	581	481	966	820	849
TDS (total dissolved salts) (ppm)	356	306	582	520	539
maximum TDS recorded	*644*	*423*	*808*	*999*	*824*

Source: Department of Natural Resources (unpublished data)

Table 11 *On-stream storages in the Brisbane valley area, and their capacities*

Storage	Capacity (GL)
Wivenhoe Dam	1150
Somerset Dam	370
Cressbrook Dam	82
Perseverance Dam	30

Source: Brisbane River Management Group, 1996a

2.6.2 Groundwater

Groundwater can be obtained from most geological units in the area, but the quality and supply is often inadequate for uses other than stock water. Generally yields are less than 2 L/s from fractured rock aquifers. The best yield and best quality groundwater is obtained from the alluvial aquifers associated with the major watercourses of the Brisbane Valley.

Table 12 shows the average groundwater characteristics of selected aquifer types in south-east Queensland. Table 13 shows the results of water samples taken from bores in five aquifer types of the upper Brisbane Valley. Surface water quality data for the Brisbane River at Gregors Creek is shown for comparison. The conditions of depth, yield and quality cited for each unit will only apply to a well sited bore, having regard for topography and local intake conditions. An outline of the groundwater potential of each of the major geological units is presented below.

1. Alluvium

During the Pleistocene Period, downcutting to at least 45 m below present sea level occurred along the Brisbane River and its tributaries, the maximum depth decreasing upstream (see Figure 11). The valleys were again filled with alluvium during times of higher sea level (Beckmann and Stevens, 1978). This has resulted in the valleys of the Brisbane River and its tributaries having buried floors and considerable quantities of alluvium, which act as a potential source of groundwater. The alluvium of the upper Brisbane River is often up to 21 m thick, while the average thickness of the Cressbrook Creek aquifer is 8.2 m (Laycock, 1964).

The most extensive deposits of alluvium are associated with the Esk Trough (Esk Formation and Neara Volcanics). The older geological units of the D'Aguilar and Yarraman Blocks tend to form steep sided valleys with only narrow gullies. Therefore they would be expected to have limited supplies of underground water.

Of the tributary creeks mentioned above, those confirmed as having significant unconfined[8] aquifers are Cressbrook Creek, Ivory Creek, Maronghi Creek and Emu Creek (McEniery, 1973). Of these, Cressbrook Creek is best documented.

2. Esk and Bryden Formations

The shales, sandstones, conglomerates and interbedded volcanics of the Esk and Bryden Formations have little effective intergranular porosity, but are highly jointed as a result of structural disruption (McEniery 1973). Field observations indicate that most of these fractured rock aquifers are unconfined (McEniery 1973).

Laycock (1964), using random borehole sampling, intersected low yielding water supplies at moderate depth in most cases. The analysis results for the Esk Formation in Table 13 are an average of thirteen bores sampled in this geological unit. The Bryden Formation is similar in lithology to the Esk Formation, so yield and quality are likely to be similar.

3. Neara Volcanics

These are predominantly andesite, which also act as an unconfined fractured rock aquifer. They may be highly vesicular in places, but this feature seems to have little bearing on their behaviour as aquifers (McEniery, 1973).

The reliability of stock water supplies from this unit is classed as good (Laycock, 1964). However, high bicarbonate levels usually mean that the water quality is too poor for human consumption, and the yield is too low for irrigation. The analysis results for Neara Volcanics in Table 13 are an average of twelve bores sampled in this geological unit.

4. Eskdale Granodiorite

Little is known on the aquifer characteristics of this unit. Granites usually possess unconfined aquifers within the zone of weathering or in fissures in the fresh rock (McEniery, 1973).

Laycock (1964) quotes one bore near 'Eskdale' which is high yielding and of good quality. The best prospects for large supplies are in the decomposed material at shallow depth. Groundwater from the fissures could be expected at moderate depth, but yields are unpredictable.

5. Cressbrook Creek group

The rocks in this group are generally highly impermeable and thus underground water occurrence is poor. The best prospects are in the coarse sedimentary rock areas. An analysis result for one bore in the Northbrook Beds is shown in Table 13. The Northbrook Beds, located just to the east of the survey area are of a similar geology to the Cressbrook Creek Group of the Yarraman Block (fine-grained sedimentary rocks).

6. D'Aguilar and Yarraman Blocks

This group includes the phyllites to the north-east of the survey area and the cherts of the Maronghi Creek Beds. These rocks are generally highly impermeable and therefore poor as underground water sources. The steep slopes and rapid fluviatile dissection of the Neranleigh-Fernvale Group (including the Jimna Phyllite) does not permit the formation of a deeply weathered profile and subsurface water could only be expected in fissures, most likely in gully sections (Laycock, 1964).

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[8] a partly saturated water bearing zone with impervious material below, and unsaturated material above (McEniery, 1973).

Table 12 *Average groundwater characteristics of selected aquifers in south-east Queensland.*

Aquifer	Typical bore depth (m)	annual bore yield (ML)	salinity† (mg/L or ppm)	Remarks
Brisbane River	20 – 40	40 – 480	300 – 30 000	stock, domestic and irrigation supplies
Stanley River alluvium	8 – 14	100 (av.)	600 (av.)	stock, domestic and small irrigation supplies
Lockyer Valley alluvium	10 – 36	300 – 900	1 000 (av.)	stock, domestic and irrigation supplies
Stanley River				
porous rocks	30 – 65	4 – 30	200 – 3 500	stock, domestic and
fractured rocks	25 – 45	4 – 70	300 – 3 500	small irrigation supplies
Brisbane River				
porous rocks	25 – 100	11 – 150	200 – 3 000	stock, domestic and
fractured rocks	20 – 50	0 – 180	300 – 6 000	small irrigation supplies

Source: Water Resources Commission (1991)

Table 13 *Analysis results for water sampled from aquifers in the upper Brisbane Valley*

TEST	Brisbane River alluvium	Cressbrook Creek alluvium	Esk Formation	Neara Volcanics	Northbrook Beds	Brisbane R. at Gregors Creek (1963–1996)
No. of samples	9	16	13	12	1	90
Sodium (ppm)	115	191	489	231	402	73
Calcium (ppm)	87	110	127	131	88	49
Magnesium (ppm)	54	80	196	45	246	32
Chloride (ppm)	336	601	1328	363	695	169
Sulfate (ppm)	15	14	37	22	62	10
Bicarbonate (ppm)	221	191	249	589	1293	204
Fluoride (ppm)	0.4	0.3	0.9	0.5	0.4	0.2
Hardness as $CaCO_3$ (ppm)	434	605	1122	513	1230	253
Alkalinity as $CaCO_3$ (ppm)	187		220	483	1060	170
pH	8.0	7.6	8.0	7.2	7.5	8.0
EC (µS/cm)†	1377	2030	4359	1997	3650	849
TDS (total dissolved salts) (ppm)†	866	1280	2752	1181	2170	539

Source: Laycock (1964)

† General upper limits for widespread use (Gill, 1986)

	EC (µS/cm)	TDS (ppm)		EC (dS/m)	TDS (ppm)
domestic	1 600	1 000	beef cattle	9 000	9 000
poultry	5 000	3 000	low salt tolerant crops	1 300	900
pigs, milking cows	8 000	5 000	high salt tolerant crops	5 000	3 300

2.6.3 Water allocation

1. Regulated water

Apart from licensing in the proclaimed area of Cressbrook Creek, restrictions do not apply to the pumping of water from any of the aquifers mentioned in Section 2.6.2 (Shoecraft, pers. comm., 1996). Thirty nine farms draw a total of 2944 ML from the Cressbrook Creek proclaimed groundwater area (Water Resources Commission annual statistics, 1994-95). At the time of the survey, regulated supplies and proclaimed groundwater areas are managed by Department of Natural Resources.

The only regulated surface water supplies in the survey area are released from Toowoomba City Council's Cressbrook Creek Dam. Water charges cover resource management but no infrastructure costs apply. There are 25 licensed users of this water (see Table 14).

2. Unregulated water

In unregulated areas, irrigation licenses to pump surface water are issued on a hectare basis and water meters are not installed. Most watercourses are considered to be fully allocated with very limited scope for any significant increase in irrigation directly from watercourses (Brisbane River Management Group, 1996b). Quantifying an extraction volume is difficult, but assuming 80% of the total licensed area is irrigated and 4 ML/ha is applied, the nominal annual water usage in the Upper Brisbane River Catchment would be in the order of 11 750 ML (see Table 14).

Table 14 *Licensed allocations and nominal annual surface water usage in the Upper Brisbane River Catchment*

Watercourse	No. licensed users (irrigation)	Total allocated hectares (irrigation)	Nominal annual water usage (ML) (irrigation)	Nominal annual use (ML) (stockwatering and domestic)	Total nominal use (ML)
Brisbane River	97	2030	6496	49	6545
Cressbrook Creek	25	269	861	11	872
Ivory Creek	12	71	227	8	235
Maronghi Creek	9	82	262	5	267
Emu Creek	22	342	1094	14	1108
Cooyar Creek	26	293	937	14	951
Yarraman Creek	7	36	115	3	118
Taromeo Creek	4	7	22	39	61
others	58	452	1448	145	1593
TOTALS	*260*	*3582*	*11462*	*282*	*11750*

Source: Department of Natural Resources, Resource Management, unpublished statistics, 1999

Whilst overall water consumption has increased over time, irrigation in some areas has declined due to changes in land use or farm type (eg. replacement of small dairy farms with non-irrigated beef production). There are many private surface water storages and groundwater bores in the Brisbane Valley, which do not require any form of registration or licensing.

Figure 17 *Irrigation in the Brisbane Valley is largely confined to the alluvial flats adjacent to major watercourses.*

The upper photograph shows irrigated pastures along the Brisbane River near Harlin. An irrigated fodder crop is shown in the lower photograph.

3. METHODOLOGY

3.1 SOIL MAPPING

The soils of the upper Brisbane Valley survey area were mapped at a 1:50 000 scale and evaluated for agricultural suitability. A combination of fixed grid and free survey techniques was used, together with air-photo interpretation.

Field work involved a reconnaissance inspection of the entire survey area to gain an insight into the soil landscapes, followed by a *reference making phase* and a *mapping phase* (Gunn *et al*., 1988). All field observations were recorded according to McDonald *et al.* (1990). Observations included landform (pattern and element), slope, morphological type, substrate lithology, disturbance, erosion, microrelief, surface rock, surface condition, and dominant vegetation relating to tallest stratum, mid stratum and lowest stratum (grasses). Soil descriptions were made to a depth of 1.5 m unless hard rock or gravel prevented access to that depth. Undisturbed soil samples for description and analysis were obtained using 50 mm push tubes, hydraulically driven. Occasionally, where vehicular access was prevented or where soils were exceptionally gravelly, samples were obtained using a Jarrett soil auger.

During the reference-making phase, 12 traverses were used to inspect a representative sample of landforms associated with each major geological unit. The 378 site descriptions obtained in these traverses were used to define preliminary soil profile classes based on similarity of morphological attributes.

During the subsequent mapping phase, an additional 2314 sites were described. Free survey techniques were used to select these sites and confirm map unit boundaries. Site density (sites per km^2 of published map) varied from approximately $5/km^2$ in intensively used areas, to less than $1/km^2$ in mountainous terrain. After the mapping phase, descriptions of the soil profile classes were finalised using all available data. All site data were stored on computer file (the site database).

The soils were mapped as compound mapping units, generally containing 60% or more of one soil profile class. At this scale of mapping (1:50 000), minor occurrences of associated soils cannot be separated as distinct mapping units. Areas of steep hilly and mountainous terrain (generally > 15% modal slope), were mapped as miscellaneous units based on geology and vegetation. These units contain a range of soil profile classes. All mapping units were first plotted on 1:25 000 black and white aerial photographs before being transferred to a 1:50 000 cadastral base map.

3.2 SOIL ANALYSIS

A total of 50 soil profiles were sampled for detailed laboratory analysis. These represented the major soil profile classes of the survey area.

These profiles were sampled to a depth of 1.5 m where possible, and analysed at the standard depths as shown in Table 15. The sampling intervals were occasionally altered to allow for thin surface horizons and avoid sampling across horizon boundaries (Baker and Eldershaw, 1993). At each of these sites, a bulk (0–0.10 m) surface sample (composed of 8–10 subsamples) was collected for surface fertility assessment. The specific analyses performed at each depth are shown in Table 15. Full site descriptions and laboratory analyses for these sites are included in Appendix 3. The laboratory methods used are listed in Appendix 6. More information on the specific analytical methods together with general interpretations are contained in Baker and Eldershaw (1993). The general ratings listed in Bruce and Rayment (1982) were also used for interpretation of the chemical analyses.

In addition to the profile samples, a further 85 bulk surface soil samples were taken from sites across the survey area, with the aim of comparing the surface fertility of the major soil profile classes as well as investigating any possible relationships with underlying geology.

Table 15 *Laboratory analyses performed for each standard soil depth sample*

ANALYSIS	Sample type and depth (m)						
	Bulk	Profile					
	0–0.10	0–0.10	0.10–0.20	0.50–0.60	0.80–0.90	1.10–1.20	1.40–1.50
pH, EC, Chloride	x	x	x	x	x	x	x
Exch. cations, CEC or ECEC		x	x	x	x	x	
Total P, K, S		x	x	x	x	x	
Organic C, Total N	x						
Bicarb. extractable P	x						
Extractable K	x						
Nitrate nitrogen	x	x	x	x	x	x	
Sulfate sulfur*	x						
DTPA ext. Fe, Mn, Cu, Zn	x						
Particle size analysis		x	x	x	x	x	
Dispersion ratio		x	x	x	x		
Moisture measurements –							
% air dry		x	x	x	x	x	
1500 kPa content		x	x	x	x		

for laboratory methods used, see Appendix 6

* not for all bulk samples

3.3 RESOURCE INVENTORY COMPILATION

Each occurrence of a mapping unit, named a unique mapping area (UMA), was given a unique number and individually described in terms of area, land resources and degradation. The land resource information includes geology, dominant soil profile class, associated soil profile classes, landform, tree species, woody weed species, disturbance (land use) and degradation. The proportion of the UMA that contains each soil profile class, degradation type and weed species is estimated. Information for each of the 1316 delineated UMAs is stored in a UMA database.

The UMAs have generally been named after the dominant soil profile class present. Where adjacent UMAs have been given the same code, delineation has been made on the basis of modal slope category (which would affect management). Some UMAs were delineated according to *phases*, based on attributes that would have particular significance in the use of the land (eg. eroded, rocky, saline). The dominant soil profile class occupies at least 60% of a map unit area. The estimated proportions of the dominant soil profile class and associated soil profile classes for each UMA are shown in the UMA database. Some UMAs were recorded as consisting entirely of the dominant soil. It is unlikely these UMAs are pure, and at more intense mapping scales other soils may be delineated. In UMAs where two soils were regarded as being co-dominant, the UMAs were not split (for practical reasons at this scale of mapping). These UMAs were given a combined name from the two co-dominant soil profile classes (eg. Bp-Wt, for a combination of **Beppo** and **Watt**). The miscellaneous soil units on steep hills and mountains (modal slope >15%) have been coded in terms of the substrate (underlying geology), and a set of component soil profile classes is listed.

3.4 LAND SUITABILITY EVALUATION

The land in each unique map area (UMA) was assessed for its suitability for each of the following:

- dryland (rainfed) cropping
- irrigated small crops
- irrigated pasture
- dryland sown pastures
- tree and vine crops

This evaluation includes both current and potential land uses and may be used as a basis for property planning, catchment management and strategic planning (including planning for Good Quality Agricultural Land).

3.4.1 Land use limitations

To determine the suitability of a UMA for a particular land use, it is necessary to consider the requirements for each land use. Soil and land attributes that cause less than optimum conditions for the particular use are known as *limitations.*

The specific land use limitations considered in this survey, together with their designated codes (Land Resources Branch Staff, 1990) were:

Soil attributes

- soil water availability (m)
- workability (k)
- surface condition (p)
- nutrient deficiency (nd)
- soil reaction or pH (–)

Land (or climate) attributes

- flooding (f)
- frost (cf)
- rockiness (r)
- soil depth (pd)
- microrelief – or gilgai (tm)

Soil and land attributes

- wetness (w)
- water erosion (e)

For workability, nutrient deficiency and soil reaction, specific attribute levels were applied to each soil profile class (SPC) on the basis of soil morphological and/or chemical properties. These are shown in Appendix 4. Similarly, for soil water availability, a particular attribute level applied to each SPC; however it was necessary for this to be modified in line with observations of soil depth (see Appendix 4). Surface condition was also largely linked to SPC, but as site disturbance and management also have an effect, it was assessed individually for each UMA on the basis of field observations.

For the land attributes, attribute levels were applied to each UMA on the basis of field observations, topographic position and/or local knowledge.

The wetness limitation takes into account soil profile drainage, slope and landscape position. The water erosion limitation also considers both soil attributes (profile form and sodicity) as well as land attributes (slope). Each limitation is considered in more detail in Section 6.1.

3.4.2 Land suitability classification

The five class suitability classification (Land Resources Branch Staff, 1990) used for dryland sown pastures, dryland cropping, irrigated small crops, irrigated pastures and tree/vine crops is as follows:

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 to maintain economic production.*
Class 3	*Suitable land with moderate limitations which either further lower production or require more than the management practices of Class 2 land to maintain economic production.*
Class 4	*Marginal land with severe limitations which make it doubtful whether the inputs required to achieve and maintain production (and/or minimise land degradation) outweigh the long term benefits.*
Class 5	*Unsuitable land with extreme limitations that preclude its use.*

The first three classes are considered suitable for the specified land use. 'Suitable' is not the same as 'useable' and implies that the continued use of the land for the specified land use would be *sustainable* and *productive* in the long term. Land is classified as suitable on the assumption that appropriate soil conservation measures are implemented and maintained. If this is not the case, the specified land use may not be sustainable in the long term.

Class 4 land is considered to be unsuitable land, given that a higher level of inputs would be required to initiate and maintain production as well as contain land degradation. It is doubtful whether the cost of these inputs would outweigh the benefits in the long term, at least in the prevailing economic and technological conditions. Most Class 5 land would always remain unsuitable for that particular land use, as it has limitations that in aggregate are so severe that production would not be considered.

The types of land use considered in this study are shown below:

Dryland cropping	Cereals (grain sorghum, maize, wheat, barley, oats), grain legumes (chick peas, navy beans, soybeans, lupins) oilseeds (sunflower) forage legumes (lablab, cowpeas) and other forage crops (sorghums, millets).
Irrigated small crops	Cucurbits, capsicum, tomato, green beans, peas, sweet corn.
Dryland sown pasture	Callide Rhodes grass, green panic, Gatton panic, Setaria, Pangola, Kikuyu, pasture legumes (Siratro, fine stem stylo, Glycine, Lotononis, Wynn cassia, Leucaena).
Irrigated pasture	Ryegrass, white clover, lucerne, forage oats.
Tree and vine crops	Citrus, avocadoes, grapes, persimmon, low-chill stonefruit, low-chill apples, custard apple, mango, macadamia.

As for crops and irrigated pastures, a five-class suitability system was used for dryland sown pastures. Lands considered *unsuitable* for sown pasture (Class 4 or 5 for dryland sown pasture) were assessed in terms of their potential native pasture productivity: moderate or low.

While tree and vine crops are a minor current land use (see Figure 2), their suitability was assessed because of the considerable potential for further plantings of suitable species.

3.4.3 Land suitability assessment

Each mapping unit (called a *unique mapping area* or UMA) was assessed as to how well it fulfils the requirements for the specified land uses. Land suitability assessment is a three stage process.

Firstly, the requirements of the specific land use are defined. Limitations to plant growth are considered as well as limitations for machinery usage and the management of land degradation.

The second stage in the process is to determine the effect of each limitation on the specific land use. This involves the derivation of *limitation classes*. Limitation classes are also rated on a scale of 1 to 5 (1 negligible, 2 minor, 3 moderate, 4 marginal, 5 severe). Limitation classes were defined following consultation with local extension staff, a literature review and field experience gained during the survey. The combination of limitation classes is then used to derive an overall *suitability class* (1–5) for each land use, for each UMA. The suitability class is usually determined by the most severe limitation identified (Land Resources Branch Staff, 1990).

For each UMA, the attribute levels for each limitation, the limitation classes and the overall suitability class for each land use are recorded in the UMA database (see Figure 18).

Included in this report are land suitability maps for *pastures* and for *irrigated agriculture*. These have been prepared for both the Esk and Moore map sheet areas at a scale of 1:75 000.

3.4.4 Agricultural land classes

In addition to the land suitability class for each particular land use (considered above), each UMA has been given a general rating in terms of its overall suitability for agriculture. Five agricultural land classes have been defined on the basis of land suitability class, as shown in Table 16.

Table 16 *Agricultural land classes for the Brisbane Valley*

Class	Description	
A	***Crop land***	*Land suitable for current and potential dryland crops* with minor or moderate limitations to production.
Bi	***Limited crop land*** – *irrigated small crops*	Land that is marginal for dryland cropping due to severe limitations, but *suitable for irrigated small crops* with minor to moderate limitations to production.
Bh	***Limited crop land*** – *horticulture*	Land that is marginal or unsuitable for dryland cropping and irrigated small crops due to severe or extreme limitations, but *suitable for selected tree and vine crops* with minor to moderate limitations to production.
C1	***Pasture land*** *(1)*	Land suitable only for improved or native pastures due to limitations that preclude continuous crop production; but some areas may tolerate a short period of ground disturbance for pasture establishment.
C2	***Pasture land*** *(2)*	Land suitable only for the grazing of native pastures due to limitations that preclude the establishment of improved pastures.

The agricultural land classes shown above differ from the four agricultural land classes defined for general use in Queensland (Land Resources Branch Staff, 1990) in that:

- Class A (crop land) is limited to land suitable for dryland crops,
- Class B (limited crop land) has been split on the basis of whether land is suitable for irrigated small crops or horticulture,
- Class C (pasture land) has been split on the basis of suitability for pasture improvement, and
- Class D (non-agricultural land) has not been defined in this survey. This reflects current land use. In the survey area, virtually all land not used for cropping (apart from a few small exceptions) is used for cattle grazing (including very steep, rocky areas).

This report does not define categorically what constitutes good quality agricultural land for the purposes of implementing State Planning Policy 1/92: *Development and the Conservation of Agricultural Land*. However, all crop land (Class A land) would ordinarily be considered *good quality agricultural land*. Limited crop land (Class Bi and Class Bh) may be considered to be *good quality agricultural land* where the crops are considered to be of local significance. In some situations pasture land (Class C) may also be considered *good quality agricultural land* (see DPI/DHLGP, 1993). It is important to note that the availability of suitable irrigation water has not been considered in this survey.

3.5 THE DATABASES

Two computer databases (Microsoft ACCESS and *Ingres*) have been established containing data for the survey area: a site database and a UMA database. Data in this form is easily queried by user selected criteria.

Field data for the 2692 sites was recorded on field sheets similar to Figure 20 in McDonald *et al.* (1990). These were entered into a computer database (Microsoft ACCESS). Laboratory analytical data has been added to the same database for all relevant sample sites.

A comprehensive UMA database containing 85 items is derived from the information on the site description sheets and additional information relating to land suitability. For each UMA, the limitation classes, overall suitability classes (for sown pastures, dryland cropping, irrigated cropping and tree/vine crops) as well as an agricultural land class are recorded. A sample sheet from the UMA database showing all the information recorded for one particular UMA is reproduced in facsimile in Figure 18.

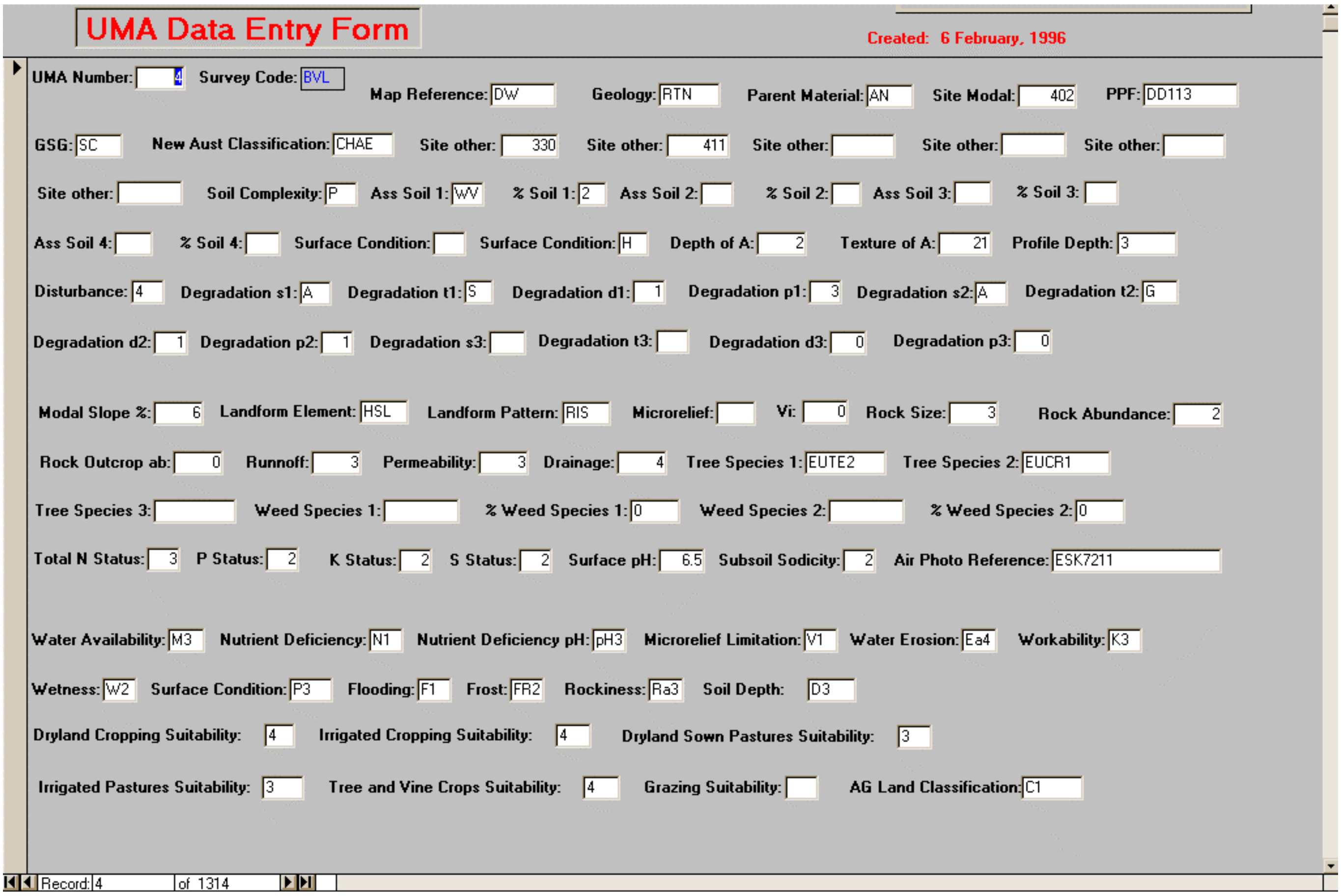

UMA Data Entry Form
Created: 6 February, 1996
UMA Number: 4 Survey Code: BVL Map Reference: DW Geology: RTN Parent Material: AN Site Modal: 402 PPF: DD113
GSG: SC New Aust Classification: CHAE Site other: 330 Site other: 411 Site other: Site other: Site other:
Site other: Soil Complexity: P Ass Soil 1: WV % Soil 1: 2 Ass Soil 2: % Soil 2: Ass Soil 3: % Soil 3:
Ass Soil 4: % Soil 4: Surface Condition: Surface Condition: H Depth of A: 2 Texture of A: 21 Profile Depth: 3
Disturbance: 4 Degradation s1: A Degradation t1: S Degradation d1: 1 Degradation p1: 3 Degradation s2: A Degradation t2: G
Degradation d2: 1 Degradation p2: 1 Degradation s3: Degradation t3: Degradation d3: 0 Degradation p3: 0
Modal Slope %: 6 Landform Element: HSL Landform Pattern: RIS Microrelief: Vi: 0 Rock Size: 3 Rock Abundance: 2
Rock Outcrop ab: 0 Runnoff: 3 Permeability: 3 Drainage: 4 Tree Species 1: EUTE2 Tree Species 2: EUCR1
Tree Species 3: Weed Species 1: % Weed Species 1: 0 Weed Species 2: % Weed Species 2: 0
Total N Status: 3 P Status: 2 K Status: 2 S Status: 2 Surface pH: 6.5 Subsoil Sodicity: 2 Air Photo Reference: ESK7211
Water Availability: M3 Nutrient Deficiency: N1 Nutrient Deficiency pH: pH3 Microrelief Limitation: V1 Water Erosion: Ea4 Workability: K3
Wetness: W2 Surface Condition: P3 Flooding: F1 Frost: FR2 Rockiness: Ra3 Soil Depth: D3
Dryland Cropping Suitability: 4 Irrigated Cropping Suitability: 4 Dryland Sown Pastures Suitability: 3
Irrigated Pastures Suitability: 3 Tree and Vine Crops Suitability: 4 Grazing Suitability: AG Land Classification: C1
Record: 4 of 1314

Figure 18 *A sample sheet from the UMA database showing all the information recorded*

The complete UMA database has been integrated with the GIS spatial data so that maps pertaining to any category of UMA data can be produced. For example: geology, surface condition, surface pH, gully erosion, frost incidence.

Information in both the site database and the UMA database is available on request from the Data Coordinator, RSK, Natural Sciences Precinct, 80 Meiers Road Indooroopilly, Q, 4068.

4. SOILS

Earlier broad scale land resource surveys (Grant *et al*., 1982[9]; Noble, 1996[10]; Co-ordinator Generals Department, 1972) included soil information for the Brisbane Valley as part of their investigations. Soils have previously been mapped at a scale of 1:2 000 000 (Isbell *et al*. 1967) and at 1:625 000 (Co-ordinator Generals Department, 1972). Murtha (1977) reported in detail on the soils occurring in three small areas of the Brisbane Valley (approximately 250 hectares each). This information has not been of sufficient detail or extent to meet the needs of government, industry and the community.

In this survey, a more comprehensive picture of the soils is presented. In all, a total of 47 soil profile classes and ten soil phases are described. A *soil profile class* is a group of similar soils, having certain profile properties in common (Isbell, 1988). The variation of selected features within a particular soil profile class is less than the variation between soil profile classes. A *soil phase* is a subdivision of the soil profile class based on attributes that have particular significance for land use (Isbell, 1988).

4.1 DESCRIPTION OF THE SOIL PROFILE CLASSES

The distinguishing attributes of each soil profile class are listed in Table 17. The soil profile classes have been grouped into landscape units that contain similar substrate material and have generally similar topography. These landscape units provide a broad scale break-up of the survey area and a convenient structure for the presentation of soils information. The landscape units have been listed in the general order of substrate age from youngest to oldest (the same order is used on the printed map reference – Maps 1 and 2).

Names for soil profile classes are generally based on localities or natural features in the survey area. However, the use of a particular name for a soil profile class does not imply that it is the dominant soil at the locality from which its name is derived. In the discussion that follows, the names are abbreviated. For example, **Gallanani** soil profile class is referred to as **Gallanani** soil or simply **Gallanani**.

The soil classification and predominant vegetation for each soil profile class is also shown in Table 17. Each soil profile class is described in greater detail in Appendix 2, which also lists variants for soil profile classes. A *variant* is a soil with one or more profile attributes outside the usual range for a defined soil profile class, but because of its restricted distribution (or because the varying properties are not considered to have particular management significance), it is not defined as a separate soil profile class. For example, the **Gallanani** soil profile class is defined as having reddish brown to black subsoils, but variants with a red subsoil also occur. Variants have not been mapped, but are indicated in the site database.

4.1.1 Soils overlying alluvium

Soils of the low terraces, and floodplains

Cressbrook and **Honey** are deep, well drained soils associated with watercourses. They are characterised by the presence of distinct layers of alluvium (stratification) and the absence of horizon development. This stratification represents changes in the original sedimentation and indicates that these are young soils. Layers of gravel and stone are often encountered, particularly in the upper reaches of the watercourses. The colour of the upper layers is usually dark brown or dark grey and this may extend down the profile, although the lower layers may be paler in colour.

[9] Terrain Patterns mapped at 1:250 000.
[10] Land Resource Areas mapped at 1:250 000.

Table 17 *The major attributes, classification and vegetation associations of the soil profile classes*

Principal profile forms: from Northcote (1979), *A Factual Key for the Recognition of Australian Soils*.
Australian soil classification: from Isbell (1996), *The Australian Soil Classification*.
Great soil group: from Stace *et al*. (1968), *A Handbook of Australian Soils*.

Soil Profile Class (SPC) and area (ha)	Distinguishing attributes	Main principal profile forms	Australian soil classification	Great soil group	Predominant vegetation
SOILS OVERLYING ALLUVIUM					
Soils of the flood plains and low terraces					
Uniform to gradational sands and loams					
CRESSBROOK 399	Stratified soil with a sandy surface and neutral reaction trend.	Uc1.21 (modal) Gn2.02 Uc1.23 Uc1.41 Uc1.43 Uc2.21 Uc2.34	Stratic Rudosols; Chernic or Chernic-Leptic Tenosols	Alluvial soils	Open woodland of river she-oak and Queensland blue gum. Black tea tree and Moreton Bay ash also occur. Woody weeds common.
CRESSBROOK rocky phase 54	Cressbrook soil with common to abundant coarse gravel or cobble in the surface soil.				[as for Cressbrook]
HONEY 1 298	Stratified soil with a loamy surface and neutral reaction trend.	Um1.23 (modal) Gn2.12 Gn2.42 Gn3.12 Um1.21 Um1.44 Um5.52 Um6.23 Um6.41	Stratic Rudosols, Chernic or Chernic-Leptic Tenosols	Alluvial soils	[as for Cressbrook]
MONSILDALE 2 288	Loamy, strongly structured soil with a gradational to uniform profile and neutral reaction trend.	Gn3.22 (modal) Gn3.12 Gn3.42 Gn3.43 Uf6.32 Uf6.33 Um6.31	Black or Brown Dermosols	Prairie soils	Open woodland of Queensland blue gum and Moreton Bay ash. River she-oak and broad leaved apple also occur.
Soils of the low to mid terraces and alluvial plains					
Texture contrast soils					
GALLANANI 3 311	Loamy surface soil overlying reddish brown to black, well structured clay subsoil. Neutral to alkaline reaction trend.	Db1.22 (modal) Db1.12 Db1.32 Dd1.12 Dd1.13 Dr2.22 Gn3.15 Gn3.22 Gn3.25	Brown, Black, Red or Grey Chromosols; Brown, Black, Red or Grey Dermosols	Red brown earths	Open woodland of Queensland blue gum, broad leaved apple and Moreton Bay ash. River she-oak, swamp mahogany and silver leaved ironbark also occur.
GALLANANI rocky phase 35	Gallanani soil with common to abundant coarse gravel in the surface soil.				[as for Gallanani]
GUNYAH 959	Loamy surface soil over black, brown or dark grey clay subsoil with neutral to alkaline reaction trend.	Dd1.13 (modal) Db1.13 Dd1.12 Dd1.33 Dd2.22 Dd2.33 Dy2.13	Brown, Black or Grey Sodosols; Brown, Black or Grey Chromosols	No suitable group (affinities with solodic soils)	[as for Gallanani]
Uniform clay soils with alkaline reaction trend					
BASEL 1 630	Grey clay (cracking or non-cracking). Subsurface may be bleached.	Ug5.24 (modal) Uf3 Uf6.33 Ug3.2 Ug5.21 Ug5.25 Ug5.28	Grey Vertosols; Grey Dermosols	Grey and brown clays	Open woodland of blue gum with broad leaved apple, swamp mahogany, silver leaved ironbark and Moreton Bay ash.
BASEL gilgai phase 1 182	Basel soil with gilgai microrelief.				[as for Basel]
DUGGUA no mapping units	Brown cracking clay.	Ug5.34 (modal) Ug5.31 Ug5.32 Ug5.33 Ug5.35	Brown Vertosols	Brown clay	[as for Basel]
COOEEIMBARDI 2 238	Self-mulching black cracking clay.	Ug5.15 or Ug5.16 (both modal) Ug5.11 Ug5.14 Ug5.17	Black Vertosols	Black earth	Open woodland of Queensland blue gum and Moreton Bay ash. Silver leaved ironbark and broad leaved apple also occur.
Soils of the mid to high terraces					
Texture contrast soils					
SPENCER 8 883	Loamy surface soil over brown, yellowish brown or grey clay subsoil with neutral to alkaline reaction trend. Subsurface often strongly bleached.	Dy2.43 or Dy3.43 (both modal) Db1.32 Db2.43 Db1.33 Db1.43 Db2.43 Dy2.33 Dy2.42	Brown or Grey Sodosols; Brown or Grey Chromosols	Solodic soil, solodised solonetz	Woodland of Queensland blue gum, narrow leaved ironbark and Moreton Bay ash. Silver leaved ironbark and swamp mahogany also occur.

Table 17 *The major attributes, classification and vegetation associations of the soil profile classes*

Soil Profile Class (SPC) and area (ha)	Distinguishing attributes	Main principal profile forms	Australian soil classification	Great soil group	Predominant vegetation
SPENCER gilgai phase 435	Spencer soil with gilgai microrelief.				[as for Spencer]
SPENCER rocky phase 37	Spencer soil with common to abundant coarse gravel or cobble in the surface soil.				[as for Spencer]
OTTABA 1 993	Sandy to loamy surface soil over mottled clay subsoil with acid reaction trend. Subsurface strongly bleached.	Dy3.41 (modal) Db2.41 Dy2.41 Dy5.41	Brown, Yellow or Grey Kurosols; Brown, Yellow or Grey Sodosols	Soloths	Open woodland to woodland of Queensland blue gum and Moreton Bay ash. Swamp mahogany, rusty gum and narrow leaved ironbark also occur.
OTTABA gilgai phase 459	Ottaba soil with gilgai microrelief.				[as for Ottaba]
OTTABA rocky phase 626	Ottaba soil with common to abundant coarse gravel or cobble in the surface soil.				[as for Ottaba]
SOILS OVERLYING COARSE-GRAINED SEDIMENTARY ROCKS		**(*Esk Formation, Bryden Formation*, *Helidon Sandstone*: sandstone, conglomerate, shale, siltstone)**			
Texture contrast soils with neutral to alkaline reaction trend					
BEPPO 14 512	Loamy surface soil over brown, yellowish brown or greyish brown clay subsoil. Subsurface strongly bleached. Subsoil generally sodic.	Dy2.43 or Dy3.43 (both modal) Db1.33 Db1.42 Db1.43 Db2.43 Dy2.42 Dy3.33	Brown or Grey Sodosols; Brown or Grey Chromosols	Solodic soil, solodised solonetz	Woodland to open forest of narrow leaved ironbark or silver leaved ironbark with Moreton Bay ash and Queensland blue gum. Gum topped box, spotted gum and pink bloodwood may also occur.
BEPPO rocky phase 966	Beppo soil with common to abundant coarse gravel or cobble in the surface soil.				[as for Beppo]
WATT 1 776	Loamy surface soil over brown, yellowish brown or black clay subsoil. Subsurface commonly with sporadic (weak) bleach. Subsoil generally sodic.	Db1.33 or Dd1.33 (both modal) Db1.32 Db2.33 Dy2.13 Dy2.33 Dy3.33	Brown, Grey or Black Sodosols; Brown, Grey or Black Chromosols	affinities with solodic soils	[as for Beppo]
WATT rocky phase 251	Watt soil with common to abundant coarse gravel or cobble in the surface soil.				[as for Beppo]
Sodic texture contrast soils with acid reaction trend					
TURTLE 1 630	Loamy surface soil over yellow, brown or red clay subsoil. Subsurface strongly bleached. Sodic subsoil.	Dr3.41 (modal) Db1.31 Dr2.41 Dy2.31 Dy2.41 Dy3.31 Dy3.41	Brown or Yellow Kurosols; Brown or Red Sodosols	Soloth	Woodland to open forest of narrow leaved ironbark with silver leaved ironbark, Moreton Bay ash and Queensland blue gum. Gum topped box, spotted gum, rusty gum and pink bloodwood also occur.
Texture contrast soils with neutral to acid reaction trend (non-sodic)					
CALABASH no mapping units	Loamy surface soil over brown or yellow clay subsoil. Subsurface may be bleached. Subsoil not sodic.	Dy2.12 Dy2.42 Dy3.21 Dy3.31 Dy3.42	Brown or Yellow Chromosols	affinities with yellow podzolics	Open forest of narrow leaved ironbark. Moreton Bay ash, silver leaved ironbark, pink bloodwood also occur.
KIPPER 174	Loamy surface soil over red subsoil grading to brown or yellowish brown with depth. Subsurface may be bleached. Subsoil not sodic.	Dr2.21 (modal) Dr2.22 Dr2.31 Dr2.41 Dr3.21 Dr4.21	Red Chromosols	Red podzolics	Open forest of narrow leaved ironbark; with Moreton Bay ash, silver leaved ironbark, pink bloodwood, broad leaved apple or spotted gum.
GREENHIDE 224	Loamy surface soil over brown or red clay subsoil. Subsoil not sodic.	Db1.12 (modal) Db1.22 Dr2.12 Dr2.22 Dy2.12	Brown or Red Chromosols	Non-calcic brown soils	Woodland to open forest of narrow leaved ironbark and Moreton Bay ash; with silver leaved ironbark and/or Queensland blue gum.

Table 17 (continued) *The major attributes, classification and vegetation associations of the soil profile classes*

Soil Profile Class (SPC) and area (ha)	Distinguishing attributes	Main principal profile forms	Australian soil classification	Great soil group	Predominant vegetation
Gradational to texture contrast soils with neutral to alkaline reaction trend					
LAKEVIEW 300	Loamy surface soil over brown clay subsoil. Softwood scrub or formerly softwood scrub vegetation.	Db2.11 Db1.12 Db1.13 Db2.12 Dy2.12 Gn3.22	Brown Chromosols; Brown Dermosols	affinities with prairie soils and non-calcic brown soils	Softwood scrub species
Gradational to uniform loamy soils with neutral to acid reaction trend					
HIBISCUS 1 587	Red loamy soil.	Gn2.11 or Gn2.12 or Um1.43 (modal) Gn2.15 Gn4.12 Um4.21	Red Kandosols	Red earth	Open forest of spotted gum, Moreton Bay ash and narrow leaved ironbark Queensland blue gum and pink bloodwood also occur.
YELLOWBANK 196	Yellow or brown loamy soil.	Gn2.22 Gn2.24 Gn2.42 Um5.21 Um5.52 Um6.13	Brown or Yellow Kandosols	Yellow earth	Open forest of spotted gum, Moreton Bay ash and narrow leaved ironbark. Swamp mahogany and Queensland blue gum also occur.
Uniform cracking clay soils					
BEER 513	Black, brown or grey cracking clay. Forest or formerly forest vegetation.	Ug5.32 (modal) Ug5.12 Ug5.13 Ug5.14 Ug5.21 Ug5.34	Black, Brown or Grey Vertosols	Grey and brown clays, black earths	Woodland to open woodland of silver leaved ironbark or narrow leaved ironbark with Queensland blue gum and Moreton Bay ash.
BEER rocky phase 13	Beer soil with common to abundant coarse gravel or cobble in the surface soil.				[as for Beer]
CABOONBAH 1222	Grey or brown cracking clays. Softwood scrub or formerly softwood scrub vegetation.	Ug5.32 (modal) Ug5.22 Ug5.24 Ug5.34	Brown or Grey Vertosols	Grey and brown clays	Softwood scrub species.
Very shallow soils overlying weathering rock					
GRIENKE 10	Shallow loamy soil, associated with upper slopes and ridges.	Um1.21 Um1.23 Um1.41 Um1.43	Leptic Rudosols	Lithosol	Open forest of narrow leaved ironbark, spotted gum open and Moreton Bay ash. Silver leaved ironbark and pink bloodwood also occur.
SOILS OVERLYING INTERMEDIATE TO BASIC VOLCANIC ROCKS			**(*Neara Volcanics*: andesite, volcanic conglomerate, agglomerate and tuff)**		
Texture contrast soils with neutral to alkaline reaction trend					
MOORE 5 097	Loamy surface soil over brown, yellowish brown or greyish brown clay subsoil. Subsurface strongly bleached.	Dy2.43 (modal) Db1.42 Db1.43 Dy2.33 Dy2.42 Dy3.42 Dy3.43	Brown, Grey or Yellow Sodosols; Brown, Grey or Yellow Chromosols	Solodic soil, solodised solonetz	Open forest of narrow leaved ironbark, silver leaved ironbark, Queensland blue gum and Moreton Bay ash.
DUNWICH 3 224	Loamy surface soil over black, brown, yellowish brown or greyish brown clay subsoil. Subsurface commonly with sporadic (weak) bleach.	Dy2.13 or Dy2.33 (both modal) Db1.13 Db1.23 Db1.32 Db1.33 Dd1.33 Dy2.32	Brown, Black, Yellow or Grey Chromosols; Brown, Black, Yellow or Grey Sodosols	affiinities with non-calcic brown soils and solodic soils	[as for Moore]
Texture contrast soils with acid reaction trend					
PADDY 780	Loamy surface soil over brown, yellowish brown or greyish brown clay subsoil. Subsurface commonly bleached.	Dy2.41 (modal) Db1.21 Db1.41 Dy2.31 Dy3.31 Dy3.41	Brown or Grey Kurosols; Brown Sodosols; Brown Chromosols	Soloths	Open forest of narrow leaved ironbark and Queensland blue gum or brush box. Gum topped box also occurs.
STEVENTON 202	Loamy surface soil over red clay subsoil.	Dr2.21 Dr2.31 Dr3.11 Dr3.31	Red Chromosols; Red Kurosols	Red podzolics	Open forest of narrow leaved ironbark or brush box. Silver leaved ironbark may also occur.
Shallow to moderately deep texture contrast soils with neutral reaction trend					
LINVILLE 4 164	Loamy surface soil over brown, black, red or greyish brown clay subsoil.	Db1.12 (modal) Db1.22 Dd1.12 Dr2.12 Dr2.22 Dy2.12 Dy2.22	Brown, Grey, Red or Black Chromosols	Non-calcic brown soils	Open forest of narrow leaved ironbark and Queensland blue gum with silver leaved ironbark and Moreton Bay ash. Brush box also occurs.

Table 17 (continued) *The major attributes, classification and vegetation associations of the soil profile classes*

Soil Profile Class (SPC) and area (ha)	Distinguishing attributes	Main principal profile forms	Australian soil classification	Great soil group	Predominant vegetation
Shallow to moderately deep soils with dark, strongly structured surface horizons and neutral reaction trend					
NEARA 2533	Uniform, gradational or texture contrast soil with a loamy to light clay surface over black, brown or greyish brown clay subsoil.	Uf6.31 or Uf6.32 (both modal) Dd1.12 Dy2.12 Gn3.12 Gn3.41 Uf6.33	Brown, Black or Grey Dermosols; Brown, Black or Grey Chromosols	Prairie soils	Open forest to woodland of narrow leaved ironbark and Moreton Bay ash with silver leaved ironbark and Queensland blue gum. Pink bloodwood and brush box also occur.
DEER 394	Uniform, gradational or texture contrast soil with a loamy to light clay surface over black or brown clay subsoil.	Uf6.31 or Uf6.32 (both modal) Db1.12 Dd1.12 Gn3.52	Brown or Black Dermosols; Brown or Black Chromosols	Prairie soils	Softwood scrub species.
Uniform cracking clay soils					
JIMNA 84	Black or brown cracking clay with alkaline reaction trend.	Ug5.32 (modal) Ug5.12 Ug5.14 Ug5.31 Ug5.35	Black or Brown Vertosols	Black earths, brown clays	Open forest to woodland of narrow leaved ironbark, silver leaved ironbark, Moreton Bay ash and Queensland blue gum.
Very shallow soils overlying weathering rock					
D'AGUILAR 313	Shallow loamy soil, usually rocky.	Um1.21 Um1.24 Um1.41 Um1.43 Um6.21 Um6.61	Leptic Rudosols	Lithosols	Open forest of narrow leaved ironbark, silver leaved ironbark and Moreton Bay ash with pink bloodwood
SOILS OVERLYING FINE-GRAINED ACID-IGNEOUS ROCKS (*Crossdale Rhyolite*, undifferentiated rhyolites/trachytes)					
Texture contrast soils					
BURRUNDON 627	Sandy to loamy surface soil over brown, black, yellowish brown or greyish brown clay subsoil with neutral to alkaline reaction trend.	Dy2.42 or Dy2.43 (both modal) Db2.43 Dd1.33 Dd2.33 Dd2.43 Dy2.13 Dy2.33	Brown, Black or Grey Sodosols	Solodic soil, solodised solonetz	Queensland peppermint and brown bloodwood open forest. Also narrow leaved ironbark, spotted gum, Moreton Bay ash and silver leaved ironbark
BERRIMA no mapping units	Loamy surface soil over brown clay subsoil with acid reaction trend.	Db2.41 Dy3.41	Brown Sodosols; Brown Chromosols	Soloth	as for Burrundon
Very shallow soils overlying weathering rock					
ESK 74	Shallow sandy soil, usually rocky.	Uc1.44 Uc2.12 Um1.41 Um2.12 Um3.21	Leptic Rudosols	Lithosols	as for Burrundon
SOILS OVERLYING COARSE-GRAINED ACID-IGNEOUS ROCKS (*Eskdale Granodiorite* and other granitic intrusions)					
Texture contrast soils with neutral to alkaline reaction trend					
PINCH 119	Sandy surface soil over brown clay subsoil. Subsurface horizon weakly developed.	Db1.12 Db1.22	Brown Chromosols	affinities with brown podzolic soils	Open forest of Queensland blue gum, Moreton Bay ash, silver leaved ironbark and broad leaved apple. With narrow leaved ironbark, rusty gum and pink bloodwood.
GILLA 557	Sandy surface soil over brown or yellowish brown clay subsoil. Subsurface bleached.	Db1.42 Dd1.33 Dy2.32 Dy2.43 Dy3.13 Dy3.42	Black or Brown Chromosols; Black or Brown Sodosols	Solodic soils	Open forest to woodland of silver leaved ironbark and narrow leaved ironbark with Moreton Bay ash and Queensland blue gum.
Texture contrast soils with neutral to acid reaction trend					
BIARRA 130	Sandy surface soil over brown to yellow clay subsoil.	Db2.41 Dy2.31 Dy3.31	Brown, Yellow or Grey Chromosols	Soloths	[as for Pinch]
REBEL 276	Sandy to loamy surface soil over red clay subsoil.	Dr2.12 or Dr2.22 (both modal) Dr2.42 Dr3.31	Red Chromosols	Red podzolic soils	[as for Pinch]

Table 17 (continued) The major attributes, classification and vegetation associations of the soil profile classes

Soil Profile Class (SPC) and area (ha)	Distinguishing attributes	Main principal profile forms	Australian soil classification	Great soil group	Predominant vegetation
Uniform sands					
IVORY 297	Deep sand showing little texture change with depth. Neutral reaction trend.	Uc1.22 Uc2.23 Uc5.23 Gn2.55	Orthic Tenosols	Earthy sands	Open forest of narrow leaved ironbark and Queensland blue gum with pink bloodwood and broad leaved apple.
Very shallow soils overlying weathering rock					
FORSTER 15	Shallow sandy soil.	Uc1.21 Uc1.22 Um1.41 Um3.21	Leptic Rudosol	Lithosols	Open forest of narrow leaved and silver leaved ironbark. Spotted gum and pink bloodwood also occur.
SOILS OVERLYING FINE-GRAINED SEDIMENTARY ROCKS			**(*Maronghi Creek Group, Cressbrook Creek Group, Marumba Beds*: chert, jasper, mudstone, shale, greywacke)**		
Texture contrast soils with neutral to alkaline reaction trend					
ESKVALE 1 808	Loamy surface soil over brown, yellowish brown or grey clay subsoil. Subsurface often strongly bleached.	Dy3.42 or Dy3.43 (both modal) Db1.32 Db1.42 Db2.42 Dy2.42 Dy2.43 Dy3.33	Brown or Grey Sodosols; Brown or Grey Chromosols	Solodic soils	Open forest of narrow leaved ironbark and Moreton Bay ash with Queensland blue gum, spotted gum, silver leaved ironbark and pink bloodwood.
Texture contrast soils with acid reaction trend					
HORSE 153	Loamy surface soil over brown to yellow clay subsoil. Subsurface often strongly bleached.	Dy3.41 (modal) Dy2.31 Dy2.21 Dy2.41	Brown, Yellow or Grey Chromosols; Brown, Yellow or Grey Kurosols	Soloths	Open forest of narrow leaved ironbark, spotted gum, and Moreton Bay ash. Gum topped box and silver leaved ironbark also occur.
FREEMAN no mapping units	Loamy surface soil over red clay subsoil.	Dr2.1 or Dr2.21 (both modal) Dr2.31 Dr2.41 Dr3.21 Dr3.31	Red Chromosols; Red Sodosols	affinities with red podzolic soils	Open forest of narrow leaved ironbark and silver leaved ironbark. Brush box, spotted gum and pink bloodwood also occur.
Gradational to texture contrast soils with neutral reaction trend					
NOON 124	Loamy surface soil over red or brown clay subsoil.	Db1.12 or Dr2.12 (both modal) Dr2.22 Dy2.12 Gn3.12 Gn3.24	Brown or Red Chromosols; Brown or Red Dermosols	Non-calcic brown soils	Open forest of narrow leaved ironbark and Moreton Bay ash; with spotted gum, pink bloodwood, silver leaved ironbark and Queensland blue gum.
Shallow soils overlying weathering rock					
WELTON no mapping units	Shallow loamy soil, associated with upper slopes and ridges.	Um1.21 (modal) Um1.23 Um1.43 Um4.11 Um4.13 Um6.23	Leptic Rudosols	Lithosols	Open forest of narrow leaved ironbark and Moreton Bay ash; with spotted gum, pink bloodwood and/or silver leaved ironbark.
SOILS OVERLYING METAMORPHIC ROCKS		**(*Jimna Phyllite*: phyllite, minor basic metavolcanics)**			
Texture contrast soils					
BUNYA 1 596	Loamy surface soil over brown, red or yellow clay subsoil. Subsurface often strongly bleached. Neutral to acid reaction trend.	Dr2.41 or Dr3.31 (both modal) Db1.42 Dr2.31 Dr3.41 Dy2.31 Dy2.41	Red or Brown Sodosols; Red or Brown Kurosols; Red or Brown Chromosols	Solodic soils, soloths	Open forest of narrow leaved ironbark or brush box. Gum topped box, Moreton Bay ash, silver leaved ironbark, broad leaved ironbark, Queensland blue gum, pink bloodwood and patches of softwood scrub (including hoop pine) occur.
Shallow soils overlying weathering rock					
YEDNIA no mapping units	Shallow loamy soil, usually rocky.	Um1.21 (modal) Um1.41 Um1.43	Leptic Rudosols	Lithosols	[as for Bunya]

Honey and **Cressbrook** have been separated on the basis of their surface soil texture. **Honey** has a surface layer (at least 0.10 m thick but often thicker) of sandy clay loam to clay loam, whereas **Cressbrook** has a surface layer of loamy sand to sandy loam. The loamy surface soil of **Cressbrook** improves the surface structure and increases plant available water capacity. Both soils may contain layers of finer textured material, even clay. The surface condition of both soils is generally loose to firm, but may also be hard setting. They have a neutral reaction trend. Where surface gravel or rock was observed to be in sufficient quantity to affect land use, a **Cressbrook rocky phase** was defined.

Monsildale displays some horizon development with a general increase in clay content with depth. It is dark coloured (dark brown to black) and well structured with a neutral reaction trend. It may overlie buried soils that are sandy in texture. Where it extends onto alluvial plains, **Monsildale** generally occupies lower positions closer to watercourses that experience flooding at least once every 50 years.

Soils of the low to mid terraces and alluvial plains

Gallanani and **Gunyah** are texture contrast soils with variable subsurface development. If an A2 horizon is present, it is no more than sporadically bleached. **Gallanani** has a deep loamy surface soil over a well-structured brown clay subsoil which is neutral to slightly alkaline (pH not higher than 8.0) and non-sodic. **Gunyah** has a dark brown to black subsoil which is alkaline (pH up to 9.0) and sodic in the lower part of the B horizon. Strongly developed moderate prismatic structure in the subsoil is often a distinctive feature of **Gallanani**. Where surface gravel or rock was observed to be in sufficient quantity to affect land use, a **Gallanani rocky phase** was defined.

Basel is a grey clay soil that may be cracking or non-cracking. Gilgai microrelief may be present and significant occurrences (where the depressions are more than 20 cm deep) have been delineated as **Basel gilgai phase** – signifying more poorly drained areas. In poorly drained situations (eg. in the gilgai depressions) **Basel** may have a sporadically bleached A2 horizon. **Duggua** is a brown clay that has a limited distribution in the survey area. It is generally associated with **Basel** in a gilgai complex (being a component of the gilgai mounds). Both **Basel** and **Duggua** may be weakly self-mulching, but are generally firm to hard setting.

Cooeeimbardi is a self-mulching black cracking clay (black earth or Vertosol) with an alkaline reaction trend. It is a common component of alluvium derived from the Neara Volcanics, Eskdale Granodiorite and finer grained members of the Esk Formation (mudstone, shale).

Soils of the mid to high terraces and older alluvial plains

Spencer is widespread on higher positions in the alluvial landscape ie. on older alluvial sediments. It also occurs in drainage depressions and on colluvial footslopes associated with a range of geological units. **Spencer** soils are distinguished by a conspicuously bleached A2 horizon and a sodic subsoil. However, as the depth at which sodicity occurs is variable and may not be in the top part of the B horizon, they are not always classified as Sodosols[11] (Isbell, 1996). **Spencer** soils generally have an alkaline reaction trend (pH often > 8.5), but the class includes soils with a neutral reaction trend. **Spencer** may be associated with **Gunyah** soils, but can be distinguished by the conspicuously bleached A2 horizon as well as the colour of the subsoil (which is yellowish brown to yellowish grey rather than black or brown, as for **Gunyah**). However, **Spencer** includes variants with black subsoils if they have a conspicuously bleached A2 horizon or a sporadically bleached A2 horizon that is greater than 0.10 m thick.

Spencer soils may have gilgai microrelief, and areas of significant gilgai have been delineated as **Spencer gilgai phase**. A **Spencer rocky phase** also occurs.

Ottaba is an acid texture contrast soil that is generally associated with the high-level alluvial terraces (possibly of Pliocene age, see Section 2.4.2 and Figure 16). As for **Spencer**, a distinctive feature of **Ottaba** is a conspicuously bleached A2 horizon and strongly sodic subsoil. The subsoil is usually

[11] Sodic texture contrast soils such as these that do not meet the criteria for Sodosols, will generally be classified as Sodic (or Bleached-Sodic), Eutrophic, (Brown or Grey) Chromosols.

strongly mottled. Gilgai microrelief may also occur, and where sufficiently developed, an **Ottaba gilgai phase** has been delineated. Rounded, water worn coarse fragments (coarse gravel to cobble) are commonly found in and on the surface of **Ottaba** soils, and where these have been observed with common to abundant frequency (>10%), an **Ottaba rocky phase** has been delineated. In several locations ferruginised gravel (presumably a product of lateritisation) was observed, but this was not a characteristic feature of these soils.

Laboratory data that provides further evidence for the older, more weathered nature of **Ottaba** soils is discussed in Section 4.3. Using Great Soil Group terminology (Stace *et al*., 1968), **Ottaba** soils are generally classified as soloths. In contrast, other soils on old river terraces (probably Pleistocene age) have been described as yellow podzolics and red podzolics (Smith *et al.*, 1983; Mew, 1978; Walker and Coventry, 1976). The soils developed on high Tertiary gravels in the lower Brisbane River are described by Smith *et al.* (1983) as lateritised red earths and krasnozems.

Three UMAs (on alluvium) that contain predominantly acid texture contrast soils but are not apparently associated with older river terraces have also been mapped as **Ottaba** soil profile class.

4.1.2 Soils overlying coarse-grained sedimentary rocks (*Esk Formation, Bryden Formation, Helidon Sandstone*)

These are a diverse group of soils that reflect the rich diversity of landforms and parent materials associated with the Esk Formation, Bryden Formation and Helidon Sandstone.

Texture contrast soils with neutral to alkaline soil reaction trend

Beppo soils are widespread on slopes and crests of the rises, low hills and hills of the Esk and Bryden Formations. **Beppo** soils generally have an alkaline reaction trend but the group also includes some soils with a neutral reaction trend. Subsoils are brown, yellowish brown or greyish brown in colour and commonly have a strong blocky structure. **Beppo** is characterised by a loamy surface soil and strongly bleached subsurface (conspicuously bleached; sporadically bleached and greater than 0.10 m thick). Surface horizons are either massive or weakly structured. Where surface rock was observed to be in sufficient quantities to affect land use, a **Beppo rocky phase** was defined.

Figure 19 *The bleached A2 horizon is clearly evident in this gully exposure of* ***Beppo*** *soil*

Watt soils occur in close association with **Beppo** soils, tending to be more common in mid to upper slope positions. The main difference between **Beppo** and **Watt** soils is the nature of the subsurface horizon. **Beppo** always has an A2 horizon that is strongly bleached, while **Watt** may or may not have an A2 horizon. [If an A2 horizon is present and bleached, it will be a sporadic bleach less than 0.10 m thick]. Where surface rock was observed to be in sufficient quantities to affect land use, a **Watt rocky phase** was defined.

Both **Beppo** and **Watt** have sodic subsoil. However, as the depth at which sodicity occurs is variable and may not be in the top part of the B horizon, they are not always classified as Sodosols (Isbell, 1996). These soils need to be managed carefully to avoid exposure of the subsoil, which could lead to gully erosion.

Texture contrast soils with acid soil reaction trend

Turtle soils are found in association with **Beppo** and **Watt** soils on the slopes and crests of the Esk and Bryden Formations. Distinctive features of this soil are the strongly bleached subsurface and the strongly acid, sodic subsoil. Acid texture contrast soils without a bleached A2 horizon are included as variants in this soil profile class.

Texture contrast soils with neutral to acid reaction trend

Calabash and **Kipper** soils are generally associated with rolling to steep topography (low hills to hills) of the Esk and Bryden Formations. Rocky outcrops, surface coarse fragments and rocks throughout the profile are common, and the soils are usually shallow to moderately shallow (less than 1 m deep). Both soil profile classes have poorly structured surface soils and non-sodic subsoils which are commonly mottled. Development of A2 horizons is variable but includes those that are bleached. **Calabash** has a yellowish brown to brown subsoil while **Kipper** is red. These soils have not been extensively developed and generally support native woodland to open forest vegetation.

Greenhide is a shallow to moderately shallow soil that is often associated with **Kipper** and **Calabash** but is also widespread in undulating topography (rises to low hills) where it is found on upper slopes and crests. It is distinguished from the two previous soils by its strong surface structure, general absence of an A2 horizon, neutral reaction trend and the absence of mottling. Subsoils are brown or red, however black variants were also described.

Lakeview soils have strongly structured surface soils and lack A2 horizon development. They are generally shallow to moderately shallow (<0.80 m) with a dark loamy surface soil overlying a neutral brown clay subsoil. Soils with a gradational profile are included, but a texture contrast profile is more common. **Lakeview** is always associated with softwood scrub species (see Section 4.2).

Gradational to uniform loamy soils with neutral to acid reaction trend

Hibiscus and **Yellowbank** soils are found exclusively on the Helidon Sandstone member of the *coarse-grained sedimentary rock* group. These soils generally have a texture profile grading from sandy loam or clay loam at the surface to light clay at depth. The *red* coloured **Hibiscus** soils are located on slopes and crests, while the *brown* to *yellow* coloured **Yellowbank** soils tend to occur on lower slope positions and drainage lines.

Uniform clay soils

Two types of clay soils have developed on sediments of the Esk Formation where labile siltstones, mudstones or shale are exposed. The topography ranges from undulating rises to rolling low hills, and all occurrences are in the south of the survey area. The clay soils have been differentiated on the basis of the natural vegetation they support: **Beer** soil is associated with eucalypt woodland to open forest while **Caboonbah** soil is associated with softwood scrub. Both **Beer** and **Caboonbah** are cracking clays, but only **Beer** is strongly self-mulching. **Beer** may be brown, black or grey while **Caboonbah** is generally brown or grey. **Caboonbah** is generally associated with **Lakeview** soils on labile siltstones and mudstones of the Esk Formation and found predominantly in the area south-east of Toogoolawah.

These clay soils are commonly shallow to moderately shallow (<1 m deep), although deeper examples of **Beer** (>1.5 m) were observed. Where surface rock was observed to be in sufficient quantities to affect land use, a **Beer rocky phase** was defined.

Very shallow soils overlying weathered rock

Grienke is a shallow, rocky soil found on ridges and steep slopes of hills and mountains. The maximum depth described (over weathering rock) was 0.20 m. The soil is generally a sandy clay loam to clay loam texture throughout.

4.1.3 Soils formed on intermediate to basic volcanic rocks (*Neara Volcanics*)

Texture contrast soils with neutral to alkaline reaction trend

Moore and **Dunwich** are the dominant soils found on the undulating rises, low hills and hills of the Neara Volcanics. Both have clay loamy surface soils overlying brown, yellowish brown or yellowish grey clay subsoil. They commonly have an alkaline reaction trend (pH > 8.0; occasionally > 9.0) with calcium carbonate segregations. However, soils with neutral reaction trend (pH of deep subsoil <8.0) are also widespread. The main difference between **Moore** and **Dunwich** soils is the nature of the subsurface horizon. **Moore** always has an A2 horizon which is conspicuously bleached, while **Dunwich** may or may not have an A2 horizon. [If an A2 horizon is present and bleached, it will be a sporadic bleach less than 0.10 m thick]. **Dunwich** is found on crests and all slope positions, while **Moore** is a more common soil on broad, flat crests and lower slopes where water has more opportunity to collect.

Both **Moore** and **Dunwich** have sodic subsoils. However, as the depth at which sodicity occurs is variable, they are not always classified as Sodosols. Moderate gully erosion is common in these soils, even in gently undulating terrain.

Texture contrast soils with acid reaction trend

Paddy soils are not so widespread, but found in association with **Moore** and **Dunwich** soils on the slopes and crests of the Neara Volcanics. Distinctive features of **Paddy** are the strongly bleached subsurface and the strongly acid subsoil.

Steventon, although strongly acid, is a very different soil to **Paddy**. It has a red subsoil which has a strong, relatively fine structure. Chemical analysis indicates that the clay type is kaolinitic which contrasts to the clay type of other soils in this group which are illites and expanding clays. **Steventon** also differs in that it has a very low percentage of exchangeable calcium. The very limited distribution of this soil (in the east of the survey area; north west of Kilcoy) seems to indicate that it is not derived from andesite, but is probably associated with a geological intrusion.

Shallow to moderately deep texture contrast soils with neutral soil reaction trend

Linville soil is dominantly located on crests and upper slopes of hills of the Neara Volcanics. **Linville** is of shallow to moderate depth (0.4–1 m) with a loamy surface soil overlying brown, black, or red clay subsoil. It has a firm to hard setting surface.

Shallow to moderately deep soils with dark, strongly structured surface horizons and neutral reaction trend

Neara and **Deer** soils have similar physical characteristics — both having strong, finely structured clay loam to clay surface horizons over black to brown clay subsoils. They have been differentiated on the basis of the natural vegetation they support: **Neara** is associated with eucalypt woodland to open forest, while **Deer** is associated with softwood scrub. As may be expected from the vegetation difference, **Deer** soils have superior surface fertility (see Appendix 1). Both **Deer** and **Neara** are common in steep terrain mapped as steep hills (forest) and steep hills (scrub) for this geological unit (*intermediate to basic volcanics*).

Uniform cracking clays

Small areas of cracking clay soils occur on the Neara Volcanics. Allocated to the **Jimna** soil profile class, these soils are black or brown in colour with an alkaline reaction trend. They are of shallow to moderate depth (0.5–1 m). While they may often be a minor soil in association with texture contrast soils, they rarely occur to an extent that is mappable at a 1:50 000 scale.

Very shallow soil overlying weathered rock

D'Aguilar soil is a very shallow to shallow, rocky soil of loamy to clayey texture. Relatively shallow soils are widespread in the Neara Volcanics, and **D'Aguilar** often intergrades with soils such as **Deer** and **Neara**. **D'Aguilar** soils were observed in a range of topographic positions including undulating rises, but they are more common on the upper slopes of rolling to steep hills.

4.1.4 Soils overlying fine-grained acid igneous rocks (*Crossdale Rhyolite, undifferentiated rhyolites and trachytes*)

This group of soils is associated with the rolling to steep rounded hills (and scree slopes) which are a prominent feature of the landscape near Esk in the south of the survey area. Only three soils have been differentiated. **Burrundon** is a texture contrast soil with a loamy surface soil overlying a brown to black clay subsoil that is generally alkaline and strongly sodic. It ranges from shallow to deep (0.5–1.4 m). **Berrima** is similar to **Burrundon** except for an acid reaction trend. **Esk** soil is very shallow and rocky with minimal subsurface development over weathering rock. Tunnel and gully erosion were frequently observed in this landscape, suggesting careful management is required.

4.1.5 Soils overlying coarse-grained acid igneous rocks (*Eskdale Granodiorite and other granitic intrusions*)

A range of texture contrast soils is associated with the rolling low hills and hills of the Eskdale granodiorite and other granitic intrusions scattered throughout the survey area. They all have sandy surface soils and a high proportion of coarse sand (30–70%) throughout the profile. They are generally only of shallow to moderate depth (<1 m) except in lower slope positions. Colour, reaction trend and the development of subsurface horizons differentiate the soil profile classes found in this unit.

Pinch soil has brown clay subsoil and a neutral reaction trend and the A2 horizon weakly developed or absent. **Gilla** soil is has strong subsurface bleach, brown to yellowish brown subsoil and an alkaline reaction trend. **Biarra** has a strong subsurface bleach, an acid reaction trend and brown to yellow subsoil. **Rebel** has strongly structured red clay subsoil and a neutral to acid reaction trend.

Ivory is a deep sandy soil found on the colluvial lower slopes and footslopes associated with the granodiorite/granite hills. Rocky ridges and slopes of granodiorite/granite hills are where the very shallow soils of the **Forster** soil profile class are found.

4.1.6 Soils overlying fine-grained sedimentary rocks (*Maronghi Creek Group, Cressbrook Creek Group, Marumba Beds*)

Texture contrast and gradational soils

The distinguishing features of **Eskvale** soil are a loamy surface soil and strongly bleached subsurface with neutral to alkaline clay subsoil, which is sodic, coarsely structured and commonly mottled. This soil is particularly prone to gullying in drainage lines and where the surface soil has been disturbed. **Horse** soil is a similar soil to **Eskvale**, apart from its acid reaction trend. **Freeman** soil has an acid reaction trend, and a red clay subsoil with moderate to strong structure. **Freeman** has variable A2 horizon development, but it is generally not strongly bleached.

Noon is a shallow to moderately deep soil (0.5–1 m) with a loamy surface soil over a brown to red clay subsoil with neutral reaction trend. It rarely has an A2 horizon. The **Noon** soil profile class includes members with a gradational texture profile. Located on hillslopes of rolling to steep hills the soil is well drained and mottling is absent.

Very shallow soils overlying rock

Upper slopes, ridges and crests are where **Welton** soil occurs. It is a very shallow soil (0.05–0.15 m) with loamy texture and common rock fragments throughout.

4.1.7 Soils overlying metamorphic rocks (*Jimna Phyllite*)

Bunya soil has a loamy surface soil and strongly bleached A2 horizon overlying brown or red clay subsoil that is strongly sodic. **Bunya** has a shallow to moderately deep profile (0.45–1.1 m) with an acid or neutral reaction trend.

Yednia is a very shallow loamy soil (0.05–0.2 m) with common rock fragments. Generally found on upper slopes and crests of steep hills and mountains.

4.2 SOIL –VEGETATION RELATIONSHIPS

The predominant vegetation associated with each soil profile class is shown in Table 17. Except for *soil associations on steep hills* and for the presence of softwood scrub, vegetation types are not included in the legend of the soils maps accompanying this report.

Relationships between soil profile class and vegetation species are generally weak, except in a few cases. As might be expected, the fringing forests of the floodplains and low terraces correspond largely to the stratified alluvial soils (**Cressbrook** and **Honey**). In another strong correlation, the Queensland peppermint – brown bloodwood (*Eucalyptus exserta – Corymbia trachyphloia*) open forest was found only on *soils overlying fine-grained acid igneous rocks* (Crossdale Rhyolite) of Mt Esk and associated peaks. The soil profile classes represented in this unit are **Esk**, **Burrundon** and **Berrima**.

Blue gum woodlands and alluvium

The blue gum flats of the alluvial plains and terraces are associated with the all the major soils that occur on the alluvium, notably **Cooeeimbardi**, **Basel**, **Spencer**, **Monsildale**, **Gallanani** and **Gunyah** soils. On the black and grey clays (**Cooeeimbardi** and **Basel**), Queensland blue gum (*Eucalyptus tereticornis*) is more likely to occur in pure stands or in association with Moreton Bay ash (*Corymbia tessellaris*). On texture contrast and gradational soils such as **Gallanani**, **Spencer**, **Monsildale** and **Gunyah** a greater range of species is associated with blue gum including *Lophostemon suaveolens* (swamp mahogany), *Angophora subvelutina* (broad-leaved apple) and *Eucalyptus melanophloia* (silver leaved ironbark).

Both *Angophora subvelutina* and *Lophostemon suaveolens* are most frequently associated with **Spencer**, **Gallanani** and **Monsildale** soils in seasonally wetter locations. On the texture contrast soils of the higher terraces (**Spencer** and **Ottaba** soils), *Eucalyptus crebra* and to a lesser extent *E. moluccana* may be found along with the previously mentioned species. *Angophora leiocarpa* (rusty gum) is almost invariably associated with the high-level terraces (**Ottaba** soil).

None of the tree species found on the alluvial flats is found exclusively there. *Eucalyptus tereticornis* and *Corymbia tessellaris*, while attaining their best development on the alluvial flats, are commonly found on slopes and sometimes ridges. *Angophora subvelutina* and *Lophostemon suaveolens* may also be found on slopes, but usually in wetter positions.

Ironbark open forests

While most common on hillslopes, the ubiquitous narrow-leaved ironbark (*Eucalyptus crebra*) is found on all geological units and in all landscape positions except the stream channels and lower terraces. Silver leaved ironbark (*Eucalyptus melanophloia*) is equally widespread but not as extensive as *E.crebra*. *E.melanophloia* is the more likely of the two ironbarks to be found on lower slopes and flats and therefore may sometimes be an indicator of deeper and more fertile soils.

Of the 47 soil profile classes described in the survey, occurrences of *Eucalyptus crebra* were documented in 45 of them. Similarly wide distributions were documented for *E. melanophloia* (40 soil profile classes), *E. tereticornis* (41) and *Corymbia tessellaris* (42).

Spotted gum open forests

Corymbia citriodora (spotted gum) is strongly associated with the deeper loamy soils of the Helidon Sandstone (**Hibiscus** and **Yellowbank**). It also occurs on shallow loamy soils and shallow texture contrast soils associated with the fine and coarse-grained sedimentary rocks (eg. **Greinke**, **Welton**, **Noon**, **Eskvale**, **Turtle** soils and to a lesser extent **Beppo** soil). All these soil profile classes are widely distributed in the steep hilly country in the south and west of the Esk sheet (**Hcf** and **Hff** mapping units).

Eucalyptus moluccana (gum topped box) is associated with texture contrast soils of acid reaction trend (eg. **Turtle** and **Horse**), but it also occurs on **Beppo** and **Spencer** soils.

Softwood scrub

In this survey, an attempt was made to delineate 'hill' country where softwood scrub predominates. The boundaries of these mapping units (ie. **Hns**, **Hcs** and **Hfs**) were established from aerial photo interpretation and were not always ground truthed. Patches of scrub also occur in areas marked as forest.

The most widespread occurrences of softwood scrub are on the *soils overlying intermediate to basic volcanic rocks* (Neara Volcanics) in the north and north-east of the survey area where scrub is associated with **Deer** soil and the **Hns** mapping unit. On *soils overlying coarse-grained sedimentary rocks* (Esk Formation), scrub is associated with the **Caboonbah** and **Lakeview** soils as well as the **Hcs** mapping unit.

A small area of softwood scrub is associated with *soils overlying fine-grained sedimentary rocks* (Cressbrook Creek Group unit) in the south-west corner of the Esk sheet (**Hfs** mapping unit). Other observed areas of scrub (but not indicated on the map) are associated with *soils overlying fine-grained acid igneous rocks* in the south and *soils overlying metamorphic rocks* in the north.

As may be expected, 'scrub soils' are generally found to be more fertile than associated 'forest soils' (see Section 4.3 and Appendix 1). Sharp boundaries between scrub and forest with no obvious change in geology or landform are probably due to differences in mineralogy of the parent rock materials. This could be the subject of fruitful further study.

4.3 SOIL ANALYTICAL DATA

4.3.1 Surface fertility

To assist in the interpretation of the surface fertility results, the soil profile classes have been grouped according to geology, in the same order they appear in the map reference. However, for *soils overlying coarse-grained sedimentary rocks*, the Helidon Sandstone member has been separated from the Esk and Bryden Formations because of distinct differences in chemical fertility. Appendix 1 contains a table summarising the surface soil fertility for each soil *group* as well as a table showing comprehensive results for individual soil profile classes. Summary figures for each soil group may be used as a *general indication of trends.* However, these figures need to be used with caution because of the inherent *variability* present in each group. Within soil profile classes, there may also be considerable variability. The range that is listed in each of the tables (for most parameters) indicates the degree of variability present. Selected results are presented graphically below.

In total, surface (0-0.10 m) samples for 146 sites were analysed as part of this project. At each sample site, an auger was used to collect samples from approximately 10 locations in the immediate vicinity. These were then bulked and a subsample removed for laboratory analysis. Care was taken to ensure that samples submitted for analysis were taken from unfertilised sites.

The preferred levels (or ratings) for individual nutrients are taken from Baker and Eldershaw (1993) and Bruce and Rayment (1982).

Soil pH

Soil pH (or soil reaction) is a measure of the acidity or alkalinity of the soil. Soils with a low pH (<5.5) may suffer from aluminium or manganese toxicity, while those with a high pH (>8.5) may suffer from trace element deficiencies. While many plants will tolerate a range in pH conditions from 5.5 to 8.5, the pH range for optimum nutrient availability occurs when the pH is between about 6.0 and 7.5. Intensive land use (irrigated pastures and cropping) on some soils, may result in a lowering of surface soil pH (to less than 6.0), necessitating the addition of lime.

Most soils in the survey area have a surface soil pH (laboratory, 1:5 soil:water) of between 5.5 and 7.5, with group averages ranging from 5.8 to 6.4. The results for soil groups (by geology) are illustrated in Figure 20.

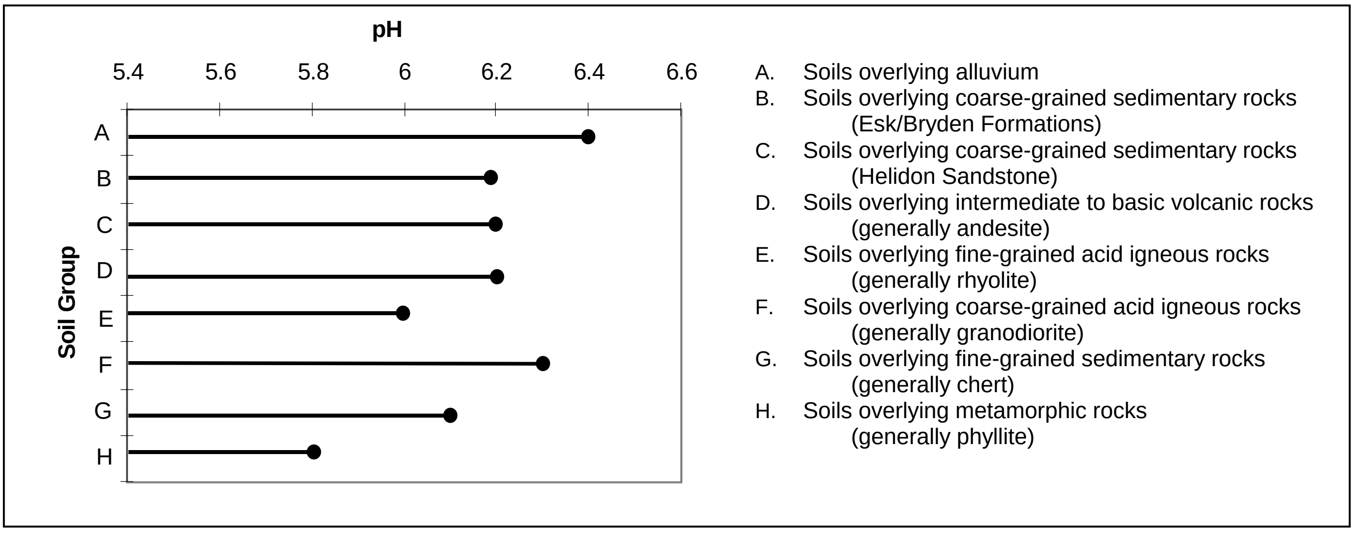


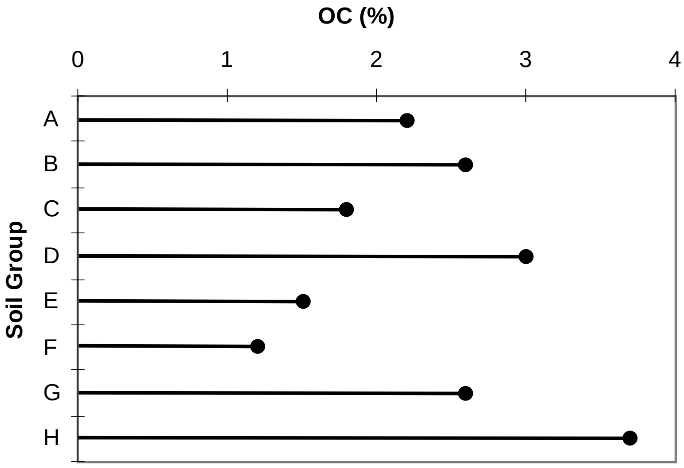
Figure 20 *Mean surface soil pH (laboratory) for Brisbane Valley soil groups*

The *soils overlying metamorphic rocks* (phyllite) and *soils overlying fine-grained acid igneous rocks* (rhyolite) are categorised as medium acid (pH <6.1), while the others are slightly acid (pH 6.1–6.5). Considering individual soil profile classes (see Appendix 2), **Cooeeimbardi** is the only soil to have a surface mean soil pH average in the neutral range (pH 6.6–7.3). It was also the only soil to have individual bulked samples in the moderately alkaline (pH 7.9–8.4) or strongly alkaline (pH 8.5–9.0) range.

Organic carbon, nitrogen and sulfur

Organic carbon is the main component of organic matter. Organic matter stabilises the soil and promotes good soil structure. It contributes significantly to the cation exchange capacity (CEC) of the soil and is a major source of nitrogen, phosphorus and sulfur. For cropping purposes, levels of soil organic carbon >1.5% are preferred. Cropping activities generally decrease the quantity of soil organic matter.

Most soils in the survey area have adequate organic carbon. Only 19 of the 146 surface soil samples taken levels of less than 1.5%. However, six out of seven samples taken from *soils overlying coarse-grained acid igneous rocks* (granodiorite) recorded values less than 1.5%, with that group averaging 1.2% which is low, although not unusual for sandy soils. The results for soil groups (by geology) are illustrated in Figure 21.



A. Soils overlying alluvium
B. Soils overlying coarse-grained sedimentary rocks (Esk/Bryden Formations)
C. Soils overlying coarse-grained sedimentary rocks (Helidon Sandstone)
D. Soils overlying intermediate to basic volcanic rocks (generally andesite)
E. Soils overlying fine-grained acid igneous rocks (generally rhyolite)
F. Soils overlying coarse-grained acid igneous rocks (generally granodiorite)
G. Soils overlying fine-grained sedimentary rocks (generally chert)
H. Soils overlying metamorphic rocks (generally phyllite)

Figure 21 *Mean surface soil organic carbon (OC) for Brisbane Valley soil groups*

The majority of total nitrogen (N) within the organic matter fraction is not immediately available to plants unless it is first mineralised to available forms such as nitrate (NO_3) or ammonium (NH_4). Low values of total N indicate potential problems in relation to N supply. Three soil groups (*soils overlying coarse-grained sedimentary rocks – Helidon Sandstone member, soils overlying fine-grained acid igneous rocks* and *soils overlying coarse-grained acid igneous rocks*) have low average values of total nitrogen.

While results for nitrate (NO_3) nitrogen are provided in Appendix 1, the calibration and interpretation of nitrate nitrogen values is always difficult (Baker and Eldershaw, 1993). Nitrate nitrogen tends to be low in pasture situations, as nitrate is released (mineralised) from stored organic matter only slowly unless the soil is disturbed (eg. cultivated). The ratio of organic carbon to total nitrogen (C/N) is often a useful indicator of the capacity of the soil to supply mineral N. A high C/N ratio (>15) indicates a slow mineralisation process and a reduced ability of that soil to supply mineral N. C/N ratios of <15 are preferred. In the survey area, C/N ratios are generally around 15 (see Figure 22). In *soils overlying alluvium*, several soil profile classes have ratios of <15 (**Cressbrook**, **Monsildale**, **Gunyah**, **Basel** and **Cooeeimbardi**). Notable for high C/N ratios are **Hibiscus** and **Yellowbank**, both *soils overlying coarse-grained sedimentary rocks – Helidon Sandstone member*, which has a group average of 23.

As is the case for nitrogen, most of the sulfur in soil is present as part of the organic matter. It has to be mineralised to the sulfate (SO_4) form before plant uptake. Sulfur deficiency is not easily determined, but in general levels of sulfate >5 mg/kg are preferred. In the survey area, those soil groups with an apparent general deficiency in sulfur are the *soils overlying acid igneous rocks* (rhyolite) and the *soils overlying fine-grained sedimentary rocks* (granodiorite). However, all the major soil groups had at least one sample that was low in sulfate sulfur.

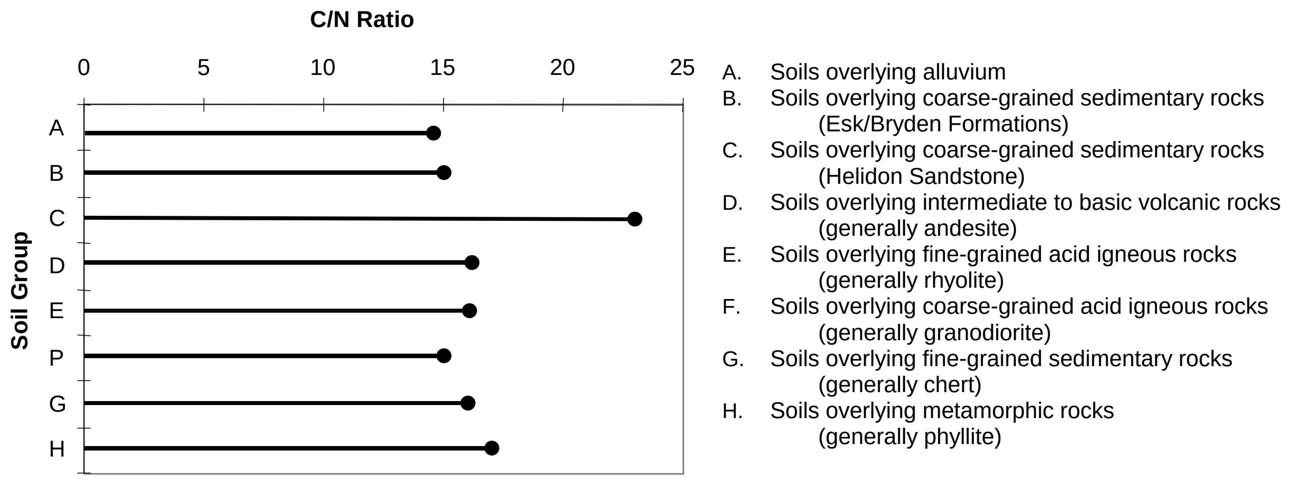


Figure 22 *Mean Organic Carbon/Total Nitrogen ratios for Brisbane Valley soil groups*

Phosphorus

Phosphorus (P) is an important plant macronutrient that may sometimes be the critical factor in determining land use in 'marginal' soils. A cropping response to additions of phosphorus can generally be expected if levels of available (or extractable) phosphorus are below 20 mg/kg. For dryland pastures, Ahern *et al.* (1994) found that pasture yield and quality and hence animal production will increase as soil P increases to 10 mg/kg. Research on texture contrast soils in the Brisbane Valley and similar areas in south-east Queensland, has shown that for establishment of tropical grass and legume based pastures, added phosphorus will produce a response if P levels are less than 20 mg/kg (Lowe *et al.*, 1981).

In the survey area, mean available phosphorus levels at uncultivated sites are generally adequate, at least for pasture improvement purposes. For *soils overlying alluvium*, bicarbonate extractable P levels are generally in the medium to high range (20–100 mg/kg). However, in a few samples, notably from **Spencer** and **Basel** soil profile classes, low values of P (<10 mg/kg) were recorded. Two samples of **Cooeeimbardi** (a Black Vertosol) were also 15 mg/kg or less. Moderate to high P levels (20–100 mg/kg) were consistently recorded in *soils overlying metamorphic rocks, soils overlying fine-grained intermediate to basic volcanic rocks* and in *soils overlying fine-grained sedimentary rocks.* In these groups, of 48 samples taken, only two recorded values lower than 17 mg/kg. The *soils overlying coarse-grained sedimentary rocks (Esk/BrydenFormation)* exhibited more variability with 15 of 37 samples recording a bicarb. extractable P value of less than 17 mg/kg, while nine recorded lower than 10 mg/kg. The **Beppo**, **Watt** and **Turtle** soils are generally deficient in phosphorus (for pasture improvement). Those soil groups with a consistently low level of available P are *soils overlying coarse-grained sedimentary rocks (Helidon Sandstone)* and *soils overlying fine-grained acid igneous rocks.* The results for soil groups (by geology) are illustrated in Figure 23.

Potassium

Mean surface soil extractable potassium (K) levels for Brisbane Valley soil groups (by geology) are shown in Figure 24. Table 2 in Appendix 1 shows that the mean for each soil profile class is 0.3 meq/100 g or greater, which is the preferred level for general interpretation. However, there is evidence that in sandy soils there may be a K deficiency if levels are below 0.4 meq/100 g (Baker and Eldershaw, 1993). Therefore, soil groups where a K deficiency is most likely to occur are *soils overlying* *coarse-grained sedimentary rocks (Helidon Sandstone)* and *soils overlying coarse-grained acid igneous rocks.* In only two of the 146 samples taken, were K levels of less than 0.2 meq/100 g recorded (in the low range).

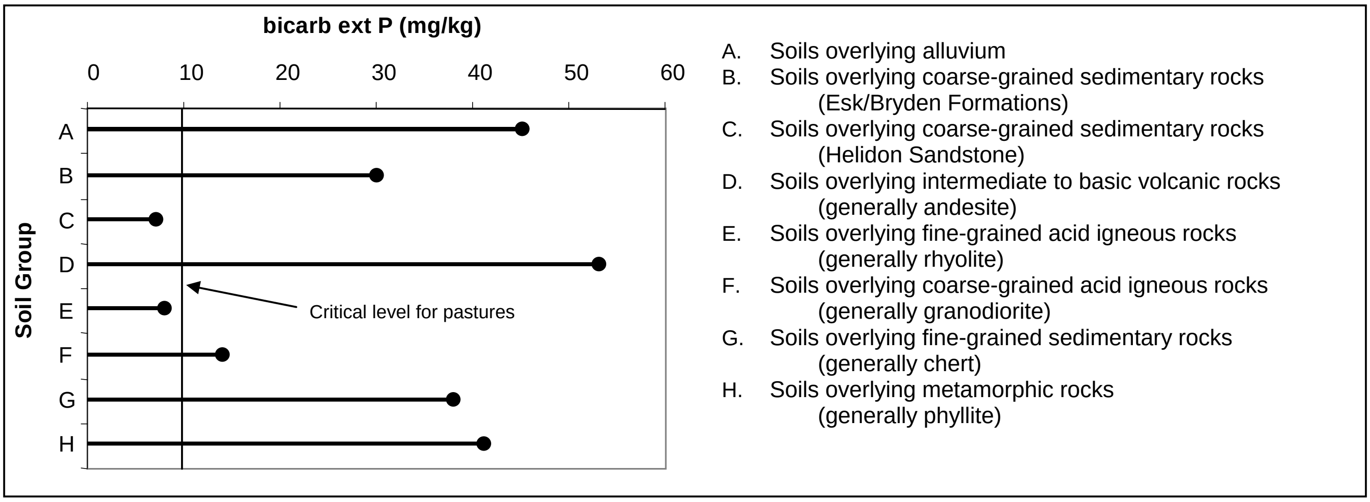


Figure 23 *Mean surface soil bicarbonate extractable phosphorus (P) for Brisbane Valley soil groups*

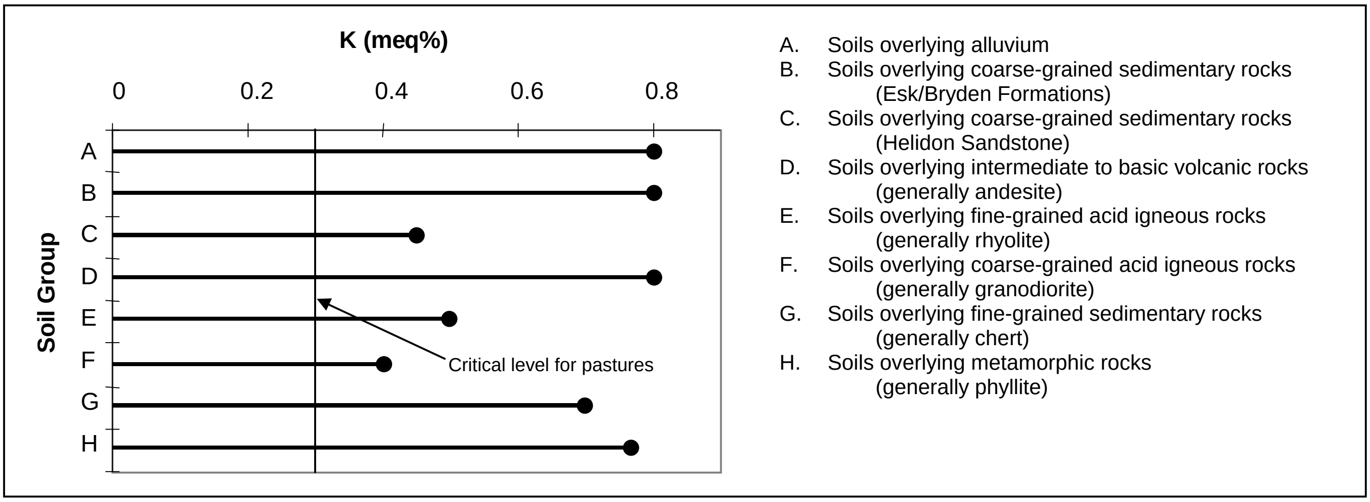


Figure 24 *Mean surface soil extractable potassium (K) for Brisbane Valley soil groups*

Micronutrients – Zn, Cu, Mn

Micronutrient supply (zinc, Zn; copper, Cu; manganese, Mn) is generally not a problem in Brisbane Valley soils. Further investigation of micronutrient status at individual sites would only be required for intensive cropping applications. Boron (B) levels were not determined as part of this survey. High soil pH reduces Zn availability and to a lesser extent Cu availability. However, surface pH is rarely alkaline in Brisbane Valley soils.

Of the 146 bulk samples analysed, only 15 recorded extractable copper (Cu) levels of <0.3 mg/kg, which is the critical level for copper[12]. All three samples taken on *soils overlying fine-grained acid igneous rocks* were found to be deficient. For extractable zinc (Zn), five samples recorded a value of <0.5 mg/kg (the critical level for zinc if pH <7) whereas 13 samples recorded values of <0.8 mg/kg.

[12] 22 samples had values of extractable copper (Cu) below 0.4 mg/kg

4.3.2 Soil profile properties

Soil pH

The range of subsoil[13] pH (laboratory, 1:5 soil:water) for Brisbane Valley soils is shown in Table 18. Seventeen soil profile classes have a neutral reaction trend, whereas 13 have an alkaline reaction trend. Five soils that are strongly alkaline (pH >8.4) are **Cooeeimbardi**, **Beppo**, **Watt**, **Caboonbah** and **Jimna**. It should be noted that several soil profile classes include representatives with neutral or alkaline reaction trend. For example, **Spencer** includes subsoils that are neutral to strongly alkaline. [The examples of **Spencer** soil included in Appendix 3 illustrate both types of pH profile.]

Of the six soils with an acid reaction trend, five are strongly acid (pH <5.6): **Ottaba**, **Turtle**, **Steventon**, **Freeman** and **Bunya**. Strongly acid soils can limit plant growth through the availability of undesirable, sometimes toxic, quantities of aluminium or manganese. There may also be a deficiency of calcium, as well as lowering the availability of plant nutrients such as phosphorus, nitrogen and molybdenum in the soil (Aitken and Cowles, 1992).

Salinity

Electrical conductivity (EC) is a measure of the total soluble salts present in a soil, while chloride (a soluble salt) concentration indicates the contribution of chloride ions to total soluble salts. Both EC (mS/cm) and Cl (%) were recorded for all soils sampled in the Brisbane Valley survey area and the results are contained in Table 18. For Brisbane Valley soils, chloride salts make the major contribution to soil salinity, so either EC or Cl^- levels may be used to derive a soil salinity rating Shaw (1988). Soils with medium and high ratings are highlighted in Table 18.

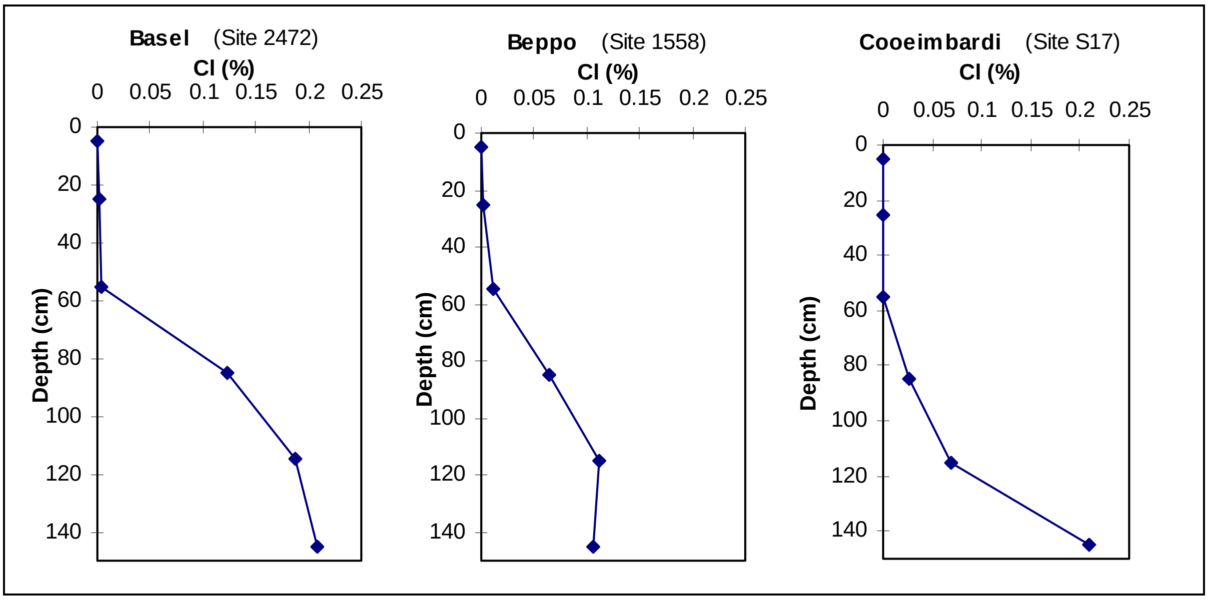


Figure 25 *The salinity (Cl^-) profile for three Brisbane Valley soils*

Soils with medium to high levels of subsoil salinity are confined almost exclusively to two broad groups of soils: *soils overlying alluvium* (mid/high terraces and plains) and *soils overlying coarse-grained sedimentary rocks* (Esk and Bryden Formations). This indicates the contribution to soil salinity of both landscape position and parent material. At low positions in the landscape, subsurface hydrology is of major importance in the distribution of soluble salts. This is reflected in the medium to high levels of salinity recorded for **Cooeeimbardi**, **Basel**, **Duggua**, **Gunyah**, **Spencer** and **Ottaba** soils. Salinity associated with soils of the Esk and Bryden Formations (**Beppo**, **Watt**, **Turtle**, **Beer** and **Caboonbah** soils), is most likely related to the origin of those sedimentary rocks (see Section 2). Sediments of the

[13] Subsoil refers to the B horizon. Minimum depth to the B horizon differs within and between soil profile classes.

Esk Trough were deposited in shallow water, which would have led to the concentration of evaporite rich lakes or swamps, and hence the accumulation of salts in what is now the soil parent material. In addition, the weathering of rock minerals also releases a quantity of salt. Soils of the Esk Formation that are low in subsoil salinity are generally associated with higher positions in the landscape (eg. **Greenhide**, **Kipper** and **Calabash** soils). Soils derived from rocks of the Helidon Formation (**Hibiscus** and **Yellowbank** soils) are well drained and leached with consequently low levels of subsoil salinity.

Within a soil profile, the trend in salinity is as important as the individual values. The chloride (Cl^-) profile for three soils is illustrated in Figure 25. An accumulation of salts lower in the profile indicates the long-term depth of wetting in these soils. The depth at which this occurs also indicates *effective rooting depth* for these soils, since water recharge and drainage following plant water use should flush salts from the active root zone. Soils overlying alluvium which have good internal drainage (eg. **Honey**, **Cressbrook**, **Monsildale** and **Gallanani** soils) have uniformly low salt profiles.

Cation exchange capacity and clay activity ratio

Cation exchange capacity (CEC) in soil is a measure of the potential storage of nutrient cations for plant use. In general, soils with a high CEC are more fertile. Brisbane Valley soils with low values of CEC are **Cressbrook** (in the lower subsoil only), **Gallanani** (lower subsoil only), **Hibiscus**, **Yellowbank**, **Steventon**, **Gilla**, **Duncan** and **Bunya**. These soils may have reduced ability to retain cations from leaching out of the root zone. CECs for Brisbane Valley soils are are shown in Table 19.

However, the *relative importance* of contributing cations within the CEC is also of importance (Baker and Eldershaw, 1993). Ca/Mg ratios can be used to indicate cation imbalance, especially if the subsoil is dominated by Mg. Ca/Mg ratios of >1.0 (but <6.0) are desirable, while ratios of <0.5 have been linked with dispersion (Emerson, 1977). Table 19 lists the values of subsoil CEC and corresponding Ca/Mg ratios for major Brisbane Valley soils. Soils with Ca/Mg ratios < 0.5 in the subsoil are **Basel**, **Duggua**, **Spencer**, **Ottaba**, **Beppo**, **Turtle**, **Kipper**, **Hibiscus**, **Steventon**, **Burrundon**, **Eskvale**, **Horse**, **Freeman** and **Bunya**. As a group, the *soils overlying coarse-grained acid igneous rocks* (granodiorite) and the *soils overlying intermediate to basic volcanic rocks* (andesite) have favourable Ca/Mg ratios in the subsoil. One notable exception is **Steventon**, which has a remarkably high proportion of magnesium (93% at 0.5– 0.6 m). Other soils with high magnesium relative to other cations are **Burrundon** [*soils overlying fine-grained acid igneous rocks* (rhyolite)] with a value of 71% (at 22–30 cm) and **Bunya** [*soils overlying metamorphic rocks* (phyllite)] with a value of 75% (at 0.5–0.6 m).

For acid soils, particularly those with a pH <5.5, high levels of exchangeable aluminium may be associated with poor plant growth. Amongst Brisbane Valley soils, those with high levels of Al are **Bunya** (50% at 0.5–0.6 m) and **Steventon** (58% at 0.5–0.6 m).

The *clay activity ratio* is the CEC per gram of clay (meq/g clay) and may be used to indicate clay mineralogy. A ratio of 0.8 or higher generally indicates expanding clays (smectites) while a ratio of < 0.2 usually indicates a dominance of kaolinite. Intermediate values (0.3–0.5) indicate illites (including non-expanding clays (Baker and Eldershaw, 1993). Results for major Brisbane Valley soils are shown in Table 19. Soils where the clay fraction is dominated by smectites tend to be derived from coarse-grained sedimentary rocks (excluding the Helidon Formation) or intermediate to basic rocks (generally andesite). Examples of such soils are **Watt**, **Beer**, **Caboonbah**, **Moore**, **Linville**, **Deer** and **Jimna.** Only one of the soils derived from alluvium (**Cooeeimbardi**) has a dominance of smectites throughout the profile. Soils dominated by kaolinite are **Hibiscus**, **Steventon**, **Bunya**, **Gilla** and **Rebel**.

As a group, **Ottaba** soils that have formed on the high level terraces (see Section 2.4.2) have significantly lower mean levels of exchangeble calcium, exchangeable potassium, and total potassium when compared to soils with similar morphology such as **Spencer**, **Beppo** and **Turtle**. These mean values are also significantly lower than the mean for the group *soils overlying coarse-grained sedimentary rocks* (Esk and Bryden Formations) and the mean for the group *soils overlying alluvium* (excluding **Ottaba**). This is further evidence of thei older, more weathered nature of **Ottaba** soils.

Table 18 *Summary of subsoil pH and salinity for Brisbane Valley soils (representative sites)*

Soil profile class		No. of samples	pH[a]	EC[b] mS/cm	Cl[c] %	Comment
Soils overlying alluvium						
Cressbrook	upper (0.2-0.3)[d]	1	6.9	0.01	.002	
	lower (0.8-0.9)	1	7.4	0.01	.001	
Honey	upper (0.2-0.3)	1	6.6	0.15	.011	
	lower (1.1-1.2)	1	7.3	0.01	.001	
Monsildale	upper (0.2-0.3)	2	6.6	0.06	.002	
	lower (1.1-1.2)	2	6.7	0.02	.002	
Gunyah	upper (0.2-0.3)	1	7.3	0.04	.001	
	lower (1.1-1.2)	1	7.3	**0.95**	**.109**	high salinity at depth may limit rooting depth
Gallanani	upper (0.5-0.6)	1	7.3	0.02	.001	
	lower (1.1-1.2)	1	7.2	0.01	.001	
Basel	upper (0.2-0.3)	3	6.9	0.22	.020	
	lower (1.1-1.2)	3	8.1	**0.86**	**.128**	high salinity at depth may limit rooting depth
Duggua	upper (0.2-0.3)	2	6.2	0.06	.025	
	lower (1.1-1.2)	2	7.8	***0.61***	***.074***	
Cooeeimbardi	upper (0.2-0.3)	2	8.0	0.12	.004	
	lower (1.1-1.2)	2	***8.9***	***0.67***	***.080***	strong alkalinity at depth may limit rooting depth
Spencer	upper (0.2-0.3; 0.5-0.6)	2	7.2	0.05	.004	
	lower (1.1-1.2)	2	7.8	***0.44***	***.056***	
Ottaba	upper (0.2-0.3; 0.5-0.6)	3	**5.6**	0.24	.026	
	lower (1.1-1.2)	3	**5.2**	***0.35***	***.073***	strong acidity at depth may limit rooting depth
AVERAGE (upper subsoil)			6.9	0.10	.010	
AVERAGE (lower subsoil)			7.3	***0.39***	.053	
Soils overlying coarse-grained sedimentary rocks						
Beppo	upper (0.5-0.6)	1	7.8	0.12	.011	
	lower (1.1-1.2)	1	***8.8***	**0.98**	**.112**	high salinity at depth may limit rooting depth
Watt	upper (0.2-0.3; 0.5-0.6)	2	7.5	0.17	.005	strong alkalinity at depth may limit rooting depth
	lower (0.8-0.9; 1.1-1.2)	2	***8.8***	***0.35***	.018	
Turtle	upper (0.2-0.3)	1	7.1	0.13	.004	
	lower (0.8-0.9)	1	**5.4**	***0.69***	***.087***	strong acidity at depth may limit rooting depth
Calabash	lower (0.8-0.9)	1	6.9	0.03	.001	
Kipper	upper (0.5-0.6)	1	5.6	0.03	.002	
	lower (0.8-0.9)	1	5.7	0.02	.001	
Greenhide	upper (0.2-0.3)	1	6.4	0.02	bq[e]	
	lower (0.45-0.55)	1	7.0	0.02	bq	
Hibiscus	upper (0.5-0.6)	1	5.7	0.04	.004	soils in this geology (Helidon Sandstone) are likely to facilitate groundwater recharge
	lower (1.1-1.2)	1	5.9	0.02	.001	
Yellowbank	lower (0.8-0.9)	1	6.3	0.01	.001	
Beer	upper (0.2-0.3)	1	7.0	0.05	.002	
	lower (1.1-1.2)	1	8.1	**0.99**	**.119**	high salinity at depth may limit rooting depth
Caboonbah	upper (0.2-0.3)	1	6.6	0.14	.007	strong alkalinity at depth may limit rooting depth
	lower (0.8-0.9)	1	**9.4**	***0.31***	.018	
AVERAGE (upper subsoil)			6.7	0.09	.004	
AVERAGE (lower subsoil)			7.3	***0.34***	.036	

[a] if soil is strongly alkaline (pH >8.4) results are ***bolded***; strongly acid (pH<5.6), values are **boxed**

[b] medium values of EC (0.30-0.70) are ***bolded***, high values (>0.70) are **boxed**

[c] medium values of Cl (0.05-0.10) are ***bolded***, high values (>0.10) are **boxed**

[d] soil depth measured in metres

[e] bq = below quantitation

Table 18 *(continued)* *Summary of subsoil pH and salinity for Brisbane Valley soils (representative sites)*

Soil profile class		No. of samples	pH[a]	EC[b] mS/cm	Cl[c] %	Comment
Soils overlying intermediate to basic volcanic rocks						
Moore	upper (0.5-0.6)[d]	2	6.8	0.10	.010	
	lower (0.8-0.9)	1	6.7	0.28	.035	
Dunwich	upper (0.2-0.3)	1	6.8	0.03	.001	
	lower (0.8-0.9)	1	8.3	0.07	.003	
Steventon	upper (0.5-0.6)	1	**5.2**	0.02	.002	strong acidity at depth may limit rooting depth
	lower (0.8-0.9)	1	**5.0**	0.02	.001	
Linville	upper (0.2-0.3)	1	6.3	0.03	.001	
	lower (0.8-0.9)	1	7.4	0.02	.001	
Neara	upper (0.2-0.3)	1	6.9	0.03	bq[e]	
	lower (0.5-0.6)	1	7.7	0.07	.003	
Deer	upper (0.25-0.35)	1	7.6	0.17	.001	soils in this geology are likely to facilitate groundwater recharge
	lower (1.0-1.1)	1	8.4	0.26	.001	
Jimna	upper (0.2-0.3)	1	7.7	0.06	.002	
	lower (0.5-0.6)	1	***8.5***	0.16	.010	strong alkalinity at depth may limit rooting depth
AVERAGE (upper subsoil)			6.8	0.06	.002	
AVERAGE (lower subsoil)			7.4	0.13	.008	
Soils overlying fine-grained acid igneous rocks						
Burrundon	upper (0.22-0.32)	1	7.5	0.17	.010	
Soils overlying coarse-grained acid igneous rocks						
Pinch	upper (0.5-0.6)	1	7.1	0.02	.001	
	lower (1.1-1.2)	1	7.6	0.02	.001	
Gilla	upper (0.5-0.6)	1	7.2	0.02	bq	
	lower (0.8-0.9)	1	7.2	0.02	.001	soils in this geology are likely to facilitate groundwater recharge
Biarra	upper (0.25-0.30)	1	6.4	0.03	.001	
	lower (0.5-0.6)	1	7.2	0.03	.001	
Rebel	upper (0.25-0.30)	1	6.8	0.04	.001	
	lower (0.7-0.8)	1	7.9	0.03	.001	
Duncan	upper (0.2-0.3)	1	6.2	.01	.001	
	lower (1.1-1.2)	1	6.9	.01	.001	
AVERAGE (upper subsoil)			6.7	0.02	.001	
AVERAGE (lower subsoil)			7.4	.02	.001	
Soils overlying fine-grained sedimentary rocks						
Eskvale	upper (0.2-0.3)	1	5.9	0.09	.008	
	lower (0.5-0.6)	1	6.7	***0.39***	***.052***	
Horse	upper (0.5-0.6)	1	6.4	0.03	.001	
	lower (0.75-0.85)	1	6.1	0.04	.002	
Freeman	upper (0.2-0.3)	1	**5.4**	0.14	.020	strong acidity at depth may limit rooting depth
	lower (0.5-0.6)	1	**5.2**	0.15	.020	
Noon	upper (0.2-0.3)	1	6.7	0.03	.001	soils in this geology are likely to facilitate groundwater recharge
	lower (0.5-0.6)	1	7.2	0.02	.001	
AVERAGE (upper subsoil)			6.1	0.07	.008	
AVERAGE (lower subsoil)			6.3	0.15	.019	
Soils overlying metamorphic rocks						
Bunya	upper (0.2-0.3)	1	5.6	0.03	.003	
	lower (0.5-0.6)	1	**5.1**	0.04	.005	

[a] if soil is strongly alkaline (pH >8.4) results are ***bolded***; strongly acid (pH<5.6), values are **boxed**

[b] medium values of EC (0.30-0.70) are ***bolded***, high values (>0.70) are **boxed**

[c] medium values of Cl (0.05-0.10) are ***bolded***, high values (>0.10) are **boxed**

[d] *soil depth measured in metres* [e] *bq = below quantitation*

Table 19 *Summary of subsoil clay content, CEC, clay activity ratio, Ca:Mg ratio, ESP and dispersion ratio (R1) for Brisbane Valley soils (representative sites)*

Soil profile class			No. samples	Clay %	CEC m.eq/ 100 g clay	clay activity ratio[a]	Ca:Mg ratio[b]	ESP[c]	R1
Soils overlying alluvium									
Cressbrook	upper	(0.2-0.3)[d]	1	17	12	0.71	2.3	1	0.47
	lower	(0.8-0.9)	1	4	4	1.00	1.9	1	–
Honey	upper	(0.2-0.3)	1	19	11	0.56	1.6	2	0.73
	lower	(1.1-1.2)	1	30	14	0.46	1.0	1	0.50
Monsildale	upper	(0.2-0.3)	2	28	16	0.58	2.9	1	0.45
	lower	(1.1-1.2)	2	30	15	0.51	4.0	1	0.49
Gunyah	upper	(0.2-0.3)	1	47	24	0.51	1.3	2	0.69
	lower	(1.1-1.2)	1	62	43	0.69	0.65	***10***	–
Gallanani	upper	(0.5-0.6)	1	25	10	0.67	1.7	1	0.75
	lower	(1.1-1.2)	1	15	5	0.33	1.6	2	–
Basel	upper	(0.2-0.3)	3	50	23	0.46	0.40	***11***	0.77
	lower	(1.1-1.2)	3	60	42	0.69	0.36	**20**	0.99
Duggua	upper	(0.2-0.3)	2	64	29	0.46	0.39	***14***	0.80
	lower	(1.1-1.2)	2		34	0.58	0.37	**23**	0.98
Cooeeimbardi	upper	(0.2-0.3)	1	52	44	**0.84**	2.1	4	0.52
	lower	(1.1-1.2)	1	51	41	**0.80**	0.4	***9***	–
Spencer	upper	(0.2-0.3; 0.5-0.6)	2	47	16	0.32	0.81	***7***	0.76
	lower	(1.1-1.2)	2	56	27	0.49	0.46	***14***	0.95
Ottaba	upper	(0.2-0.3; 0.5-0.6)	2	54	14	0.80	0.11 (3)	**22** (3)	0.81
	lower	(1.1-1.2)	2	50	19	0.42	0.07 (3)	**34** (3)	0.99
Soils overlying coarse-grained sedimentary rocks									
Beppo	upper	(0.5-0.6)	1	58	19	0.33	0.43	***11***	0.66
	lower	(1.1-1.2)	1	53	31	0.58	0.42	**17**	0.90
Watt	upper	(0.2-0.3; 0.5-0.6)	2	54	26	0.48	1.27	***7***	0.60
	lower	(0.8-0.9; 1.1-1.2)	2	33	28	**0.85**	1.80	**20**	–
Turtle	upper	(0.2-0.3)	1	57	26	0.46	0.70	***7***	0.70
	lower	(0.8-0.9)	1	38	22	0.76	0.57	**22**	0.67
Calabash	lower	(0.8-0.9)	1	40	16	0.4	1.22	***6***	0.86
Kipper	upper	(0.5-0.6)	1	52	13	0.25	0.70	2	0.72
	lower	(0.8-0.9)	1	54	9	0.17	0.55	5	0.52
Greenhide	upper	(0.2-0.3)	1	27	14	0.52	1.94	1	0.66
	lower	(0.45-0.55)	1	33	26	0.79	1.70	2	0.54
Hibiscus	upper	(0.5-0.6)	1	47	5	0.11	0.41	4	0.13
	lower	(1.1-1.2)	1	28	3	0.11	0.17	3	–
Yellowbank	lower	(0.8-0.9)	1	22	3	0.14	1.14	3	0.75
Beer	upper	(0.2-0.3)	1	64	37	0.58	2.18	3	0.42
	lower	(1.1-1.2)	1	50	49	0.98	1.75	***9***	–
Caboonbah	upper	(0.2-0.3)	1	59	29	0.53	1.55	***8***	0.64
	lower	(0.8-0.9)	1	30	32	**1.07**	2.15	***11***	0.45

[a] where clay activity ratio is >0.8, values are **boxed**. Where clay activity ratio is <0.2 throughout the profile, values are shaded. Values are highlighted only if clay content is >20%.

[b] where Ca/Mg ratios are <0.8 (approx.) throughout the profile, values are shaded

[c] if soil is not sodic (ESP<6) values are shaded; if soil is sodic (ESP between 6 and 15) values are ***bolded***; if soil is strongly sodic (ESP>15) values are **boxed**

[d] soil depth measured in metres

Table 19 *(continued)* *Summary of subsoil clay content, CEC, clay activity ratio, Ca:Mg ratio, ESP and dispersion ratio (R1) for major Brisbane Valley soils*

Soil profile class		No. samples	Clay %	CEC meq/ 100 g clay	clay activity ratio[a]	Ca:Mg ratio[b]	ESP[c]	R1
Soils overlying intermediate to basic volcanic rocks								
Moore	upper (0.5-0.6)[d]	2	57	28	0.50	2.16	***7***	0.79
	lower (0.8-0.9)	1	30	32	**1.1**	2.47	***13***	0.81
Dunwich	upper (0.2-0.3)	1	66	21	0.32	0.96	4	0.49
	lower (0.8-0.9)	1	35	38	**1.1**	1.06	***8***	0.69
Steventon	upper (0.5-0.6)	1	59	8	0.13	0.11	2	0.12
	lower (0.8-0.9)	1	47	7	0.15	0.06	2	0.11
Linville	upper (0.2-0.3)	1	74	28	0.38	0.93	2	0.35
	lower (0.8-0.9)	1	26	55	**2.12**	1.57	2	0.67
Neara	upper (0.2-0.3)	1	68	26	0.38	1.86	3	–
	lower (0.5-0.6)	1	59	32	0.54	1.58	4	–
Deer	upper (0.25-0.35)	1	41	41	**1.00**	3.00	2	0.67
	lower (1.0-1.1)	1	33	45	**1.36**	2.31	3	0.63
Jimna	upper (0.2-0.3)	1	56	24	0.43	0.92	4	0.51
	lower (0.5-0.6)	1	51	47	**0.92**	0.96	5	0.64
Soils overlying fine-grained acid igneous rocks								
Burrundon	upper (0.22-0.32)	1	48	14	0.29	0.06	**18**	0.90
Soils overlying coarse-grained acid igneous rocks								
Pinch	upper (0.5-0.6)	1	35	10	0.29	1.70	2	0.53
	lower (1.1-1.2)	1	35	16	0.46	1.72	3	
Gilla	upper (0.5-0.6)	1	43	5	0.12	2.06	2	0.72
	lower (0.8-0.9)	1	24	7	0.29	1.90	2	0.78
Biarra	upper (0.25-0.30)	1	37	15	0.41	1.29	4	0.87
	lower (0.5-0.6)	1	19	16	**0.84**	1.44	5	0.83
Rebel	upper (0.25-0.30)	1	50	9	0.18	3.8	1	0.53
	lower (0.7-0.8)	1	13	11	0.85	5.2	2	0.90
Duncan	upper (0.2-0.3)	1	6	2	0.33	2.4	5	0.72
	lower (1.1-1.2)	1	9	4	0.44	1.1	2	0.99
Soils overlying fine-grained sedimentary rocks								
Eskvale	upper (0.2-0.3)	1	55	15	0.27	0.36	***14***	0.82
	lower (0.5-0.6)	1	55	21	0.38	0.44	**25**	0.89
Horse	upper (0.5-0.6)	1	33	7	0.21	1.68	2	0.76
	lower (0.75-0.85)	1	59	12	0.20	0.69	5	0.73
Freeman	upper (0.2-0.3)	1	70	26	0.37	0.52	***10***	0.83
	lower (0.5-0.6)	1	63	27	0.43	0.47	***10***	0.95
Noon	upper (0.2-0.3)	2	49	20	0.41	0.81	1	0.28
	lower (0.5-0.6)	2	31	21	0.68	0.89	1	0.32
Soils overlying metamorphic rocks								
Bunya	upper (0.5-0.6)	1	66	23	0.35	0.05	***7***	0.57
	lower (0.8-0.9)	1	65	26	0.40	0.02	***8***	0.71

[a] where clay activity ratio is >0.8, values are **boxed**. Where clay activity ratio is <0.2 throughout the profile, values are shaded. Values are highlighted only if clay content is >20%.

[b] where Ca/Mg ratios are <0.8 (approx.) throughout the profile, values are shaded

[c] if soil is not sodic (ESP<6) values are shaded; if soil is sodic (ESP between 6 and 15) values are ***bolded***; if soil is strongly sodic (ESP>15) values are **boxed**

[d] soil depth measured in metres

Sodicity and dispersion

Sodicity is a measure of the exchangeable sodium percentage (ESP) in the soil. A scale for assessing the sodicity of Australian soils (Northcote and Skene, 1972) is as follows:

non-sodic	sodic	strongly sodic
ESP <6%	ESP 6–15%	ESP >15%

[ESP = Na/CEC expressed as a %]

Sodicity has both chemical effects on plants and physical effects on the soil structure. The sodium weakens the bonds between the clay particles when wetted. This causes the clay particles to *disperse* making the soil water cloudy. The fine clay particles, in suspension, clog up the small pores in the soil, which restricts root growth and water movement.

In the rooting zone of plants, the symptoms of sodicity include poor infiltration and drainage resulting in waterlogging. These soils are often difficult to manage and have low productivity. Some soils may be both sodic and saline. These soils will often not show symptoms of sodicity as the salt acts against the clay particles dispersing.

Sodicity (ESP >6%) was recorded in surface soil (0–0.10 m) of the following soils: **Basel**, **Duggua**, **Ottaba** and **Burrundon** (see Appendix 3). The subsoil ESP of Brisbane Valley soils is shown in Table 19. Sodic soils occur in all the broad geological groups, except for *soils overlying coarse-grained acid igneous rocks* (granodiorite). Soils that may have strongly sodic subsoils are **Basel**, **Duggua**, **Ottaba**, **Beppo**, **Watt**, **Turtle**, **Burrundon**, and **Eskvale**. The ESP profiles for three sodic soils are shown in Figure 26.

It should be noted that dispersion may still occur if ESP is less than 6. As mentioned in a previous section, Ca/Mg ratios of <0.5 may cause dispersion. When ESP is medium to high (>6), and the Ca/Mg ratio is <1, then there is a high susceptibility to dispersion (Baker and Eldershaw, 1993). Brisbane Valley soils with low ESP and low Ca/Mg ratios are **Hibiscus** and **Steventon**.

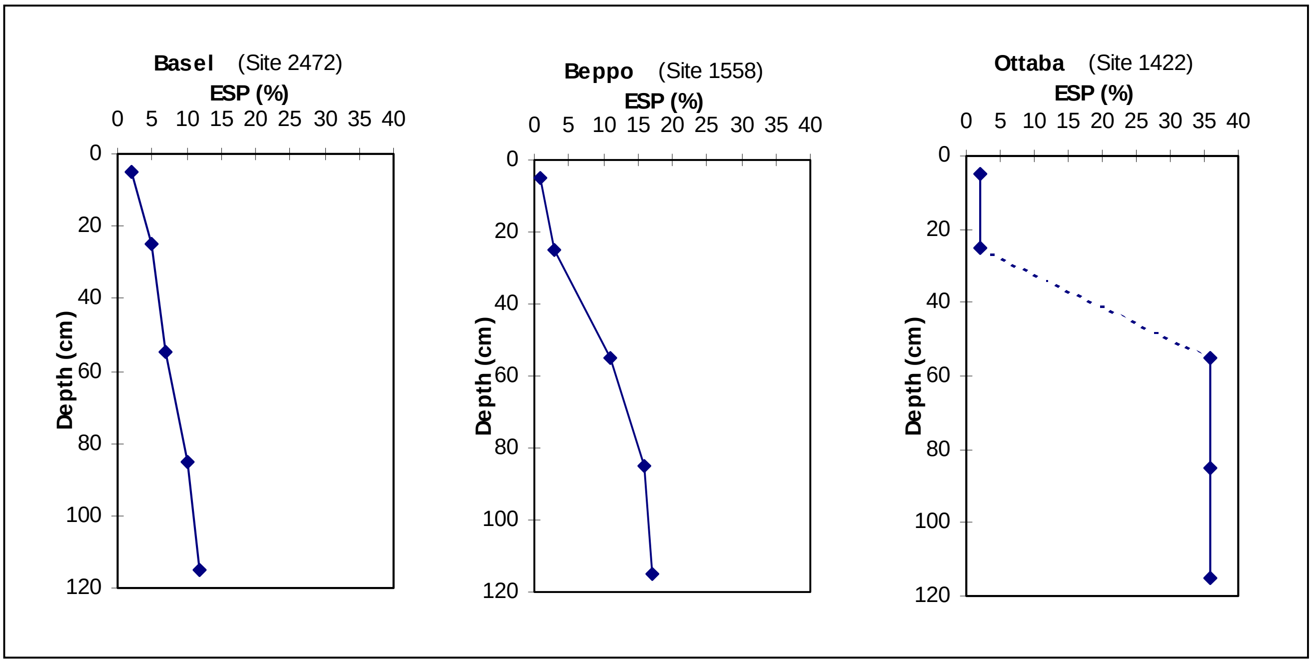


Figure 26 *ESP profiles for three sodic soils in the Brisbane Valley*

The *dispersion ratio* (R1) can be used to predict whether dispersion is likely to occur. The following ratings can be applied to values of R1 where smectite clays predominate:

low dispersion	moderate dispersion	high dispersion
R1 = 0.6	0.6–0.8	> 0.8

However, in isolation, the dispersion ratio is only an indicator of soil stability and should be considered in conjunction with particle size and ESP values (Baker and Eldershaw, 1993). Values of R1 for Brisbane Valley soils are shown in Table 19.

Moisture availability

One of the main functions of soil is to store moisture and supply it to plants between rainfall and irrigations. Evaporation from the soil surface, transpiration by plants and deep percolation combine to reduce soil moisture status. The plant available water capacity (PAWC) of a soil provides a buffer that determines a plant's capacity to withstand dry spells. PAWC is quoted as a measure of *equivalent depth of water* in the soil in millimetres.

Soil properties that affect PAWC include:

- the *ability of the soil to retain moisture* – determined by the number and size of pore spaces. This is largely determined by *soil texture* (the combination of particle sizes which make up the soil) and *soil structure* (the arrangement of those soil particles).
- the *effective rooting depth* – this is the depth to which plant roots can grow and function effectively. Root growth can be retarded by factors such as low pH (<5.5), low levels of calcium (Ca <2%) or dense intractable clay. If a subsoil is strongly sodic (ESP >15%) the clay particles may disperse (go into suspension) and clog the small pores in the soil, thereby restricting root growth and water movement.
- *landscape position.* All slopes shed water, thereby reducing the opportunity for drainage through the soil profile. However, certain types of slopes concentrate the flow of water while other slopes spread it out. In flat, poorly drained or flooded areas, water supply may exceed deep drainage and use by the plant causing the soil to become waterlogged. If water logging continues for a long period, most plants will die.

Ratings of plant available water for each soil profile class (for three different rooting depths) are found in Appendix 4. Effective rooting depth has been estimated from field observations and laboratory data. The depth at which salt accumulates in the soil profile is often a good guide to the effective rooting depth. The theory of water and salt movement suggests an accumulation of salt should occur at the bottom of the root zone, since water recharge and drainage following plant water use would flush salts from the active root zone. PAWC has been estimated from laboratory particle size analysis and wilting point (1500 kPa) moisture contents using the method of Littleboy (1997). It should be noted that considerable variation in effective rooting depth is to be expected within soil groups. Quoted figures are therefore to be used as a guide only.

The following ratings have been used to interpret the results:

PAWC in root zone (mm)	rating
<60	very low
60-90	low
90-120	medium
>120	high

5. LAND DEGRADATION

5.1 SOIL EROSION AND PASTURE DEGRADATION

Land degradation in the survey area was assessed at field inspection sites during the course of the survey. The field observations were supplemented by interpretation of aerial photographs (taken in 1990) to provide an estimate of the extent of land degradation throughout the survey area. Types of land degradation recorded were:

- sheet erosion
- rill erosion
- gully erosion
- tunnel erosion
- mass movement
- streambank erosion
- saline seepages
- salt affected soils

Where possible, for each observed type of land degradation, the following parameters were recorded (using criteria and codes from McDonald *et al.*, 1990):

- state of degradation: active, stabilised or partly stabilised
- severity of degradation: minor, moderate or severe

In addition, the proportion (percentage area) of each unique map area (UMA) affected by the observed soil related land degradation class was estimated.

Caution should be used in applying the land degradation statistics provided in this report. Further assessments would be required to show trends in degradation over time. Field assessment of land degradation is highly subjective, being strongly dependent on climatic conditions and management practices prior to inspection, and the observer.

5.1.1 Sheet erosion

Sheet erosion is the relatively uniform removal of surface soil from an area. Soil particles are initially dislodged when raindrops fall on bare soil. Lands most susceptible to this form of erosion are cultivated areas and heavily grazed hillsides. Sheet erosion may occur at low rates over long periods of time and consequently may go unnoticed by landholders.

The occurrence of minor and moderate sheet erosion in the survey area is shown in Table 20. Estimates of the proportion affected in each UMA are derived from field observations, local experience and aerial photo interpretation. Indicators of minor sheet erosion include shallow downslope deposits in sediment traps such as fencelines or grass tussocks. Minor sheet erosion is often difficult to assess, as evidence may be lost with cultivation. Lowered stocking rates and/or favourable growing conditions result in improved ground cover in grazing land which may also hide evidence of sheet erosion. Indicators of moderate sheet erosion include moderate soil deposits in downslope sediment traps including farm dams and partial exposure of roots.

Thirty six percent of the survey area is estimated to be affected by minor sheet erosion and a further 7% by moderate sheet erosion. Because of the masking effects of both cultivation and vigorous crop and pasture growth, the occurrence of sheet erosion in the group *soils overlying alluvium* has probably been underestimated, especially where soils are flood prone. As a group, the *soils overlying fine-grained acid igneous rocks* (rhyolite/trachyte) are the most affected by sheet erosion with 70% of the area being affected. The other major group affected (at 60% of the area) is *soils overlying coarse-grained sedimentary rocks.* Of this particular soil group, the steep hills (scrub) are 75% affected, reflecting the fact that these scrub soils are almost entirely cleared and intensively grazed. The most affected soils in this group are **Caboonbah** (a ‘scrub’ soil) with 61%, **Hibiscus** with 70% and **Beppo** with 65%. As a sub-group, the *soils overlying coarse-grained sedimentary rock* (*Helidon Sandstone* member) are 68% affected. Indicators of severe sheet erosion include loss of surface horizons, exposure of subsoil, pedestalling, root exposure and substantial soil deposits in downslope sediment traps. Severe sheet erosion was observed in only three UMAs and covering a total area of 73 hectares.

Figure 27 *Surface scalding, caused by overgrazing, has led to the exposure of the highly erodible subsoil (**Eskvale** soil)*

5.1.2 Rill and gully erosion

Rill and gully erosion occur when runoff water begins to concentrate in definite channels. As the water flows down the slope, the channels become deeper, wider and longer. Rills are channels up to 30 cm deep, while gullies are deeper (McDonald *et al.*, 1990).

Most rills are ephemeral in nature (seasonal), and are usually filled by subsequent cultivation. Despite the fact that rill erosion is likely to be found at certain times on the majority of bare and cultivated slopes, during the survey it was only documented in 11 UMAs and a total area of 112 hectares.

The occurrence of minor and moderate gully erosion in the survey area is shown in Table 20. The following definitions from McDonald *et al.*, (1990) are applied in this survey. Minor gully erosion is where gullies are isolated, linear, discontinuous and restricted to primary and minor drainage lines. Moderate gully erosion differs in that the gullies are continuous. Severe gully erosion is where gullies tend to branch away from primary drainage lines and on to footslopes, or have multiple branches within primary drainage lines.

Six percent (or 7457 ha) of the survey area is estimated to be affected by minor gully erosion and a further 1% (or 1289 ha) by moderate gully erosion. Soil groups most affected by gully erosion are *soils overlying coarse sediments* (9%), *soils overlying fine sediments* (9%) and *soils overlying intermediate to basic volcanics* (7%). Individual soils most affected are **Moore** (12%), **Yellowbank** (10%), **Burrundon** (10%), **Esk** (10%), **Beppo** (9%), **Deer** (9%) and **Spencer** (7%). Of the soil associations on steep hills, *coarse-grained sedimentary rocks (forest)* with 11% and *fine-grained sedimentary rocks (forest)* with 12% are most affected.

Severe gully erosion was documented for only five individual UMAs, belonging to the following soil profile classes: **Spencer** (twice), **Beppo**, **Turtle** and **Eskvale**. Gullies up to two metres deep were observed in some cases. The soils in these UMAs are Sodosols (ESP >6 in the top 20 cm of the B horizon) which disperse and erode rapidly if the subsoil is exposed. [See Section 4.3 for a discussion of chemical properties of soil profile classes.]

Figure 28 *Severe gully erosion in a drainage depression (**Spencer** soil)*

5.1.3 Tunnel erosion

Tunnel erosion is a subsurface form of erosion which occurs when water scours underground channels through highly dispersive subsoils. Water may enter through access points such as old tree roots, fence post hole, animal burrows or old pipe/cable trench lines. Tunnels may eventually cave in to form gullies.

The occurrence of tunnel erosion was only documented on two occasions during the course of the survey: in the **Burrundon** (*overlying fine-grained acid igneous rocks*) and **Caboonbah** (*overlying coarse-grained sedimentary rocks*) soils.

5.1.4 Mass movement

Mass movement includes all relatively large downslope movements of soil, rock or mixtures of both, for example land slides, slumps and earth flows. (McDonald *et al.*, 1990). Mass movement occurs when the forces holding soil particles together are overcome by gravitational force, and may be triggered by the removal of vegetation and/or heavy rainfall.

The presence of modern mass movement was documented at 26 sites during the course of the survey. Soils represented are **Beppo** (twice), **Deer**, **D'Aguillar**, **Dunwich**, **Greinke** (twice), **Linville** (five times), **Moore** (five times), **Neara** (twice), **Noon** (twice), **Turtle** (three times), **Welton** and **Watt**. Hillslope creep associated with cattle movement was observed (but not documented) on various soils with moderate to steep slopes (>20%). This contrasts with a significantly higher incidence of mass movement documented in the nearby Lockyer Creek Catchment where 1135 land slips were observed in a 1979 study (Shaw, 1979).

Table 20 *Sheet and gully erosion in the survey area*

	Total Area (ha)	Minor sheet erosion	%	Moderate sheet erosion	%	Minor gully erosion	%	Moderate gully erosion	%
ALLUVIUM									
CRESSBROOK	453	19	4			2	0.4		
HONEY	1298	43	3			6	1		
MONSILDALE	2288	122	5			9	0.4		
GALLANANI	3311	186	6			39	1		
GUNYAH	959	36	4			47	5		
BASEL	2812	172	6			99	4		
COOEEIMBARDI	2238	245	11			89	4		
SPENCER	9355	1373	15	687	7	264	3	281	3
OTTABA	3078	417	14	143	5			58	3
Total for unit	***25 601***	***2613***	***10***	***830***	***3***	***555***	***2***	***388***	***2***
COARSE SEDIMENTS									
BEPPO	15478	7150	46	2730	18	698	5	592	4
WATT	2027	936	46	76	4	62	3		
KIPPER	174	87	50						
GREENHIDE	224	89	40			4	2		
TURTLE	1630	628	38	234	14	74	5		
LAKEVIEW	300	139	46			16	5		
HIBISCUS	1587	1019	64	89	6	60	4	2	0.1
YELLOWBANK	196	22	11	78	40	3	2		
BEER	526	159	30			4	1		
CABOONBAH	1222	747	61			119	10	9	1
GREINKE	10	2	20						
steep hills (forest)	14251	6405	45	2002	14	907	6	603	4
steep hills (scrub)	826	619	75			63	8		
Total for unit	***38 643***	***18 002***	***47***	***5209***	***14***	***2010***	***5***	***1206***	***3***
INTERMEDIATE AND BASIC IGNEOUS									
MOORE	5097	1922	38	1400	27	302	6	262	5
DUNWICH	3224	1573	49	89	3	185	6	15	1
PADDY	780	95	12	116	15	6	1	13	2
STEVENTON	202	101	50						
LINVILLE	4164	1664	40	194	5	196	5	51	1
NEARA	2533	1397	55			125	5		
DEER	394	150	38			34	9		
JIMNA	84	42	50						
D'AGUILLAR	313	34	11						
steep hills (forest)	15919	8958	56	76	1	1044	7	23	0.1
steep hills (scrub)	9696	3367	34			379	4		
Total for unit	***42 406***	***19 303***	***46***	***1950***	***5***	***2271***	***5***	***364***	***1***
FINE-GRAINED ACID IGNEOUS									
BURRUNDON	627	35	6	391	62	11	2	53	9
ESK	74	56	76			7	9		
steep hills	2163	1514	70						
Total for unit	***2 864***	***1605***	***56***	***391***	***14***	***18***	***1***	***53***	***2***
COARSE-GRAINED ACID IGNEOUS									
PINCH	119	27	23						
GILLA	557	306	55			16	3		
BIARRA	130	65	50						
REBEL	276	103	37			17	6		
IVORY	297	147	50					5	2
FORSTER	15	4	27						
steep hills	1205	617	51			27	2	33	3
Total for unit	***2 599***	***1269***	***49***	***0***	***0***	***60***	***2***	***38***	***2***
FINE SEDIMENTS									
ESKVALE	1808	688	38	103	6	70	4	12	1
HORSE	153	89	58	1	1	20	13	16	11
NOON	124	36	29			4	3		
WELTON									
steep hills (forest)	12258	4507	37	1181	10	1473	12	848	7
steep hills (scrub)	670	91	14						
Total for unit	***15 013***	***5411***	***36***	***1285***	***9***	***719***	***5***	***876***	***6***
METAMORPHICS									
BUNYA	1596	558	35						
steep hills	4047	31	1	68	*2*	14	0.3	12	0.3
Total for unit	***5643***	***589***	***10***	***68***	***1***	***14***	***0.2***	***12***	***0.2***
TOTAL (SURVEY AREA)	***137 376[14]***	***48 792***	***36***	***9733***	***7***	***5647***	***4***	***2937***	***2***

[14] Total area includes 4 573 ha which was not assessed for erosion (urban, stream etc.)

5.1.5 Saline seepages

Saline seepages occur when salty groundwater is discharged and moves across the land surface. During the course of the survey, this was observed in eight individual UMAs. All of these were associated with lower slope or 'break of slope' positions in the Esk Formation (*soils overlying coarse-grained sedimentary rocks*). The discharge occurs at these locations because of reduced soil depth and/or soil porosity which restricts subsurface water movement and causes water to accumulate and 'escape' to or near to the surface.

Compared to other areas of south-east Queensland such as the Lockyer Valley, the Brisbane Valley appears to have a relatively minor salinity problem[15]. There is little evidence of salt affected soils due to high water tables. However, it should be noted that the land resource survey was carried out during an extensive period of drought (1992–1995). Salinity occurrences may be expected to increase following wet seasons.

5.1.6 Streambank erosion

Johnson (1997) rated the stream bank stability of the Brisbane River between Wivenhoe Dam and Monsildale Creek, as ranging from moderately stable to very stable. However, many sites were recorded as being affected by some degree of erosion, aggradation and/or slumping. The extent of these processes on the upper and lower banks in four survey areas is shown in Table 21.

Predominant factors affecting bank stability are grazing activities, stream flow and waves, clearing of vegetation and sand and gravel extraction. Runoff, floodplain scours and people tracks are also listed as affecting bank stability (Johnson, 1997).

Table 21 *Streambank Erosion in the Brisbane Valley — LOWER BANK/***UPPER BANK**

PROCESS	Non-Extraction Areas Mean % of the Bank Length	Past Extraction Areas Mean % of the Bank Length	Minor Current Extraction Areas Mean % of the Bank Length	Major Current Extraction Areas Mean % of the Bank Length
Bare ground	*32*/**13**	*48*/**39**	*32*/**15**	*60*/**33**
Stable	*65*/**68**	*71*/**66**	*51*/**70**	*63*/**65**
Eroded	*21*/**24**	*26*/**21**	*33*/**23**	*37*/**24**
Slumping	*10*/**12**	*0*/**20**	*0*/**15**	*10*/**20**
Aggrading	*20*/**28**	*23*/**20**	*43*/**18**	*15*/**5**

Note: Total length of river (Wivenhoe Dam to Monsildale Creek) 63.1 km

Non Extraction areas	15.6 km	Past extraction areas	14.3 km
Minor current extraction areas	20.1 km	Major current extraction areas	13.1 km

Source: Johnson, 1997.

In the course of the Brisbane Valley Land Resource Assessment, streambank erosion was documented at 146 sites (in 53 UMAs) along the Brisbane River and tributaries. However, assessment of this form of land degradation was not treated as a priority, and in many cases could not be assessed accurately without access to the stream itself, which was sometimes difficult, especially for the Brisbane River.

[15] Bremer River Catchment: 859 ha affected by saline outbreaks in 1979 (Johnston, 1979)
Lockyer Creek Catchment: 517 ha affected by saline outbreaks in 1979 (Shaw, 1979)

5.1.7 Pasture degradation

Pasture degradation is a term used to describe the process by which a pasture's ability to return to its natural state is reduced (Pressland *et al*., 1988). This can usually be attributed to too many stock being grazed on a pasture for prolonged periods. This generally leads to:

- a reduced cover of perennial pasture species
- depleted pasture yield and reduced cycling of nutrients through decomposing litter, and
- changes in botanical composition toward less desirable perennials and an increase in annual grasses (see Section 2.5.3)

As pasture degradation proceeds, more of the soil surface is left bare and vulnerable to soil erosion which compounds the symptoms of degradation. The loss of surface soil restricts pasture vigour and regrowth due to the loss of plant nutrients and stored seed, and in the long term it reduces the pasture's ability to regenerate from seedlings.

A change in pasture composition from speargrass to less desirable species is associated with increased runoff. This has been shown to be associated with changes in soil hydrological conditions corresponding to a marked reduction in the occurrence of 1 to 3 mm macropores of the surface soil (Sallaway and Waters, 1994).

During the Brisbane Valley survey, pasture species composition was described at the majority of field inspection sites. These observations confirm the occurrence of considerable pasture degradation in the survey area. However, quantification of this form of degradation was beyond the scope of this survey.

5.2 SOIL ERODIBILITY AND RUNOFF FOR BRISBANE VALLEY SOILS

Grazing pressure, through its effect on the surface soil and plant cover, affects rainfall infiltration and hence runoff and soil movement (erosion). As part of the Brisbane Valley Land Resource Assessment, a rainfall simulator was used to investigate soil erodibility and the effects of pasture cover on soil erosion at four selected sites (representing the **Beer**, **Neara**, **Pinch** and **Beppo** soil profile classes)[16]. Soil morphology and analytical data for each of these sites is included in Appendix 3.

Other experiments on grazing country in central and southern Queensland have demonstrated that both stocking rate and land (soil) type significantly affect soil loss. At Keilambete, west of Rockhampton, an average annual soil loss of 3.9 t/ha was recorded under high stocking rates over a three year period from 1994 (Waters, 1997). At Mt Mort in south-east Queensland, an average annual soil loss of 34 t/ha was recorded for bare soil (5% cover) over four years to 1996[17] (D.M. Silburn, personal communication). This figure is roughly of the same order of magnitude as the average annual soil losses of 61 t/ha and 32 t/ha measured for bare fallow on two cropping soils in the Darling Downs (Freebairn *et al*., 1989).

Runoff, infiltration and sediment transport were recorded over a 40 minute 'rainfall event' equivalent to the intensity of a 100 mm/hr storm (ie. approximately 67 mm in 40 minutes). A summary of recorded runoff, infiltration and sediment loss is shown in Table 22. Treatments were as follows:

- 'bare' – sprayed, mown, raked and left bare for some months to create a worst case over-grazed surface with no grass or litter cover
- 'reduced cover' – mown and raked, resulting in short grass but generally having <60% cover
- 'high cover' – untreated pasture with almost 100% cover.

Infiltration curves for each soil at the three different cover treatments are illustrated in Figure 29. These show that **Beer** soil has the highest infiltration rate, probably due to its self-mulching surface and superior

[16] The rainfall simulator study was performed in 1995 and 1996 by Mark Silburn, Ralph deVoil, Steve Glanville and Denis Orange, Agricultural Production Systems Research Unit, Department of Natural Resources, Toowoomba.
[17] This period included three years in the lowest 20 percentile annual rainfall.

surface soil stability. However, due to problems associated with the response of the **Beer** soil during the 1995 trial (stable infiltration rate not obtained for the bare plot), the rainfall simulation for this soil (bare and reduced cover treatments) was repeated in the following year.

In terms of infiltration and runoff, the **Neara**, **Pinch** and **Beppo** soils are quite similar when bare, but **Pinch** and **Neara** respond better than **Beppo** if cover is present. A large proportion of the rainfall became runoff on these soils, even for the high cover treatment (50–55% runoff for **Pinch** and **Neara**; 63% runoff for **Beppo**).

Beer soil is significantly different to the other three soils studied. Under high cover, little runoff occurred (only 4% of rain registered as runoff). The surface soil remained loose (ie. did not set hard) after spraying, clipping and being left bare. In addition, the larger water holding capacity of this soil means that the soil has a larger soil moisture deficit to satisfy before runoff becomes significant. It was also noted that in 1995 there was approximately twice the amount of coarse organic matter (roots, grass litter) present in the top 25 mm of the **Beer** soil compared to the soils at the other sites. When repeated in 1996, the **Beer** site still had a large amount of coarse organic matter in the surface soil, but gave about 10–15% more rain as runoff. After the rainfall simulator applied extra rain (about 150 mm in total), a final infiltration rate similar to the other soils (about 10 mm/hr) was obtained. This shows that once the **Beer** soil is fully wet, subsoil properties (eg. coarse structure, high clay content) limit infiltration.

Table 22 *Runoff, infiltration and soil loss data for four sites in the Brisbane Valley*

Soil profile class	Treatment and cover	Slope (%)	runoff as a proportion of rain	final infiltration rate (mm/hr)	rain before final infilt. rate (mm)	soil loss (t/ha)
Beer						
(site 1555)	bare (1996, 17%)	8.1	55%	32	41	4.02
	bare (1996, 17%) with extra rain	*–*	*–*	*8*	*153*	*–*
	bare (1995, 22%)	8.6	43%	21	56	3.08
	reduced cover (37%, 1996)	8.0	56%	34.4	24	1.97
	reduced cover (61%, 1995)	5.3	34%	62	21	0.87
	high cover (99%)	7.2	4.1%	92	24	0.02
Neara						
(site 1557)	bare (2%)	8.5	81%	12	23	10.3
	reduced cover (76%)	10.3	67%	31	24	0.85
	high cover (99%)	7.4	54%	43	24	0.22
Pinch						
(site 1556)	bare (2%)	13.2	86%	11	23	20.4
	reduced cover (80%)	12.7	64%	33	14	2.34
	high cover (98%)	11.9	50%	47	17	0.28
Beppo						
(site 1558)	bare (2%)	7.4	86%	12	9	13.6
	reduced cover (38 %)	9.0	83%	12.2	38	3.49
	reduced cover (77%)	7.2	74%	23	20	1.27
	high cover (99%)	8.4	63%	30	16	0.22

Note: approx. 67 mm ‘rain’ for each treatment, except for bare 1996 (**Beer** soil), which had over 150 mm ‘rain’

The relative erodibility of the soils can be assessed by comparing the sediment transported at each of the sites (same treatment) during the rainfall simulation (equivalent to a 40-minute storm or 67 mm rainfall). Sediment loss, converted to tonnes per ha is shown in Table 22. However, it is necessary to account for the fact that slope varied between sites and between individual treatments at each site. Table 23 contains soil loss results corrected for slope (a nominal 9% slope) for bare (0% cover) soil.

Soil erodibility factors (K factors) were calculated for each of the soils using two different methods, and the results are shown in Table 23. The *soil erodibility factor* (K) is a characteristic of the soil (independent of slope and cover) and generally depends on particle size distribution, percentage organic matter, soil structure and the infiltration rate (or profile permeability).

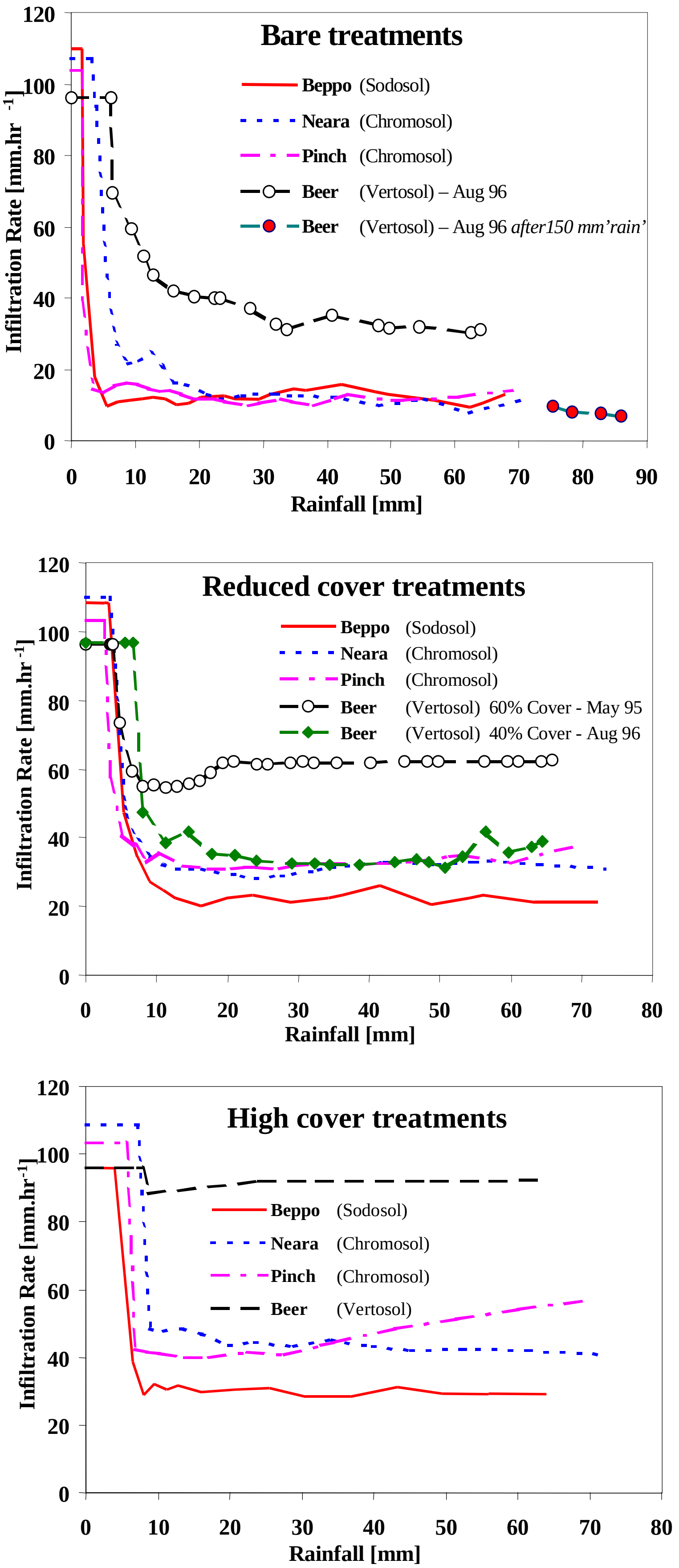


Figure 29 *Infiltration rates during rainfall*
Note: Bare treatments had a cover of 2%, except ***Beer****, which had 15–20%. Reduced cover treatments had cover of 75–80%, except for* ***Beer*** *which had 60% (in 1995) and 37% (in 1996). High cover treatments had about 100% cover.*

Calculation of the K factor for each soil allows the soils to be ranked on the basis of their relative erodibility (see Table 23). The first K factor (K_1) was calculated from the experimental results using the Rose (1985) soil loss equation. This can be regarded as the 'efficiency of entrainment' for bare soil (ie. the propensity of the soil to lose soil particles by detachment and removal with runoff). The second K factor (K_2) was calculated using the revised 'nomograph' [18] method of Loch and Rosewell (1992) from laboratory analysis results and field soil structure assessment. This is a Universal Soil Loss Equation (USLE) soil erodibility factor, which assumes that the soil is cultivated.

Given the small area studied under the rainfall simulator, the results and the K_1 factor describe soil loss and erodibility due to sheet erosion processes. Sheet erosion is a widespread form of soil erosion on hillslopes under pasture in the survey area, as discussed in Section 5.1.1. However, under cultivation rill erosion would also occur. To provide some insight into the likely erosion of these soils under cultivation (with both sheet and rill erosion) the K_2 soil erodibility factor may be used. Included for comparison are soil erodibility factors calculated for two other soils in south-east Queensland (Greenmount and Greenwood on the eastern Darling Downs).

Table 23 *Relative soil loss and soil erodibility at four sites in the Brisbane Valley*

Soil profile class	Soil loss (t/ha) [corrected to 9% slope and 0% cover]	K_1	K_2	Relative erodibility (based on corrected soil loss)	Erodibility rank
Beppo (Sodosol)	19	0.113	0.40	1.0	1
Pinch (Chromosol)	13	0.099	0.37	0.7	2
Neara (Chromosol)	12	0.082	0.32	0.6	3
Beer (Vertosol)	8	0.076	0.31	0.4	4
cultivated Vertosol at Greenmount – small plots (rainflow)		0.25[a]			
cultivated Vertosol at Greenmount – field contour bays (rilling)		0.77[b]	0.38[c]		
cultivated Vertosol at Greenwood		–	0.38[c]		

[a] DM Silburn (pers.comm.) [b] Silburn and Loch, 1992 [c] Freebairn *et al.*, 1989

The relative soil loss (corrected to 9% slope and 0% cover) as shown in Table 23, gives the most direct comparison between soils of soil erodibility due to sheet erosion. Soil loss for the most erodible soil (**Beppo**) is about twice that of the least erodible soil (**Beer**), with **Pinch** and **Neara** soils about halfway between those two. Soil loss is lower for the **Beer** soil partly because infiltration rates were higher and the amount of runoff lower. However, the K_1 factor shows that **Beer** soil is also inherently less erodible. This lower erodibility can be attributed to the strongly structured self-mulching surface soil and superior surface soil organic matter content of **Beer** soil.

The K_1 factor describes how easily surface soil is detached and transported by rainfall and runoff water, allowing for differences in the total amount of runoff. That is, it indicates how much soil would be transported if the same amount of runoff occurred on each soil. The K_1 values for **Beer** and **Neara** soils are 33% and 28% lower respectively than for **Beppo** soil. Both **Beer** and **Neara** soils have higher organic carbon (4.6% and 2.6% OC respectively) and moderate to strong aggregates in the surface soil compared with **Beppo** (1.9% OC, weak aggregates).

The surface soil organic matter content and structure of **Pinch** soil (1.4% OC, weak aggregates) are similar to those of **Beppo** soil. However, there is a significant difference between the two soils in both soil loss and K_1 values. This could be due to differences in surface soil texture. **Beppo** has a clay loam surface (34% silt and clay), while **Pinch** has a coarse sandy loam surface (21% silt and clay). Fine mineral particles (silt and clay) are more easily transported once detached. Soil erosion research generally indicates that soils with a clay loam surface texture are more erodible than those with a sandy textured surface soil.

[18] Uses a model derived from data collected from a range of cultivated soils in Australia and the United States

The K_1 factors for Brisbane Valley soils (shown in Table 23) are much lower than for the cultivated black earth (Vertosol) at Greenmount. This reflects the higher transportability of cultivated soil (due to the occurrence of rill erosion and the run down of organic carbon due to prolonged tillage). The K_2 erodibility factors (also shown in Table 23), suggest that under cultivation **Beppo** and **Pinch** soils would be more erodible than **Neara** and **Beer** soils, again reflecting their lower organic matter content and lower permeability.

The results of this erodibility study indicate that soil loss is strongly linked to pasture cover for all four soils. Figure 30 illustrates that soil loss declined as cover increased. When cover was 70% or more, soil loss was ten times less than for bare soil (0% cover).

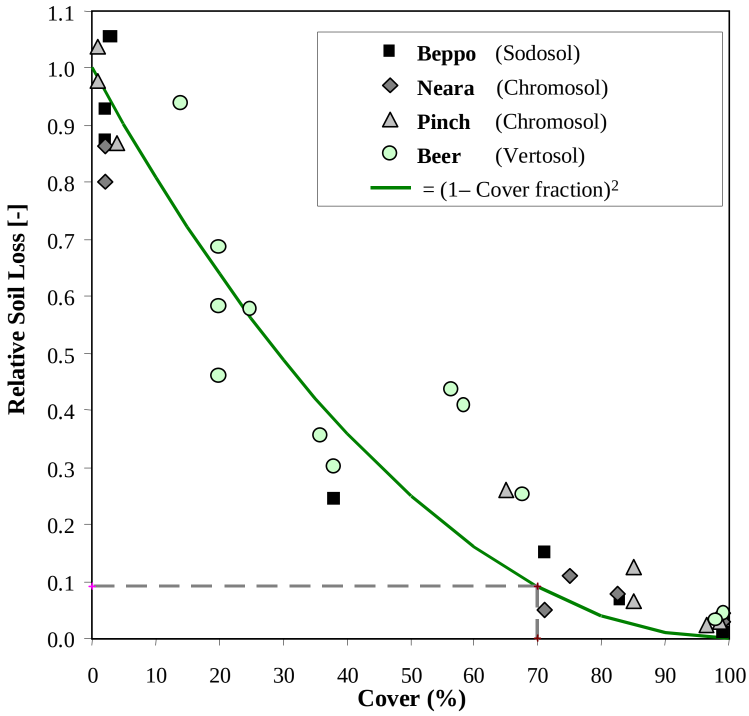


Figure 30 *Relative soil loss versus soil cover for each soil profile class*

5.3 CONTROL MEASURES FOR SOIL EROSION

Reclamation of degraded areas is slow, difficult and costly. As demonstrated in the soil erodibility study detailed above, the best way to prevent soil erosion in pasture country is to maintain adequate surface cover. This is particularly important for hard setting texture contrast soils with a clay loam surface texture such as **Beppo**, and for soils that are depleted in organic matter (organic carbon <1.5%).

Adequate groundcover improves soil infiltration rates and ensures that overland flow velocities are reduced when runoff does occur, thereby reducing and the risk of erosion. *The adoption of conservative stocking rates – that are flexible enough to be adjusted to seasonal conditions – is the key to maintaining good pasture cover*.

Ways to reduce erosion in cropping lands are many and varied. On sloping land, the installation of a contour layout incorporating banks and waterways is an important first step. Diversion banks and waterways may also need to be incorporated. Management strategies such as zero tillage and reduced tillage are recommended in all cases to reduce erosion and promote water infiltration. Maintaining a permanent surface cover under tree crops is also essential for erosion control.

Regardless of the enterprise or the erosion control system employed, the secret to success is to retain as much soil surface cover as possible to minimise detachment of soil particles and hence soil erosion.

6. LAND EVALUATION

6.1 LAND USE LIMITATIONS BY SOIL PROFILE CLASS

The agricultural potential of land in the survey area was assessed for:

- dryland (rainfed) cropping
- irrigated small crops
- dryland sown pastures
- irrigated pasture
- tree and vine crops

The five-class land suitability classification used in this study is outlined in Section 3. To quantify the limitations that apply in each UMA, particular *attribute levels* are recorded for *each* limitation. For example, in Table 24, there are four attribute levels for soil water availability coded M1 to M4, in order of increasing severity. On the basis of the attribute levels recorded, each UMA is then allocated to one of the pre-determined soil water limitation classes for each land use. All the limitations are considered in turn, and the combination of limitation classes in each UMA is then used to derive an overall *suitability class* (1 to 5) for each land use. The suitability class is usually determined by the most severe limitation identified (Land Resources Branch Staff, 1990). The attribute level codes listed in each table in this section are the soil/land attribute level recorded in the UMA database.

6.1.1 Soil water availability

One of the main functions of soil is to store moisture and supply it to plants between rainfall (or irrigation) events. Plant yield is decreased by periods of water stress, particularly during critical growth periods. For irrigated land, a reduced water storage capacity means more frequent irrigation is required to attain optimum yields.

The amount of water stored in the soil that is available for plant growth is called the PAWC (plant available water capacity). Soil morphological and analytical properties (texture, structure and soil depth) are used to derive estimates of PAWC for each soil profile class (see Section 4.3.2); however, it is necessary for this to be modified depending on observations (or estimations) of soil depth. Maximum rooting depth is assumed to be 1 metre.

Soil water availability is a critical limiting factor for rainfed land use options. An attribute level of M3 (PAWC 60–90 mm) is considered inadequate for dryland cropping and is therefore given a limitation class of 4. An attribute level of M4 (PAWC <60 mm) is regarded as a prohibitive limitation for dryland sown pasture. Soil water availability is not a prohibitive limitation for irrigated land uses, but may be a moderate limitation in terms of the frequency of irrigation required. Irrigation is standard management practice for tree and vine crops.

Table 24 *Soil water availability limitation*

Attribute level	*Code*	*Limitation class for various land uses*				
		Dryland sown pastures	Dryland crops	Irrigated pastures	Irrigated small crops	Tree and vine crops
PAWC >120 mm	M1	1	2	1	1	1
PAWC 90 - 120 mm	M2	2	3	1	1	2
PAWC 60 - 90 mm	M3	3	4	2	2	2
PAWC <60 mm	M4	4	5	3	3	3

The majority of soils with an M1 or M2 attribute level for soil water availability are in the group *soils overlying alluvium*: **Basel**, **Cooeeimbardi**, **Gallanani**, **Monsildale** and **Gunyah** (in some situations). Lighter soils on alluvium (**Honey** and **Cressbrook)** have an attribute level of M3 due to the dominance of sand in the soil profile. The other soils overlying alluvium (**Spencer** and **Ottaba)** have an M3 attribute level for soil water availability due to strong subsoil sodicity and unfavourable soil reaction (pH). The only non-alluvial soils to record an M1 or M2 attribute level for soil water availability were **Beer**, **Neara**, **Deer**, **Linville** and **Lakeview**. However, the attribute level for these soils is strongly linked to soil depth (over rock). Almost all of the texture contrast soils of the rises and hillslopes in the survey area have an M3 or M4 attribute level for soil water availability. This is because of shallow depth to rock or other limitations to plant rooting depth (strongly sodic subsoils or in a few cases strongly acid pH).

6.1.2 Workability

Soil workability refers to the suitability of land for cultivation based on the physical attributes of the soil. The major physical attributes affecting workability are strength, moisture range and abrasiveness.

Strength of soil is its resistance to breaking or deformation (McDonald and Isbell, 1990); it is a measure of how 'tough' the soil is. Moisture range refers to the appropriate range in soil moisture content over which a soil can be successfully cultivated (without compacting or pulverising the soil, both of which can lead to long term soil damage). Some soils can be worked at any moisture content, while others have only a narrow suitable range. Where irrigation is used, surface conditions may be managed by maintaining moisture at the surface thereby reducing its strength.

Attribute levels are established from a knowledge of soil properties. Limitation classes are derived from local knowledge and extension advice. Extra management is required on soils with physical limitations.

Table 25 *Workability limitation*

Attribute level	*Code*	*Limitation class for various land uses*				
		Dryland sown pastures	Dryland crops	Irrigated pastures	Irrigated small crops	Tree and vine crops
Sands; loose to firm loams	K1	1	1	1	1	1
Strongly structured light clays and clay loams; coarse sandy clay loams	K2	1	2	2	2	1
Self-mulching clays; hard setting sandy loams to clay loams	K3	2	2	2	2	2
Coarse structured (hard) clays; very rocky soils	K4	2	3	3	3	2
Eroded and very hard setting soils	K5	4	5	5	5	4

Workability is not a severe limitation for any of the land uses investigated except in the case of eroded and/or very hard setting soils (K5 attribute level). This attribute level was recorded for **Beppo** (3 times), **Turtle** (twice), **Watt** (twice) and **Spencer** (twice). All soil profile classes were allocated an attribute level for workability that applied throughout the survey area, except if a particular UMA was downgraded to a K5 level. The attribute level allocated to each soil profile class is shown in Appendix 4.

6.1.3 Surface condition

Seedling emergence and establishment are affected by adverse physical conditions of the surface soil including hard setting, crusting or coarse self-mulching conditions. Surface condition is not a precluding limitation for any of the investigated land uses. However, soils with hard setting or crusting surfaces are given a moderate limitation for dryland cropping, irrigated pastures and irrigated crops.

All soil profile classes were allocated an attribute level for soil condition that applied generally throughout the survey area. However, these were modified on the basis of field observations. For example, for some soils such as **Basel**, two or three surface condition categories may apply in different situations. Site disturbance and management also have an effect.

Table 26 *Surface condition limitation*

Attribute level	Code	Limitation class for various land uses				
		Dryland sown pastures	Dryland crops	Irrigated pastures	Irrigated small crops	Tree and vine crops
Sands, fine self-mulching clays	P1	1	1	1	1	1
Coarse self-mulching clays, firm surface duplex soils	P2	2	2	2	2	1
Other soils – hard setting or crusting	P3	2	3	3	3	1

6.1.4 Nutrient deficiency

Inadequate nutrient supply causes reduction in plant yield, especially during critical periods such as flowering and fruiting. Livestock production may be limited by either a reduction in pasture growth or pasture nutritive value caused by low soil nutrients.

Attribute levels and limitation classes are based on critical levels of key nutrients required for *pasture* production (Rayment and Bruce, 1984; Ahern *et al*., 1994). Critical levels for nitrogen have not been included as nitrate-nitrogen varies according to the rate of mineralisation from soil organic matter and losses of nitrate by leaching and biological removal. Temperature, rainfall and other soil conditions also influence these processes (Rayment and Bruce, 1984). Addition of nutrients is standard management practice for irrigated pastures and crops as well as tree and vine crops.

Table 27 *Nutrient deficiency limitation*

Attribute level	Code	Limitation class for various land uses				
P = bicarb. extr. P (mg/kg) S = extr. sulfate S (mg/kg) K = extr. K (m. equiv./100g)		Dryland sown pastures	Dryland crops	Irrigated pastures	Irrigated small crops	Tree and vine crops
>30 P, >5 S, >0.25 K	N1	1	1	1	1	1
>30 P, >5 S, <0.25 K	N2	2	2	2	2	1
>30 P, <5 S, >0.25 K	N3	2	2	2	2	1
>30 P, <5 S, <0.25 K	N4	2	2	2	2	1
20 - 30 P, >5 S, >0.25 K	N5	2	2	2	2	1
20 - 30 P, >5 S, <0.25 K	N6	2	2	2	2	1
20 - 30 P, <5 S, >0.25 K	N7	2	2	2	2	1
20 - 30 P, <5 S, <0.25 K	N8	3	3	2	2	1
10 - 20 P, >5 S, >0.25 K	N9	3	3	2	2	1
10 - 20 P, >5 S, <0.25 K	N10	3	3	3	3	2
10 - 20 P, <5 S, >0.25 K	N11	3	3	3	3	2
10 - 20 P, <5 S, <0.25 K	N12	4	4	3	3	2
<10 P, >5 S, >0.25 K	N13	4	4	3	3	2
<10 P, >5 S, <0.25 K	N14	4	4	3	3	2
<10 P, <5 S, >0.25 K	N15	4	4	3	3	2
<10 P, <5 S, <0.25 K	N16	4	4	3	3	2

On the basis of laboratory analyses, all soil profile classes were allocated an attribute level for nutrient deficiency that applied throughout the survey area (see Appendix 4). Soils with a severe nutrient deficiency limitation for dryland cropping and dryland sown pastures (Code N12 to N16) are **Esk**, **Forster**, **Ivory**, **Pinch**, **Rebel**, **Hibiscus** and **Yellowbank**.

6.1.5 Soil reaction (pH)

Soil pH has a marked effect on nutrient availability. Low pH can lead to toxicity of some elements (aluminium and manganese), and deficiencies of magnesium, calcium and potassium. High pH may also cause deficiencies (Baker and Eldershaw, 1993).

Attribute levels are based on pH levels likely to be encountered in the top 0.60 m of the soil profile, established from both field and laboratory measurement of pH.

Table 28 *Soil pH limitation*

Attribute level	*Code*	*Limitation class for various land uses*				
		Dryland sown pastures	Dryland crops	Irrigated pastures	Irrigated small crops	Tree and vine crops
5.5 < pH < 7.5	pH1	1	1	1	1	1
pH ≥ 7.5	pH2	2	2	2	2	3
pH ≤ 5.5	pH3	2	3	2	3	3

On the basis of field and laboratory pH, all soil profile classes were allocated an attribute level for soil pH that applied throughout the survey area (see Appendix 4).

Soil reaction is not a precluding limitation for any of the investigated land uses. However, soils with very strongly to strongly acid subsoils (Code pH 3) are given a moderate limitation for dryland crops, irrigated crops and tree and vine crops. Soils with this attribute level are **Biarra**, **Berrima**, **Bunya**, **Horse**, **Ottaba**, **Paddy**, **Steventon** and **Turtle**.

6.1.6 Flooding

Land periodically inundated by water from stream channel overflow has a flooding limitation. Flooding causes damage due to both fast flowing water and submersion by water. The severity of flooding as a limitation depends on the frequency, duration, depth and velocity of the floodwaters. The duration of inundation is perhaps the most critical factor of all — and the most difficult to estimate.

Attribute levels and limitation classes are based on landform observations and local knowledge.

Table 29 *Flooding limitation*

Attribute level (flood frequency)	*Code*	*Limitation class for various land uses*				
		Dryland sown pastures	Dryland crops	Irrigated pastures	Irrigated small crops	Tree and vine crops
Flood free	F1	1	1	1	1	1
<1:10 years	F2	1	2	1	2	2
1:2 to 1:10 years	F3	2	2	2	3	3
> 1:2 years	F4	2	4	3	4	4

Areas with an average flood frequency of more than one flood every two years (attribute level F4) were given a severe flooding limitation for dryland crops, irrigated crops and tree and vine crops. This attribute level was recorded for UMAs where the dominant soils are **Basel** (twice), **Cressbrook** (four times), **Cressbrook (rocky phase)**, **Honey** (four times), **Spencer** (five times), and **Spencer (gilgai phase)**.

6.1.7 Frost

Frosts may suppress growth, reduce yield or kill plants. Plant species vary in their tolerance to frost. Frost may damage the flowers or fruit of moderately sensitive crops.

Attribute levels and limitation classes are based on crop tolerance information, local knowledge, climate data and an assessment of local topography and landscape position. Low-lying areas may receive on average about 10 – 20 frosts in the period May to September (see Section 2.3.2).

Areas with frequent light and infrequent heavy frosts (Code FR4) were given a moderate frost limitation for tree and vine crops. An attribute level of FR5 was not recorded in the survey area.

Table 30 *Frost limitation*

Attribute level	Code	Limitation class for various land uses				
		Dryland sown pastures	Dryland crops	Irrigated pastures	Irrigated small crops	Tree and vine crops
frost free	FR1	1	1	1	1	1
infrequent light frosts	FR2	1	1	1	1	2
frequent light frosts	FR3	2	2	1	2	3
frequent light and infrequent heavy frosts	FR4	2	2	2	2	3
frequent light and heavy frosts	FR5	3	3	2	3	4

An attribute level of FR4 was recorded in a total of 388 UMAs, and was almost exclusively recorded for those soils in the group *soils overlying alluvium*. The only non-alluvial soils to record this attribute level were **Beppo**, **Beer**, and **Dunwich** (once each).

6.1.8 Rockiness

Rock fragments in the plough zone, can damage and interfere with the effective use of farm machinery (including harvesting machinery).

Attribute levels are based on the size and abundance of coarse fragments (McDonald *et al.*, 1990), as described in the field. Coarse gravel refers to fragments that are 20 to 60 mm in size (average maximum dimension) and cobble/stone refers to fragments that are 60 to 600 mm in size.

Rockiness limitation classes are based on the added inputs required to cultivate and establish crops and pastures as well as harvest on stony soils, or the inputs required to remove the limitation.

Table 31 *Rockiness limitation*

Attribute level	Code	Limitation class for various land uses				
		Dryland sown pastures	Dryland crops	Irrigated pastures	Irrigated small crops	Tree and vine crops
rock free	Ra1	1	1	1	1	1
<2% coarse gravel (20-60 mm)	Ra2	1	1	2	2	1
2-10% coarse gravel	Ra3	2	3	2	3	2
10-20% coarse gravel	Ra4	3	4	3	4	2
20-50% coarse gravel	Ra5	4	5	4	5	3
>50% coarse gravel	Ra6	5	5	5	5	4
<2% cobble/stone (60-600 mm)	Rb1	1	2	1	2	1
2-10% cobble/stone	Rb2	2	3	2	3	2
10-20% cobble/stone	Rb3	3	4	3	4	3
20-50% cobble/stone	Rb4	4	5	4	5	4
>50% cobble/stone	Rb5	5	5	5	5	5

For a particular soil profile class, where a significant number of UMAs (three or more) were observed to have surface rock (rocky outcrop, coarse gravel or cobble) in sufficient quantity[19] for it to be a severe limitation for land use, a rocky phase was defined. Rocky phases were defined for **Beppo**, **Cressbrook**, **Gallanani**, **Ottaba**, **Spencer** and **Watt**. Other soils to record at least one UMA with a severe rockiness limitation were **Burrundon**, **Caboonbah**, **Dunwich**, **Esk**, **Eskvale**, **Greinke**, **Horse**, **Linville**, **Lakeview**, **Moore**, **Neara**, **Noon**, **Paddy**, **Steventon** and **Turtle**.

[19] gravel >20% and cobble >10%

6.1.9 Soil depth

Shallow soils limit root growth and the ability of the plant to support itself. Requirements for anchorage are particularly important for tree crops with large canopies. Areas with a soil depth of <0.6 m (attribute level of D3) were given a severe soil depth limitation for tree and vine crops. Areas assessed as having a soil depth of 0.4 m or less were considered to have a severe or extreme soil depth limitation for cropping enterprises (see Table 32).

Thirty soil profile classes were given a moderate to severe soil depth limitation (D3, D4 or D5). Shallow depth (<0.6 m) is a common characteristic[20] of the following soil profile classes: **Burrundon**, **Biarra**, **Bunya**, **Deer**, **D'Aguilar**, **Dunwich**, **Esk**, **Forster**, **Greenhide**, **Greinke**, **Horse**, **Jimna**, **Linville**, **Lakeview**, **Moore**, **Neara**, **Noon**, **Paddy**, **Pinch** and **Rebel**. Note that this group of soils includes all the soil profile classes (except **Steventon**) in the group *soils overlying intermediate to basic volcanic rocks* and all the soil profile classes (except **Ivory**) in the group *soils overlying coarse-grained sedimentary rocks*.

Table 32 *Soil depth limitation*

Attribute level (soil depth)	*Code*	*Limitation class for various land uses*				
		Dryland sown pastures	Dryland crops	Irrigated pastures	Irrigated small crops	Tree and vine crops
> 1 m	D1	1	1	1	1	1
0.61-1.0 m	D2	2	2	1	2	3
0.41-0.6 m	D3	2	3	2	3	4
0.3-0.4 m	D4	3	4	3	4	5
<0.3 m	D5	4	5	4	5	5

6.1.10 Microrelief

Microrelief refers to the uneven land surface due to gilgai. Gilgai (or melonhole) is usually associated with soils containing shrink-swell clays. In the study area, gilgai was sometimes observed in non-cracking clays and texture contrast soils. Gilgai microrelief results in water ponding and uneven crop production.

Attribute levels are based on the vertical interval (depth) of the depressions. In the study area, the vertical interval was rarely greater than 0.30 m. Limitation classes indicate the cost of works to level the land and/or the reductions in yield expected.

Table 33 *Microrelief limitation*

Attribute level (vertical interval)	*Code*	*Limitation class for various land uses*				
		Dryland sown pastures	Dryland crops	Irrigated pastures	Irrigated small crops	Tree and vine crops
≤ 0.10 m	V1	1	1	1	1	1
0.11 m to 0.30 m	V2	1	2	1	2	1
0.31 m to 0.60 m	V3	2	3	2	3	3
>0.60 m	V4	3	3	3	3	4

An attribute level of V4 was not recorded in the survey area. **Basel gilgai phase** was the only soil profile class to be given a V3 attribute level (once). Soils (apart from **Basel gilgai phase**) for which an attribute level of V2 was recorded are **Cooeeimbardi** (seven times), **Gunyah** (once), **Ottaba gilgai phase** (five times) and **Spencer gilgai phase** (11 times).

[20] occurring more than 50% of UMAs

6.1.11 Wetness

Waterlogged soils reduce plant growth and delay effective machinery operation. Excess water in the soil impedes oxygen supply to plant roots and promotes plant diseases. Excess water can occur due to poor soil permeability, restricted surface drainage or a combination of both.

Attribute levels for wetness are based on field observations of site drainage (slope, topographic position) and soil morphological features such as mottling, colour, segregations, structure and impermeable layers. Limitation classes have been derived from knowledge of plant tolerance information and consultation with research and extension staff.

Table 34 *Wetness limitation*

Attribute level	*Code*	*Limitation class for various land uses*				
(drainage class - from McDonald *et.al., 1990*)		Dryland sown pastures	Dryland crops	Irrigated pastures	Irrigated small crops	Tree and vine crops
5 and 6 (rapidly drained to well drained)	W1	1	1	1	1	1
4 (moderately well drained)	W2	1	2	2	2	2
3 (imperfectly drained)	W3	2	3	3	3	4
2 (poorly drained)	W4	3	4	4	4	5
1 (very poorly drained)	W5	4	5	5	5	5

Wetness is a critical limitation for all land uses. Areas with imperfect drainage (attribute level W3) were given a severe limitation for tree and vine crops, while poorly drained sites (attribute level W4) were given a severe limitation for dryland crops, irrigated pastures and irrigated crops. Attribute levels of W4 or W5 were recorded for UMAs where the dominant soils are: **Beppo** (once), **Basel** (eight times), **Basel gilgai phase** (14 times), **Cooeeimbardi** (three times), **Gunyah** (once), **Honey** (once), **Ottaba** (11 times), **Ottaba gilgai phase** (five times), **Ottaba rocky phase** (twice), **Spencer** (23 times), **Spencer gilgai phase** (seven times) and **Turtle** (once).

6.1.12 Water erosion

Soil erosion depends on rainfall intensity, land slope, soil erodibility, vegetative cover and management practices (see Section 5.2). For land uses involving regular cultivation to be sustainable, soil conservation measures are required on all sloping land. Soils in the survey area have been divided into two groups based their erodibility and the stability of the subsoil. Texture contrast (duplex) soils with sodic subsoils are more at risk than other soils and therefore have lower cultivation slope limits

Table 35 *Water erosion limitation*

Attribute level	*Code*	*Limitation class for various land uses*				
		Dryland sown pastures	Dryland crops	Irrigated pastures	Irrigated small crops	Tree and vine crops
Sodic texture contrast soils						
<1% slope	Ea1	1	2	1	2	1
1-3%	Ea2	2	2	2	2	1
4-5%	Ea3	2	3	3	3	2
6-8%	Ea4	3	4	3	4	2
9-12%	Ea5	4	4	4	4	3
13-15%	Ea6	5	5	5	5	3
>15%	Ea7	5	5	5	5	4
Other soils						
<1% slope	Eb1	1	1	1	1	1
1-3%	Eb2	2	2	2	2	1
4-5%	Eb3	2	2	2	2	2
6-8%	Eb4	3	3	3	3	2
9-12%	Eb5	3	4	3	4	2
13-15%	Eb6	4	4	4	4	3
>15%	Eb7	5	5	5	5	4

Limitation classes for water erosion are based on the added management requirements required to control erosion. They have been determined by consultation with soil conservation extension staff.

6.2 LAND SUITABILITY ASSESSMENT

The land suitability assessment of the survey area is summarised in Table 36. The land suitability for each soil group is summarised in Table 37. In each table, the land area in each category is shown as hectares (ha) and as a percentage (%) of the total survey area of 136 376 ha. There is no Class 1 land for any land use. Areas not assessed (water, urban etc.) are 4 573 ha (3.3% of the total area).

The land suitability classification for each soil profile class is summarised in Appendix 5.

Table 36 *Summary of the land suitability assessment for the survey area*

Suitability Class	Dryland crops		Irrigated small crops		Dryland sown pastures		Irrigated pastures		Tree and vine crops	
	ha	%	ha	%	ha	%	ha	%	ha	%
2	–	–	5 810	4.2	10 371	7.5	7 281	5.3	150	0.1
3	10 848	7.9	16 563	12.1	30 094	21.9	33 423	24.3	30 859	22.5
4	41 546	30.2	39 932	29.1	24 316	17.7	22 677	16.5	68 276	49.7
5	80 407	58.5	70 497	51.3	68 021	49.5	69 422	50.5	33 517	24.4

Table 37 *Summary of the land suitability assessment for soil groups (by geological unit)*

	Suitable for dryland crops		Suitable for irrigated small crops		Suitable for dryland sown pastures		Suitable for irrigated pastures		Suitable for tree and vine crops	
SOIL GROUP	ha	%	ha	%	ha	%	ha	%	ha	%
Soils overlying alluvium	10 075	40	19 540	77	24 699	96	22 160	86	7 754	30
Soils overlying coarse-grained sedimentary rocks	663	2	2 155	6	9 157	24	10 301	27	16 769	43
Soils overlying intermediate to basic volcanic rocks	26	0.1	271	1	5 771	14	6 745	16	4 167	10
Soils overlying fine-grained acid igneous rocks	–	–	–	–	22	0.8	77	3	604	21
Soils overlying coarse-grained acid igneous rocks	56	2	305	12	343	13	913	34	955	36
Soils overlying fine-grained sedimentary rocks	28	0.2	102	0.7	473	3	488	3	705	5
Soils overlying metamorphic rocks	–	–	–	–	–	–	20	–	55	1
TOTALS	10 407	8	22 373	16	40 465	29	40 704	30	31 009	23

Table 37 shows that the *soils overlying alluvium* account for about 50% of the land suitable for intensive development. *Soils overlying coarse-grained sedimentary rocks* and s*oils overlying intermediate to basic volcanic rocks* account for about a further 40% of the suitable land.

6.2.1 Land suitability for dryland cropping

The broadacre field crops considered in the land suitability assessment include cereals (grain sorghum, maize, wheat, barley and oats), grain legumes (chick peas, navy beans, soybeans, lupins) oilseeds (sunflower) forage legumes (lablab, cowpeas) and other forage crops (sorghums, millets). Their agronomic and management requirements were considered similar enough not to warrant separate classification for each crop. For simplification, no attempt was made to separate winter and summer growing crops. 8% of the survey area is considered suitable for dryland cropping.

Eight soil and/or land attributes were identified as being potential severe limitations for dryland cropping in the Brisbane Valley area. The most important of these is soil water availability. Plant available water capacity (PAWC) of less than 90 mm in the root zone (maximum depth considered to be 1 m) was considered to be a prohibitive limitation for dryland cropping.

Land may also be considered unsuitable for dryland cropping because of the following limitations:

- Eroded and/or extremely hard setting soils (workability limitation).
- Nutrient availability. Soils low in available phosphorus, sulfate sulfur and extractable potassium are considered unsuitable as the cost of applying all nutrients would, in most situations be prohibitive.
- Wetness (poor drainage). Poorly/very poorly drained sites are considered unsuitable.
- Flooding. Areas with an average flood frequency of more than one flood every two years were given a severe flooding limitation.
- Soil depth. For dryland cropping, this limitation is strongly linked to soil moisture availability. Areas assessed as having a soil depth of 0.4 m or less were considered to have a severe or extreme soil depth limitation.
- Rockiness. 10–20% coarse gravel or cobble is considered to be prohibitive.
- Water erosion. Sodic texture contrast soils of 5% slope or more and other soils of slope greater than 8% are considered unsuitable for dryland crops.

For dryland cropping no UMAs were given a negligible or minor limitation — all were given at best a moderate limitation. A moderate limitation for dryland cropping was recorded for UMAs where the following soils or soil associations are dominant: **Beer** (7 of 12 UMAs), **Basel** (30 of 38), **Basel (gilgai phase)** (6 of 20), **Caboonbah** (2 of 8), **Cooeeimbardi** (30 of 33), **Cooeeimbardi-Basel** (2 of 2), **Gallanani** (127 of 127), **Gallanani-Monsildale**, (1 of 1), **Gunyah** (24 of 27), **Monsildale** (69 of 69) and **Neara** (2 of 17 UMAs).

6.2.2 Land suitability for irrigated small crops

The irrigated small crops considered in the land suitability assessment include cucurbits, capsicum, tomato, green beans peas and sweet corn. 16% of the survey area is considered suitable for irrigated small crops. The availability of suitable irrigation water was not evaluated. Land suitability for small crops is presented in the accompanying maps: Map 3 – Esk sheet; Map 4 – Moore sheet.

Six soil and/or land attributes were identified as having the potential to severely limit the production of irrigated small crops in the Brisbane Valley area. They are:

- Eroded and/or extremely hard setting soils (workability limitation).
- Wetness (poor drainage). Poorly and very poorly drained sites are considered unsuitable.
- Flooding. Areas with an average flood frequency of more than one flood every two years were considered unsuitable.
- Soil depth. Areas assessed as having a soil depth of 0.4 m or less were considered to have a severe or extreme soil depth limitation.
- Rockiness. 10–20% coarse gravel or cobble is considered to be prohibitive.
- Water erosion. Sodic texture contrast soils of 5% slope or more and other soils of slope greater than 8% are considered unsuitable for irrigated small crops.

As soil water availability is not a prohibitive limitation for irrigated small crops, sandy and loamy soils that are unsuitable for dryland cropping may be considered suitable for irrigated cropping. In some situations, texture contrast soils that are unsuitable for dryland cropping are also considered suitable for irrigated small crops. The only soils or soil associations where a minor limitation for irrigated small crops was recorded were **Beer** (1 of 12 UMAs), **Cressbrook** (5 of 33 UMAs), **Gallanani** (105 of 127), **Gallanani-Monsildale** (1 of 1), **Gunyah** (5 of 27), **Honey** (28 of 74), **Monsildale** (53 of 69), **Monsildale-Honey** (1) and **Neara** (1 of 17 UMAs).

A moderate limitation for irrigated small crops was recorded for UMAs where the following soils or associations are dominant: **Beppo** (8 of 90 UMAs), **Beppo-Watt** (1 of 7), **Beer** (7 of 12), **Basel** (30 of 38), **Basel (gilgai phase)** (7 of 20), **Caboonbah** (2 of 8), **Cooeeimbardi** (30 of 33), **Cressbrook** (24 of 33), **Cooeeimbardi-Basel** (2 of 2), Dunwich (1 of 39), Eskvale (2 of 52), **Gallanani** (22 of 127 UMAs), **Gallanani-Gunyah** (1 of 1), **Gallanani-Honey** (2 of 2)**, Gallanani** Gilla (1 of 7), **Gunyah** (20 of 27), **Hibiscus** (1 of 8), **Honey** (41 of 74)), **Ivory** (2 of 5), **Jimna** (1 of 1), **Linville** (1 of 33), **Monsildale** (16 of 69), **Neara** (3 of 17), Noon (1 of 8), **Ottaba** (1 of 21), **Paddy** (1 of 9), **Spencer** (158 of 189), **Spencer gilgai phase** (4 of 11), **Turtle** (4 of 27), **Watt** (9 of 24) and **Yellowbank** (1 of 3 UMAs).

6.2.3 Land suitability for dryland sown pastures

The dryland sown pastures considered in the land suitability assessment include Callide Rhodes grass, green panic, Gatton panic, setaria, pangola, kikuyu, pasture legumes (Siratro, fine stem stylo, Glycine, Lotononis, Wynn cassia, Leucaena). 29% of the survey area is considered suitable for dryland sown pastures. Land suitability for dryland sown pastures is presented in the accompanying maps: Map 3 – Esk sheet; Map 4 – Moore sheet.

Seven soil and/or land attributes were identified as being potential severe limitations for dryland sown pastures in the Brisbane Valley area. The most important of these is soil water availability. A plant available water capacity (PAWC) of less than 60 mm in the root zone (maximum depth considered to be 1 m) was considered to be a prohibitive limitation for dryland cropping.

Land may also be considered unsuitable for dryland sown pasture because of the following limitations:

- Eroded and/or extremely hard setting soils (workability limitation).
- Nutrient availability. Soils low in available phosphorus, sulfate sulfur and extractable potassium are considered unsuitable as the cost of applying all nutrients would, in most situations be prohibitive.
- Wetness (poor drainage). Very poorly drained sites are considered unsuitable.
- Soil depth. For dryland cropping, this limitation is strongly linked to soil moisture availability. Areas assessed as having a soil depth of 0.3 m or less were considered to have a severe or extreme soil depth limitation.
- Rockiness. 20–50% coarse gravel or cobble is considered to be prohibitive.
- Water erosion. Sodic texture contrast soils of 8% slope or more and other soils of slope greater than 12% are considered unsuitable for dryland sown pasture.

No UMAs were given a negligible limitation for dryland sown pastures. A minor limitation for dryland pastures was recorded for UMAs where the following soils or soil associations are dominant: **Beer** (3 of 12 UMAs), **Basel** (29 of 38), **Basel (gilgai phase)** (6 of 20), **Caboonbah** (2 of 8), **Cooeeimbardi** (30 of 33), **Cooeeimbardi-Basel** (2 of 2), **Gallanani** (127 of 127), **Gallanani (rocky phase)** (1 of 3), **Gallanani-Monsildale**, (1 of 1), **Gunyah** (24 of 27), **Monsildale** (69 of 69) and **Neara** (2 of 17 UMAs).

A moderate limitation for dryland sown pastures was recorded at least once for UMAs where the following soils or soil associations are dominant: **Burrundon**, **Beppo**, **Beppo-Watt**, **Beer**, **Beer (rocky phase)**, **Basel**, **Basel (gilgai phase)**, **Basel-Spencer**, **Caboonbah**, **Caboonbah-Lakeview**, **Cooeeimbardi**, **Cressbrook**, **Cressbrook (rocky phase)**, **Dunwich**, **Eskvale**, **Gallanani (rocky phase)**, **Gallanani-Gunyah**, **Gallanani-Honey**, **Gilla**, **Gunyah**, **Honey**, **Jimna**, **Linville**, **Linville-Neara**,

Lakeview, **Monsildale-Honey**, **Moore**, **Moore-Dunwich**, **Neara**, **Ottaba**, **Ottaba (gilgai phase)**, **Ottaba (rocky phase)**, **Paddy**, **Spencer**, **Spencer (gilgai phase)**, **Turtle** and **Watt**.

6.2.4 Land suitability for irrigated pastures

The irrigated pastures considered in this land suitability assessment include ryegrass, white clover, lucerne and forage oats. 30% of the survey area is considered suitable for irrigated pastures (see Map 3 – Esk Sheet; Map 4 – Moore sheet). The availability of suitable irrigation water was not evaluated.

Five soil and/or land attributes were identified as having the potential to severely limit the production of irrigated pasture in the Brisbane Valley area. The most important of these are slope (water erosion limitation) and soil depth. Areas assessed as having a soil depth of 0.3 m or less were considered to have a severe or extreme soil depth limitation. Sodic texture contrast soils of 8% slope or more and other soils of slope greater than 12% are considered unsuitable for irrigated pasture.

Land may also be considered unsuitable for irrigated pasture because of the following limitations:

- Eroded and/or extremely hard setting soils (workability limitation).
- Wetness (poor drainage). Poorly and very poorly drained sites are considered unsuitable.
- Rockiness. 10–20% coarse gravel or cobble is considered to be prohibitive.

A moderate (or minor) limitation for irrigated sown pastures was recorded at least once for almost all the soil profile classes in the Brisbane Valley. Apart from *soil associations on steep hills*, a minor or moderate limitation for irrigated sown pastures was *not* recorded for UMAs where the following soils or soil associations are dominant: **Biarra** (1 UMA in the survey area), **Beppo rocky phase** (6 UMAs) , **D'Aguila**r (3 UMAs), **Forster** (1 UMA), **Greinke** (1 UMA), **Horse** (5 UMAs), **Kipper** (3 UMAs), **Moore-D'Aguilar** (1 UMA), **Pinch** (1 UMA), **Steventon** (2 UMAs) and **Watt-Greenhide** (1 UMA).

6.2.5 Land suitability for tree and vine crops

The tree and vine crops considered most suitable for the Brisbane Valley (and hence evaluated in this land suitability assessment) include citrus, avocadoes, grapes, persimmon, low-chill stonefruit, low-chill apples, custard apple, mango and macadamia. Other crops that also have potential for production in the Brisbane Valley are pecans, kiwifruit, raspberries, blueberries, apples and olives (N.Vock, pers. comm.).

For simplification, no attempt was made to provide information on suitability classes for each individual crop. The suitability information contained in this report is therefore general in nature. Details of specific land use and management requirements for the range of tree and vine crops suitable for south-east Queensland may be found in the *Agrilink* Series[21]. The choice of crop will depend on both a careful analysis of crop requirements (including irrigation requirements) and careful site selection. Site layout to account for variations in soil depth, site drainage, frost and wind is important.

Twenty three percent of the survey area is considered suitable for tree and vine crops. The availability of suitable irrigation water was not evaluated in this assessment.

Six soil and/or land attributes were identified as having the potential to severely limit the production of tree and vine crops in the Brisbane Valley area. They are:

- Eroded and/or extremely hard setting soils (workability limitation).
- Wetness (poor drainage). Imperfectly drained, poorly drained and very poorly drained sites are considered unsuitable. Clay soils on alluvial flats and most of the texture contrast soils (where there is inadequate site drainage) will generally have a severe drainage limitation.
- Flooding. Areas with an average flood frequency of more than one flood every two years were considered unsuitable.

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[21] *Agrilink: your growing guide to better farming.* Series first published by the Department of Primary Industries (Queensland) 1997 (ISSN 13228-0457)

- Soil depth. Areas assessed as having a soil depth of 0.6 m or less were considered to have a severe or extreme soil depth limitation. Most tree crops prefer 0.6–1.5 m of well drained soil with no rock or clay layers to impede drainage. In some instances, it may be possible to achieve the minimum depth requirement by the use of mounds.
- Rockiness. >50% coarse gravel or 20–50% cobble is considered to be prohibitive.
- Water erosion. Soils of 15% slope or more are considered unsuitable for tree and vine crops.

While frost is an important factor to consider for tree and vine crops, the Brisbane Valley generally does not have the incidence of severe frosts that would make this a severe limitation for the crops mentioned. However, it may be necessary for protective measures to be taken for some crops and certain times of the year and at certain stages in the growing cycle. For example, avocadoes and citrus are susceptible to frost when young, while mature plants have a degree of resistance.

A minor or moderate limitation for tree and vine crops was recorded at least once for UMAs where the following soils are dominant: **Burrundon**, **Beppo**, **Beppo (rocky phase)**, **Basel**, **Beppo-Watt**, **Beer**, **Bunya**, **Caboonbah**, **Caboonbah-Lakeview**, **Cressbrook**, **Cressbrook (rocky phase)**, **Deer**, **Dunwich**, **Eskvale**, **Gallanani**, **Gallanani (rocky phase)**, **Gallanani-Gunyah**, **Gallanani-Honey**, **Gallanani-Monsildale**, **Gilla**, **Greenhide**, **Gunyah**, **Hibiscus**, **Horse**, **Honey**, **Ivory**, **Jimna**, **Kipper**, **Linville**, **Linville-Neara**, **Lakeview**, **Monsildale**, **Monsildale-Honey**, **Moore**, **Moore-Dunwich**, **Neara**, **Noon**, **Paddy**, **Rebel**, **Rebel-Pinch**, **Spencer**, **Steventon**, **Turtle**, **Watt**, **Watt-Greenhide** and **Yellowbank**.

6.3 AGRICULTURAL LAND CLASSIFICATION

Land in each UMA has been given a general rating in terms of its overall suitability for agriculture. Five agricultural land classes have been defined on the basis of the land suitability classes defined in the previous section and these are shown in Table 38. The area (hectares, ha) and percentage (%) of the total survey area in each agricultural land class is also included. The agricultural land classification for or each soil profile class is summarised in Appendix 5.

As mentioned in Section 3.4.4, the agricultural land classification used in the Brisbane Valley Land Resource Assessment differs from the four agricultural land classes defined for general use in Queensland. In particular, Class A land is restricted to land suitable for dryland cropping (rather than for irrigated cropping).

Table 38 *Agricultural land classification of the Brisbane Valley survey area*

Class	Description		ha	%
A	***Crop land*** –	*Land suitable for current and potential dryland crops* with minor or moderate limitations to production.	10 848	7.9
Bi	***Limited crop land*** – *irrigated small crops*	Land that is marginal for dryland cropping due to severe limitations, but *suitable for irrigated small crops* with minor to moderate limitations to production.	11 537	8.4
Bh	***Limited crop land*** – *horticulture*	Land that is marginal or unsuitable for dryland cropping and irrigated small crops due to severe or extreme limitations, but *suitable for tree and vine crops* with minor to moderate limitations to production.	22 236	16.2
C1	***Pasture land*** *(1)*	Land suitable only for improved or native pastures due to limitations that preclude continuous crop production; but some areas may tolerate a short period of ground disturbance for pasture establishment.	11 299	8.2
C2	***Pasture land*** *(2)*	Land suitable only for the grazing of native pastures due to limitations that preclude the establishment of improved pastures.	76 882	56.0
	Not assessed	Areas of non-agricultural activity (water, urban etc.).	4 573	3.3

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APPENDIX 1

SURFACE SOIL FERTILITY OF BRISBANE VALLEY SOILS

Table 1: Surface soil fertility of soil groups

Table 2: Surface soil fertility of soil profile classes

APPENDIX 1 **Table 1** Surface soil fertility for Brisbane Valley soil groups. Mean and range for selected laboratory analyses.

Notes: All samples bulked surface soil (0-0.10 m). Number of samples in parentheses if different to that shown in second column.

SOIL GROUP	No. samples	pH 1:5 H_2O (lab)	pH range	OC %	OC range	Tot. N %	Tot. N range	C/N ratio	Extr. P mg/kg (bicarb)	Extr. P range	Extr. K m.eq%	Extr. K range	SO_4-S mg/kg	SO4-S range	NO_3-N mg/kg	Cu mg/kg	Zn mg/kg
Soils overlying alluvium	38	**6.4**	5.3-8.6	**2.2**	0.8-4.9	**0.16**	.05-.38	**14.5**	**45**	6-99	**0.8**	0.12-2	**9.0 (20)**	3-15	**19 (29)**	**1.4**	**2.6**
– ***general rating***		***slightly acid***		***medium***		***medium***			***high***		***high***		***medium***			***medium***	***medium***
Soils overlying coarse-grained sedimentary rocks (Esk/Bryden Formations)	34	**6.2**	5.4-6.8	**2.6**	0.8-5.1	**0.17**	.04-.34	**15**	**30**	4-109	**0.8**	0.3-2.1	**7 (25)**	3-12	**15 (30)**	**1.0**	**2.7**
– ***general rating***		***slightly acid***		***med-high***		***medium***			***high***		***high***		***medium***		***medium***	***medium***	***medium***
Soils overlying coarse-grained sedimentary rocks (Helidon Sandstone)	5	**6.2**	5.4-6.9	**1.8**	1.2-2	**0.08**	.05-.11	**23**	**7**	2-15	**0.45**	.21-.81	-	-	**1.0**	**0.5**	**1.5**
– ***general rating***		**slightly acid**		**medium**		**low**			**low**		**medium**		**low**		**very low**	**medium**	**medium**
Soils overlying intermediate to basic volcanic rocks	29	**6.2**	5.7-7.3	**3.0**	1.9-5.6	**0.21 (19)**	.12-.51	**16**	**53**	17-212	**0.8**	0.38-1.8	**9.5**	1-21	**18 (26)**	**1.0**	**3.3**
– ***general rating***		***slightly acid***		***high***		***medium***			***high***		***high***		***medium***		***medium***	***medium***	***medium***
Soils overlying fine-grained acid igneous rocks	3	**6.0**		**1.5**		**0.10**		**16**	**8**		**0.5**		**5.5 (2)**		**24**	**0.1**	**1.2**
– ***general rating***		***medium acid***		***low***		***low***			***low***		***medium***		***low***		***medium***	***very low***	***medium***
Soils overlying coarse-grained acid igneous rocks	7	**6.3**	5.9-6.5	**1.2**	1.0-1.4	**0.09**	.06-.11	**15**	**14**	7-21	**0.4**	0.3-0.5	**4.8 (4)**	4-6	**6 (4)**	**0.5**	**0.9**
– ***general rating***		**slightly acid**		**low**		**low**			**medium**		**medium**		**low**		**low**	**medium**	**medium**
Soils overlying fine-grained sedimentary rocks	14	**6.1**	5.9-6.4	**2.6**	1.1-4.4	**0.17**	.05-.25	**16**	**38**	1-64	**0.7**	0.2-1.4	**5.5**	3-9	**12 (13)**	**0.8**	**3.2**
– ***general rating***		***slightly acid***		***high***		***medium***			***high***		***high***		***low***		***medium***	***medium***	***medium***
Soils overlying metamorphic rocks	5	**5.8**	5.4-6.1	**3.7**	1.9-5.4	**0.24 (4)**	.09-.39	**17**	**41**	19-62	**0.77 (4)**	0.31-1.4	**8.0 (4)**	4-15	**1 (4)**	**0.5**	**2.9**
– ***general rating***		***medium***		***high***		***medium***			***high***		***high***		***medium***		***v. low***	***medium***	***medium***
AVERAGE FOR ALL SAMPLES (142)		***6.21***		***2.5***		***0.17***		***15.6***	***38***		***0.74***		***7.8***		***16***	***1.03***	***2.69***
AVERAGE FOR ALL SAMPLES minus 'Soils overlying alluvium' (103)		***6.15***		***2.6***		***0.17***		***15.9***	***36***		***0.74***		***7.5***		***16***	***0.87***	***2.72***

APPENDIX 1 Table 2 Surface fertility for Brisbane Valley soil profile classes. Mean and range for selected laboratory analyses.

Notes: All samples bulked surface soil (0-0.10 m). Number of samples in parentheses if different to that shown in last column.

Soils overlying alluvium

	pH mean	pH range	**OC**	OC range	**Tot N**	Tot. N range	**C:N**	**NO_3-N**	**P bicarb. mean**	P bicarb. range	**Extr. K mean**	Extr. K range	**SO_4-S**	**Cu**	**Zn**	**No. samples**
Cr	6.2		1.8		0.13		14	35	8.5		1.1		8 (1)	0.6	4.5	2
Hy	6.5		1.5		0.13		12	30	50		1.2		7	1.2	1.7	1
Md	6.5	6.1-7.1	2.6	1.6-4.9	0.19	.08-.38	14	39 (4)	79	45-99	1.1	0.58-1.5	9.7	1.3	3.9	5
Gl	6.4		2.0		0.14		14	6.5	80		0.8		4.5	0.8	4.5	2
Gy	6.2		2.4		0.21		12	63 (1)	70		0.9		15	1.4	4.0	2
Bs	6.3	6.0-6.8	2.2	1.5-3.1	0.17	0.1-0.21	13	20 (7)	36	11-81	0.6	0.4-0.8	9.2	2.0	2.6	8
Du	6.6		2.9		0.16		18		7		0.6			1.9	0.9	1
Cb	7.0	6.3-8.5	2.4	0.8-3.4	0.19	0.05-.33	13	8.0 (3)	18	9-34	0.7	0.4-1.0	12	1.9	1.1	4
Sp	6.3	5.5-7.5	2.5	1.0-3.3	0.16	0.06-.20	16	2.3 (4)	35	6-81	0.5	0.12-.98	6.5	1.9	2.2	7
Ot	6.0	5.3-7.6	2.1	1.2-3.1	0.15	0.06-.27	14	9.0 (5)	33	8-69	0.7	0.12-2.0	10	0.5	1.9	6
Average	6.4		2.2		0.16		15	19 (29)	45		0.8		9.0 (20)	1.4	2.6	38

Soils overlying coarse-grained sedimentary rocks

	pH mean	pH range	**OC**	OC range	**Tot N**	Tot N range	**C:N**	**NO_3-N**	P bicarb. mean	P bicarb. range	**Extr. K mean**	Extr. K range	**SO_4-S**	**Cu**	**Zn**	**No. samples**
Bp	6.0	5.4-6.3	2.0	0.8-3.1	0.14	0.04-.26	15	5.5 (11)	18	5-66	0.6	0.3-1.3	5.6 (7)	0.8	1.8	12
Wt	6.2		2.5		0.17		15	79 (1)	10		0.9		(0)	0.8	1.6	2
Cl	5.9		2.1		0.12		18	4.3	10		0.6		6.0	0.6	1.4	3
Kp	6.0		2.8		0.20		14	21	14		0.9		9	1.9	5.0	1
Gh	6.2	6.1-6.3	2.2	1.6	2.6		15	23	47	23-75	1.1	0.9-1.3	7.0	0.8	2.7	5
Tu	6.1		3.7		0.25		15	27 (3)	29		0.8		8.5	0.6	3.8	4
Lv	6.3		2.6		0.25		10	41	63		0.9		12	1.8	3.9	1
Hb	6.2	5.4-6.9	1.8	1.2-2.0	0.08	.05-0.11	23	1.0 (2)	6.5	2-15	0.5		(0)	0.5	1.9	4
Yb	6.2		1.6		0.09		18	(0)	8		0.4		(0)	0.25	0.99	1
Br	6.3	6.1-6.8	2.6	1.1-4.6	0.21	0.11-0.3	13	14 (2)	56	8-105	1.1	0.5-2.1	9.5	2.2	2.7	3
Ca	6.3		2.5		0.21		12	21	71		1.3		(0)	2.5	4.0	2
Gk	6.3		5.1		0.28		18	1	109		2.0		8	0.47	10	1
Average	6.2		2.5		0.16		15	14 (34)	28		0.8		7.1 (25)	1.0	2.6	39

APPENDIX 1 Table 2 (continued)

Notes: All samples bulked surface soil (0-0.10 m). Number of samples in parentheses if different to that shown in last column.

Soil overlying intermediate to basic-volcanic rocks

	pH mean	pH range	OC	OC range	Tot N	Tot. N range	C:N	NO_3-N	P bicarb. mean	P bicarb. range	Extr. K mean	Extr. K range	SO_4-S	Cu	Zn	No. samples
Mo	6.1	5.7-6.6	3.0	2.3-3.8	0.19 (3)	0.17-.23	16	14 (3)	25	21-28	0.8 (3)	0.5-1.2	10.7	0.6	2.2	4
Dw	6.0	5.7-6.2	2.6	2.4-2.9	0.17 (4)	0.13-.19	15	21	38	22-50	0.8 (4)	0.5-1.2	5.3 (4)	1.0	2.9	7
Pd	6.0		2.0		0.2		13	34	34		0.4		8 (1)	0.5	2.7	2
St	6.2		2.4		0.1		17	19	34		0.8		7.5	0.2	1.7	2
Le	6.2		3.8		0.34 (1)		11	8.0 (2)	40		1.0 (1)		10 (2)	2.1	3.7	3
Na	6.2	5.9-6.4	3.0	1.9-4.3	0.17 (2)		18	8.6	35	17-65	0.6 (2)	0.4-0.8	8.4	1.3	2.6	5
De	6.5	6.5-6.7	3.7	2.8-4.4	0.39 (3)	0.38-.51	9	38 (3)	135	56-212	1.4 (3)	1.0-1.8	14 (3)	1.2	6.9	4
Jm	7.3		1.8		0.13		14	3	17		0.59		10	2.1	0.88	1
Dg	5.7		2.2		0.12		18	2	27		0.63		10	0.04	1.5	1
Average	6.2		3.0		0.21		16	18 (26)	53		0.8		9.5	1.0	3.3	29

Soils overlying fine-grained acid-igneous rocks

	pH mean	pH range	OC	OC range	Tot N	Tot. N range	C:N	NO_3-N	P bicarb. mean	P bicarb. range	Extr. K mean	Extr. K range	SO_4-S	Cu	Zn	No. samples
Bd	6.0		1.6		0.11		14	35	9		0.6		6 (1)	0.2	1.2	2
Bm																0
Ek	5.9		1.6		0.08		19	3	6		0.3		5	0.05	1.2	1
Average	6.0		1.5		0.10		16	24	8		0.5		5.5 (2)	0.1	1.2	3

APPENDIX 1 Table 2 (continued)

Notes: All samples bulked surface soil (0-0.10 m). Number of samples in parentheses if different to that shown in last column.

Soils overlying coarse grained acid-igneous rocks

	pH mean	pH range	**OC**	OC range	**Tot N**	Tot. N range	**C:N**	**NO_3-N**	**P bicarb. mean**	P bicarb. range	**Extr. K mean**	Extr. K range	**SO_4-S**	**Cu**	**Zn**	**No. samples**
Ph	6.4		1.4		0.09		16	4	7		0.3		4	0.36	0.86	1
Gi	6.5		1.1		0.10		11	5	21		0.46		4	0.24	1.1	1
Bi	5.9		1.4		0.11		13	7	12		0.42		5	0.09	1.1	1
Rb	6.2		1.0		0.06		17	(0)	9		0.4		(0)	0.9	0.7	2
Iv	6.3		1.2		0.10		13	7 (1)	11		0.4		6 (1)	0.5	0.82	2
Fs																0
Average	6.3		1.2		0.09		15	6 (4)	14		0.4		4.8 (4)	0.5	0.9	7

Soils overlying fine-grained sedimentary rocks

	pH mean	pH range	**OC**	OC range	**Tot N**	Tot. N range	**C:N**	**NO_3-N**	**P bicarb. mean**	P bicarb. range	**Extr. K mean**	Extr. K range	**SO_4-S**	**Cu**	**Zn**	**No. samples**
Ev	5.9		2.2		0.17		13	20	18		0.6		9.0 (1)	0.3	2.4	2
Hs	5.9		2.0		0.13		16	5	37		0.6		4.0	0.5	2.0	2
Fm	6.1		3.2		0.21		15	17	38		1.0		6.5	0.7	3.5	2
Nn	6.4	6.2-6.8	2.2	1.1-4.4	0.13	0.05-.23	17	8 (3)	23	1-62	0.5	0.2-0.8	5.0 (3)	1.4	2.1	4
Wl	6.2	5.8-6.3	3.2	2.5-4.2	0.2	0.17-.24	15	13	46	31-64	0.8	0.8-1.4	5.3	0.5	5.1	4
Average	6.1		2.6		0.17		16	12 (13)	38		0.7		5.5 (12)	0.8	3.2	14

Soils overlying metamorphic rocks

	pH mean	pH range	**OC**	OC range	**Tot N**	Tot. N range	**C:N**	**NO_3-N**	**P bicarb. mean**	P bicarb. range	**Extr. K mean**	Extr. K range	**SO_4-S**	**Cu**	**Zn**	**No. samples**
Bu	6.6		2.1		0.21 (1)		10	1	22		0.4 (1)		3	0.3	0.4	2
Yn	5.7	5.4-6.1	3.7	1.9-5.4	0.20	0.09-0.26	19	1 (2)	47	30-62	1.1	0.8-1.4	5.0 (2)	0.4	3.9	3
Average	5.8	3.7	0.24				17	1 (4)	41		0.77		8.0	0.5	2.9	5

APPENDIX 2

DESCRIPTION OF THE BRISBANE VALLEY SOIL PROFILE CLASSES

Alphabetical listing of soil profile classes:

Soil Profile Class	*Symbol*	*Page*
Basel	Bs	89
Beer	Br	89
Beppo	Bp	90
Berrima	Bm	90
Biarra	Bi	91
Bunya	Bu	91
Burrundon	Bd	92
Caboonbah	Ca	92
Calabash	Cl	93
Cooeeimbardi	Cb	93
Cressbrook	Cr	94
D'Aguilar	Dg	94
Deer	De	95
Duggua	Du	95
Dunwich	Dw	96
Esk	Ek	96
Eskvale	Ev	97
Forster	Fs	97
Freeman	Fm	98
Gallanani	Gl	98
Gilla	Gi	99
Greenhide	Gh	99
Greinke	Gk	100
Gunyah	Gy	100
Hibiscus	Hb	101
Honey	Hy	101
Horse	Hs	102
Ivory	Iv	102
Jimna	Jm	103
Kipper	Kp	103
Lakeview	Lv	104
Linville	Le	104
Monsildale	Md	105
Murrumba	Mu	105
Neara	Na	106
Noon	Nn	106
Ottaba	Ot	107
Paddy	Pd	107
Pinch	Ph	108
Rebel	Rb	108
Spencer	Sp	109
Steventon	St	109
Turtle	Tu	110
Watt	Wt	110
Welton	Wl	111
Yednia	Yn	111
Yellowbank	Yb	112

TERMINOLOGY USED TO DESCRIBE THE SOILS

The soil profile class descriptions represent the range of soil attributes compiled from many soil profile descriptions. The horizon notation indicates significant trends across the range of soil profiles that constitute the soil profile class. These soil profile classes are represented by individual profiles in Appendix 3.

The location, soil profile attributes, land surface and vegetation structural formation are described according to McDonald *et al*., (1990)

The soil colours used to describe individual horizons of the representative profiles are those of the Munsell Soil Colour Charts. Colour class limits used to define the in the soil profile class concept are based on the scheme of Isbell (1996):

Black:	The dominant colour (moist) for all hues has a value of 3 or less and a chroma of 2 or less
Red	The dominant colour (moist) has a hue of 5YR or redder and a chroma of 3 or more
Brown	The dominant colour (moist) has a hue yellower than 5YR and a value of 5 or less and a chroma of 3 or more
Yellow	The dominant colour (moist) has a hue yellower than 5YR and a value of 6 or more and a chroma of 4 or more
Grey	The dominant colour (moist) for all hues has a value of 4 and chroma of 2 or less; for hues yellower than 5YR values of 6 or more and chromas of 3 are allowed.

BASEL (Bs)

Concept: Grey clay with alkaline soil reaction trend. Surface or subsurface horizons* may be sporadically bleached. Overlying unconsolidated material.

Classification: **Principal Profile Form:** Ug5.21 or Ug5.24 (modal), Uf2, Uf3, Uf6.11, Uf6.33, Uf6.41, Ug2, Ug3.2, Ug5.25, Ug5.28, Ug5.29.
Great Soil Group:
Australian Soil Classification: Grey Vertosols; Grey Dermosols.

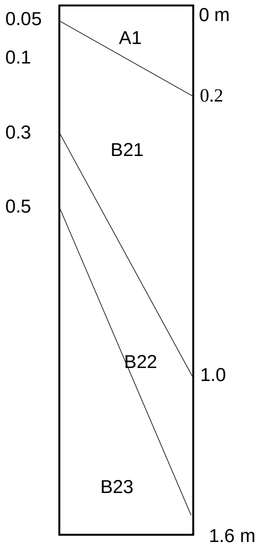
Landform: Level to gently undulating alluvial plains, stagnant alluvial plains, plains and terraces.

Geology: Quaternary alluvium.

Vegetation: Open woodland of Queensland blue gum with broad leaved apple, swamp mahogany, silver leaved ironbark and Moreton Bay ash.

Surface features: Generally cracking but may be non-cracking. Weakly self-mulching, firm or hard setting. Gilgai common.

Profile diagram and description:



A1: Black to brown (7.5YR 3/2-4/3 to 10YR 2/1-4/2); light clay to light medium clay; strong 5-10 mm angular to subangular; field pH 6.0 to 7.0. Gradual to –

B21: Dark grey to pale brown/grey (7.5YR 4/1-5/2; 10YR 4/1-5/6; 2.5Y 4/2-5/3); may be mottled; light medium clay to medium clay; strong 10-50 mm angular to lenticular; field pH 6.0 to 9.0; may have few manganese and/or ferromanganiferous nodules and/or calcareous concretions. Gradual to –

B22 (may be k): Dark grey to pale brown (7.5YR 3/1-6/3; 10YR 3/1-6/4; 2.5Y 3/1-6/3); may be mottled; light medium clay to medium clay; strong 20-50 mm lenticular to angular; field pH 7.0 to 9.0; may have few manganese/ferromanganiferous nodules and/or calcareous nodules and concretions . Gradual to –

B23 (may be k): Dark grey to light yellowish brown (10YR 3/1-6/4; 2.5Y 4/3-6/3); commonly mottled; light medium clay to medium clay; moderate to strong 20-50 mm angular blocky to lenticular; field pH 7.5 to 9.0; may have few manganese nodules and/or common calcareous nodules and concretions. Gradual to –

Variants: A2 horizon conspicuously bleached.
B21 horizon black (10YR 2/1-3/2) [with A2 horizon bleached]: Uf3, Ug2, Ug3.1.

Number of sites: 133

BASEL gilgai phase, Bs(gp), is similar to Basel except for the presence of gilgai microrelief.

BEER (Br)

Concept: Black, brown or grey cracking clay with an alkaline soil reaction trend. Overlying sandstone, siltstone or mudstone.

Classification: **Principal Profile Form:** Ug5.32 (modal), Ug5.12, Ug5.13, Ug5.14, Ug5.15, Ug5.21, Ug5.22, Ug5.24, Ug5.34.
Great Soil Group:
Australian Soil Classification: Black, Brown or Grey Vertosols.

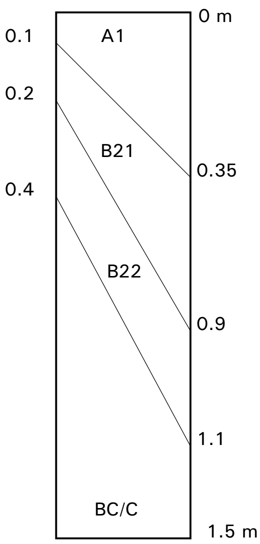
Landform: Gently undulating to undulating rises and low hills.

Geology: Triassic Sediments: Bryden Formation and Esk Formation.

Vegetation: Woodland to open forest of silver leaved ironbark or narrow leaved ironbark with Queensland blue gum and Moreton Bay ash.

Surface features: Cracking, weakly self-mulching

Profile diagram and description:



A1: Black to very dark greyish brown (10YR 2/1-3/2); light clay to light medium clay; strong 5-10 mm granular; field pH 6.0 to 7.0. Gradual to –

B21: Black to dark yellowish brown (10YR 2/1-4/4); light medium clay to medium clay; strong 10-50 mm angular or lenticular; field pH 6.5 to 9.0; may have few manganese nodules. Gradual to –

B22: Very dark greyish brown to brown (7.5YR4/2 to 10YR 3/2-5/3); light medium clay to medium clay; strong 10-50 mm subangular to lenticular; field pH 7.0 to 9.0; may have few manganese nodules or common calcareous nodules and soft segregations. Gradual to –

BC/C: Dark greyish brown to yellowish brown (10YR 4/2-5/4); light clay to light medium clay; moderate 10-20 mm lenticular to angular; field pH 7.0 to 8.5; may have few manganese or calcareous nodules.

Number of sites: 30

Br(rp) BEER rocky phase is similar to Beer except for the presence of surface rock in the surface soil (top 0.2-m).

* A1, A2, B1 or B2 horizons

BEPPO (Bp)

Concept: Texture contrast soil with loamy surface and strongly bleached subsurface over a neutral to alkaline brown, yellowish brown or greyish brown clay subsoil. Overlying sandstone, siltstone or conglomerate.

Classification: **Principal Profile Form:** Dy2.43 or Dy3.43 (modal), Db1.33, Db1.42, Db1.43, Db2.42, Db2.43, Dy2.42, , Dy2.33, Dy3.33, Dy3.42.
Great Soil Group:
Australian Soil Classification: Brown or Grey Sodosols; Eutrophic, Sodic Brown (or Grey) Chromosols

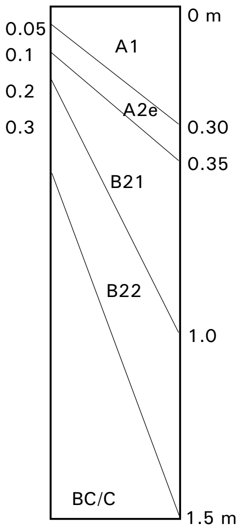
Landform: Gently undulating to rolling rises, low hills and hills.

Geology: Triassic Sediments: Bryden Formation and Esk Formation; Triassic-Jurassic Sediments: Helidon Sandstone.

Vegetation: Woodland to open forest of narrow leaved ironbark or silver leaved ironbark with Moreton Bay ash and Queensland blue gum. Gum topped box , spotted gum and pink bloodwood may also occur.

Surface features: Hard setting.

Profile diagram and description:



A1: Brown to grey brown (7.5 YR to 10 YR 3/1, 3/2, 4/2); fine sandy clay loam to clay loam fine sandy; massive to weak 2-5 mm granular; field pH 6.0 to 6.5. Clear or gradual to –

A2e: Greyish brown to pale brown (10 YR 5/2-6/3 moist, 7/2-8/2 dry); conspicuously bleached (or sporadically bleached >100 mm); fine sandy clay loam to clay loam fine sandy; massive to weak 2-5 mm granular; field pH 6.0 to 6.5; may have few manganese nodules. Abrupt to –

B21: Brown to yellowish brown (10YR 4/3, 5/4); light medium clay to medium clay; occasionally mottled; strong to moderate 10-50 mm angular (sometimes 50-100 mm columnar); field pH 6.5 to 9.0; may have few manganese nodules and soft segregations or ferruginous nodules. Gradual to –

B22: Brown to yellowish brown (10YR 5/3, 5/4); often mottled; light medium clay to medium clay; strong 10-50 mm angular with strong 20-100 mm lenticular common at depth; field pH 8.5 to 9.0; may have few manganese or ferromanganiferous nodules or carbonate nodules and/or soft segregations. Gradual to –

BC/C: Yellowish brown (10YR 5/4, 5/6); sandy light clay to sandy light medium clay; moderate 10-20 mm angular to subangular; field pH 7.5 to 9.0.

Variants: B21 horizon red (5YR 4/3, 4/4): Dr2.33, Db2.43.
B21 horizon black (10YR 3/2): Dd1.43.

Number of sites: 225

BEPPO rocky phase (**BPrp**) is similar to Beppo except for the presence of common to abundant coarse gravel or cobble in the surface soil (top 0.2 m).

BERRIMA (Bm)

Concept: Texture contrast soil with a loamy surface, over a brown to yellowish brown clay subsoil, with acid soil reaction trend. Overlying rhyolite or trachyte.

Classification: **Principal Profile Form:** Db2.41, Dy3.41.
Australian Soil Classification: Brown Sodosols; Brown Chromosols.

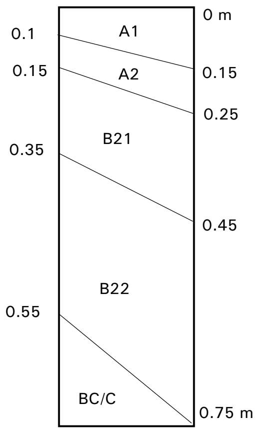
Landform: Steep hills and mountains.

Geology: Triassic-Jurassic intrusion/extrusion - Crossdale Rhyolite.

Vegetation: Queensland peppermint and brown bloodwood open forest. Also narrow leaved ironbark, spotted gum, Moreton Bay ash and silver leaved ironbark.

Surface features: Hard setting.

Profile diagram and description:



A1: Very dark greyish brown to brown (10YR 3/2-4/3); sandy clay loam to clay loam; massive; field pH 5.5. Gradual to –

A2e: Brown to pale brown (10 YR 5/3) moist, 10YR 8/2 dry); fine sandy clay loam; massive; field pH 5.5 to 6.0. Abrupt to –

B21: Brown to yellowish brown (10YR 4/3-5/6); medium clay; strong columnar 50-100 mm columnar (angular sub-blocky); field pH 6.0 to 6.5; may have very few ferromanganiferous nodules; gradual to –

B22: Dark greyish brown to yellowish brown (10YR 4/2-5/6); light medium clay to medium clay; moderate 20-50 mm subangular blocky; field pH 5.5 to 6.0; may have very few ferromanganiferous nodules. Gradual to –

BC/C: Brown (10YR 4/2-5/2); clay loam fine sandy; weak structure, field pH 5.5 to 6.5.

Number of sites: 1

BIARRA (Bi)

Concept: Texture contrast soil with a loamy surface over a brown to yellow clay subsoil with an acid soil reaction trend. Overlying granite or granodiorite.

Classification: **Principal Profile Form:** Db2.41, Dy2.31, Dy3.31.
Australian Soil Classification: Brown, Yellow or Grey Chromosols.

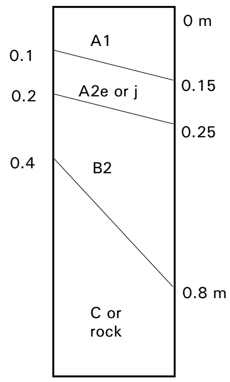
Landform: Lower slopes of rolling to undulating hills.

Geology: Permian-Triassic acid intrusions - Eskdale Granodiorite and another unnamed group.

Vegetation: Narrow leaved ironbark, spotted gum and silver leaved ironbark open forest to woodland.

Surface features: Firm to hard setting**.**

Profile diagram and description:



A1: Dark brown to very dark grey (7.5YR 3/2 to 10YR 3/1); coarse sandy loam to fine sandy clay loam; massive to weak granular; field pH 5.5 to 6.0. Gradual to –

A2e or j: Brown to yellowish brown (10YR 4/3-5/4 moist, 10YR 6/2-8/2 dry); coarse sandy loam to fine sandy clay loam; massive; field pH 5.5 to 6.0. Clear to –

B2: Strong brown to very pale brown (7.5YR 4/6 to 10YR 5/3-7/3); commonly mottled; coarse sandy light medium clay to medium clay; moderate to strong 10-20 mm angular; field pH 5.5 to 6.0. Gradual to –

C: Weathered granite or granodiorite

Number of sites: 3

BUNYA (Bu)

Concept: Texture-contrast soil with a firm to hard setting loamy surface and bleached subsurface, over a brown, red or yellow clay subsoil. Neutral to acid soil reaction. Overlying phyllite.

Classification: **Principal Profile Form:** Dr2.41 or Dr3.31 (modal), Db1.21, Db1.31, Db1.42, Dr1.41, Dr2.31, Dr3.41, Dr3.42, Dy2.31, Dy2.41.
Australian Soil Classification: Red or Brown Sodosols; Red or Brown Kurosols; Red or Brown Chromosols.

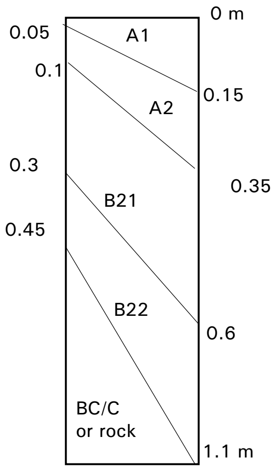
Landform: Undulating to steep low hills, hills and mountains.

Geology: Carboniferous metamorphics - Jimna Phyllite.

Vegetation: Open forest of narrow leaved ironbark or brush box. Gum topped box, Moreton Bay ash, silver leaved ironbark, broad-leaved ironbark, Queensland blue gum, pink bloodwood and patches of softwood scrub (including hoop pine) occur.

Surface features: Firm to hard setting.

Profile diagram and description:



A1: Black to dark greyish brown (7.5YR 3/2, 4/2 to 10YR 2/1-4/2); fine sandy clay loam to clay loam fine sandy; weak 2-5 mm granular; field pH 6.0 to 7.0. Gradual to –

A2e or j: Brown to very pale brown (7.5YR 4/3-5/4 to 10 YR 4/2-7/4 moist, 7.5YR 7/3 to 10YR 6/2-8/2 dry); fine sandy clay loam to clay loam fine sandy; massive to weak 2-5 mm granular; field pH 6.0 to 7.0.
Clear or abrupt to –

B21: Dark red to brownish yellow (2.5YR 3/4-4/6 to 10YR 4/3-6/6); light medium clay to medium clay; strong 10-20 mm angular; field pH 4.5 to 6.0; may have very few manganese nodules. Gradual to –

B22: Dark red to brownish yellow (2.5YR 4/6 to 10YR 4/3-6/6); light medium clay to medium clay; strong 10-20 mm angular; field pH 4.5 to 6.0; may have very few manganese nodules. Gradual to –

BC/C: Dark reddish brown to yellow (5YR 3/3-5/6 to 10YR 5/4-7/6); light clay to light medium clay; moderate 10-20 mm angular; field pH 4.5 to 6.0; may have very few manganese soft segregations.

Variants: Alkaline reaction trend: Db1.13
Gradational reaction trend: Gn2.11, Gn3.14.

Number of sites: 35

BURRUNDON (Bd)

Concept: Texture contrast soil with a loamy surface over brown, black, yellowish brown or greyish brown clay subsoil. Neutral to alkaline soil reaction trend. Overlying rhyolite or trachyte.

Classification: **Principal Profile Form:** Dy2.42 or Dy2.43 (modal), Db2.43, Dd1.33, Dd1.43, Dd2.33, Dd2.43, Dy2.13, Dy2.33.
Australian Soil Classification: Brown, Black or Grey Sodosols.

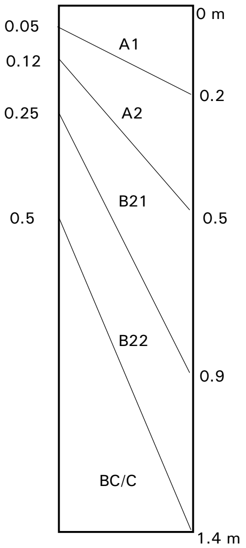
Landform: Undulating to steep low hills, hills and mountains.

Geology: Triassic-Jurassic intrusion/extrusion - Crossdale Rhyolite.

Vegetation: Queensland peppermint and brown bloodwood open forest. Also narrow leaved ironbark, spotted gum, Moreton Bay ash and silver leaved ironbark.

Surface features: Hard setting.

Profile diagram and description:



A1: Very dark grey to light grey (7.5YR 3/2, 5/3 to 10YR 3/1-7/2); fine sandy clay loam to clay loam; massive; field pH 6.0 to 7.0. Gradual to –

A2e or j: Dark grey to light yellowish brown (7.5YR 5/2 to 10 YR 4/1-6/4 moist, 7.5YR7/2-8/2 to 10YR7/1-8/2 dry); fine sandy clay loam to clay loam; massive; field pH 6.0 to 7.0. Gradual to –

B21: Strong brown to yellowish brown (7.5YR 5/6 to 10YR 2/1-5/4); light medium clay to medium clay; moderate to strong 10-20 mm angular (or 50-100 mm columnar); field pH 6.5 to 8.0; may have very few manganese nodules. Gradual to –

B22: Very dark grey to brown (10YR 3/1-5/3); light medium clay to medium clay; moderate to strong 10-50 mm angular; field pH 8.0 to 9.0; may have very few manganese nodules and/or calcareous nodules. Gradual to –

BC/C: Dark greyish brown to brownish yellow (10YR 4/2-6/6); light medium clay; moderate 10-20 mm angular; field pH 8.0 to 9.0.

Number of sites: 25

CABOONBAH (Ca)

Concept: Grey or brown cracking clays. Generally light clay surface. Neutral to alkaline reaction trend. Overlying sandstone or siltstone.

Classification: **Principal Profile Form**: Ug5.32 (modal), Ug5.22, Ug5.24, Ug5.34, Uf6.31.
Australian Soil Classification: Brown or Grey Vertosols.

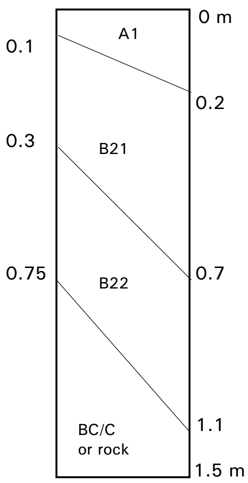
Landform: Gently undulating to rolling rises, low hills and hills.

Geology: Triassic Sediments: Bryden Formation and Esk Formation.

Vegetation: Softwood scrub species.

Surface features: Cracking, occasionally self-mulching.

Profile diagram and description:



A1: Very dark greyish brown to brown (10YR 3/2-4/3 to 7.5YR 3/2, 4/4); light clay to light medium clay; strong 5-10 mm angular, subangular or granular; field pH 6.0 to 7.0. Gradual to –

B21: Dark brown to greyish brown or grey (10YR 3/3-5/6 to 7.5YR 4/4-4/6) or grey (10YR4/1 to 10YR5/2); light clay to light medium clay; strong angular or lenticular; field pH 7.0 to 8.5; may have few manganese soft segregations. Gradual to –

B22: Dark greyish brown to brown (10YR 4/2-5/3); light medium clay to medium clay; strong angular or lenticular; field pH 7.0 to 9.0; may have few manganese nodules or carbonate nodules/soft segregations. Gradual to –

BC/C: Dark greyish brown to yellowish brown (10YR4/2-5/4); sandy light clay to sandy light medium clay; moderate angular; field pH 6.0 to 9.0.

Variants: Black subsoil (10YR3/2): Ug5.13.
Carbonate segregations present: Ug5.31.

Number of sites: 22

CALABASH (Cl)

Concept: Texture contrast soil with a loamy surface over a neutral to slightly acid brown to yellow clay subsoil. Subsurface may be bleached. Overlying sandstone, siltstone or conglomerate.

Classification: **Principal Profile Form:** Dy3.42, Dy2.42, Dy2.12, Dy3.21, Dy3.31.
Australian Soil Classification: Brown or Yellow Chromosols.

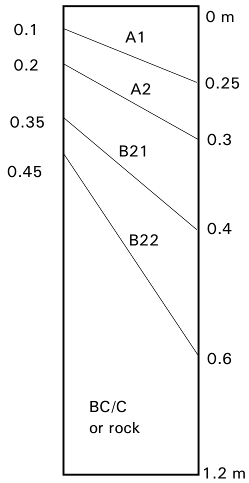
Landform: Rolling to steep hills. Predominantly mid to upper slopes and crests.

Geology: Triassic Sediments: Bryden Formation and Esk Formation.

Vegetation: Open forest of narrow leaved ironbark. Moreton Bay ash, silver leaved ironbark, pink bloodwood also occur.

Surface features: Hard setting. Rocky outcrops and surface coarse fragments common.

Profile diagram and description:



A1: Dark brown to brown (7.5YR 3/2-5/3 to 10YR 3/2); sandy clay loam to clay loam fine sandy; weak 5 mm granular; field pH 6.0 to 6.5. Clear to –

A2: Dark greyish brown to yellowish brown (10 YR 4/2-4/4 moist, 10YR 6/4-8/4 dry); sandy clay loam to clay loam fine sandy; massive to weak structure; field pH 6.0 to 6.5. Clear to –

B21: Greyish brown to brownish yellow (10YR 5/2-6/6, 7.5YR 5/3,5/8); light medium clay to medium clay; moderate to strong 5-20 mm angular or subangular; field pH 5.8 to 6.8. Gradual to –

B22: Yellowish brown to brownish yellow (10YR 5/6-6/8); light medium clay to medium clay; moderate to strong 5-20 mm angular or subangular; field pH 6.3 to 7.0. Gradual to –

BC/C: Yellowish brown to brownish yellow(10YR 5/6,5/6); coarse sandy clay loam to fine sandy light medium clay; weak to moderate 20-50 mm angular; field pH 4.5 to 6.5; may have very few manganese nodules.

Number of sites: 6

COOEEIMBARDI (Cb)

Concept: Self-mulching black clay with an alkaline soil reaction trend. Overlying unconsolidated material.

Classification: **Principal Profile Form:** Ug5.15 or Ug5.16 (modal), Ug5.11, Ug5.14, Ug5.17.
Australian Soil Classification: Black Vertosols.

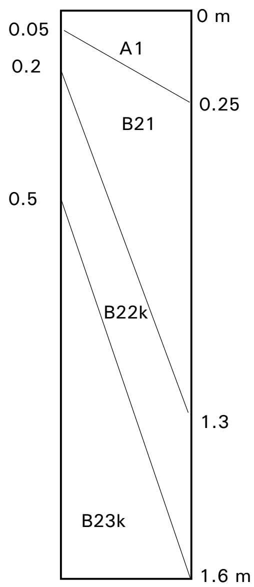
Landform: Level to gently undulating alluvial plains, stagnant alluvial plains and terraces.

Geology: Quaternary alluvium.

Vegetation: Open woodland of Queensland blue gum and Moreton Bay ash. Silver leaved ironbark and broad-leaved apple also occur.

Surface features: Cracking and mulching, gilgai common.

Profile diagram and description:



A1: Black to dark grey (7.5YR 2/1-3/2, to 10YR 2/1-4/1); light clay to light medium clay; strong 5-10 mm angular to subangular; field pH 6.5 to 7.5. Gradual to –

B21: Black to very dark greyish brown (7.5YR 3/1-3/2 to 10YR 2/1-3/2); light medium clay to medium clay; strong 10-50 mm angular to lenticular; field pH 6.5 to 8.5; may have very few manganese nodules. Gradual to –

B22k: Black to yellowish brown (10YR 2/1-5/4 to 2.5Y 2/0-5/3); light medium clay to medium clay; strong 20-50 mm lenticular; field pH 7.5 to 9.5; may have very few manganese nodules and/or common calcareous nodules and soft segregations. Gradual to –

B23k: Black to brownish yellow (10YR 2/1-6/6 to 2.5Y 4/1-5/4); may be mottled; light medium clay to medium clay; strong 20-50 mm lenticular; field pH 8.5 to 9.5; may have few manganese nodules and/or common calcareous nodules and concretions.

Number of sites: 114

CRESSBROOK (Cr)

Concept: Stratified soil with loose to hard setting sandy surface and neutral soil reaction trend. Overlying unconsolidated material.

Classification: **Principal Profile Form:** Uc1.21(modal), Uc1.13, Uc1.23, Uc1.41, Uc1.43, Uc1.44, Uc2.21, Uc2.34, Uc5.11, Gn2.02, Gn2.42.
Australian Soil Classification: Stratic Rudosols.

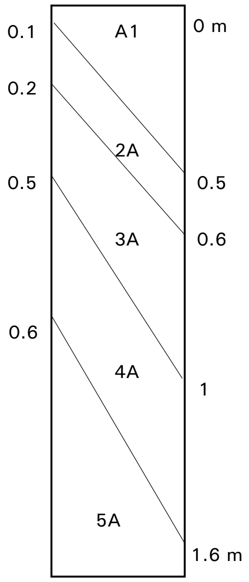
Landform: Level to undulating flood plains and low terraces.

Geology: Quaternary alluvium.

Vegetation: Open woodland of river she-oak and Queensland blue gum. Black tea tree and Moreton Bay ash also occur. Woody weeds common.

Surface features: Loose to hard setting, may have many surface rocks.

Profile diagram and description:



A1: Black to dark yellowish brown (7.5YR 3/2-4/4 to 10YR 2/1-4/4); loamy sand to sandy loam; single grained to weak granular; field pH 6.5 to 7.5; may have few coarse fragments. Clear or gradual to –

2A: Black to dark yellowish brown (7.5YR 3/2-4/4 to 10YR 2/1-4/4); loamy sand to sandy loam; single grained; field pH 6.5 to 7.5; may have few coarse fragments. Clear or gradual to –

3A: Very dark greyish brown to yellowish brown (7.5YR 3/2-4/4 to 10YR 3/2-5/4); sand to sandy clay loam; massive to single grained; field pH 6.5 to 7.5; may have few coarse fragments. Clear or gradual to –

4A: Very dark brown to dark yellowish brown (7.5YR 2/1-4/4 to 10YR 2/2-4/4); sand to sandy clay loam; massive to single grained; field pH 7.0 to 7.5; may have few coarse fragments. Clear or gradual to –

5A: Very dark brown to dark yellowish brown (7.5YR 2/1-4/4 to 10YR 2/2-4/4); sand to sandy clay loam; massive to single grained; field pH 7.0 to 7.5; may have few coarse fragments.

Number of sites: 39

CRESSBROOK rocky phase (**CRrp**) is similar to Cressbrook except for the presence of common to abundant coarse gravel or cobble in the surface soil (top 0.2 m).

D'AGUILAR (Dg)

Concept: Shallow loamy soil overlying rock (andesite, volcanic conglomerate, occasionally shale, siltstone).

Classification: **Principal Profile Form:** Uf4.1, Uf6.21, Um1.21, Um1.24, Um1.41, Um1.43, Um3.12, Um4.11, Um5.11, Um6.21, Um6.61.
Australian Soil Classification: Leptic Rudosols.

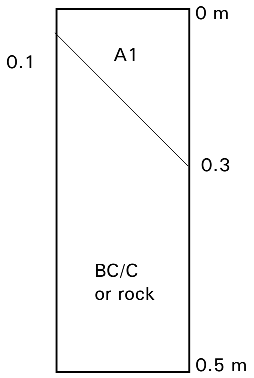
Landform: Undulating to steep low hills and mountains. Ridge crests and upper slopes.

Geology: Triassic volcanics - Neara Volcanics; Permian-Triassic volcanics - Gilla Andesite; Brisbane Valley Porphyrites.

Vegetation: Open forest of narrow leaved ironbark, silver leaved ironbark and Moreton Bay ash with pink bloodwood.

Surface features: Firm to hard setting. Surface rocks common.

Profile diagram and description:



A1: Black to brown (7.5YR 3/2-4/3; 10YR 2/2-4/2); clay loam to light clay; strong 2-5 mm granular or subangular; field pH 6.0 to 6.5. Gradual to –

BC/C: Very dark grey to yellowish brown (5YR 3/1, 7.5YR 4/2 to 10YR 4/3-5/4); sandy light clay to sandy light medium clay; moderate 10-20 mm angular to lenticular; field pH 6.5 to 7.5.

Number of sites: 35

DEER (De)

Concept: Uniform to texture contrast soil with a strongly structured loamy or clay surface over a black or brown clay subsoil with a neutral reaction trend. Overlying andesite and volcanic conglomerate (occasionally shale, siltstone).

Classification: **Principal Profile Form:** Uf6.31 or Uf6.32 (modal), Db1.12, Dd1.12, Gn3.52, Uf6.42.
Australian Soil Classification: Brown or Black Dermosols; Brown or Black Chromosols.

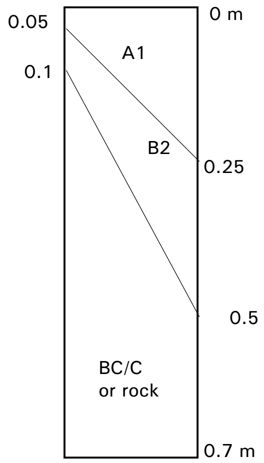
Landform: Rolling to undulating rises, low hills and hills. Often on steep slopes.

Geology: Triassic volcanics - Neara Volcanics; Permian-Triassic volcanics - Gilla Andesite; Brisbane Valley Porphyrites.

Vegetation: Softwood scrub species.

Surface features: Firm to hard setting.

Profile diagram and description:



A1: Black to brown (7.5YR 3/2; 10YR 3/1-4/3; 5YR 2/1-3/1); clay loam to light clay; strong 2-5 mm granular or subangular; field pH 6.0 to 6.5. Gradual to –

B2: Reddish brown to brownish yellow (10YR 3/1-5/3; 5YR 3/2); light clay to medium clay; strong 10-20 mm angular to subangular; field pH 6.5 to 7.0; may have very few manganese nodules. Gradual to –

BC: Very dark grey to yellowish brown (7.5YR 4/2; 10YR 4/3-5/4; 5YR 3/1); sandy light clay to sandy light medium clay; moderate 10-20 mm angular to lenticular; field pH 6.5 to 7.5.

Number of sites: 10

Variants: Alkaline reaction trend (Db1.13) - 1 site.

DUGGUA (Du)

Concept: Brown cracking clay, generally associated with *Basel* (gilgai phase). Overlying unconsolidated material.

Classification: **Principal Profile Form:** Ug5.34 (modal), Ug 5.31, Ug5.32, Ug5.33, Ug5.35.
Australian Soil Classification: Brown Vertosols.

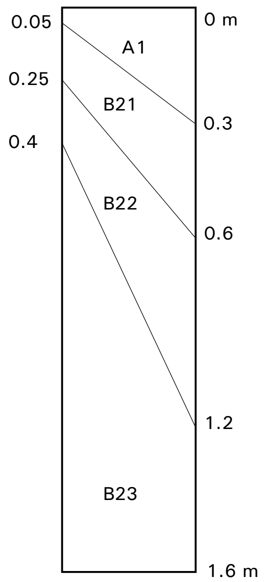
Landform: Levels to gently undulating plain, alluvial plain, terrace, or stagnant alluvial plain.

Geology: Quaternary or tertiary alluvium.

Vegetation: Queensland blue gum, narrow leaved ironbark and Moreton Bay ash open forest to woodland.

Surface features: Cracking (sometimes mulching), gilgai common.

Profile diagram and description:



A1: Very dark grey to dark greyish brown (7.5YR 3/2-4/2 to 10YR 3/1-4/2); light clay to light medium clay; strong 5-10 mm subangular; field pH 6.0 to 7.0; may have few manganese nodules. Gradual to –

B21: Brown to olive brown (10YR 4/3-4/4 to 2.5Y 4/3-4/4); light medium clay to medium clay; strong 20-50 mm angular to lenticular; field pH 7.0 to 8.5; may have few manganese nodules and segregations and/or few carbonate nodules. Gradual to –

B22: Black to light olive brown (10YR 2/1-5/4 to 2.5Y 4/3-5/6); may be mottled; light medium clay to medium clay; strong 20-50 mm angular to lenticular; field pH 7.0 to 8.5; may have very few manganese, calcareous or ferruginous nodules. Gradual to –

B23: Very dark greyish brown to light olive brown (10YR 3/2-5/3 to 2.5Y 5/4-5/6); may be mottled; light medium clay to medium heavy clay; strong 20-50 mm angular to lenticular; may have few calcareous nodules and concretions, or manganese nodules; field pH 8.0 to 9.0.

Number of sites: 12

DUNWICH (Dw)

Concept: Texture contrast soil with a loamy surface over black, brown, yellowish brown or greyish brown clay subsoil. Neutral to alkaline soil reaction trend. Subsurface weakly bleached. Overlying andesite and volcanic conglomerate (occasionally shale, siltstone).

Classification: **Principal Profile Form:** Dy2.13 or Dy2.33 (modal), Db1.13, Db1.23, Db1.32, Db1.33, Dd1.13, Dd1.32, Dd1.33, Dy3.32.
Australian Soil Classification: Brown, Black, Yellow or Grey Sodosols; Eutrophic, Sodic (Brown, Black, Yellow or Grey) Chromosols.

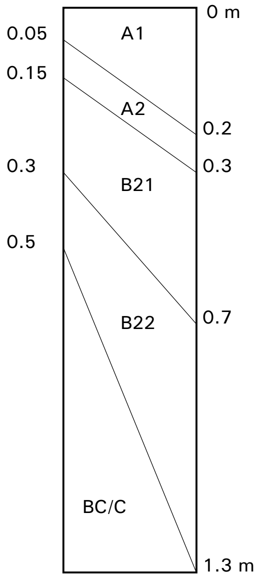
Landform: Undulating to rolling rises, low hills and hills. Crests and all slope positions to drainage lines.

Geology: Triassic volcanics - Neara Volcanics; Permian-Triassic volcanics - Gilla Andesite; Brisbane Valley Porphyrites.

Vegetation: Narrow leaved ironbark, Moreton Bay ash and silver leaved ironbark box open forest to woodland.

Surface features: Hard setting.

Profile diagram and description:



A1: Black to greyish brown (7.5YR 3/2-4/3 to 10YR 2/1-5/2); fine sandy clay loam to clay loam fine sandy; weak to moderate 2-5 mm granular; field pH 6.0 to 7.0. Gradual to –

A2j (where present): Dark brown to yellowish brown (7.5YR 3/2-5/3 to 10 YR 3/1-5/4 moist, 10YR 6/2-7/2 dry); fine sandy clay loam to clay loam sandy; massive to weak 2-5 mm granular; field pH 6.0 to 7.0; may have few manganese nodules and soft segregations. Clear or abrupt to –

B21: Dark brown to yellowish brown (10YR5/2-6/6); light medium clay to medium clay; strong 10-20 mm angular or prismatic; field pH 6.5 to 8.0; may have very few manganese nodules or soft segregations and/or calcareous nodules. Gradual to –

B22: Very dark greyish brown to light olive brown (10YR3/2-6/4 to 2.5YR 4/4-5/4); occasionally a few mottles; light clay to light medium clay; strong 10-20 mm angular to lenticular; field pH 7.0 to 8.5; may have few manganese nodules and/or calcareous soft segregations. Gradual to –

BC/C: Very dark grey to light brownish grey (10YR 3/1-7/4 to 2.5YR 5/3-6/2); light clay to light medium clay; moderate 10-20 mm angular; field pH 7.5 to 8.5.

Number of sites: 79

ESK (Ek)

Concept: Shallow loamy soil, usually rocky. Overlying rhyolite.

Classification: **Principal Profile Form:** Uc1.44, Uc2.12, Um1.41, Um2.12, Um3.21.
Australian Soil Classification: Leptic Rudosols.

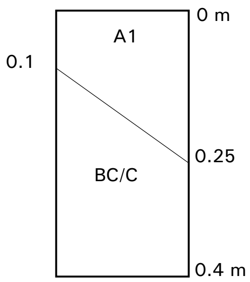
Landform: Undulating to rolling rises, low hills and hills.

Geology: Triassic-Jurassic intrusion/extrusion - Crossdale Rhyolite.

Vegetation: Queensland peppermint and brown bloodwood open forest. Also narrow leaved ironbark, spotted gum, Moreton Bay ash and silver leaved ironbark.

Surface features: Hard setting with surface rocks common.

Profile diagram and description:



A1: Dark greyish brown to brown (7.5YR 3/2-5/3 to 10YR 3/2); fine sandy loam to fine sandy clay loam; massive to weak 2-5 mm granular; field pH 6.0 to 6.5. Gradual to –

BC/C: Brown (10YR 4/2-5/2); Fine sandy loam to clay loam fine sandy; weak 2-5 mm granular; field pH 6.0 to 7.0.

Number of sites: 9

ESKVALE (Ev)

Concept: Texture contrast soil with a hard setting loamy surface and strongly bleached subsurface, over a brown, yellowish brown or grey clay subsoil. Overlying chert, mudstone, siltstone or sandstone.

Classification: **Principal Profile Form:** Dy3.42 or Dy3.43 (modal), Db1.32, Db1.42, Db2.32, Db2.42, Dy2.42, Dy2.43, Dy3.33.
Australian Soil Classification: Brown or Grey Sodosols; Brown or Grey Chromosols.

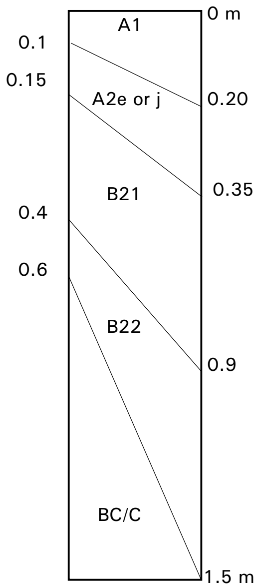
Landform: Rolling hills.

Geology: Permian sediments - Cressbrook Creek Group, Marumba Beds; Devonian-Carboniferous sediments - Maronghi Creek Beds.

Vegetation: Open forest of narrow leaved ironbark and Moreton Bay ash with Queensland blue gum, spotted gum, silver leaved ironbark and pink bloodwood.

Surface features: Hard setting.

Profile diagram and description:



A1: Black to brown (7.5YR 3/2, 4/2 to 10YR 2/1-4/3); fine sandy clay loam to clay loam fine sandy; weak granular; field pH 6.0 to 7.0. Gradual to –

A2: Dark brown to light yellowish brown (7.5YR 4/2-5/4 to 10 YR 3/3-6/4 moist, 10YR 7/2-8/2 dry); fine sandy clay loam to clay loam fine sandy; massive to weak structure; field pH 6.0 to 7.0; may have few ferromanganiferous nodules. Clear or abrupt to –

B21: Brown to yellowish brown (7.5YR4/4-5/6 to 10YR 3/1-5/6); often mottled; light medium clay to medium clay; strong 10-50 mm angular to lenticular; field pH 7.0 to 8.0; may have very few manganese soft segregations or nodules. Gradual to –

B22: Brown to olive yellow (7.5YR 4/4-5/2, 10YR 4/1-6/8 to 2.5Y 4/3-6/6); often mottled; light medium clay to medium clay; strong 20-50 mm angular to lenticular; field pH 7.0 to 9.0; may have very few manganese nodules. Gradual to –

BC/C: Brown to yellow (7.5YR 4/4-6/6 to 10YR 4/3-7/6); light clay to sandy clay; moderate to strong 5-20 mm angular; field pH 7.0 to 9.0; may have few manganese nodules and calcareous soft segregations nodules.

Variants: A2 horizon not bleached: Db1.23
B21 horizon red (5YR 4/4-4/6): Dr3.42

Number of sites: 33

FORSTER (Fs)

Concept: Shallow uniform textured soil with hard setting loamy surface overlying granite or granodiorite.

Classification: **Principal Profile Form:** Um1.41, Um3.21, Um1.43, Uc1.21, Uc1.22.
Australian Soil Classification: Leptic Rudosols.

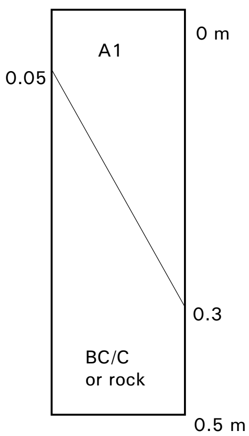
Landform: Steep low hills to hills.

Geology: Permian-Triassic acid intrusions - Eskdale Granodiorite and another unnamed group.

Vegetation: Open forest of narrow leaved ironbark and silver leaved ironbark. Spotted gum and pink bloodwood also occur.

Surface features: Firm to hard setting.

Profile diagram and description:



A1: Very dark greyish brown to brown (7.5YR 3/2-4/3-4/3); coarse sandy loam to sandy clay loam; massive to weak 2-5 mm granular; field pH 6.5 to 7.0. Gradual to –

BC/C: Dark yellowish brown (10YR 4/4);); coarse sandy loam to sandy clay loam; massive to weak 2-5 mm granular; field pH 6.5 to 7.0.

Number of sites: 1

FREEMAN (Fm)

Concept: Texture contrast soil with a loamy surface over red clay subsoil. Acid reaction trend. Overlying chert, mudstone, siltstone or sandstone.

Classification: **Principal Profile Form:** Dr2.11 or Dr2.21 (modal), Dr2.31, Dr2.41, Dr3.11, Dr3.21, Dr3.31, Dr3.41.
Australian Soil Classification: Red Kurosols; Red Chromosols; Red Sodosols.

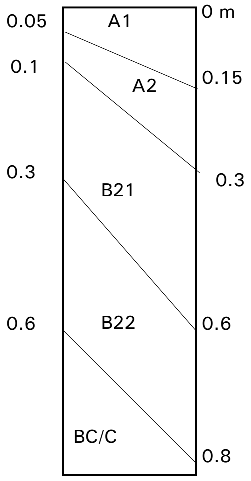
Landform: Rolling to steep low hills to hills.

Geology: Permian sediments - Cressbrook Creek Group, Marumba Beds; Devonian-Carboniferous sediments - Maronghi Creek Beds.

Vegetation: Open forest of narrow leaved ironbark and silver leaved ironbark. Brush box, spotted gum and pink bloodwood also occur.

Surface features: Hard setting.

Profile diagram and description:



A1: Dark brown to brown (7.5YR 3/2, 4/3 to 10YR 2/2-4/2); sandy clay loam to clay loam fine sandy; weak granular; field pH 5.5 to 6.5. Gradual to –

A2: Brown to yellowish brown (7.5YR 4/2-5/4 to 10 YR 4/3-5/6); sandy clay loam to clay loam fine sandy; weak granular; field pH 5.5 to 6.5. Clear or abrupt to –

B21: Red (2.5YR 3/4-4/8 to 5YR4/6); commonly mottled; light medium clay to medium clay; strong 5-20 mm angular, subangular or polyhedral; field pH 5.0 to 6.0; may have very few manganese soft segregations. Gradual to –

B22: Dusky red to light yellowish brown (2.5YR 3/4-4/6, 5YR3/4-4/6 to 10YR 6/4); common distinct mottling; light medium clay to medium clay; strong 20-50 mm angular to prismatic; field pH 5.0 to 6.0. Gradual to –

BC/C: Brown to yellow (2.5YR 6/6, 5YR 4/6, 7.5YR 5/4 to 10YR 6/4-7/4); light medium clay; moderate 10-20 mm angular; field pH 5.5 to 6.0; may have few manganese soft segregations.

Number of sites: 12

GALLANANI (Gl)

Concept: Gradational to texture contrast soil with a loamy surface over a brown, black, red or grey clay subsoil with a neutral to alkaline soil reaction trend. Overlying unconsolidated material.

Classification: **Principal Profile Form:** Db1.12 or Db1.22 (modal), Db1.13, Db2.22, Db1.32, Dd1.12, Db2.13, Dd1.13, Dd1.32, Dr2.13, Dr2.22, Dy2.12, Dy2.13, Dy2.32, Gn3.15, Gn3.22, Gn3.15, Gn3.25, Gn3.92.
Australian Soil Classification: Brown, Black, Red or Grey Chromosols; Brown, Black, Red or Grey Dermosols.

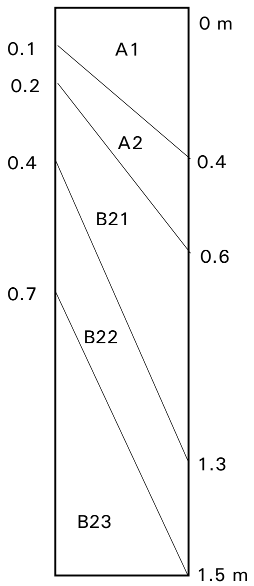
Landform: Level to gently undulating alluvial plains and terraces.

Geology: Quaternary alluvium.

Vegetation: Open woodland of Queensland blue gum, broad-leaved apple and Moreton Bay ash. River she-oak, swamp mahogany and silver leaved ironbark also occur.

Surface features: Firm to hard setting.

Profile diagram and description:



A1: Very dark brown to brown (7.5YR3/2-5/3; 10YR2/2-5/3); sandy clay loam to clay loam fine sandy; weak to moderate 2-5 mm granular; field pH 6.0 to 6.5. Gradual to –

A2 (where present): Brown to pale brown (7.5YR 4/3-5/4; 10YR3/2-5/4 moist); sporadic bleach common; sandy clay loam to clay loam fine sandy; massive to weak 2-5 mm granular; field pH 6.5 to 7.0. Clear or abrupt to –

B21: Black to yellowish brown (7.5YR3/2-5/3 to 10YR2/1-5/6) or red (2.5YR4/3 - 5YR4/4); sporadic bleach common; fine sandy light medium clay to light medium clay; strong 10-50 mm prismatic to angular; field pH 6.5 to 7.5; may have very few manganese nodules or soft segregations. Gradual to diffuse boundary to –

B22: Brown to light yellowish brown (7.5YR4/2-5/8 to 10YR4/2-6/4) or red (2.5YR4/3 - 5YR4/4); sandy light medium clay to light medium clay; strong 20-50 mm prismatic to angular; field pH 6.5 to 8.0; may have few manganese nodules or soft segregations. Gradual to –

D: Very dark grey to yellowish brown (7.5YR3/3-5/4; 10YR3/1-5/4); sandy clay loam to light medium clay; weak to moderate 10-20 mm prismatic to angular blocky; field pH 6.5 to 7.5.

Variants: Conspicuously bleached A2 horizon: Db1.42, Dy2.43

Number of sites: 240

GALLANANI rocky phase (**GLrp**) is similar to Gallanani except for the presence of common to abundant coarse gravel or cobble in the surface soil (top 0.2 m).

GILLA (Gi)

Concept: Texture contrast soil with a loamy surface over a brown or yellowish brown clay subsoil with neutral to alkaline soil reaction trend. A2 horizon bleached. Overlying granite or granodiorite.

Classification: **Principal Profile Form:** Db1.42, Dd1.33, Dr2.23, Dy2.32, Dy2.43, Dy3.42.
Australian Soil Classification: Black or Brown Chromosols; Black or Brown Sodosols.

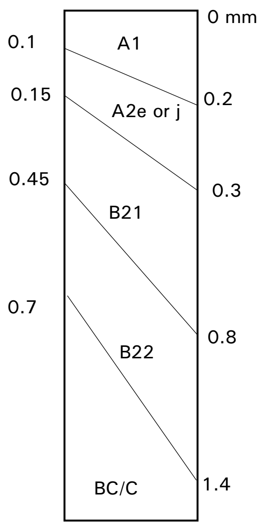
Landform: Gently undulating to rolling rises and low hills. Gentle slopes, broad crests.

Geology: Permian-Triassic acid intrusions - Eskdale Granodiorite and another unnamed group.

Vegetation: Open forest to woodland of silver leaved ironbark and narrow leaved ironbark with Moreton Bay ash and Queensland blue gum.

Surface features: Hard setting.

Profile diagram and description:



A1: Dark brown to dark greyish brown (7.5YR 3/2-3/3, to 10YR 2/1-4/2); coarse sandy clay loam to clay loam fine sandy; weak 2-5 mm granular; field pH 6.0 to 7.5. Gradual to –

A2e or A2j: Brown to greyish brown (7.5YR 4/2 to 10YR 5/3 moist, 7.5YR 7/2 to 10YR 7/2-8/1 dry); coarse sandy loam to clay loam fine sandy; massive to weak 2-5 mm granular; field pH 6.5 to 7.5. Clear or abrupt to –

B21: Dark brown to yellowish brown (7.5YR 3/2 to 10YR 5/6); may few to common mottles (distinct or faint); sandy light medium clay to medium clay; medium to strong 10-20 mm angular or 20-50 mm columnar; field pH 7.0 to 8.0; may have few manganese nodules and concretions. Gradual to –

B22: Brown to yellowish brown (7.5YR 5/3-5/6 to 10YR 4/3-5/6); few to common mottles (distinct or faint); sandy light medium clay to medium clay; medium to strong 10-20 mm angular; field pH 8.0 to 9.0; may have very few manganese nodules. Gradual to diffuse to –

BC/C: Dark brown to yellowish brown (7.5YR 3/2, 10YR 5/6); clay loam sandy to light clay; moderate 10-20 mm angular; field pH 8.0 to 9.0; may have very few manganese nodules and few calcareous soft segregations.

Number of sites: 12

GREENHIDE (Gh)

Concept: Texture contrast soil with firm to hard setting loamy surface over brown or red clay subsoil. Subsurface horizons may or may not be present, A2 horizons never bleached. Neutral to slightly alkaline or slightly acid reaction trend. Overlying sandstone, siltstone or conglomerate.

Classification: **Principal Profile Form**: Db1.12 (modal), Db1.22, Dr2.12, Dr2.22, Dy2.12.
Australian Soil Classification: Brown or Red Chromosols.

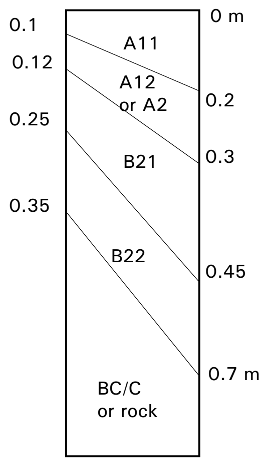
Landform: Gently undulating to steep rises, low hills and hills. Occurring mainly on mid to upper slopes and crests.

Geology: Triassic Sediments: Bryden Formation and Esk Formation; Triassic-Jurassic Sediments: Helidon Sandstone.

Vegetation: Woodland to open forest of narrow leaved ironbark and Moreton Bay ash. Silver leaved ironbark and Queensland blue gum also occur.

Surface features: Firm to hard setting.

Profile diagram and description:



A11: Black to dark greyish brown (10YR 2/1-4/2 to 7.5YR 3/2, 4/2); fine sandy clay loam to clay loam fine sandy; weak to strong 2-10 mm granular; field pH 6.0 to 7.0. Clear or gradual to –

A12 or A2 (where present**):** Dark greyish brown to dark yellowish brown (10 YR 4/2-4/4, 7.5YR 3/3-4/3); fine sandy clay loam to clay loam fine sandy; weak to moderate 2-5 mm granular; field pH 6.0 to 6.5. Abrupt or clear to –

B21: Dark brown to yellowish red (10YR 3/3-4/4, 7.5YR 4/3,4/6, 5YR 4/4-5/6); light medium clay to medium clay; moderate to strong 10-20 mm angular, subangular or prismatic; field pH 6.0 to 7.0; may have very few manganese nodules. Gradual to –

B22: (where present) Brown to light olive brown (10YR 4/3-4/4, 7.5YR 4/4, 2.5Y 5/3); light medium clay to medium clay; moderate to strong 10-50 mm angular, subangular or prismatic; field pH 6.0 to 7.5; may have very few manganese nodules. Gradual to –

BC/C: Dark yellowish brown to yellowish brown (10YR 4/4, 5/6); sandy light clay to sandy light medium clay; weak to moderate 5-20 mm angular to subangular; field pH 6.5 to 8.0; may have very few manganese concretions, nodules or soft segregations.

Variants: B21 horizon black (10YR 3/2): Dd2.12.

Number of sites: 41

GRIENKE (Gk)

Concept: Shallow loamy soil, usually rocky. Overlying sandstone, siltstone or conglomerate.

Classification: **Principal Profile Form:** Um1.13, Um1.21, Um1.23, Um1.41, Um1.43, Um5.51.
Australian Soil Classification: Leptic Rudosols.

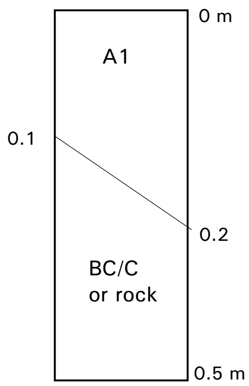
Landform: Rolling to steep low hills, hills and mountains. Upper slopes and ridges.

Geology: Triassic Sediments: Bryden Formation and Esk Formation. Triassic-Jurassic Sediments: Helidon Sandstone.

Vegetation: Open forest of narrow leaved ironbark, spotted gum open and Moreton Bay ash. Silver leaved ironbark and pink bloodwood also occur.

Surface features: Firm to hard setting, surface rocks common.

Profile diagram and description:



A1: Dark brown to brown (7.5YR 3/2, 4/4); sandy clay loam to clay loam fine sandy; massive to weak 2-5 mm granular; field pH 6.0 to 7.0. Gradual to –

BC/C: Yellowish red to brownish yellow (5YR 3/4 to 10YR 6/6); sandy clay loam to clay loam sandy; massive to weak 2-5 mm granular; field pH 6.0 to 7.5.

Number of sites: 25

GUNYAH (Gy)

Concept: Texture contrast soil with loamy surface over black, brown or dark grey clay subsoil with a neutral to alkaline soil reaction trend. Overlying unconsolidated material.

Classification: **Principal Profile Form:** Dd1.13 (modal), Db1.13, Db1.23, Dd1.12, , Dd1.23, Dd1.32, Dd1.33, Dd2.12, Dd2.22, Dd2.33, Dy2.13.
Australian Soil Classification: Brown, Black or Grey Sodosols (or Eutrophic Sodic Chromosols)

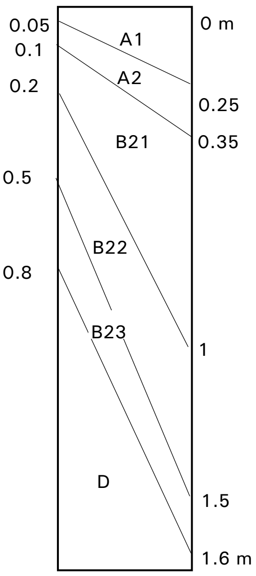
Landform: Level to undulating terrace, stagnant alluvial plain or alluvial plain.

Geology: Quaternary or Tertiary alluvium.

Vegetation: Open woodland of Queensland blue gum, broad-leaved apple and Moreton Bay ash. River she-oak, swamp mahogany and silver leaved ironbark also occur.

Surface features: Hard setting.

Profile diagram and description:



A1: Black to brown (10YR2/1-4/3; 7.5YR 3/2-4/3); fine sandy clay loam to clay loam fine sandy; massive to strong 2-5 mm granular; field pH 6.0 to 7.0. Clear or gradual to –

A2 or A2j: Dark greyish brown to brown (10YR 3/2-5/3 moist; 10YR 5/1-6/2 dry); sandy clay loam to clay loam fine sandy; massive to weak 2-5 mm granular; field pH 6.0 to 7.0; may have few manganese, ferruginous or ferromanganiferous nodules or concretions. Abrupt or clear to –

B21: Black, dark brown or dark grey (10YR2/1-4/3; 10YR4/2; 7.5YR2/1-4/3); fine sandy light clay to medium clay; medium to strong 10-50 mm angular to prismatic; field pH 6.0 to 8.5; may have few manganese nodules. Gradual or diffuse to –

B22 (may be k): Black to yellowish brown or light olive brown (10YR2/1-5/4; 7.5YR3/2-4/4; 2.5Y 3/2-5/3); occasionally mottled; light medium clay to medium clay; strong 10-20 mm angular to prismatic or strong 20-50 mm lenticular; field pH 7.0 to 9.0; may have few ferromanganiferous nodules or common carbonate nodules. Gradual to –

B23 (may be k): Very dark grey to light olive brown (10YR3/1-5/4; 2.5Y 2/1-5/4); occasionally mottled; light medium clay to medium clay; strong 10-50 mm angular to lenticular; field pH 7.5 to 9.0; may have few carbonate and/or manganese nodules and concretions. Gradual to –

D: Dark brown to light olive brown (7.5YR 3/2-5/6; 10YR 3/2-5/6; 2.5Y 4/3-4/4); sandy light medium clay to sandy clay loam; weak to strong structure, field pH 7.0 to 9.5; may have common carbonate and/or manganese nodules/concretions.

Variants: Gradational profile form (clay loam over light clay): Gn3.23, Gn3.33, Gn3.45, Gn3.92.

Number of sites: 102

HIBISCUS (Hb)

Concept: Red, massive to weakly structured, gradational to uniform textured soil. Loamy surface and subsurface with neutral to slightly acid reaction trend. Overlying sandstone.

Classification: **Principal Profile Form**: Gn2.11 or Gn2.12 or Um1.43 (modal), Gn2.14, Gn2.15, Gn4.12, Um4.21, Um5.22, Um5.52, Um6.13.
Australian Soil Classification: Red Kandosols.

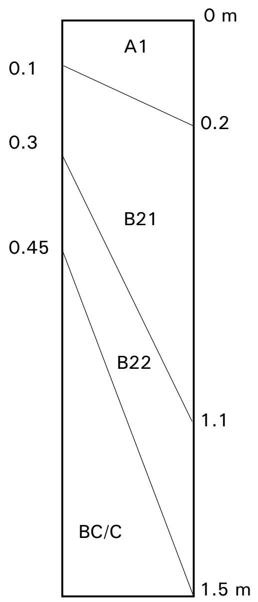
Landform: Undulating to rolling rises and low hills.

Geology: Triassic-Jurassic Sediments: Helidon Sandstone.

Vegetation: Open forest of spotted gum, Moreton Bay ash and narrow leaved ironbark Queensland blue gum and pink bloodwood also occur.

Surface features: Firm to hard setting.

Profile diagram and description:



A1: Very dusky red to reddish brown (2.5YR 2/2-3/3 to 7.5YR 3/2); coarse sandy clay loam to clay loam sandy; massive to weak granular; may have very few manganese soft segregations; field pH 6.0 to 7.0. Gradual to –

B21: Dusky red to dark red (2.5YR 3/3-4/6); coarse sandy clay loam to sandy light clay; massive to weak granular; field pH 6.0 to 7.0; may have few manganese nodules. Gradual to –

B22: Dark red to yellowish red (10R3/6, 2.5YR 4/3-4/4, 5YR 5/8) clay loam sandy to sandy light medium clay; massive to weak granular; field pH 6.0 to 7.5; may have few manganese nodules. Gradual to –

BC/C: Dark red (2.5YR3/6); sandy clay loam to sandy light clay; massive to weak granular; field pH 6.0 to 7.0.

Variants: Light textured (KSL throughout).
Shallow (to 0.6 m).
Moderate to strongly structured: Gn3.12

Number of sites: 36

HONEY (Hy)

Concept: Layered soil with a firm to hard setting loamy surface and neutral soil reaction trend. Overlying unconsolidated material.

Classification: **Principal Profile Form:** Um1.23 (modal), Um1.21, Um1.24, Um1.41, Um 1.44, Um5.52, Um6.23, Um6.41, Gn2.12, Gn3.12, Gn2.42.
Australian Soil Classification: Stratic Rudosols, Chernic or Chernic-Leptic Tenosols.

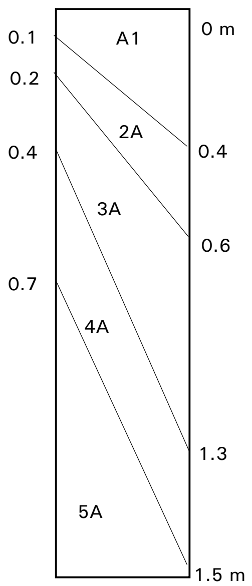
Landform: Level to gently undulating flood plains and low terraces.

Geology: Quaternary alluvium.

Vegetation: Open woodland of river she-oak and Queensland blue gum. Black tea tree and Moreton Bay ash also occur. Woody weeds common.

Surface features: Firm to hard setting.

Profile diagram and description:



A1: Black to brown (7.5YR 2/1-5/3 to 10YR 3/2-4/2); sandy clay loam to clay loam sandy; massive to weak 2-5 mm granular; field pH 6.5 to 7.0. Gradual to –

2A: Black to dark yellowish brown (7.5YR 3/2-5/4 to 10YR 2/1-4/4); sandy clay loam to clay loam sandy; massive to weak 2-5 mm granular; field pH 6.5 to 7.5. Gradual to –

3A: Black to dark yellowish brown(7.5YR3/2-4/3 to 10YR 2/1-4/4); loamy sand to sandy light clay; massive to weak 2-5 mm granular; field pH 7.0 to 7.5; may have very few manganese nodules. Gradual to –

4A: Black to yellowish brown (7.5YR 3/2-4/6 to 10YR 2/1-5/4); coarse sand to sandy clay loam; massive to weak granular; field pH 7.0 to 7.5; may have few coarse fragments; may have few manganese nodules. Gradual to –

5A: Black to yellowish brown (7.5YR 3/2-4/6 to 10YR 2/1-5/4); coarse sand to sandy clay loam; massive to weak granular; field pH 7.0 to 7.5; may have few coarse fragments; may have few manganese nodules.

Number of sites: 128

HORSE (Hs)

Concept: Texture-contrast soil with hard setting loamy surface and bleached subsurface over a brown to yellow clay subsoil with an acid soil reaction trend. Overlying chert, mudstone, siltstone or sandstone.

Classification: **Principal Profile Form:** Dy3.41 (modal), Dy2.21, Dy2.31, Dy2.41, Dy3.31
Australian Soil Classification: Brown, Yellow or Grey Chromosols; Brown, Yellow or Grey Kurosols.

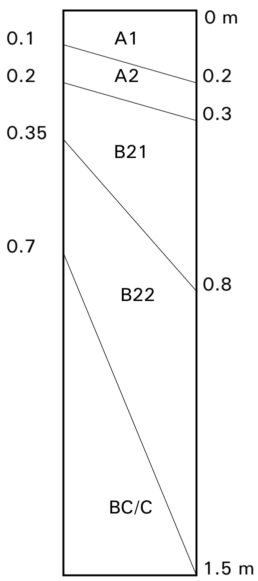
Landform: Rolling low hills to hills.

Geology: Permian sediments - Cressbrook Creek Group, Marumba Beds; Devonian-Carboniferous sediments - Maronghi Creek Beds

Vegetation: Open forest of narrow leaved ironbark, spotted gum, and Moreton Bay ash. Gum topped box and silver leaved ironbark also occur.

Surface features: Hard setting.

Profile diagram and description:



A1: Dark brown to brown (7.5YR 3/2 to 10YR 3/2-5/3); fine sandy clay loam to clay loam fine sandy; weak to moderate 2-5 mm granular; field pH 5.5 to 6.5. Gradual or clear to –

A2: Brown to greyish brown (7.5YR 5/2-5/3 to 10 YR 4/3-5/3 moist, 10YR 7/2-8/2 dry); fine sandy clay loam to clay loam sandy; massive to weak granular; field pH 5.5 to 6.5; may have few ferromanganiferous nodules. Abrupt to –

B21: Greyish brown to brownish yellow (10YR5/2-6/6); light medium clay to medium clay; moderate to strong 10-50 mm angular or columnar; field pH 4.5 to 6.0; may have very few manganese and ferromanganiferous nodules. Gradual to –

B22: Yellowish red to light yellowish brown (5YR4/6 to 10YR 5/8-6/4); light medium clay; strong 10-50 mm angular to lenticular; field pH 4.5 to 6.0; may have very few ferruginous and manganiferous concretions. Gradual to –

BC/C: Greyish brown to brownish yellow (10YR 5/2,6/6); light clay to light medium clay; moderate 10-20 mm angular; field pH 4.5 to 6.0.

Variants: B21 horizon red (5YR5/4-5/6): Dr2.41
A2 horizon absent or not bleached: Dy2.11, Dy2.21

Number of sites: 14

IVORY (Iv)

Concept: Uniform to gradational textured soil with a sandy texture throughout and a slightly acid to neutral reaction trend. Overlying granite or granodiorite.

Classification: **Principal Profile Form:** Uc1.22, Uc2.23, Uc5.22, Uc5.23, Gn2.15, Gn2.55.
Australian Soil Classification: Orthic Tenosols.

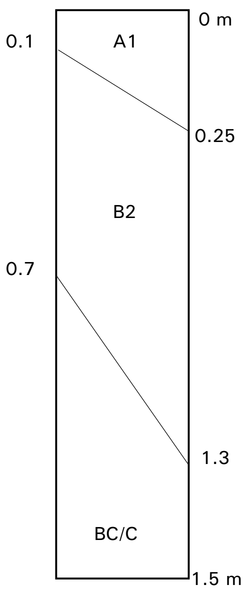
Landform: Undulating to rolling rises and low hills, especially on colluvial slopes.

Geology: Permian-Triassic acid intrusions - Eskdale Granodiorite and another unnamed group.

Vegetation: Open forest of narrow leaved ironbark and Queensland blue gum with pink bloodwood and broad leaved apple.

Surface features: Loose to firm.

Profile diagram and description:



A1: Dark reddish brown to brown (5YR 3/3, 7.5YR 3/2-4/6 to 10YR 4/2-4/3); loamy coarse sand to coarse sandy clay loam; massive to weak 2-5 mm granular; field pH 5.5 to 6.5. Gradual to –

A2: Very dark grey to light brownish grey (7.5YR 3/1-4/3 to 10YR 3/2-6/2 moist, 7.5YR 7/2 to 10YR 7/2-8/1 dry); coarse sandy loam to clay loam fine sandy; massive to weak 2-5 mm granular; field pH 6.5 to 7.5; may have few manganese nodules. Clear or abrupt to –

B2: Brown to brownish yellow (7.5YR 5/4 - 10YR 5/4 or 6/6); loamy coarse sand to sandy clay loam; massive (occasionally weak) structure; field pH 6.5 to 7.5. Gradual to –

BC/C: Brown to strong brown (7.5YR 4/3-5/8); loamy coarse sand to sandy clay; massive to weak structure; field pH 6.0 to 7.0.

Number of sites: 8

JIMNA (Jm)

Concept: Black and brown cracking clays with an alkaline soil reaction trend. Overlying andesite and volcanic conglomerate (occasionally shale, siltstone).

Classification: **Principal Profile Form:** Ug5.32 (modal), Ug5.12, Ug5.14, Ug5.31, Ug5.35.
Australian Soil Classification: Black or Brown Vertosols.

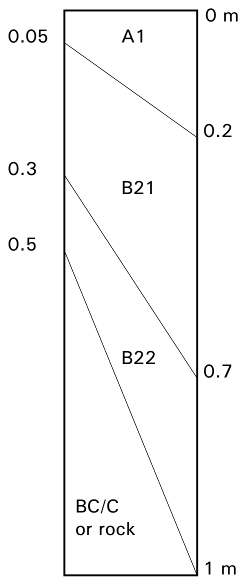
Landform: Undulating to steep hills. Various slope positions; limited distribution.

Geology: Triassic volcanics - Neara Volcanics, and another unnamed group; Permian-Triassic volcanics - Gilla Andesite.

Vegetation: Open forest to woodland of narrow leaved ironbark, silver leaved ironbark, Moreton Bay ash and Queensland blue gum.

Surface features: Cracking, weakly self-mulching.

Profile diagram and description:



A1: Black to dark greyish brown (7.5YR 3/2; 10YR 2/1-4/2); light clay to light medium clay; strong 2-5 mm granular or subangular; field pH 6.0 to 6.5. Clear or gradual to –

B21: Dark brown to dark greyish brown (7.5YR 3/2-4/4; 10YR3/2-4/2); light medium clay to medium clay; strong 10-20 mm angular; field pH 7.0 to 8.5; may have very few manganese nodules. Gradual to –

B22: Very dark grey to dark greyish brown (7.5YR 3/3-4/2; 10YR3/1); light medium clay; strong 10-20 mm angular to lenticular; field pH 7.0 to 9.0; may have few calcareous nodules. Gradual to –

BC/C: Dark brown to greyish brown (7.5YR 4/2; 10YR 4/2-5/2); light clay to light medium clay; moderate 10-20 mm granular to polyhedral; field pH 8.5 to 9.0; may have few calcareous soft segregations.

Variants: Non cracking surface: Uf6.32, Uf6.33

Number of sites: 9

KIPPER (Kp)

Concept: Texture contrast soil with a loamy surface over a neutral to slightly acid, red subsoil that grades to brown or yellowish brown with depth. Subsurface may be bleached. Overlying sandstone, siltstone or conglomerate.

Classification: **Principal Profile Form:** Dr2.21 (modal), Dr2.22, Dr2.31, Dr2.41, Dr3.21, Dr3.22, Dr4.21.
Australian Soil Classification: Red Chromosols.

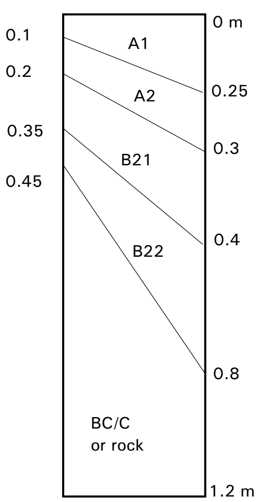
Landform: Rolling to steep hills. Mid to upper slopes.

Geology: Triassic Sediments: Bryden Formation and Esk Formation.

Vegetation: Open forest of narrow leaved ironbark. Moreton Bay ash, silver leaved ironbark, pink bloodwood, spotted gum and broad-leaved apple also occur.

Surface features: Hard setting. Surface coarse fragments and rock outcrops common.

Profile diagram and description:



A1: Dark brown to very dark greyish brown (7.5YR 3/2 to 10YR 2/1-3/2); clay loam fine sandy; weak to moderate 2-5 mm granular; field pH 6.0 to 7.0. Gradual to –

A2: Brown to yellowish brown (7.5YR 4/3 to 10 YR 3/3-5/4 moist, 10YR 5/3-7/3 dry); clay loam fine sandy; massive to weak granular structure; field pH 6.0 to 6.5. Clear to –

B21: Dark red to yellowish red (2.5YR 3/6-4/6 to 5YR 4/6); light medium clay; strong 5-10 mm angular or subangular to polyhedral; field pH 5.5 to 6.5; may have few manganese nodules. Gradual to –

B22: Brown to light brown (10YR 5/4-6/3); light medium clay; strong 5-10 mm subangular to polyhedral; field pH 5.5 to 6.5. Gradual to –

BC/C: Strong brown to brownish yellow (7.5YR 4/6 to 10YR 5/6,6/6); sandy light medium clay; moderate to strong 5-10 mm angular or subangular; field pH 5.0 to 6.0.

Number of sites: 25

LAKEVIEW (Lv)

Concept: Gradational to texture contrast soil with a loamy surface over a brown to yellowish brown clay subsoil. Neutral to alkaline reaction trend. Overlying sandstone, siltstone or conglomerate.

Classification: **Principal Profile Form**: Db1.13, Db2.11, Db2.12, Dy2.12, Gn3.22.
Australian Soil Classification: Brown Dermosols; Brown Chromosols.

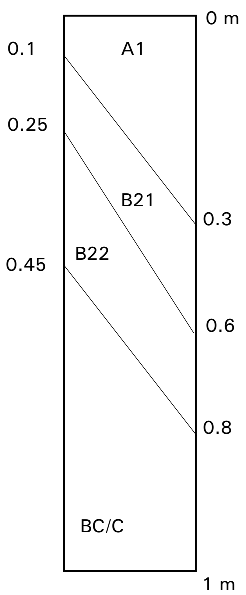
Landform: Undulating to rolling low hills.

Geology: Triassic Sediments: Bryden Formation and Esk Formation.

Vegetation: Softwood scrub species.

Surface features: Firm to hard setting.

Profile diagram and description:



A1: Black to dark greyish brown (10YR 2/1-4/2 to 7.5YR 3/2, 4/2); clay loam to clay loam fine sandy; weak to strong 2-5 mm granular; field pH 6.0 to 7.0. Clear to gradual to –

B21: Very dark greyish brown to yellowish brown (10YR 4/2-5/6, 7.5YR 4/4); light clay to medium clay; moderate to strong angular, subangular or prismatic; field pH 6.0 to 7.0; may have very few manganese nodules. Gradual to –

B22: Brown to light olive brown (10YR 4/3-4/4, 7.5YR 4/4, 2.5Y 5/3); light medium clay to medium clay; moderate to strong angular, subangular or prismatic; field pH 6.0 to 7.5; may have very few manganese nodules. Gradual to –

BC/C: Dark yellowish brown to yellowish brown (10YR 4/3-5/6); sandy light clay to sandy light medium clay; weak to moderate angular to subangular; field pH 6.5 to 8.5; may have very few manganese concretions, nodules or soft segregations.

Variants: Coarse fragments throughout profile.
Red subsoil.

Number of sites: 9

LINVILLE (Le)

Concept: Texture contrast soil with a loamy surface over brown, greyish brown, black or red clay subsoil. Neutral to slightly alkaline or slightly acid soil reaction. Overlying andesite and volcanic conglomerate (occasionally shale, siltstone).

Classification: **Principal Profile Form:** Db1.12 (modal), Db1.22, Dd1.12, Dd1.22, Dr2.12, Dr2.22, Dy2.12, Dy2.22.
Australian Soil Classification: Brown, Grey, Red or Black Chromosols.

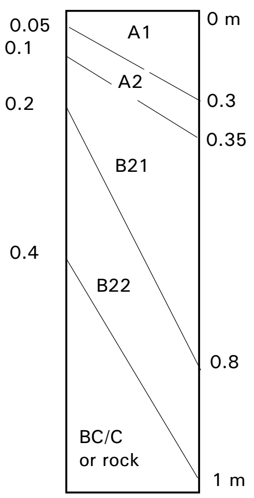
Landform: Rolling to steep rises, low hills and hills.

Geology: Triassic volcanics - Neara Volcanics; Permian/Triassic volcanics - Gilla Andesite; Brisbane Valley Porphyrites.

Vegetation: Open forest of narrow leaved ironbark and Queensland blue gum with silver leaved ironbark and Moreton Bay ash. Brush box may also occur.

Surface features: Hard setting to firm.

Profile diagram and description:



A1: Black to greyish brown (7.5YR 3/2, 4/2; 10YR 2/1-5/1); fine sandy clay loam to clay loam fine sandy; weak to moderate 2-10 mm granular or subblocky; field pH 6.0 to 7.0. Gradual to –

A2 (if present): Dark greyish brown (10 YR 3/2-5/2); fine sandy clay loam to clay loam fine sandy; weak to moderate 2-5 mm granular; field pH 6.0 to 7.0; may have few manganese nodules or soft segregations. Clear or abrupt to –

B21: Reddish brown to yellowish brown (5YR 4/3-4/6, 7.5YR 3/2-5/3; 10YR 2/1-5/4); light medium clay to medium clay; moderate to strong 5-20 mm angular to lenticular; field pH 6.5 to 7.5; may have very few manganese soft segregations or nodules. Gradual to –

B22 (if present): Dark reddish brown to brownish yellow (5YR 3/3-4/6, 7.5YR 4/2-5/8; 10YR 2/1-6/6); occasionally mottled; light medium clay to medium clay; strong 10-20 mm angular; field pH 6.5 to 7.5; may have very few manganese nodules or soft segregations. Gradual to –

BC/C: Reddish brown to brownish yellow (7.5YR 4/4-6/6; 10YR 4/3-7/6); light clay to light medium clay; moderate 10-20 mm angular; field pH 6.5 to 7.5; may have very few manganese soft segregations.

Number of sites: 111

MONSILDALE (Md)

Concept: Gradational to uniform textured soil with a well structured loamy to light clay surface over a well structured brown to black clay subsoil. Neutral soil reaction trend. Overlying unconsolidated material.

Classification: **Principal Profile Form:** Uf6.32 or Gn3.22 (modal), Gn3.12, Gn3.42, Gn3.43, Uf6.33, Um6.31.
Australian Soil Classification: Black or Brown Dermosols.

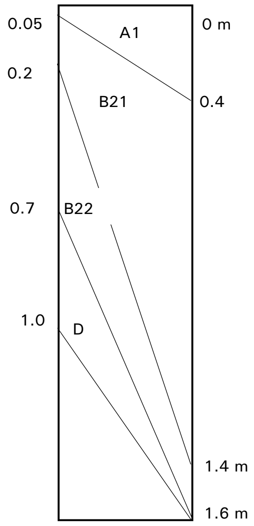
Landform: Level to gently undulating alluvial plain, terrace, or stagnant alluvial plain.

Geology: Quaternary alluvium.

Vegetation: Open woodland of Queensland blue gum and Moreton Bay ash. River she-oak and broad-leaved apple also occur.

Surface features: Firm to hard setting.

Profile diagram and description:



A1: Black to brown (7.5YR 3/2-4/4 to 10YR 2/1-4/3); sandy clay loam to fine sandy light clay; moderate to strong 2-5 mm granular or subangular; field pH 6.5 to 7.5. Gradual to –

B21: Black to brown (7.5YR 2/1-4/4 to 10YR 2/1-4/4); fine sandy light clay to medium clay; strong 10-20 mm angular to prismatic; field pH 6.5 to 7.5; may have very few manganese nodules or segregations. Gradual to –

B22: Black to dark yellowish brown (5YR 3/1-3/3, 7.5YR3/2-4/3, 10YR 2/1-4/4); light clay to light medium clay; strong 10-20 mm angular to 10-50 mm prismatic; field pH 6.5 to 7.5; may have few manganese nodules or soft segregations. Gradual to –

D: Very dark grey to dark yellowish brown (7.5YR 3/3-4/4 to 10YR 3/1-4/4); sandy clay loam to clay loam sandy; single grained to weak angular; field pH 6.5 to 7.5.

Variants: Sandy surface: A1 horizon sandy loam.
Texture contrast soil (well structured throughout): Black Chromosols (Dd1.12).

Number of sites: 163

MOORE (Mo)

Concept: Texture contrast soil with a loamy surface and strongly bleached subsurface, over a brown to yellowish brown or greyish brown clay subsoil with a neutral to alkaline soil reaction trend. Overlying andesite and volcanic conglomerate (occasionally shale, siltstone).

Classification: **Principal Profile Form:** Dy2.42 or Dy2.43 (modal), Db1.42, Db1.43, Db2.42, Dy2.32, Dy2.33, Dy3.33, Dy3.42, Dy3.43.
Australian Soil Classification: Brown, Grey or Yellow Sodosols; Brown, Grey or Yellow Chromosols.

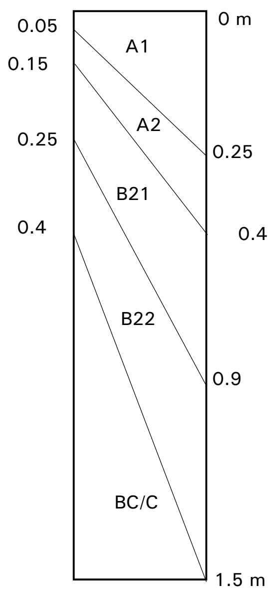
Landform: Undulating to steep rises, low hills and hills. Broad flat crests and lower slopes.

Geology: Triassic volcanics - Neara Volcanics; Permian-Triassic volcanics - Gilla Andesite; Brisbane Valley Porphyrites.

Vegetation: Open forest of narrow leaved ironbark, silver leaved ironbark, Queensland blue gum and Moreton Bay ash. Brush box may also occur.

Surface features: Hard setting.

Profile diagram and description:



A1: Black to greyish brown (7.5YR 3/2, 4/2; 10YR 2/1-5/1); fine sandy clay loam to clay loam fine sandy; weak to moderate 2-5 mm granular; field pH 6.0 to 7.0. Gradual to –

A2e or j: Very dark greyish brown to light yellowish brown (7.5YR 4/2-6/3; 10 YR 3/2-6/4); fine sandy clay loam to clay loam fine sandy; massive to weak 2-5 mm granular; field pH 6.0 to 7.5; may have very few manganese nodules. Abrupt to –

B21: Very dark greyish brown to brownish yellow (7.5YR 3/3-5/6; 10YR 3/3-6/6); light medium clay to medium clay; strong 10-20 mm angular (occasionally 50-100 mm columnar); field pH 6.5 to 8.0; may have very few manganese soft segregations or nodules. Gradual to –

B22: Brown to light olive brown (7.5YR 4/4, 10YR 4/2-6/6; 2.5Y 4/2-5/6); occasionally mottled; light medium clay to medium clay; strong 10-50 mm angular to lenticular; field pH 7.0 to 9.0; may have very few manganese nodules and/or calcareous nodules or concretions. Gradual to –

BC/C: Reddish brown to brownish yellow (7.5YR 3/2-5/6; 10YR 3/2-7/6; 2.5Y 5/3); light clay to light medium clay; moderate 10-50 mm angular; field pH 7.0 to 8.5; may have few manganese nodules and soft segregations.

Variants: B21 horizon may be red (5YR 4/3, 2.5YR 4/6): Dr2.42, Dr2.43.
B21 horizon may be black (7.5YR 3/2, 10YR 3/1, 3/2): Dd1.33, Dd1.43.

Number of sites: 93

NEARA (Na)

Concept: Uniform, gradational to texture contrast soil with a strongly structured loamy or clay surface over black, brown or greyish brown clay subsoil. Neutral reaction trend. Overlying andesite and volcanic conglomerate (occasionally shale, siltstone).

Classification: **Principal Profile Form:** Uf6.31 or Uf6.32 (modal), Db1.12, Dd1.12, Dy2.12, Dy4.12, Gn3.12, Gn3.22, Gn3.41, Uf6.33.
Australian Soil Classification: Brown, Black or Grey Dermosols; Brown, Black or Grey Chromosol.

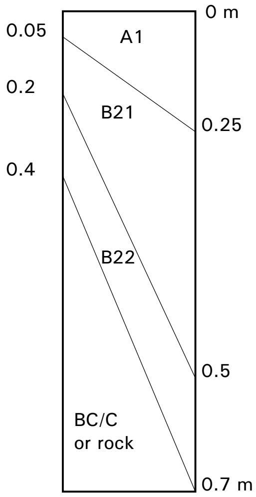
Landform: Undulating to rolling rises, low hills and hills. Occurs on low ridge crests and all slopes to drainage lines.

Geology: Triassic volcanics - Neara Volcanics; Permian-Triassic volcanics - Gilla Andesite; Brisbane Valley Porphyrites.

Vegetation: Open forest to woodland of narrow leaved ironbark and Moreton Bay ash with silver leaved ironbark and Queensland blue gum. Pink bloodwood and brush box also occur.

Surface features: Firm to hard setting.

Profile diagram and description:



A1: Black to greyish brown (7.5YR 3/2-4/3 to 10YR 2/1-5/2); fine sandy clay loam to fine sandy light clay; strong 2-10 mm granular or subangular; field pH 6.0 to 7.0. Clear or gradual to –

B21: Black, brown or greyish brown (7.5YR 3/2-4/4; 10YR 2/1-5/4); light clay to medium clay; strong 10-20 mm angular or subangular; field pH 6.5 to 7.0; may have very few manganese nodules or soft segregations. Gradual to –

B22: Very dark grey to light olive brown (7.5YR 3/3-4/3; 10YR3/1-5/6); occasionally with faint mottling; light medium clay to medium clay; strong 10-20 mm angular to lenticular; field pH 6.5 to 7.5; may have very few manganese nodules. Gradual or clear to –

BC/C: Very dark grey to pale brown (7.5YR 3/2-5/3; 10YR 3/1-6/3); light clay to light medium clay; moderate to strong 10-20 mm angular or subangular; field pH 6.5 to 7.5.

Number of sites: 80
Variants: alkaline reaction trend: 4 sites
calcareous segregations: 1 site.

NOON (Nn)

Concept: Gradational to texture-contrast soil with loamy surface over a red or brown clay subsoil with a neutral soil reaction trend. Overlying chert, mudstone, siltstone or sandstone.

Classification: **Principal Profile Form:** Db1.12 or Dr2.12 (modal), Db1.22, Dr2.12, Dr2.22, Dy2.12, Dy2.22, Gn3.12, Gn3.24.
Australian Soil Classification: Brown or Red Chromosols; Brown or Red Dermosols.

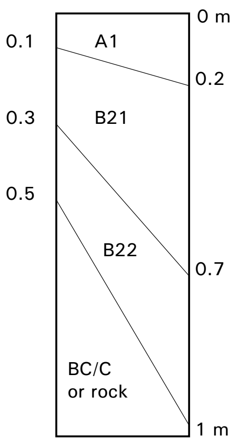
Landform: Rolling to steep hills.

Geology: Permian sediments -Cressbrook Creek Group, Marumba Beds; Devonian-Carboniferous sediments -Maronghi Creek Beds

Vegetation: Open forest of narrow leaved ironbark and Moreton Bay ash. Spotted gum, pink bloodwood, silver leaved ironbark and Queensland blue gum also occur.

Surface features: Firm to Hard setting.

Profile diagram and description:



A1: Black to brown (7.5YR 3/2-4/4 to 10YR 3/2); sandy clay loam to clay loam fine sandy; weak to strong 2-5 mm granular; field pH 6.0 to 7.0. Gradual or clear to –

B21: Dark reddish brown to strong brown (5YR 3/2-5/6 to 7.5YR 3/4-5/6); light clay to medium clay; strong 5-20 mm angular or columnar; field pH 6.0 to 7.0; may have few manganese soft segregations and nodules. Gradual to –

B22: Yellowish red to light yellowish brown (5YR4/4-4/6, 7.5YR 3/3-4-6 to 10YR 4/3-5/4); light medium clay to medium clay; strong 5-10 mm angular to lenticular; field pH 6.5 to 7.5; may have few manganese nodules or concretions. Gradual to –

BC/C: Greyish brown to brownish yellow (2.5YR 3/4-5/4, 5YR 4/6, 7.5YR 3/3-4/4 to 10YR 4/3,6/8); light clay to light medium clay; moderate 5-10 mm angular to subangular; field pH 6.0 to 7.5.

Number of sites: 31

OTTABA (Ot)

Concept: Texture contrast soil with a sandy to loamy surface over a mottled brown, yellow or grey clay subsoil with acid soil reaction trend. Overlying unconsolidated material.

Classification: **Principal Profile Form:** Dy3.41 (modal), Db2.41, Dy5.41.

Australian Soil Classification: Brown, Yellow or Grey Kurosols; Brown, Yellow or Grey Sodosols.

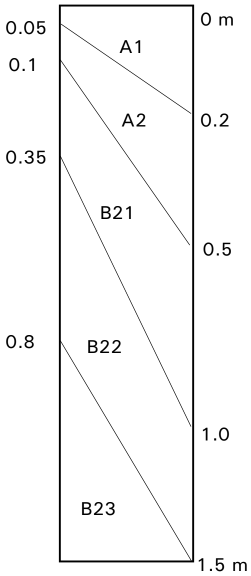
Landform: Gently undulating to undulating plains, terraces and rises.

Geology: Quaternary or Tertiary alluvium.

Vegetation: Open woodland to woodland of Queensland blue gum and Moreton Bay ash. Swamp mahogany, rusty gum and narrow leaved ironbark also occur.

Surface features: Hard setting.

Profile diagram and description:



A1: Dark brown to brown (7.5YR 3/2-4/3, to 10YR 3/1-4/3); sandy loam to clay loam fine sandy; massive to weak 2-5 mm granular; field pH 5.5 to 6.5; may have common ferromanganiferous nodules. Clear or gradual to –

A2e or j: Brown to pale brown (7.5YR 4/3-6/4 to 10YR 4/3-6/3 moist, 10YR 7/2-8/2 dry); sandy clay loam to clay loam fine sandy; massive to weak 2-5 mm granular; field pH 5.5 to 6.5; may have common ferromanganiferous nodules. Abrupt to –

B21: Brown to light yellowish brown (7.5YR4/2-5/3 to 10YR 4/2-6/4); 2 - 20% distinct mottles; light medium clay to medium clay; moderate to strong 10-50 mm angular (occasionally 50-100 columnar) ; field pH 4.5 to 6.5; may have few ferruginous nodules, very few manganese soft segregations through to concretions. Gradual to –

B22: Brown to light yellowish brown (7.5YR 4/2-5/8 to 10YR 4/2-6/4); 10 - 20% distinct or prominent mottles (orange/red); light medium clay to medium clay; strong 20-50 mm angular to lenticular; field pH 4.0 to 6.0; may have few ferruginous and/or manganese nodules and concretions; often strongly mottled. Gradual to –

B23: Brown to light olive brown (10YR 5/3-6/8, 2.5Y 5/3); 10 - 20% distinct or prominent mottles (orange/red); light medium clay to medium clay; strong 20-50 mm lenticular; field pH 4.0 to 6.0.

Variants: Rocky surface
Mottles < 10% throughout the profile: Db3.41, Dy2.31, Dy2.41.
Neutral soil reaction: Dy3.42 (usually has ferromanganiferous nodules in A2).

Number of sites: 77

OTTABA gilgai phase (**OTgp**) is similar to Ottaba except for the presence of gilgai microrelief.
OTTABA rocky phase (**OTrp**) is similar to Ottaba except for the presence of common to abundant coarse gravel or cobble in the surface soil (top 0.2 m).

PADDY (Pd)

Concept: Texture contrast soil with a loamy surface over brown, yellowish brown or greyish brown clay subsoil with an acid soil reaction trend. Subsurface commonly bleached. Overlying andesite and volcanic conglomerate (occasionally shale, siltstone).

Classification: **Principal Profile Form:** Dy2.41 (modal), Db1.21, Db1.41, Dy2.31, Dy3.31, Dy3.41.
Australian Soil Classification: Brown or Grey Kurosols; Brown Chromosols; Brown Sodosols.

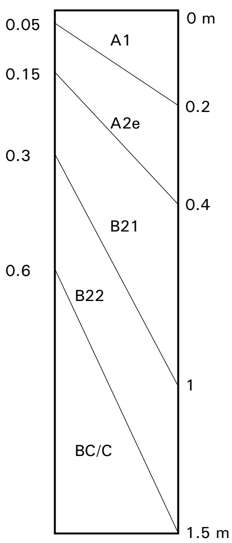
Landform: Undulating to steep low hills, hills and mountains. Predominantly upper slopes and ridges.

Geology: Triassic volcanics - Neara Volcanics; Permian-Triassic volcanics - Gilla Andesite; Brisbane Valley Porphyrites.

Vegetation: Open forest of narrow leaved ironbark and Queensland blue gum or brush box. Gum topped box also occurs.

Surface features: Hard setting.

Profile diagram and description:



A1: Dark brown to greyish brown (7.5YR 3/2; 10YR 3/1-5/2); fine sandy clay loam clay loam fine sandy; weak 2-5 mm granular or subangular; field pH 5.5 to 7.0. Clear or gradual boundary to –

A2e: Dark greyish brown to pale brown (7.5YR 5/2, 10YR4/2-6/3 moist; 10YR 5/2-8/3 dry); fine sandy clay loam to clay loam fine sandy; massive to weak 2-5 mm granular; field pH 5.5 to 6.5. Abrupt to –

B21: Dark red to yellowish brown(2.5YR 4/6; 7.5YR 4/4-5/4; 10YR4/2-5/4); often with 10-20% distinct mottles; light medium clay to medium clay; strong 10-20 mm angular; field pH 5.5 to 6.0; gradual to –

B22: Weak red to yellowish brown (2.5YR 5/4; 5YR 5/6; 10YR5/1-5/6); often with 10-20% distinct mottles; light medium clay to medium clay; strong 10-20 mm lenticular; field pH 4.0 to 6.0. Gradual to –

BC/C: Strong brown to yellow (7.5YR 4/6; 10YR 5/3-7/8); light clay to light medium clay; weak 10-20 mm granular; field pH 4.0 to 6.0.

Number of sites: 19

PINCH (Ph)

Concept: Texture contrast soil with a loamy surface over brown clay subsoil with neutral soil reaction trend. A2 horizon weakly developed. Overlying granite or granodiorite.

Classification: **Principal Profile Form:** Db1.12, Db1.22, Db1.32, Db2.12
Australian Soil Classification: Brown Chromosol.

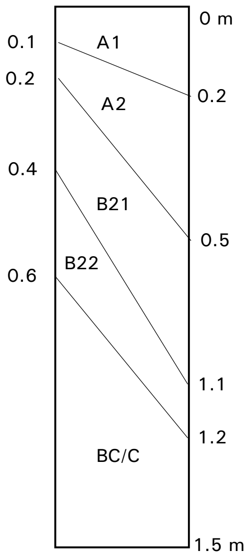
Landform: Rolling to steep hills. Limited distribution – mid to lower slopes.

Geology: Permian-Triassic acid intrusions: Eskdale Granodiorite and another unnamed group.

Vegetation: Open forest of Queensland blue gum, Moreton Bay ash, silver leaved ironbark and broad leaved apple. With narrow leaved ironbark, rusty gum and pink bloodwood.

Surface features: Hard setting.

Profile diagram and description:



A1: Black to dark brown (10YR 2/1 to 7.5YR 3/2); coarse sandy loam to clay loam sandy; weak to moderate 2-5 mm granular; field pH 6.0 to 7.0. Gradual to –

A2: Brown to dark greyish brown (7.5YR4/3, 10YR 4/2); coarse sandy clay loam to clay loam fine sandy; weak to moderate 2-5 mm granular; field pH 6.0 to 7.0. Clear to –

B21: Brown, dark brown or dark yellowish brown (7.5YR4/3-4/4 to 10YR4/4); occasionally a few mottles; light clay to light medium clay; strong 10-20 mm angular; field pH 6.0 to 7.0; may have few manganese soft segregations. Gradual to –

B22: Reddish brown to yellowish brown (5YR4/4 to 10YR 5/6); occasionally a few mottles; sandy clay to light medium clay; moderate 10-20 mm angular; field pH 6.0 to 7.0; may have few manganese soft segregations. Gradual to –

BC/C: Brown to yellowish brown (7.5YR 4/4 to 10YR 5/4); sandy clay loam to fine sandy light clay; weak to moderate 10-20 mm angular; field pH 6.5 to 7.0.

Number of sites: 6

REBEL (Rb)

Concept: Duplex soil with a loamy surface over red clay subsoil with a neutral to acid reaction trend. Variable A2 horizon development. Overlying granite or granodiorite.

Classification: **Principal Profile Form:** Dr2.12 or Dr2.22 (modal), Dr2.42, Dr3.31, Dr4.22.
Australian Soil Classification: Red Chromosols.

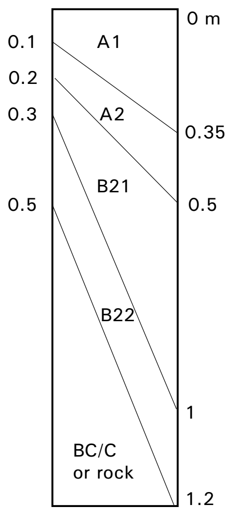
Landform: Rolling to steep low hills to hills.

Geology: Permian-Triassic acid intrusions - Eskdale Granodiorite and another unnamed group. Crests and steeper slopes (mid to upper slope positions)

Vegetation: Open forest of Queensland blue gum, Moreton Bay ash, silver leaved ironbark and broad leaved apple. With narrow leaved ironbark, rusty gum and pink bloodwood.

Surface features: Firm to hard setting.

Profile diagram and description:



A1: Dark reddish brown to brown (5YR 3/2-4/3, 7.5YR 3/2-4/3 to 10YR 2/2-3/2); coarse sandy clay loam to clay loam fine sandy; weak 2-5 mm granular; field pH 6.0 to 6.5. Gradual boundary to –

A2, A2j or A2e: Reddish brown to brown (5YR 4/4, 7.5YR3/3-5/3 to 10YR 5/3 moist; 10YR 7/3 dry if bleached); coarse sandy clay loam to clay loam fine sandy; massive to weak granular; field pH 6.0 to 7.0. Clear to –

B21: Red (2.5YR 3/6, 5YR 3/3-4/6); coarse sandy light medium clay to medium clay; moderate to strong 5-50 mm angular or subangular; field pH 5.5 to 7.0; may have very few manganese soft segregations. Gradual to diffuse boundary to –

B22: Red to yellowish brown (2.5YR 3/6, 5YR 3/4 to 7.5YR 6/2); may be mottled; coarse sandy clay loam to medium clay; strong 10-50 mm angular; field pH 5.5 to 7.0; may have very few manganese soft segregations. Gradual to –

BC/C: Dark red to strong brown (2.5YR 4/6, 5YR 4/4 to 7.5 YR 4/3); may be mottled; sandy loam to sandy clay; weak 20-50 mm angular; field pH 6.0 to 6.5; may have very few manganese nodules.

Number of sites: 12

SPENCER (Sp)

Concept: Texture contrast soil with loamy surface soil over a yellowish brown, brown or grey clay subsoil with a neutral to alkaline soil reaction trend. Subsurface often strongly bleached. Overlying unconsolidated material.

Classification: **Principal Profile Form:** Dy2.43 or Dy3.43 (modal), Db1.32, Db1.33, Db1.42, Db1.43, Db2.43, Dy2.13, Dy2.33, Dy2.42, Dy3.33
Australian Soil Classification: Brown or Grey Sodosols; Brown or Grey Chromosols (Eutrophic Sodic).

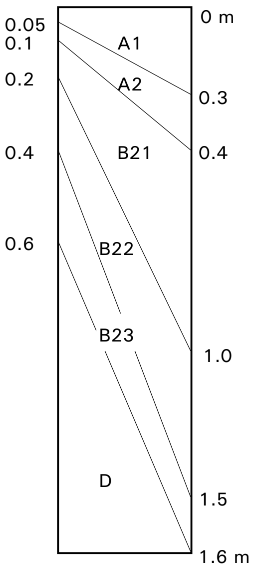
Landform: Level to undulating terrace, alluvial plain or stagnant alluvial plain. Drainage depressions.

Geology: Quaternary or Tertiary alluvium and colluvium.

Vegetation: Open woodland to woodland of Queensland blue gum, narrow leaved ironbark and Moreton Bay ash. Silver leaved ironbark and swamp mahogany also occur.

Surface features: Hard setting.

Profile diagram and description:



A1: Black to brown (10YR2/1-5/3; 7.5YR 3/2-4/3); sandy clay loam to clay loam fine sandy; massive to weak 2-5 mm granular; field pH 5.5 to 7.0. Clear or gradual to –

A2e or j: Dark grey to pale brown (10YR4/1-6/3; 7.5YR4/2-7/3) moist; light grey to very pale brown (10YR7/1-8/3; 7.5YR5/3-8/2) dry; sandy clay loam to clay loam fine sandy; massive to weak 2-5 mm granular; field pH 5.5 to 7.0; may have few manganese, ferruginous or ferromanganiferous nodules or concretions; abrupt or clear to –

B21: Dark grey to light olive brown (10YR4/1-6/6; 7.5YR3/4-5/8; 2.5Y4/2-6/2); may be mottled; light medium clay to medium clay; moderate to strong 10-50 mm angular (occasionally 50-100 mm columnar); field pH 6.5 to 8.5; may have few manganese nodules and soft segregations; gradual or diffuse to –

B22 (may be k): Black to light olive brown (7.5YR3/2-5/6; 10YR2/1-6/8; 2.5Y 4/2-5/6); often mottled; light medium clay to medium clay; moderate to strong 10-50 mm angular to lenticular; field pH 7.0 to 9.5; may have few manganiferous nodules and soft segregations and/or common carbonate nodules, concretions and soft segregations; gradual to –

B23 (may be k): Brown to light olive brown (7.5YR4/3-4/4; 10YR3/2-6/4; 2.5Y2/1-6/2); often mottled; light medium clay to medium clay; moderate to strong 10-50 mm angular to lenticular; field pH 7.5 to 9.0; may have few manganese nodules and common carbonate nodules, concretions and soft segregations; gradual to –

D: Dark brown to olive brown (7.5YR 3/2-5/6; 10YR 3/2-6/4; 2.5Y 4/3-4/4); sandy light medium clay; strong 10-50 mm angular to lenticular; field pH 7.5 to 9.0; may have few carbonate/ manganese nodules.

Variants: A2 horizon absent: Db1.13, Dd1.13, Dy2.13; B1 horizon bleached.
Black subsoil: Dd1.33, Dd1.43, Dd2.43.

Number of sites: 384

SPENCER gilgai phase (**SPgp**) is similar to Spencer except for the presence of gilgai microrelief.
SPENCER rocky phase (**SPrp**) is similar to Spencer except for the presence of common/abundant coarse gravel/cobble in the surface soil (top 0.2 m).

STEVENTON (St)

Concept: Texture contrast soil with a loamy surface over red clay subsoil with a neutral to acid soil reaction trend.

Classification: **Principal Profile Form:** Dr2.21, Dr2.31, Dr3.11, Dr3.31.
Australian Soil Classification: Red Kurosols or Red Chromosols.

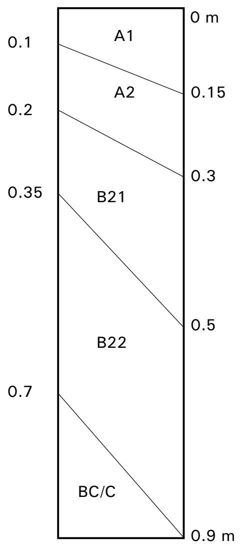
Landform: Undulating to rolling low hills.

Geology: Triassic volcanics - Neara Volcanics; Brisbane Valley Porphyrites. Parent material unconfirmed.

Vegetation: Open forest of narrow leaved ironbark or brush box. Silver leaved ironbark may also occur.

Surface features: Hard setting.

Profile diagram and description:



A1: Black to dark greyish brown (7.5YR 3/2 to 10YR 2/1-4/2); sandy clay loam clay loam fine sandy; weak 2-5 mm granular; field pH 6.0 to 6.5. Gradual to –

A2: Brown to light yellowish brown (7.5YR 4/2 to 10YR 5/6-6/4); fine sandy clay loam to clay loam sandy; massive; field pH 6.0 to 6.5. Clear or abrupt to –

B21: Dark red (2.5YR 3/4-4/6); light medium clay to medium clay; strong 10-20 mm angular to subangular; field pH 5.5 to 6.0. Gradual to –

B22: Dark red (2.5YR 3/6-4/6); may be strongly mottled (distinct); medium clay; strong 10-20 mm angular; field pH 4.5 to 5.0. Gradual to –

BC/C: Reddish brown to very pale brown (5YR4/4, 7.5YR 5/8 to 10YR 7/1-7/4); fine sandy light clay to light medium clay; weak platy; field pH 4.5 to 6.0.

Number of sites: 5

TURTLE (Tu)

Concept: Texture contrast soil with loamy surface and bleached subsurface over yellow, brown or red clay subsoil (usually mottled). Acid to strongly acid reaction trend. Overlying sandstone, conglomerate or siltstone**.**

Classification: **Principal Profile Form:** Dy3.41 (modal), Db1.31, Dr2.41, Dr3.41, Dy2.31, Dy2.41, Dy3.31.
Australian Soil Classification: Brown or Yellow Kurosols; Brown or Red Sodosols.

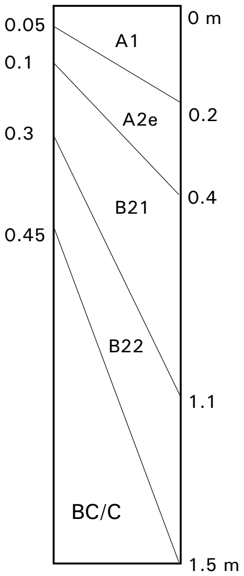
Landform: Gently undulating to steep rises, low hills and hills.

Geology: Triassic Sediments: Bryden Formation and Esk Formation; Triassic-Jurassic Sediments: Helidon Sandstone.

Vegetation: Woodland to open forest of narrow leaved ironbark with silver leaved ironbark, Moreton Bay ash and Queensland blue gum. Gum topped box, spotted gum, rusty gum and pink bloodwood also occur.

Surface features: Hard setting.

Profile diagram and description:



A1: Dark grey to brown (10YR 3/1-4/3 to 7.5YR 3/2, 4/2); fine sandy clay loam to clay loam fine sandy; massive to weak 2-5 mm granular; field pH 5.5 to 6.5. Clear to gradual to –

A2e: Greyish brown to very pale brown (7.5YR to 10 YR 4/2-7/2 moist, 5/2-8/2 dry); fine sandy clay loam to clay loam fine sandy; massive to weak 2-5 mm granular; field pH 5.5 to 6.5; may have very few ferruginous or ferromanganiferous nodules. Abrupt or clear to –

B21: Brown to light yellowish brown (10YR 5/3-6/4 to 7.5YR 4/2); mottling common; light medium clay to medium clay; moderate to strong 10-50 mm angular (occasionally 50-100 mm columnar); field pH 4.0 to 6.5; may have few ferruginous, manganese or ferromanganiferous nodules. Gradual to –

B22: Dark greyish brown to brownish yellow (10YR 4/2-6/6); mottling common; light medium clay to medium clay; strong angular with strong lenticular common at depth; field pH 4.0 to 6.0; may have few ferruginous, manganese, or ferromanganiferous nodules or. Gradual to –

BC/C: Greyish brown to brownish yellow (10YR5/2-6/8); sandy light clay to sandy light medium clay; moderate to strong 10-20 mm angular to subangular; field pH 4.0 to 6.0, may have very few ferruginous or manganese nodules and soft segregations.

Variants: A2 horizons not bleached: Dy2.11, Dy3.21.

Number of sites: 78

WATT (Wt)

Concept: Texture contrast soil with loamy surface and weakly bleached subsurface over a neutral to alkaline brown, yellowish brown or black clay subsoil. Overlying sandstone, siltstone or conglomerate.

Classification: **Principal Profile Form**: Db1.33 or Dd1.33 (modal), Db1.13, Db1.32, Db2.33, Dy2.13, Dy2.32, Dy2.33, Dy3.33.
Australian Soil Classification: Brown, Grey or Black Chromosols; Brown, Grey or Black Sodosols.

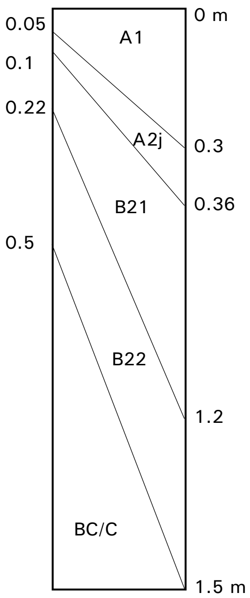
Landform: Gently undulating to rolling rises, low hills and hills.

Geology: Triassic Sediments: Bryden Formation and Esk Formation; Triassic-Jurassic Sediments: Helidon Sandstone.

Vegetation: Woodland to open forest of narrow leaved ironbark or silver leaved ironbark with Moreton Bay ash and Queensland blue gum. Gum topped box , spotted gum and pink bloodwood also occur.

Surface features: Hard setting.

Profile diagram and description:



A1: Brown to grey brown (7.5 YR to 10 YR 3/1, 3/2, 4/2); clay loam to clay loam fine sandy; weak to moderate 2-5 mm granular; field pH 5.5 to 6.5. Clear to gradual to –

A2j: Greyish brown to pale brown (10 YR 4/2-5/4 moist, 5/3-6/2 dry); clay loam to clay loam fine sandy; weak to moderate 2-5 mm granular; field pH 6.0 to 6.5; may have very few manganese or ferromanganiferous nodules. Abrupt to –

B21: Dark grey to yellowish brown (10YR 3/1-5/4, 7.5YR 4/3,4/4); light medium clay to medium clay; strong 10-50 mm angular; field pH 6.0 to 9.0; may have few ferruginous, manganese or calcareous nodules. Gradual to –

B22: Dark greyish brown to yellowish brown (10YR 3/2-5/4, 2.5Y 4/2); occasionally mottled, light medium clay to medium clay; occasionally mottled; strong 10-50 mm angular with strong 20-100 mm lenticular common at depth; field pH 6.5 to 9.5; may have few ferruginous or manganese nodules or calcareous nodules and/or soft segregations. Gradual to –

BC/C: Brown to yellowish brown (10YR5/4, 5/6); sandy light clay to sandy light medium clay; moderate angular to subangular; field pH 6.5 to 9.5, may have few ferruginous, manganiferous or calcareous nodules and soft segregations.

Variants: A2 horizon absent or not bleached: Db1.13, Db1.23, Dd1.13, Dy2.13.
B21 horizon red (5YR 4/3, 4/4): Dr2.33, Dr2.23.

Number of sites: 18

WATT rocky phase (**WTrp**) is similar to Watt except for the presence of common to abundant coarse gravel or cobble in the surface soil (top 0.2 m).

WELTON (Wl)

Concept: Shallow loamy soil overlying rock (chert, mudstone or siltstone).

Classification: **Principal Profile Form:** Um1.21 (modal), Um1.23, Um1.43, Um1.44, Um4.11, Um4.13, Um6.23.
Australian Soil Classification: Leptic Rudosols.

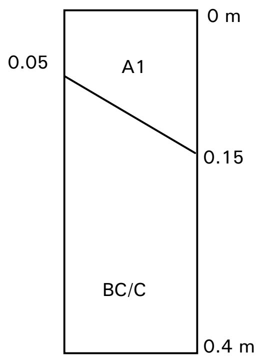
Landform: Rolling to steep hills.

Geology: Permian sediments - Cressbrook Creek Group, Marumba Beds; Devonian-Carboniferous sediments - Maronghi Creek Beds

Vegetation: Open forest of narrow leaved ironbark and Moreton Bay ash. Spotted gum, pink bloodwood and silver leaved ironbark also occur.

Surface features: Firm to Hard setting. Surface rocks common.

Profile diagram and description:



A1: Very dark brown to brown (7.5YR 3/2-4/3 to 10YR 2/2); sandy clay loam to clay loam fine sandy; weak granular; field pH 6.0 to 7.0. Gradual or clear to –

BC/C: Dark brown to greyish brown (7.5YR 3/4-5/6 to 10YR 3/2-5/2); sandy clay loam to clay loam fine sandy; weak granular; field pH 6.0 to 6.5.

Number of sites: 14

YEDNIA (Yn)

Concept: Shallow loamy soil, usually rocky. Overlying phyllite.

Classification: **Principal Profile Form:** Um1.21 (modal), Um1.41, Um1.43.
Australian Soil Classification: Leptic Rudosols.

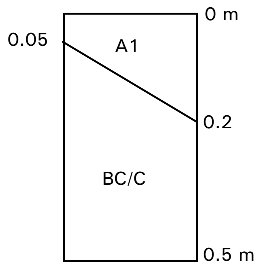
Landform: Rolling to steep hills and mountains. Upper slopes and ridges.

Geology: Carboniferous metamorphics - Jimna (Bunya) Phyllite.

Vegetation: Open forest of narrow leaved ironbark or brush box. Gum topped box, Moreton Bay ash, silver leaved ironbark, broad-leaved ironbark, Queensland blue gum, pink bloodwood and patches of softwood scrub (including hoop pine) occur.

Surface features: Hard setting.

Profile diagram and description:



A1: Dark brown to brown (7.5YR 3/2, 4/4); sandy clay loam to clay loam fine sandy; massive to weak 2-5 mm granular; field pH 6.0 to 7.0. Gradual to –

BC/C: Yellowish red to brownish yellow (5YR 3/4 to 10YR 6/6); sandy clay loam to clay loam sandy; massive to weak 2-5 mm granular; field pH 6.0 to 7.5.

Number of sites: 11

YELLOWBANK (Yb)

Concept: Yellow to brown, , gradational to uniform textured soil. Massive to weakly structured. Loamy surface and subsurface with neutral to acid reaction trend. Overlying sandstone.

Classification: **Principal Profile Form**: Gn2.22, Gn2.24, Gn2.42, Um5.21, Um5.52.
Australian Soil Classification: Brown or Yellow Kandosols.

Landform: Undulating to rolling low hills. Predominantly lower slopes and drainage depressions.

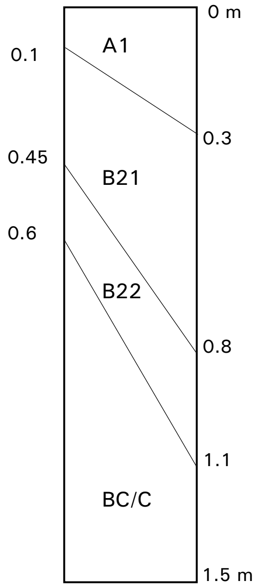
Geology: Triassic-Jurassic Sediments: Helidon Sandstone.

Vegetation: Open forest of spotted gum, Moreton Bay ash and narrow leaved ironbark. Swamp mahogany and Queensland blue gum also occur.

Open forest of spotted gum, Moreton Bay ash and narrow leaved ironbark Queensland blue gum and pink bloodwood also occur.

Surface features: Cracking to mulching.

Profile diagram and description:



A1: Very dark grey to dark brown (7.5YR 3/2, 4/4 to 10YR 3/1-5/3); loamy coarse sand to sandy clay loam; massive to weak granular; field pH 6.0 to 7.0. Gradual to –

B21: Brown to brownish yellow (7.5YR4/3-5/6 to 10YR 5/4-5/6); sandy clay loam to sandy clay; massive to weak granular; field pH 6.0 to7.0; may have few nodules. Gradual to –

B22: Brown to brownish yellow (7.5YR 4/4 to 10YR 6/8); sandy clay loam to sandy clay; massive to weak granular; field pH 6.0 to 7.5; may have very few manganese soft segregations. Gradual to –

BC/C: Yellowish red to brownish yellow (5YR 4/6 to 10YR 4/4-6/8); sandy clay loam; massive to weak granular; field pH 6.0 to 7.5; may have few ferromanganiferous nodules.

Variants: Bleached A2 horizon.

Number of sites: 13

APPENDIX 3

MORPHOLOGICAL AND ANALYTICAL DATA FOR REPRESENTATIVE SOIL PROFILES

Soil profile classes arranged by soil groups (geological units):

Soils overlying alluvium		***page***
Cressbrook	Cr	119
Honey	Hy	119
Monsildale	Md	120
Gallanani	Gl	120
Gunyah	Gy	121
Basel	Bs	121, 122
Duggua	Du	122
Cooeeimbardi	Cb	123
Spencer	Sp	124
Ottaba	Ot	125
Soils overlying coarse-grained sedimentary rocks		
Beppo	Bp	126
Watt	Wt	126
Calabash	Cl	127
Kipper	Kp	127
Greenhide	Gh	128
Turtle	Tu	128
Lakeview	Lv	129
Hibiscus	Hb	129
Yellowbank	Yb	130
Beer	Br	130
Caboonbah	Ca	131
Greinke	Gk	131
Soils overlying intermediate to basic volcanic rocks		
Moore	Mo	132
Dunwich	Dw	132
Paddy	Pd	133
Steventon	St	133
Linville	Le	134
Neara	Na	134
Deer	De	135
Jimna	Jm	135
D'Aguilar	Dg	136
Soils overlying fine-grained acid igneous rocks		
Burrundon	Bd	137
Esk	Ek	137
Soils overlying coarse-grained acid igneous rocks		
Pinch	Ph	138
Gilla	Gi	138
Biarra	Bi	139
Rebel	Rb	139
Ivory	Iv	140
Soils overlying fine-grained sedimentary rocks		
Eskvale	Ev	140
Horse	Hs	141
Freeman	Fm	141
Noon	Nn	142
Welton	Wl	142
Soils overlying metamorphic rocks		
Bunya	Bu	143
Yednia	Yn	143

Soil profile class: **CRESSBROOK**
Site No: 1392
AMG reference: 431 920 mE 6 993 350 mN
Great soil group: Alluvial soil
Principal profile form: Uc1.24
Australian soil classification: Basic, Stratic Rudosol

Substrate material: unconsolidated material
Slope: 1%
Landform element channel bench
Landform pattern: level plain
Vegetation:
Structural form: cleared
Dominant species: *Eucalyptus tereticornis, Cynodon dactylon*

Profile morphology:

Condition of surface soil when dry: firm

Horizon	Depth (m)	Description
A	0-0.30	Dark brown (7.5YR3/2) moist; sandy loam; weak granular; moderately moist; moderately weak.
2A	0.30-0.60	Dark brown (7.5YR3/2) moist; loamy sand; single grain; moderately moist; very weak.
3D	0.60-0.90	Brown (7.5YR4/2) moist; sand; few large pebbles, rounded detrital sedimentary rock (unidentified); single grain; moderately moist; loose.
4D	0.90-1.00	Very dark brown (10YR2/2) moist; sandy clay loam; weak granular; moderately moist; very weak.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.5	0.03	.002																	
0.00-0.10	6.6	0.03	.002	16	61	11	10	9	6.30	2.50	0.06	0.38	1	.061	1.47	.044	1.22	6.75	0.34	
0.20-0.30	6.9	0.01	.001	20	60	4	17	12	8.10	3.50	0.06	0.15	1	.053	1.38	.036	1.11	7.653	0.47	
0.50-0.60	7.2	0.01	.001	40	47	9	10	9	6.20	2.90	0.07	0.09	1	.044	1.43	.031	0.96	5.503	0.38	
0.80-0.90	7.4	0.01	.001	70	22	3	4	4	2.30	1.20	0.04	0.04	1	.028	1.59	.024	0.45	2.282	0.92	

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	1.7	0.10	22	0.70	43	23	0.65	2.4

aqueous cations at pH 7.0
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **HONEY**
Site No: 497
AMG reference: 436 860 mE 6 989 780 mN
Great soil group: Alluvial soil
Principal profile form: Uf1.43
Australian soil classification: Basic, Stratic Rudosol

Substrate material: unconsolidated material
Slope: 1%
Landform element bench
Landform pattern: level plain
Vegetation:
Structural form: cleared
Dominant species: *Lophostemon suaveolens, Eucalyptus tereticornis, Trifolium repens, Cynodon dactylon*

Profile morphology:

Condition of surface soil when dry: periodic cracking, self-mulching

Horizon	Depth (m)	Description
A1	0-0.10	Brown (7.5YR4/4) moist; light medium clay; moist; moderately weak; few fine ferruginous veins.
D1	0.10-0.20	Brown (7.5YR4/4) moist; loamy coarse sand; fragments, quartz; moderately moist; loose.
D2	0.20-0.30	Yellowish brown (10YR5/6) moist; sandy loam; fragments, quartz; moderately moist; very weak.
D3	0.30-0.42	Grey (10YR5/1) moist; light medium clay; moist; moderately weak; few fine ferruginous veins.
D4	0.42-0.47	Yellowish brown (10YR5/4) moist; sandy loam; fragments, quartz; moist; loose; medium manganiferous nodules.
D5	0.47-0.60	Grey (10YR5/1) moist; light medium clay; moist; moderately weak; few fine ferruginous veins.
D6	0.60-0.65	Greyish brown (10YR5/2) moist; coarse sandy clay loam; fragments, quartz; moist; loose; few medium manganiferous soft segregations.
D7	0.65-0.95	Grey (10YR5/1) moist; light medium clay; moist; moderately weak; few fine ferruginous veins.
D8	0.95-1.12	Grey (10YR5/1) moist; coarse sandy clay loam; fragments, quartz; wet; loose; very few medium manganiferous soft segregations.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	7.3	0.15	.003																	
0.00-0.10	7.5	0.06	.001	60	9	8	22	14	6.5	3.8	0.09	0.42	1	.059	.967	.042	1.3		0.63	
0.20-0.30	7.6	0.04	.001	62	12	8	19	12	6.2	3.4	0.16	0.19	1	.049	.925	.032	1.4		0.73	
0.50-0.60	7.9	0.07	.004	32	22	15	30	19	10	6.0	0.34	0.20	2	.048	1.16	.027	3.0			
0.80-0.90	7.8	0.10	.011	9	23	27	39	19	8.9	6.6	0.26	0.25	1	.034	1.61	.024	2.8		0.78	
1.10-1.20	8.0	0.08	.007	41	14	13	30	16	7.0	6.7	0.15	0.24	1	.041	1.10	.022	1.3		0.50	
1.40-1.50	8.1	0.09	.008																	

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	3.0	0.22	46	0.67	192	57	2.2	2.0

alcoholic cations at pH 8.5
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class:	**MONSILDALE**	**Substrate material:**	unconsolidated material
Site No:	832	**Slope:**	1%
AMG reference:	432 150 mE 6 996 350 mN	**Landform element**	plain
		Landform pattern:	level plain
Great soil group:	Prairie soil	**Vegetation:**	
Principal profile form:	Gn3.42	**Structural form:**	cleared woodland
Australian soil classification:	Haplic, Eutrophic, Brown Dermosol	**Dominant species:**	*Eucalyptus tereticornis, Bothriochloa decepiens, Cynodon dactylon*

Profile morphology:

Condition of surface soil when dry: firm

Horizon	**Depth (m)**	**Description**
A1	0-0.18	Very dark greyish brown (10YR3/2) moist; sandy clay loam; weak <2mm granular; moderately moist; moderately weak. Gradual to –
B21	0.18-0.42	Black (10YR2/1) moist; fine sandy clay loam; strong 10-20 mm angular blocky parting to strong 20-50 mm prismatic; moderately moist; moderately weak; very few fine manganiferous soft segregations. Gradual to –
B22	0.42-1.20	Brown (10YR4/3) moist; few medium distinct dark mottles; fine sandy light clay; strong 20-50 mm prismatic parting to strong 20-50 mm angular blocky; dry; moderately strong; few medium manganiferous soft segregations. Gradual to –
D	1.20-1.47	Very dark greyish brown (10YR3/2) moist; sandy light clay; moderate 20-50 mm angular blocky; moderately moist; moderately firm; few medium manganiferous soft segregations.

depth metres	1:5 soil/water			particle size % @105C				exchangeable cations# meq/100g					ESP %	total elements % @65C			moistures % @105C		disp. ratio R1	pH $CaCl_2$
	pH	EC dS/m	Cl %	CS	FS	SIL	CLA	CEC	Ca	Mg	Na	K		P	K	S	ADM	1500+		
B† 0-0.10	6.3	0.07	.002																	
0.00-0.10	6.1	0.05	.003	4	65	17	19	11	7.5	2.90	0.07	0.44	1	.087	1.48	.039	1.32	7.8	0.58	
0.20-0.30	6.5	0.03	.003	5	51	22	28	19	13.0	5.20	0.15	0.20	1	.081	1.34	.045	1.83	12.9	0.39	
0.50-0.60	6.8	0.02	.003	7	58	13	23	13	9.1	3.60	0.19	0.20	1	.079	1.51	.034	1.46	9.5	0.55	
0.80-0.90	6.6	0.02	.003	7	47	19	30	16	11.0	4.20	0.21	0.26	1	.091	1.41	.034	1.62	11.9	0.49	
1.10-1.20	6.6	0.02	.002	11	44	14	32	17	12.0	4.20	0.25	0.27	1	.093	1.36	.034	1.93			
1.40-1.50	6.9	0.01	.002																	

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable K meq/100g HCl	DTPA-extractable elements mg/kg			
					Fe	Mn	Cu	Zn
B† 0-0.10	1.6	0.08	67	0.77	68	21	1.2	3.2

aqueous cations at pH 7.0
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class:	**GALLANANI**	**Substrate material:**	unconsolidated material
Site No:	627	**Slope:**	1%
AMG reference:	436 500 mE 6 992 150 mN	**Landform element**	levee
		Landform pattern:	level plain
Great soil group:	affinities with Red Brown Earth	**Vegetation:**	
Principal profile form:	Gn3.25	**Structural form:**	open woodland
Australian soil classification:	Haplic, Eutrophic, Brown Dermosol	**Dominant species:**	*Eucalyptus tessellaris, Eucalyptus tereticornis, Angophora subvelutina, Cynodon dactylon, Digitaria ciliaris*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	**Depth (m)**	**Description**
A1	0-0.15	Dark brown (7.5YR3/2) moist; sandy clay loam; moderate <2mm granular; dry; very weak. Gradual to –
A2	0.15-0.40	Brown (7.5YR4/4) moist; clay loam, coarse sandy; weak <2mm granular; dry; moderately weak. Gradual to –
B21	0.40–0.50	Brown (7.5YR4/4) moist; coarse sandy light clay; few small pebbles, rounded detrital sedimentary rock (unidentified); moderate 5–10 mm polyhedral; dry; moderately weak; very few medium manganiferous nodules.
D	0.50–0.65	Brown (7.5YR4/4) moist; clay loam, coarse sandy; few small pebbles, rounded detrital sedimentary rock (unidentified); weak 2–5 mm granular; dry; very weak; very few medium manganiferous nodules.

depth metres	1:5 soil/water			particle size % @105C				exchangeable cations# meq/100g					ESP %	total elements % @65C			moistures % @105C		disp. ratio R1	pH $CaCl_2$
	pH	EC dS/m	Cl %	CS	FS	SIL	CLA	CEC	Ca	Mg	Na	K		P	K	S	ADM	1500+		
B† 0-0.10	6.5	.03	.001																	
0.00-0.10	6.6	.02	.001	33	31	22	17	6	4.2	1.2	.07	.43	1	.073	1.60	.032	1.1	8	.65	
0.20-0.30	6.6	.02	.001	34	30	15	21	6	4.2	1.3	.08	.44	1	.059	1.64	.025	0.6	7	.76	
0.50-0.60	7.3	.02	.001	54	10	8	25	10	5.9	3.5	.13	.49	1	.056	1.21	.025	0.5	8	.75	6.0
0.80-0.90	7.2	.01	.001	74	7	4	14	6	4.5	1.6	.07	.31	1	.042	.990	.021	0.5	4	.76	
1.10-1.20	7.3	.01	.001	67	8	3	15	5	2.7	1.7	.11	.25	1	.034	1.11	.021	0.5		.99	
1.40-1.50	7.2	.01	.001																	

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable K meq/100g HCl	DTPA-extractable elements mg/kg			
					Fe	Mn	Cu	Zn
B† 0-0.10	1.4	0.08	40	0.59	63	53	0.89	3.5

aqueous cations at pH 7.0
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **GUNYAH**
Site No: S20
AMG reference: 439 060 mE 6 988 900 mN

Great soil group: no suitable group
Principal profile form: Dd2.12
Australian soil classification: Sodic, Eutrophic, Grey Chromosol

Substrate material: unconsolidated material
Slope: 1%
Landform element plain
Landform pattern: level plain
Vegetation:
Structural form: cleared
Dominant species: *Eucalyptus tereticornis, Eucalyptus tessellaris, Angophora subveltunia, Heteropogon contortus, Cynodon dactylon*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A1	0–0.06	Dark brown (7.5YR3/2) moist; sandy clay loam; moderate <2mm granular; dry; moderately weak. Clear to –
B21t	0.06–0.40	Brown (7.5YR4/2) moist; light medium clay; strong 10–20 mm angular blocky; dry; moderately strong; very few fine ferromanganiferous nodules, very few fine ferruginous nodules. Gradual to –
B22t	0.40–0.65	Yellowish brown (10YR5/4) moist; few medium faint grey mottles, few fine distinct orange mottles; medium clay; strong 20-50 mm angular blocky parting to moderate 20-50 mm lenticular; dry; moderately strong; very few fine manganiferous nodules. Gradual to –
D	0.65-1.50	Grey (10YR5/1) moist; medium clay; strong 20–50 mm lenticular; moderately moist; very firm; few medium ferruginous nodules.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations[#] meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500[+]	disp. ratio R1	pH $CaCl_2$
B[†] 0-0.10	6.4	.04	.001																	
0.00-0.10	6.5	.04	.001	30	34	9	27	13	7.40	4.4	.10	.61	1	.071	1.30	.035	3.00	11	.57	5.6
0.20-0.30	7.3	.04	.001	3	19	28	47	24	13.0	10.0	.44	.45	2	.03	1.29	.024	3.10	20	.74	6.2
0.50-0.60	7.7	.27	.028	2	12	25	57	30	13.0	15.0	1.6	.39	5	.026	1.1	.02	2.90	24	.27	6.9
0.80-0.90	7.4	.70	.075	3	13	19	58	37	14.0	20.0	3.0	.43	8	.024	.91	.018	0.60	26		6.9
1.10-1.20	7.3	.95	.109	4	10	17	62	43	15.0	23.0	4.1	.41	10	.018	.84	.018	2.30			6.9
1.40-1.50	7.5	1.00	.125																	

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B[†] 0-0.10	2	0.14	55	0.80	89	38	0.87	2.3

[#] alcoholic cations at pH 8.5
[+] -1500 kPa (-15 bar) using pressure plate apparatus
[†] refers to bulking of a number of surface samples prior to analysis

Soil profile class: **BASEL**
Site No: 2472
AMG reference: 439 637 mE 6 989 018 mN

Great soil group: Grey clay
Principal profile form: Ug5.21
Australian soil classification: Endocalcareous, Self–mulching, Grey Vertosol

Substrate material: unconsolidated material
Slope: 1%
Landform element plain
Landform pattern: level plain
Vegetation:
Structural form: woodland
Dominant species: *Eucalyptus tereticornis, Eucalyptus crebra, Sporobolis creber, Bothriochloa decepiens*

Type of microrelief: normal gilgai
vertical interval 0.20 m
horizontal interval 3 m
Component of microrelief sampled: mound

Profile morphology:

Condition of surface soil when dry: self-mulching

Horizon	Depth (m)	Description
A1	0–0.02	Dark grey (10YR4/1) moist; light clay; moderate 2-5 mm granular; moderately moist; moderately weak. Abrupt to –
A12	0.02–0.10	Dark grey (10YR4/1) moist; medium clay; strong 5-10 mm subangular blocky; moderately moist; moderately firm; few fine manganiferous nodules. Clear to –
B21	0.10–0.60	Greyish brown (10YR5/2) moist; medium heavy clay; moderate 10-20 mm angular blocky; moist; moderately firm; few medium manganiferous nodules. Gradual to –
B22k	0.60–1.10	Greyish brown (2.5Y5/2) moist; medium heavy clay; few large pebbles, subrounded detrital sedimentary rock (unidentified); moderate 10-20 mm angular blocky parting to weak 20-50 mm lenticular; moist; moderately firm; few coarse manganiferous nodules, common coarse calcareous concretions. Gradual to –
B23	1.10-1.60	Greyish brown (2.5Y5/2) moist; common medium prominent yellow mottles; medium heavy clay; few medium pebbles, subrounded detrital sedimentary rock (unidentified); strong 20-50 mm lenticular; moist;; common fine ferruginous nodules, common fine manganiferous nodules, very few very coarse calcareous concretions.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations[#] meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500[+]	disp. ratio R1	pH $CaCl_2$
B[†] 0-0.10	6.8	0.06	.001																	
0.00-0.10	6.8	0.06	bq	7	18	23	52	24	8.1	16	0.50	1.0	2	.047	.892	.036	3.95	23	.39	5.4
0.20-0.30	7.5	0.06	.001	5	17	25	56	28	8.2	19	1.3	0.57	5	.022	.842	.018	3.67	24	.59	6.0
0.50-0.60	8.8	0.46	.030	7	17	20	58	38	9.2	26	2.7	0.46	7	.018	.712	.016	3.95	24	.61	7.6
0.80-0.90	8.6	1.02	.124	9	15	18	60	44	8.4	31	4.4	0.30	10	.016	.556	.012	4.98	27	.65	8.0
1.10-1.20	8.6	1.36	.187	6	14	18	64	43	7.1	31	5.1	0.38	12	.013	.528	.012	5.70			8.0
1.40-1.50	8.5	1.45	.209					42	7.0	30	4.9	0.48	12							

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B[†] 0-0.10	2.2	0.18	12.0	11	0.65	70	60	1.3	0.65

[#] alcoholic cations at pH 8.5
[+] -1500 kPa (-15 bar) using pressure plate apparatus
[†] refers to bulking of a number of surface samples prior to analysis

Soil profile class:	**BASEL** (bleached)	**Substrate material:**	unconsolidated material
Site No:	S12	**Slope:**	1%
AMG reference:	439 110 mE 7 007 690 mN	**Landform element**	plain
		Landform pattern:	plain
Great soil group:	Grey clay	**Vegetation:**	
Principal profile form:	Ug5.24	**Structural form:**	woodland
Australian soil classification:	Episodic, Epipedal, Grey Vertosol	**Dominant species:**	*Eucalyptus tereticornis, E.crebra, Eucalyptus tessellaris, Imperata cylindrica, Sporobolis creber*
Type of microrelief:	normal gilgai		
vertical interval	0.20 m		
horizontal interval	4 m		
Component of microrelief sampled:	depression		

Profile morphology:

Condition of surface soil when dry: periodic cracking, crusting

Horizon	Depth (m)	Description
A11j	0-0.10	Dark greyish brown (10YR4/2) moist; few medium distinct pale mottles; light clay; strong 5-10 mm subangular blocky; dry; moderately firm; few fine ferromanganiferous nodules. Gradual to –
A12j	0.10-0.30	Dark greyish brown (10YR4/2) moist; light medium clay; strong 10-20 mm subangular blocky; dry; very firm; very few fine ferruginous nodules. Gradual to –
B21	0.30-0.90	Greyish brown (10YR5/2) moist; medium clay; strong 20-50 mm angular blocky parting to strong 10-20 mm angular blocky; moderately moist; moderately firm; very few fine ferruginous nodules. Gradual to –
B22	0.90-1.10	Dark greyish brown (10YR4/2) moist; medium clay; strong 20-50 mm lenticular parting to strong 10-20 mm angular blocky; moderately moist; very firm; very few fine ferruginous nodules. Gradual to –
B23	1.10-1.40	Greyish brown (2.5Y5/2) moist; light medium clay; strong 20-50 mm lenticular parting to strong 20-50 mm angular blocky; moderately moist; moderately firm; very few fine ferruginous nodules.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.1	0.10	.006																	
0.00-0.10	6.1	0.08	.006	8	13	42	36	8	5.80	0.20	1.30	0.35	17	.043	.787	.039	2.70	19	0.74	4.8
0.20-0.30	6.0	0.28	.035	3	16	35	43	19	4.30	11.0	3.70	0.21	19	.021	.726	.023	3.50	19	0.99	4.9
0.50-0.60	6.3	0.41	.057	1	15	33	48	23	4.50	13.0	5.20	0.23	23	.017	.691	.018	3.20	20	0.99	5.3
0.80-0.90	7.4	0.56	.070	1	12	31	54	31	5.80	17.0	7.40	0.31	24	.018	.771	.017	3.60	22	0.99	6.5
1.10-1.20	8.0	0.56	.071	1	9	33	55	35	6.80	20.0	8.00	0.40	23	.02	.657	.018	3.80			7.1

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	3.2	0.22	18	0.56	227	66	2.0	2.2

alcoholic cations at pH 8.5
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class:	**DUGGUA**	**Substrate material:**	unconsolidated material
Site No:	S13 (same locality as S12)	**Slope:**	1%
AMG reference:	439 112 mE 7 007 695 mN	**Landform element**	plain
		Landform pattern:	level plain
Great soil group:	Brown clay	**Vegetation:**	
Principal profile form:	Ug5.34	**Structural form:**	woodland
Australian soil classification:	Episodic, Self-mulching, Brown Vertosol	**Dominant species:**	*Eucalyptus tereticornis, E.crebra, Eucalyptus tessellaris, Imperata cylindrica, Sporobolis creber*
Type of microrelief:	normal gilgai		
vertical interval	0.20 m		
horizontal interval	4 m		
Component of microrelief sampled:	mound		

Profile morphology:

Condition of surface soil when dry: periodic cracking, self-mulching

Horizon	Depth (m)	Description
A11	0-0.03	Very dark greyish brown (10YR3/2); light medium clay; strong 5-10 mm subangular blocky; dry; moderately firm; very few fine ferromanganiferous nodules.
A12	0.03-0.20	Brown (10YR4/3); medium clay; strong 10-20 mm angular blocky; moderately moist; very firm; very few fine ferromanganiferous nodules.
B21	0.20-0.55	Brown (10YR4/3); medium heavy clay; strong 20-50 mm lenticular; moderately moist; very firm.
B22	0.55-0.85	Yellowish brown (10YR5/4); few medium faint grey mottles; medium heavy clay; strong 20-50 mm angular blocky; moderately moist; very firm; very few fine ferromanganiferous nodules.
B23	0.85-1.12	Very dark greyish brown (10YR3/2); few medium distinct yellow mottles; medium heavy clay; strong 10-20 mm angular blocky parting to moderate 20-50 mm lenticular; moderately moist; very firm; very few fine ferromanganiferous nodules.
B24	1.12-1.30	Brown (10YR4/3); common medium distinct grey mottles; medium clay; strong 20-50 mm lenticular; moderately moist; moderately firm.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.6	0.10	0.004																	
0.00-0.10	6.3	0.10	0.007	4	14	33	48	22	6.90	13.0	1.80	0.57	8	.043	.758	.039	3.80	23	0.67	5.1
0.20-0.30	6.5	0.27	0.035	2	10	24	63	29	7.10	18.0	4.00	0.37	14	.028	.717	.026	4.90	26	0.87	5.5
0.50-0.60	6.2	0.62	0.071	2	9	26	61	29	5.60	17.0	6.30	0.32	22	.023	.712	.02	5.20	25	0.86	5.5
0.75-0.85	7.5	0.56	0.064	1	13	33	53	24	4.40	13.0	6.30	0.22	26	.017	.763	.018	3.90	20	0.96	6.7
1.12-1.20	8.1	0.60	0.064	1	12	33	53	32	6.00	18.0	7.80	0.24	24	.014	.676	.018	5.80			7.3

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	3.0	0.17	7	0.60	110	38	2.0	0.95

aqueous cations at pH 7.0
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

COOEEIMBARDI (1)

Soil profile class: COOEEIMBARDI (1)
Site No: 910
AMG reference: 434 610 mE 7 001 415 mN
Great soil group: Black Earth
Principal profile form: Ug5.15
Australian soil classification: Endocalcareous, Self-mulching, Black Vertosol

Substrate material: unconsolidated material (granodiorite alluvium)
Slope: 2%
Landform element plain
Landform pattern: gently undulating plain
Vegetation:
Structural form: cleared woodland
Dominant species: *Eucalyptus melanophloia, E.tereticornis, Eucalyptus tessellaris, Bothriochloa bladhii, Eragrostis species*

Profile morphology:

Condition of surface soil when dry: periodic cracking, self-mulching

Horizon	Depth (m)	Description
A1	0-0.18	Black (10YR2/1) moist; light medium clay; moderately moist; moderately weak.
B21	0.18-0.30	Very dark grey (10YR3/1) moist; light medium clay; few small pebbles, angular quartz; moderately moist; moderately firm; few medium manganiferous nodules.
B22	0.30-0.80	Very dark greyish brown (10YR3/2) moist; medium clay; very few medium pebbles, subrounded detrital sedimentary rock (unidentified); few faint clay skins; moderately moist; moderately firm; few medium manganiferous nodules.
B23k	0.80-1.60	Dark yellowish brown (10YR5/6) moist; light medium clay; very few medium pebbles, subrounded detrital sedimentary rock (unidentified); few faint clay skins; moderately moist; very firm; few medium manganiferous nodules, common coarse calcareous soft segregations.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.2	0.07	.003																	
0.00-0.10	6.2	0.06	.002	22	29	21	30	17	7.30	9.20	0.39	0.25	2	.063	.151	.057	2.30	15	0.37	
0.20-0.30	7.3	0.07	.007	17	20	16	50	27	8.70	17.0	1.60	0.13	6	.036	.118	.041	3.52	20	0.41	
0.50-0.60	8.1	0.50	.076	15	22	11	51	30	7.50	20.0	2.80	0.09	9	.023	.095	.036	3.35	20	0.52	
0.80-0.90	9.0	0.55	.063	19	24	18	40	26	6.00	17.0	2.70	0.06	10	.032	.221	.027	2.40	16	0.67	
1.10-1.20	8.9	0.67	.090	20	27	17	42	30	5.70	21.0	3.30	0.08	11	.029	.344	.024	3.29			

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	3.4	0.23	35	0.83	160	57	1.7	1.6

\# alcoholic cations at pH 8.5
\+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

COOEEIMBARDI (2)

Soil profile class: COOEEIMBARDI (2)
Site No: S17
AMG reference: 435 250 mE 7 001 610 mN
Great soil group: Black Earth
Principal profile form: Ug5.16
Australian soil classification: Magnesic, Mottled-Mesonatric, Black Vertosol
Type of microrelief: normal gilgai
vertical interval 0.20 m
horizontal interval 3 m
Component of microrelief sampled: mound

Substrate material: unconsolidated material (Cressbrook Creek alluvium))
Slope: 2%
Landform element backplain
Landform pattern: level alluvial plain
Vegetation:
Structural form: cleared woodland
Dominant species: *Cynodon dactylon, Sporobolis creber*

Profile morphology:

Condition of surface soil when dry: periodic cracking, self-mulching

Horizon	Depth (m)	Description
A1	0-0.10	Black (10YR2/1); light medium clay; strong 5-10 mm subangular blocky; moderately moist; very firm. Gradual to –
B21	0.10-1.00	Black (10YR2/1); medium clay; strong 20-50 mm lenticular; moderately moist; very firm; few medium calcareous nodules. Gradual to –
B22k	1.00-1.50	Greyish brown (10YR5/2); few medium distinct dark mottles; medium clay; strong 20-50 mm lenticular parting to moderate 10-20 mm angular blocky; moist; moderately firm; common medium calcareous nodules, very few fine ferromanganiferous nodules.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	7.0	0.21	.002																	
0.00-0.10	7.8	0.24	.001	11	15	14	54	52	35.0	16.0	0.35	1.00	1	.057	.256	.067	6.40	32	0.50	7.2
0.20-0.30	8.6	0.17	.001	13	18	16	52	44	27.0	16.0	0.40	0.26	1	.032	.158	.032	5.60	27	0.63	7.8
0.50-0.60	8.8	0.21	.001	10	17	16	55	48	21.0	25.0	1.50	0.17	3	.027	.143	.027	5.90	28	0.69	7.9
0.80-0.90	8.8	0.41	.027	10	17	13	59	53	17.0	33.0	3.10	0.15	6	.026	.141	.027	6.30	31	0.69	8.0
1.10-1.20	8.8	0.66	.070	11	19	16	51	41	11.0	27.0	3.00	0.11	7	.024	.143	.02	5.40			8.2
1.40-1.50	8.8	0.86	.086																	

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	3.6	0.35	16	0.81	111	30	2.8	1.5

\# alcoholic cations at pH 8.5
\+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class:	**SPENCER (1)**	**Substrate material:**	unconsolidated material
Site No:	S11	**Slope:**	1%
AMG reference:	435 980 mE 7 019 400 mN	**Landform element**	plain
		Landform pattern:	level plain
Great soil group:	affinities with Solodic soil	**Vegetation:**	
Principal profile form:	Dy2.42	**Structural form:**	open woodland
Australian soil classification:	Bleached-Sodic, Eutrophic, Brown Chromosol	**Dominant species:**	*Eucalyptus crebra, Eucalyptus tereticornis, Angophora subvelutina, Cynodon dactylon*
Surface coarse fragments:	very few large pebbles, rounded detrital sedimentary rock.		

Profile morphology:

Condition of surface soil when dry: firm

Horizon	Depth (m)	Description
A11	0-0.13	Very dark brown (10YR2/2) moist; coarse sandy loam; weak granular; moderately moist; very weak.
A12	0.13-0.30	Dark greyish brown (10YR4/2) moist; coarse sandy loam; few medium pebbles, rounded detrital sedimentary rock (unidentified); weak granular; moderately moist; very weak; few medium ferromanganiferous nodules.
A2E	0.30-0.48	Yellowish brown (10YR5/4) moist, very pale brown (10YR7/3) dry; coarse sandy clay loam; few large pebbles, rounded detrital sedimentary rock (unidentified); massive; dry; very weak. Abrupt to –
B21	0.48-1.00	Strong brown (7.5YR5/6); few medium faint dark mottles; light medium clay; very few small pebbles, subangular detrital sedimentary rock (unidentified); strong 10-20 mm angular blocky parting to strong 5-10 mm subangular blocky; moderately moist; moderately firm.
D?	1.00-1.20	Strong brown (7.5YR5/6); common medium distinct grey mottles; medium clay; few small pebbles, subangular detrital sedimentary rock (unidentified); moderate 20-50 mm angular blocky; moderately moist; moderately strong; very few fine manganiferous soft segregations.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	7.5	0.09	0.006																	
0.00-0.10	6.4	0.03	0.001	48	34	10	9	6	3.50	1.60	0.09	0.34	2	.086	1.13	.046	0.8	5	0.56	5.3
0.20-0.30	6.7	0.01	0.001	48	36	9	8	3	1.30	1.10	0.05	0.14	2	.046	1.19	.021	0.6	4	0.88	5.5
0.50-0.60	6.7	0.02	0.001	28	23	8	39	7	2.40	3.90	0.38	0.31	5	.032	1.03	.024	1.8	14	0.53	5.5
0.80-0.90	6.8	0.02	0.001	19	18	6	55	11	3.50	6.50	0.88	0.20	8	.026	.795	.023	2.4	20	0.46	5.4
1.00-1.10	7.0	0.02	0.001	24	21	6	46	12	3.90	7.10	1.00	0.16	8	.023	.916	.019	2.6	17	0.51	5.5
1.40-1.50																				

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	1.7	0.13	18	0.45	113	12	0.33	1.8

alcoholic cations at pH 8.5
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class:	**SPENCER (2)**	**Substrate material:**	unconsolidated material
Site No:	S15	**Slope:**	1%
AMG reference:	446 680 mE 7 001 170 mN	**Landform element**	drainage depression
		Landform pattern:	level plain
Great soil group:	no suitable group	**Vegetation:**	
Principal profile form:	Db1.13	**Structural form:**	
Australian soil classification:	Sodic, Eutrophic, Brown Chromosol	**Dominant species:**	*Eucalyptus tereticornis, Lophostemon suaveolens, Eucalyptus tessellaris, Imperata cylindrica, Cynodon dactylon*
Type of microrelief:	normal gilgai		
vertical interval	0.20 m		
horizontal interval	6 m		
Component of microrelief sampled:	mound		

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A1	0-0.10	Dark brown (10YR3/3); clay loam, fine sandy; moderate 2-5 mm granular; dry; moderately weak; few medium ferromanganiferous nodules. Gradual to –
B1	0.10-0.21	Dark yellowish brown (10YR3/4); few fine faint orange mottles; light medium clay; strong 5-10 mm subangular blocky; dry; very firm; common medium ferromanganiferous nodules. Gradual to –
B21	0.21-1.05	Brown (10YR4/3); very few medium faint orange mottles, few medium faint yellow mottles; medium clay; strong 20-50 mm lenticular; dry; very firm; few medium ferromanganiferous nodules. Gradual to –
B22	1.05-1.55	Yellowish brown (10YR5/4); few medium faint grey mottles; medium heavy clay; moderate 20-50 mm lenticular; moderately moist; very firm; few medium ferromanganiferous nodules, very few fine calcareous nodules.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.2	0.05	.002																	
0.00-0.10	6.4	0.04	.001	9	28	32	34	11	5.10	5.20	0.26	0.53	2	.059	.689	.039	2.70	15	0.65	5.2
0.20-0.30	7.1	0.03	.001	14	15	20	50	16	6.90	8.50	0.74	0.35	4	.032	.483	.026	3.40	21	0.76	5.8
0.50-0.60	7.7	0.13	.017	9	11	16	62	23	8.60	13.0	1.70	0.16	7	.024	.379	.023	5.00	24	0.80	6.6
0.80-0.90	8.1	0.33	.035	10	11	16	61	25	8.40	14.0	2.50	0.12	10	.019	.351	.02	3.90	25	0.87	7.1
1.10-1.20	8.4	0.47	.057	7	15	19	58	27	8.00	16.0	3.10	0.10	11	.017	.37	.018	3.60			7.5
1.40-1.50	8.6	0.62	.072																	

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	1.7	0.13	18	0.45	113	12	0.33	1.8

alcoholic cations at pH 8.5
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **OTTABA (1)**
Site No: 1039
AMG reference: 449 910 mE 6 999 240 mN
Great soil group: Soloth
Principal profile form: Dy3.41
Australian soil classification: Bleached-Sodic, Natric, Grey Kurosol

Substrate material: unconsolidated material
Slope: 0.5%
Landform element terrace flat
Landform pattern: terraced land
Vegetation:
Structural form: cleared
Dominant species: *Eucalyptus tereticornis, Lophostemon suaveolens, Corymbia tessellaris, Cynodon dactylon, Bothriochloa decepiens*

Type of microrelief: melonhole gilgai
vertical interval 0.30 m
horizontal interval 12 m
Component of microrelief sampled: mound

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	**Depth (m)**	**Description**
A1	0-0.11	Greyish brown (10YR5/2) moist; fine sandy clay loam; massive; dry; moderately weak. Clear to –
A2e	0.11-0.25	White (10YR8/2) dry, light brownish grey (10YR6/2) moist; fine sandy clay loam; massive; dry; moderately weak. Clear to –
B1t	0.25-0.38	Greyish brown (10YR5/2) moist; light clay; few medium pebbles, rounded detrital sedimentary rock (unidentified); strong 2-5 mm subangular blocky; moderately moist; moderately firm. Clear to –
B21t	0.38-0.60	Brown (10YR5/3) moist; common medium distinct orange mottles; light medium clay; very few large pebbles, rounded detrital sedimentary rock (unidentified); strong 5-10 mm prismatic; moist; very firm. Gradual to –
B22t	0.60-1.20	Greyish brown (10YR5/2) moist; few fine faint orange mottles; light clay; strong 10-20 mm lenticular; moist; very firm.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations[#] meq/100g ECEC	Ca	Mg	Na	K	Exch. Al meq/100 g	Exch. acid meq/100 g	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500[+]	disp. ratio R1	pH CaCl2
B[†] 0-0.10	5.8	0.10	.009																			
0.00-0.10	5.6	0.09	.006	7	47	35	16	6	2.00	2.8	0.53	0.42	0.1	0.1	9	.04	.262	.063	1.01	9	0.60	
0.25-0.35	5.7	0.06	.004	5	26	19	50	15	2.60	9.5	1.30	0.21	0	0	9	.019	.183	.033	2.56	21	0.68	
0.50-0.60	5.1	0.24	.034	2	21	19	56	20	2.70	12.0	2.60	0.18	1.5	2.2	13	.015	.155	.029	3.10	22	0.71	
0.80-0.90	4.8	0.56	.083	3	20	22	57	23	2.80	14.0	5.00	0.19	0.8	1.4	21	.013	.172	.027	3.09	24	0.89	
1.10-1.20	4.7	0.73	.124	3	19	20	58	21	3.10	16.0	6.40	0.21	0	0	30	.012	.18	.027	3.84			
1.40-1.50	4.8	0.70	.112																			

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO_4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B[†] 0-0.10	2.3	0.14	16		0.42	296	7.9	0.42	0.80

[#] aqueous cations at pH 7.0
[+] -1500 kPa (-15 bar) using pressure plate apparatus
[†] refers to bulking of a number of surface samples prior to analysis

Soil profile class: **OTTABA (2)**
Site No: 1422
AMG reference: 440 190 mE 7 013 150 mN
Great soil group: Soloth
Principal profile form: Dy3.41
Australian soil classification: Bleached-Sodic, Magnesic-Natric, Grey Kurosol

Substrate material: unconsolidated sediments
Slope: 2%
Landform element terrace plain
Landform pattern: terrace (high level terrace)
Vegetation:
Structural form: cleared
Dominant species: *Eucalyptus tereticornis, Eucalyptus tessellaris, Cynodon dactylon*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	**Depth (m)**	**Description**
A1	0-0.15	Very dark grey (10YR3/1) moist; sandy loam; weak 2-5 mm granular; dry; moderately weak. Gradual to –
A2e	0.15-0.30	Greyish brown (10YR5/2) moist, light grey (10YR7/2) dry; sandy loam; common medium pebbles, rounded quartz; weak <2mm granular parting to massive; dry; very weak. Field pH 6.5. Abrupt to –
B21t	0.30-1.35	Brown (7.5YR4/2) moist; light medium clay; few medium distinct orange mottles; very few small pebbles, rounded quartz; moderate 20-50 mm columnar parting to strong 10-20 mm lenticular; dry; moderately strong. Field pH 4.5. Gradual to –
B22t	1.35-1.50	Greyish brown (10YR5/2) moist; common medium prominent red mottles; light medium clay; very few small pebbles, rounded quartz; strong 20-50 mm lenticular; moderately moist; moderately firm.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations[#] meq/100g ECEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500[+]	disp. ratio R1	pH CaCl2
B[†] 0-0.10	5.9	0.08	.007																	
0.00-0.10	5.9	0.05	.002	28	52	12	10	3	1.5	0.70	0.18	0.41	na	.045	.123	.037	0.80	4.5	0.84	4.7
0.20-0.30	6.0	0.03	.002	33	50	12	7	1	0.44	0.32	0.13	0.15	na	.024	.15	.015	0.20	2	0.77	4.8
0.50-0.60	5.4	0.37	.041	19	17	8	58	14	0.33	8.9	5.0	0.20	36	.011	.146	.015	2.51	22	0.92	3.9
0.80-0.90	5.3	0.37	.046	30	21	6	42	17	0.15	10	6.2	0.19	36	.009	.191	.011	2.40	22	0.93	3.8
1.10-1.20	5.4	0.32	.041	27	23	6	42							.008	.236	.009	5.42			3.8

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B[†] 0-0.10	2.1	0.17	57	10	0.50	432	9.3	0.27	2.0

[#] aqueous cations at pH 7.0
[+] -1500 kPa (-15 bar) using pressure plate apparatus
[†] refers to bulking of a number of surface samples prior to analysis

Soil profile class: **BEPPO**
Site No: 1558
AMG reference: 437 100 mE 6 999 200 mN

Great soil group: Solodic Soil
Principal profile form: Db1.43
Australian soil classification: Eutrophic, Subnatric, Brown Sodosol

Substrate material: sandstone
Slope: 6%
Landform element hillslope
Landform pattern: undulating rises
Vegetation:
Structural form: cleared woodland
Dominant species: *Corymbia intermedia, Eucalyptus crebra, E.melanophloia, Heteropogon contortus, Bothriochloa decepiens*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A1	0-0.13	Brown (7.5YR4/2) moist; sandy clay loam; weak 2-5 mm granular; dry; moderately weak. Gradual to –
A2e	0.13-0.37	Brown (10YR5/3) moist; light sandy clay loam; weak <2mm granular; dry; very weak; few medium ferromanganiferous nodules. Abrupt to –
B21t	0.37-0.72	Brown (10YR4/3) moist; light medium clay; strong 10-20 mm angular blocky; moderately moist; moderately firm; common coarse manganiferous nodules. Diffuse to –
B22t	0.72-1.20	Yellowish brown (10YR5/4) moist; light medium clay; strong 20-50 mm lenticular; moderately moist; moderately firm; common coarse manganiferous nodules.
B23k	1.20-1.50	Light yellowish brown (10YR6/4) moist; few medium distinct yellow mottles; light medium clay; strong 10-20 mm lenticular; moderately moist; moderately firm; few coarse calcareous soft segregations.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations[#] meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500[+]	disp. ratio R1	pH $CaCl_2$
B[†] 0-0.10	5.9	0.04	.001																	4.9
0.00-0.10	5.9	0.03	bq	41	27	17	17	4	2.00	1.80	0.04	0.49	1	.047	.504	.020	1.00	8	0.64	4.8
0.20-0.30	6.4	0.01	.001	41	28	17	17	4	1.60	2.20	0.13	0.20	3	.029	.517	.012	0.90	7	0.76	5.2
0.50-0.60	7.8	0.12	.011	20	15	9	58	19	5.20	12.0	2.10	0.13	11	.016	.275	.014	3.00	24	0.66	6.6
0.80-0.90	8.2	0.56	.065	19	15	10	56	24	5.90	14.0	3.80	0.11	16	.011	.225	.013	3.60	24	0.83	7.5
1.10-1.20	8.8	0.98	.112	18	16	13	53	31	7.60	18.0	5.30	0.15	17	.011	.215	.008	4.00			8.1
1.40-1.50	8.8	0.96	.106																	8.2

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B[†] 0-0.10	1.9	0.14	10	5	0.56	110	30	0.61	0.90

[#] alcoholic cations at pH 8.5
[+] -1500 kPa (-15 bar) using pressure plate apparatus
[†] refers to bulking of a number of surface samples prior to analysis

Soil profile class: **WATT**
Site No: S2
AMG reference: 430 875 mE 7 016 258 mN

Great soil group: affinities with solodic soil
Principal profile form: Db1.33
Australian soil classification: Haplic, Eutrophic, Brown Chromosol

Substrate material: mudstone
Slope: 5%
Landform element hillslope
Landform pattern: undulating rises
Vegetation:
Structural form: cleared
Dominant species: *Aristida queenslandica, Sporobolis creber*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A1	0-0.15	Dark brown (7.5YR3/2) moist; clay loam, sandy; moderate <2mm granular; moderately moist; very weak. Clear to –
A2j	0.15-0.22	Dark yellowish brown (10YR4/4) moist; few medium distinct pale mottles; clay loam, sandy; moderate <2mm granular; moderately moist; moderately weak. Abrupt to –
B21	0.22-0.45	Brown (7.5YR4/4) moist; few fine faint dark mottles; medium clay; very few medium pebbles, angular mudstone; moderate 20-50 mm lenticular parting to strong 10-20 mm angular blocky; dry; moderately strong; very few fine manganiferous nodules.
B3	0.45-0.60	Dark yellowish brown (10YR4/4); few medium distinct yellow mottles; medium clay; common medium pebbles, angular mudstone; strong 20-50 mm angular blocky; moderately moist; very firm; very few fine manganiferous nodules, few medium calcareous soft segregations.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations[#] meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500[+]	disp. ratio R1	pH $CaCl_2$
B[†] 0-0.10	6.6	0.12	.001																	
0.00-0.10	6.7	0.12	.001	27	23	25	24	10	5.50	3.90	0.15	0.67	1	.048	.958	.046	2.10	11	0.56	5.1
0.20-0.30	7.1	0.12	.001	11	15	13	57	27	15.0	11.0	1.00	0.22	3	.025	.690	.030	3.70	23	0.50	5.6
0.50-0.60	8.3	0.29	.004	22	22	19	35	33	19.0	12.0	1.50	0.10	5	.061	.875	.025	3.80	17	0.54	7.5
0.80-0.90	8.8	0.32	.012	32	30	15	21	29	16.0	11.0	2.00	0.10	7	.065	1.06	.019	3.20	12	0.31	7.9

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B[†] 0-0.10	2.9	0.18	9		0.97	100	23	0.83	1.9

[#] alcoholic cations at pH 8.5
[+] -1500 kPa (-15 bar) using pressure plate apparatus
[†] refers to bulking of a number of surface samples prior to analysis

Soil profile class:	**CALABASH**	**Substrate material:**	conglomerate
Site No:	1736	**Slope:**	50%
AMG reference:	429 790 mE 7 022 163 mN	**Landform element**	hillslope
		Landform pattern:	steep hills
Great soil group:	affinities with yellow podzolic soil	**Vegetation:**	
Principal profile form:	Dy2.42	**Structural form:**	open forest
Australian soil classification:	Bleached-Sodic, Eutrophic, Brown Chromosol	**Dominant species:**	*Eucalyptus crebra, E.tereticornis, Angophora subvelutina, Lantana camara, Heteropogon contortus, Bothriochloa bladhii*
Surface coarse fragments:	very few cobbles, remnant conglomerate		

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	**Depth (m)**	**Description**
A1	0-0.10	Dark brown (7.5YR3/2); clay loam, sandy. Clear to –
A2e	0.10-0.25	Yellowish brown (10YR5/4), very pale brown (10YR7/4) dry; clay loam, sandy. Clear to –
B21t	0.25-0.80	Strong brown (7.5YR5/8); few medium faint yellow mottles; medium clay; many stones, angular conglomerate, common large pebbles, angular conglomerate; moderate 20-50 mm subangular blocky. Clear to –
B3	0.80-1.20	Yellowish brown (10YR5/8); sandy medium clay; many large pebbles, angular conglomerate.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	5.6	0.04	.001																	
0.00-0.10	5.9	0.06	.001	27	25	19	27	14	8.30	4.90	0.27	0.27	2	.04	1.19	.026	2.15	14	0.55	5.0
0.20-0.25	6.2	0.02	.001	23	28	20	31	13	6.70	5.60	0.49	0.16	4	.016	1.26	.009	1.92	12	0.77	4.8
0.50-0.60	6.7	0.03	.002	16	21	21	43	18	9.10	7.60	1.00	0.20	6	.01	1.32	.009	2.72	17	0.78	5.1
0.80-0.90	6.9	0.03	.001	19	23	18	40	16	8.30	6.80	1.00	0.18	6	.009	1.33	.007	2.26	15	0.86	5.2

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	1.7	0.1	7	7	0.25	81	37	0.52	0.73

aqueous cations at pH 7.0
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class:	**KIPPER**	**Substrate material:**	siltstone
Site No:	2456	**Slope:**	12%
AMG reference:	440 740 Me 7 039 760 mN	**Landform element**	hillslope
		Landform pattern:	rolling hills
Great soil group:	affinities with red podzolic soil	**Vegetation:**	
Principal profile form:	Dr2.21	**Structural form:**	cleared open forest
Australian soil classification:	Haplic, Eutrophic, Red Chromosol	**Dominant species:**	*Brachichiton populneus, Eucalyptus crebra, E.melanophloia, Gomphocarpus physocarpus, Sporobolis creber, Bothriochloa decepiens*
Surface coarse fragments:	angular sandstone		

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	**Depth (m)**	**Description**
A1	0-0.10	Black (10YR2/1) moist; clay loam, sandy; very few large pebbles, rounded detrital sedimentary rock (unidentified); weak 2-5 mm granular; moderately moist; moderately weak. Gradual to –
A2	0.10-0.30	Brown (7.5YR4/3) moist; clay loam, sandy; few large pebbles, rounded quartz; weak 2-5 mm granular; moderately moist; moderately weak. Clear to –
B21	0.30-0.80	Reddish brown (2.5YR4/4) moist; medium clay; fragments, rounded detrital sedimentary rock (unidentified); strong 5-10 mm subangular blocky; moderately moist; moderately firm; few medium ferromanganiferous nodules. Gradual to –
BC	0.80-0.90	Dark red (2.5YR3/6) moist; light medium clay; few medium pebbles, angular siltstone; moderate 5-10 mm subangular blocky; moderately moist; moderately firm.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g ECEC	Ca	Mg	Na	K	Exch. Al meq/100 g	Exch. acid meq/100 g	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.0	0.10	.002																			
0.00-0.10	6.3	0.17	.001	25	31	18	26	15	8.80	4.70	0.07	1.90			0	.083	1.3	.045	2.29	15	0.44	5.5
0.20-0.30	6.6	0.03	bq	25	32	18	28	9	5.00	3.10	0.07	0.57			1	.041	1.13	.015	1.23	10	0.77	5.4
0.50-0.60	5.6	0.03	.002	12	20	18	52	13	4.90	7.00	0.29	0.33	2.2	2.8	2	.02	2.2	.01	2.41	18	0.72	4.3
0.80-0.90	5.7	0.02	.001	20	24	2	54		2.80	5.10	0.45	0.16	4.5	5	5	.019	2.34	.008	2.09	11	0.52	4.1
1.10-1.20	5.3	0.05	.005	4	18	28	48						11.9	16.9		.006	.358	.009	5.00			3.5

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO_4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	2.8	0.2	14	9	0.88	97	72	1.9	5

aqueous cations at pH 7.0
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **GREENHIDE**
Site No: 2527
AMG reference: 427 480 mE 7 023 880 mE

Great soil group: Non-calcic brown soil
Principal profile form: Dr2.12
Australian soil classification: Haplic, Eutrophic, Red Chromosol

Surface coarse fragments: Few cobbles, rounded sandstone

Substrate material: sandstone
Slope: 22%
Landform element hillslope
Landform pattern: rolling hills
Vegetation:
Structural form: cleared woodland
Dominant species: *Lantana camara, Heteropogon contortus, Bothriochloa decepiens*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A1	0-0.20	Dark brown (7.5YR3/2) moist; sandy clay loam; weak 10-20 mm subangular blocky. Clear to –
B21t	0.20-0.55	Reddish brown (5YR4/3) moist; light medium clay; strong 10-20 mm angular blocky; few medium manganiferous nodules. Clear to –
BC	0.55-0.60	Brown (7.5YR4/2) moist; light clay; sandstone fragments; few medium manganiferous soft segregations.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.3	0.13	.001																	
0.00-0.10	6.6	0.12	.001	35	23	17	25	17	12.0	3.80	0.07	0.78	0	.093	1.87	.031	1.90	12	0.51	5.9
0.20-0.30	6.4	0.02	bq	35	24	11	27	14	9.30	4.80	0.14	0.16	1	.058	1.78	.015	1.90	11	0.66	5.2
0.45-0.55	7.0	0.02	bq	38	20	12	33	26	16.0	9.40	0.40	0.19	2	.064	1.39	.016	3.50	14	0.54	5.7

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	2.2	0.14	57	9	1.2	57	30	0.54	4.4

aqueous cations at pH 7.0
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **TURTLE**
Site No: S1
AMG reference: 434 650 mE 7 017 400 mN

Great soil group: affinities with soloth
Principal profile form: Dy3.11
Australian soil classification: Eutrophic, Mottled-Subnatric, Red Sodosol

Surface coarse fragments: few large pebbles, rounded remnant conglomerate clasts

Substrate material: siltstone
Slope: 20%
Landform element hillslope
Landform pattern: rolling low hills
Vegetation:
Structural form: partly cleared woodland
Dominant species: *Eucalyptus crebra, Lantana camara, Cynodon dactylon*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A1	0-0.15	Dark brown (7.5YR3/2) moist; sandy clay loam; moderate <2mm granular; moderately moist; very weak. Clear to –
B21t	0.15-0.40	Yellowish red (5YR5/6) moist; common medium distinct grey mottles, very few fine faint yellow mottles; light medium clay; common medium pebbles, rounded quartz; strong 10-20 mm subangular blocky; dry; moderately strong; very few fine manganiferous nodules. Clear to –
B22t	0.40-0.62	Strong brown (7.5YR5/6) moist; common medium distinct grey mottles, few medium faint yellow mottles; medium clay; fragments, quartz; strong 20-50 mm angular blocky; dry; moderately strong. Gradual to –
BC	0.62-1.10	Reddish brown (5YR4/4); many coarse distinct yellow mottles, few medium faint grey mottles; many medium pebbles, angular tabular siltstone; dry; moderately firm; very few fine manganiferous soft segregations.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g ECEC	Ca	Mg	Na	K	Exch. Al meq/100 g	Exch. acid meq/100 g	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.4	0.16	.004																			
0.00-0.10	6.4	0.14	.001	36	23	20	21	9	5.40	2.90	0.16	0.86			2	.067	.935	.059	1.80	11	0.21	4.9
0.20-0.30	6.4	0.21	.017	6	15	20	57	26	9.80	14.0	1.70	0.45			7	.024	1.39	.028	3.20	17	0.70	4.9
0.50-0.60	5.8	0.54	.072	1	24	37	38	29	7.90	14.0	4.30	0.34	1.6	2.1	16	.029	1.93	.024	2.80	15	0.75	4.5
0.80-0.90	5.4	0.69	.087	4	17	42	38	29	6.80	12.0	5.50	0.36	2.7	4.7	22	.045	1.96	.026	3.00	16	0.67	4.2
1.00-1.10	5.6	0.51	.064					26	5.70	9.80	4.70	0.32	3.2	5.5	23							4.1

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO_4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	5.7	0.43	32		1.1	279	32	1.2	9.8

alcoholic cations at pH 8.5
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class:	**LAKEVIEW**	**Substrate material:**	siltstone
Site No:	773	**Slope:**	10%
AMG reference:	442 430 mE 6 996 030 mN	**Landform element**	hillslope
		Landform pattern:	rolling rises
Great soil group:	no suitable group	**Vegetation:**	
Principal profile form:	Dy2.12	**Structural form:**	cleared
Australian soil classification:	Brown Dermosol (probable)	**Dominant species:**	softwood scrub species

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	**Depth (m)**	**Description**
A11	0-0.23	Brown (7.5YR 4/3); clay loam fine sandy; strong fine granular; field pH 6.5. Clear to –
A12j	0.23-0.40	Brown (7.5YR 5/4); clay loam fine sandy; few angular coarse fragments (siltstone); moderate medium granular; field pH 7.0; Clear to –
B1	0.40-0.60	Brown (7.5YR 5/4); medium clay; few angular coarse fragments (siltstone); moderate medium subblocky; field pH 6.5. Clear to –
B2	0.60-0.80	Strong brown (7.5YR 5/6); few faint mottles; medium clay; moderate coarse subblocky; few manganiferous soft segregations; field pH 6.5. Gradual to –
BC	0.80-1.05	Red (2.5YR 5/6); common distinct grey mottles; light clay; common coarse fragments; moderate platy structure; few manganiferous nodules; field pH 6.3.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.3	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–	–

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	2.5	0.25	74	12	0.93	64	109	1.8	3.9

Note: no profile laboratory data for Lakeview

aqueous cations at pH 7.0
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class:	**HIBISCUS**	**Substrate material:**	sandstone
Site No:	S19	**Slope:**	5%
AMG reference:	436 720 mE 6 987 890 mN	**Landform element**	hillcrest
		Landform pattern:	low hills
Great soil group:	Red earth	**Vegetation:**	
Principal profile form:	Gn2.11	**Structural form:**	partly cleared woodland
Australian soil classification:	Haplic, Mesotrophic, Red Kandosol	**Dominant species:**	*Eucalyptus crebra, Corymbia citriodora*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	**Depth (m)**	**Description**
A11	0-0.10	Dusky red (2.5YR3/2); clay loam, sandy; very few small pebbles, subangular quartz; moderate <2mm granular; dry; moderately firm. Gradual to –
A12	0.10	Dark reddish brown (2.5YR3/4); very few medium faint dark mottles; clay loam, sandy; very few small pebbles, subangular quartz; weak granular; dry; very firm; massive discontinuous duripan; very few fine ferromanganiferous nodules. Gradual to –
B21	0.30-1.15	Dark red (10R3/6); sandy light clay; few small pebbles, subangular quartz; weak subangular blocky; dry; moderately firm; few medium ferromanganiferous nodules. Gradual to –
B3	1.15-1.30	Red (2.5YR4/6); very few fine faint yellow mottles; sandy clay; common small pebbles, subangular quartz; massive; dry; moderately firm.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.1	0.02	.001																	
0.00-0.10	5.9	0.02	.001	50	23	5	23	3	1.40	1.40	0.07	0.37	2	.037	.324	.032	0.70	6	0.51	4.7
0.20-0.30	5.9	0.01	.001	39	24	7	30	3	0.71	1.70	0.06	0.39	2	.035	.384	.027	0.80	8	0.41	4.6
0.50-0.60	5.7	0.04	.004	31	14	4	47	5	1.10	2.70	0.18	0.32	4	.041	.391	.027	1.50	14	0.13	4.8
0.80-0.90	5.9	0.01	.001	41	13	5	37	4	0.71	2.90	0.09	0.16	2	.045	.354	.028	1.20	12	0.10	5.1
1.10-1.20	5.9	0.02	.001	48	15	9	28	3	0.43	2.50	0.11	0.12	3	.045	.384	.025	1.90			5.3

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	2	0.06	2		0.39	61	39	0.14	0.43

alcoholic cations at pH 8.5
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **YELLOWBANK**
Site No: MFM S14
AMG reference: 43300 mE 6 983 500 mN
Great soil group: Yellow earth
Principal profile form: Gn2.62
Australian soil classification: Haplic, Mellic, Brown Kandosol

Substrate material: sandstone
Slope: 3%
Landform element hillslope
Landform pattern: undulating low hills
Vegetation:
Structural form: open forest
Dominant species: *Lophostemon suaveolens, Angophora subvelutina, Eucalyptus tereticoris, E. crebra, Corymbia tessellaris*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	**Depth (m)**	**Description**
A1	0-0.10	Brown (7.5YR 4/4); sandy loam; moderate granular <2 mm; very few manganiferous concretions 2-6 mm. Clear to –
A3	0.10-0.35	Strong brown (7.5YR 5/8); fine sandy clay loam; massive; very few manganiferous concretions 2-6 mm; very few ferromanganiferous nodules 6-20 mm. Gradual to –
B21t	0.35-0.60	Yellowish brown (10YR 5/8); clay loam, sandy; massive; few ferromanganiferous nodules 6-20 mm. Gradual to –
B22t	0.60-0.80	Yellowish brown (10YR 5/8); clay loam, sandy; massive; common ferromanganiferous nodules 6-22 mm; common pale mottles distinct 5-15 mm; very few coarse fragments 6-20 mm. Gradual to –
B3t	0.80-1.20	Reddish yellow (7.5YR 6/6); clay loam coarse sandy; common pale mottles, distinct 5-15 mm; few coarse fragments 6-20 mm (sandstone).

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.2	0.19	.002																	5.5
0.00-0.10	6.0	0.13	.002	49	21	13	17	4	2.5	1.2	0.06	0.35	2	.043	1.39	.034	1.00	6	0.61	5.1
0.20-0.30	5.8	0.02	.001	45	19	11	25	3	1.4	0.85	0.05	0.35	2	.031	1.38	.025	1.00	8	0.72	4.5
0.50-0.60	5.7	0.02	.001	43	22	12	22	2	1.1	1.1	0.05	0.20	3	.028	1.69	.020	1.00	8	0.79	4.4
0.80-0.90	6.3	0.01	.001	43	20	13	22	3	1.6	1.6	0.08	0.21	3	.025	1.52	.019	1.20	7	0.75	4.9

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	1.6	0.09	8.0		0.39	21	50	0.25	0.99

aqueous cations at pH 7.0
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **BEER**
Site No: 1555
AMG reference: 440 750 mE 6 989 350 mN
Great soil group: Grey clay
Principal profile form: Ug5.21
Australian soil classification: Endocalcareous, Self-mulching, Grey Vertosol

Substrate material: siltstone
Slope: 6%
Landform element hillslope
Landform pattern: undulating low hills
Vegetation:
Structural form: cleared
Dominant species: *Eucalyptus crebra, Bothriochloa decepiens, Cynodon dactylon*

Profile morphology:

Condition of surface soil when dry: Self-mulching, periodic cracking

Horizon	**Depth (m)**	**Description**
A11	0-0.08	Black (10YR2/1) moist; light clay; moderate 2-5 mm subangular blocky; moderately moist; moderately firm. Clear to –
B21	0.08-0.18	Very dark grey (10YR3/1) moist; medium clay; strong 5-10 mm subangular blocky; moderately moist; moderately strong. Abrupt to –
B22	0.18-0.40	Dark greyish brown (10YR4/2) moist; light medium clay; very few large pebbles; strong 20-50 mm lenticular; moderately moist; very firm. Gradual to –
B23k	0.40-0.70	Dark greyish brown (2.5Y4/2) moist; light medium clay; very few small pebbles, subrounded siltstone; strong 20-50 mm lenticular; moderately moist; very firm; very few medium calcareous nodules. Gradual to –
B24k	0.70-1.20	Brown (10YR4/3) moist; light medium clay; moderate 20-50 mm lenticular; moderately moist; very firm; very few coarse calcareous nodules. Gradual to –
B25	1.20-1.50	Dark grey (10YR4/1) moist; light medium clay; strong 20-50 mm lenticular; moderately moist; very firm; common very coarse calcareous nodules.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.2	0.10	32	7	27	23	42	26	16.0	7.5	0.49	2.30								5.4
0.00-0.10	7.0	0.05	23	3	14	17	64	37	24.0	11.0	1.20	0.71	2	.148	1.15	.072	4.60	24	0.28	5.4
0.20-0.30	8.3	0.27	162	6	26	19	49	48	31.0	14.0	2.60	0.19	3	.059	0.74	.026	5.90	28	0.42	5.9
0.50-0.60	8.4	0.56	566	12	32	20	36	50	31.0	15.0	4.00	0.19	5	.124	0.708	.019	4.40	23	0.51	7.5
0.80-0.90	8.1	0.99	1187	9	22	19	50	49	28.0	16.0	4.40	0.24	8	.156	0.896	.011	4.70	21	0.67	7.7
1.10-1.20	8.3	0.94	1087										9	.094	0.904	.009	5.10			7.7
1.40-1.50	8.8	0.96	.106																	7.9

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	4.6	0.33	105	10	2.1	196	44	1.9	6.2

alcoholic cations at pH 8.5
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **CABOONBAH**
Site No: 761
AMG reference: 443 400 mE 6 997 350 mN

Great soil group: Brown clay
Principal profile form: Ug5.32
Australian soil classification: Haplic, Epipedal, Brown Vertosol

Substrate material: mudstone
Slope: 5%
Landform element hillslope
Landform pattern: undulating low hills
Vegetation:
Structural form: cleared
Dominant species: remnant softwood scrub species, *Panicum maximum, Bothriochloa decepiens*

Profile morphology:

Condition of surface soil when dry: periodic cracking

Horizon	Depth (m)	Description
A1	0-0.15	Brown (7.5YR4/4) moist; light clay; strong 2-10 mm subangular blocky (or granular); moderately moist; moderately weak. Gradual to –
B21	0.15-0.70	Strong brown (7.5YR4/6) moist; few fine distinct yellow mottles; light medium clay; strong 20-50 mm angular blocky; moist; moderately firm; few medium manganiferous soft segregations. Gradual to –
BC	0.70-0.90	Reddish yellow (7.5YR6/6) moist; light medium clay; few medium pebbles, angular mudstone; moderate 10-20 mm angular blocky; moderately moist; moderately firm.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations[#] meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500[+]	disp. ratio R1	pH CaCl2
B[†] 0-0.10	6.1	0.23	.002																	
0.00-0.10	6.4	0.12	.012	8	22	17	56	25	15.0	8.40	0.83	0.85	3	.078	.82	.031	3.60	18	0.41	
0.20-0.30	6.6	0.14	.007	4	20	19	59	29	17.0	10.0	2.10	0.36	7	.051	.899	.041	2.98	19	0.64	
0.50-0.60	7.6	0.29	.008	1	32	17	48	31	15.0	12.0	3.90	0.16	13	.057	1.38	.04	2.77	16	0.77	
0.80-0.90	9.4	0.31	.018	6	40	27	30	32	14.0	13.0	4.80	0.09	15	.133	1.25	.037	2.93	13	0.45	

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B[†] 0-0.10	2.0	0.18	63	-	1.5	67	132	3.1	4.1

[#] alcoholic cations at pH 8.5
[+] -1500 kPa (-15 bar) using pressure plate apparatus
[†] refers to bulking of a number of surface samples prior to analysis

Soil profile class: **GREINKE**
Site No: 2116
AMG reference: 434 100 mE 7 040 500 mN

Great soil group: Lithosol
Principal profile form: Um1.2
Australian soil classification: Leptic Rudosol

Substrate material: sandstone
Slope: 35%
Landform element hillcrest
Landform pattern: steep mountains
Vegetation:
Structural form: woodland
Dominant species: *Eucalyptus melanophloia, Eucalyptus crebra, Eucalyptus tereticornis, Hyparrhenia filipendula, Heteropogon contortus*

Surface coarse fragments: few cobbles, rounded conglomerate

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A1	0-0.15	Very dark greyish brown (10YR3/2) moist; clay loam, fine sandy; weak; dry; very weak.
C	0.15-0.20	Weathered conglomerate.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations[#] meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500[+]	disp. ratio R1	pH CaCl2
B[†] 0-0.10	6.3	0.10	.005	–	–	–	–	17	11	4.3	0.09	1.9	1	–	–	–	–	–	–	–

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B[†] 0-0.10	5.1	0.28	109	8	2.0	108	37	0.47	10

[#] alcoholic cations at pH 8.5
[+] -1500 kPa (-15 bar) using pressure plate apparatus
[†] refers to bulking of a number of surface samples prior to analysis

Soil profile class: **MOORE**
Site No: S10
AMG reference: 434 180 mE 7 025 590 mN

Great soil group: Solodic soil
Principal profile form: Dy2.42
Australian soil classification: Eutrophic, Subnatric, Brown Sodosol

Substrate material:
Slope: 7%
Landform element pediment
Landform pattern: rolling low hills
Vegetation:
Structural form: woodland
Dominant species: *Eucalyptus crebra, E.tereticornis, Chloris gayana, Sporobolis creber*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A1	0-0.15	Dark brown (7.5YR3/2) moist; clay loam, fine sandy; moderate 2-5 mm granular; moderately moist; moderately weak. Gradual to –
A2e	0.15-0.28	Pinkish white (7.5YR8/2) dry, brown (7.5YR4/3) moist; clay loam, fine sandy; moderate 2-5 mm granular; moderately moist; moderately weak. Clear to –
B21t	0.28-0.70	Yellowish brown (10YR5/4) moist; light medium clay; very few medium pebbles, angular sandstone; strong 20-50 mm lenticular with strong 20-50 mm angular blocky; moderately moist; very strong; very few fine manganiferous nodules. Gradual to –
BCt	0.70-0.90	Brownish yellow (10YR6/6) moist; few medium faint dark mottles, common medium distinct pale mottles; light clay; common medium pebbles, angular platy sandstone; strong 10-20 mm angular blocky; moderately moist; moderately strong; few medium manganiferous soft segregations.

depth	1:5 soil/water			particle size				exchangeable cations#					ESP	total elements			moistures		disp.	pH
metres	pH	EC	Cl	%				meq/100g					%	%			%		ratio	$CaCl_2$
		dS/m	%	@105C										@65C			@105C		R1	
				CS	FS	SIL	CLA	CEC	Ca	Mg	Na	K		P	K	S	ADM	1500+		
B† 0-0.10	6.6	0.06	.002																	
0.00-0.10	6.1	0.04	.001	16	25	33	26	11	7.20	2.90	0.31	0.80	3	.075	1.80	.043	1.80	13	0.61	5.0
0.20-0.27	6.2	0.03	.001	14	24	32	29	10	6.10	2.80	0.42	0.27	4	.046	1.85	.027	1.40	13	0.78	4.9
0.50-0.60	6.4	0.10	.013	5	21	18	50	26	16.0	7.70	1.90	0.31	7	.025	1.28	.02	3.40	22	0.76	5.5
0.80-0.90	6.7	0.28	.035	23	27	18	30	32	20.0	8.10	4.10	0.22	13	.07	1.43	.018	3.10	17	0.81	6.5

depth	organic C	total N	extractable P	extractable	extractable K	DTPA-extractable elements			
	%	%	mg/kg	SO4-S	meq/100g	mg/kg			
metres			bicarb.	mg/kg	HCl	Fe	Mn	Cu	Zn
B† 0-0.10	3.9	0.23	29		1.2	135	48	0.6	3

alcoholic cations at pH 8.5
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **DUNWICH**
Site No: 2458
AMG reference: 445 580 mE 7 017 620 mN

Great soil group: Solodic soil
Principal profile form: Dy2.33
Australian soil classification: Eutrophic, Sodic, Brown Chromosol

Surface coarse fragments: very few cobbles, angular andesite

Substrate material: andesite
Slope: 5%
Landform element hillslope
Landform pattern: undulating low hills
Vegetation:
Structural form: woodland
Dominant species: *Eucalyptus tereticornis, E.crebra, Bothriochloa decepiens*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A1	0-0.17	Black (10YR2/1) moist; clay loam, fine sandy; weak 2-5 mm granular; moderately moist; very weak. Gradual to –
A2j	0.17-0.22	Greyish brown (10YR5/2) moist, light brownish grey (10YR6/2) dry; clay loam, fine sandy; very few medium fragments, angular andesite; weak 2-5 mm granular; moderately moist; very weak. Abrupt to –
B21t	0.22-0.40	Yellowish brown (10YR5/4) moist; very few fine faint red mottles; medium clay; strong 10-20 mm angular blocky; moderately moist; moderately firm; very few medium manganiferous nodules. Gradual to –
B22t	0.40-0.75	Brown (10YR4/3) moist; medium clay; strong 10-20 mm angular blocky with moderate 10-20 mm lenticular; moderately moist; moderately firm; few medium manganiferous nodules. Gradual to –
BCt	0.75-0.90	Very dark grey (10YR3/1) moist; weak platy; moderately moist; moderately firm; very few fine manganiferous soft segregations.

depth	1:5 soil/water			particle size				exchangeable cations#					ESP	total elements			moistures		disp.	pH
metres	pH	EC	Cl	%				meq/100g					%	%			%		ratio	$CaCl_2$
		dS/m	%	@105C										@65C			@105C		R1	
				CS	FS	SIL	CLA	CEC	Ca	Mg	Na	K		P	K	S	ADM	1500+		
B† 0-0.10	5.8	0.10	.002																	
0.00-0.10	6.1	0.05	bq	21	25	25	29	13	8.30	3.80	0.15	0.55	1	.097	.545	.031	2.37	15	0.52	5.1
0.20-0.30	6.8	0.03	.001	11	11	16	66	21	9.60	10.0	0.84	0.28	4	.031	.384	.013	4.68	24	0.49	5.5
0.50-0.60	7.4	0.04	.002	8	13	13	64	26	11.0	13.0	1.50	0.31	6	.019	.548	.011	5.21	25	0.66	5.9
0.80-0.90	8.3	0.07	.003	27	24	15	35	38	18.0	17.0	3.00	0.23	8	.078	1.1	.008	5.02	18	0.69	6.6

depth	organic C	total N	extractable P	extractable	extractable K	DTPA-extractable elements			
	%	%	mg/kg	SO4-S	meq/100g	mg/kg			
metres			bicarb.	mg/kg	HCl	Fe	Mn	Cu	Zn
B† 0-0.10	2.4	0.13	38	11	0.5	113	86	1.4	2.7

aqueous cations at pH 7.0
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **PADDY**
Site No: 1464
AMG reference: 443 690 mE 7 016 340 mN
Great soil group: Soloth
Principal profile form: Dy3.31
Australian soil classification: Brown Chromosol (probable)

Substrate material: andesite
Slope: 15%
Landform element hillslope
Landform pattern: rolling hills
Vegetation:
Structural form: woodland
Dominant species: *Eucalyptus crebra, E.tereticornis, Araucaria cunninghamii, Lantana camara, Aristida queenslandica, Cynodon dactylon*

Surface coarse fragments: common large pebbles, angular andesite

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A1	0-0.15	Very dark grey (10YR3/1) moist; clay loam, fine sandy; moderate 2-5 mm granular; moderately moist; moderately weak. Field pH 6.5. Gradual to –
A2j	0.15-0.20	Dark grey (10YR4/1) moist; clay loam, fine sandy; moderate 2-5 mm granular; moderately moist; moderately weak. Abrupt to –
B21	0.20-0.35	Brown (10YR5/3) moist; common coarse prominent dark mottles; light medium clay; strong 20-50 mm prismatic parting to moderate 10-20 mm angular blocky; dry; moderately strong; very few fine manganiferous nodules. Field pH 7.0. Gradual to –
B22	0.35-0.65	Light olive brown (2.5Y5/4) moist; light medium clay; strong 10-20 mm lenticular; dry; moderately strong. Field pH 7.0. Gradual to –
BC	0.65-1.55	Yellow (10YR7/8) moist; common coarse prominent grey mottles; light clay; moderately moist; moderately weak. Field pH 4.5.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations[#] meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500[+]	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.2	0.11	.001	–	–	–	–	15	9.0	5.6	0.30	0.56		–	–	–	–	–	–	5.9

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	2.9	0.20	26	8	0.59	89	41	0.50	1.5

Note: no profile laboratory data for Paddy

[#] aqueous cations at pH 7.0
[+] -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **STEVENTON**
Site No: 2457
AMG reference: 449 390 mE 7026 050 mN
Great soil group: Red podzolic soil
Principal profile form: Dr2.21
Australian soil classification: Haplic, Mesotrophic, Red Kurosol

Substrate material: ?
Slope: 7%
Landform element hillslope
Landform pattern: undulating low hills
Vegetation:
Structural form: cleared
Dominant species: *Eucalyptus crebra, Lophostemon contortus, Eucalyptus melanophloia, Cymbopogon refractus, Sporobolis creber*

Surface coarse fragments: few stones, angular chert(?)

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A1	0-0.10	Black (10YR2/1) moist; sandy clay loam; few medium pebbles, angular chert(?); weak granular; moderately moist; moderately weak. Gradual to –
A2	0.10-0.30	Brown (7.5YR4/3) moist; sandy clay loam; few medium pebbles, angular chert; weak to massive; moderately moist; moderately weak. Clear to –
B2t	0.30-0.90	Red (2.5YR4/6) moist; light medium clay; strong 5-10 mm angular blocky; moderately moist; moderately firm; very few fine manganiferous soft segregations. Field pH 5.0. Gradual to –
BCt	0.90-1.20	Strong brown (7.5YR5/8) moist; few medium distinct grey mottles; fine sandy light clay; weak platy; moderately moist; moderately firm.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations[#] meq/100g ECEC	Ca	Mg	Na	K	Exch. Al meq/100 g	Exch. acid meq/100 g	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500[+]	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.0	0.08	.001																			
0.00-0.10	6.2	0.05	bq	27	33	16	23	9	5.30	3.20	0.06	0.74			1	.135	.356	.036	1.65	12	0.46	5.0
0.20-0.30	6.2	0.02	.001	23	34	14	29	4	1.90	2.00	0.09	0.24			2	.074	.297	.012	0.94	10	0.71	4.8
0.50-0.60	5.2	0.02	.002	13	21	6	59	8	0.31	2.80	0.14	0.16	4.6	4.6	2	.056	.590	.013	2.36	17	0.12	4.0
0.80-0.90	5.0	0.02	.001	19	26	6	47	7	0.08	1.40	0.11	0.08	4.8	4.9	2	.060	.528	.013	1.73	14	0.11	3.8

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO_4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	2	0.13	47	8	0.78	73	16	0.2	1.4

[#] aqueous cations at pH 7.0
[+] -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: LINVILLE
Site No: S7
AMG reference: 444 190 mE 7 039 840 mN
Great soil group: Affinities with non-calcic brown soil
Principal profile form: Dr2.12
Australian soil classification: Haplic, Eutrophic, Red Chromosol
Substrate material: andesite
Slope: 11%
Landform element hillcrest
Landform pattern: rolling hills
Vegetation:
Structural form: woodland
Dominant species: *Eucalyptus crebra, E.tereticornis, Eucalyptus acmenoides, Allocasuarina torulosa, Themeda australis*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A1	0-0.15	Dark reddish brown (5YR3/2) moist; clay loam; moderate 5-10 subangular blocky; moderately moist; moderately weak. Clear to –
B21t	0.15-0.45	Reddish brown (5YR4/4) moist; medium clay; strong 10-20 mm subangular blocky parting to 5-10 mm polyhedral; moderately moist; moderately firm; very few fine manganiferous nodules. Gradual to –
B22t	0.45-0.75	Yellowish red (5YR4/6) moist; medium clay; strong 10-20 mm angular blocky with moderate 20-50 mm lenticular; moderately moist; moderately strong; very few fine manganiferous soft segregations.
BCt	0.75-1.20	Reddish brown (5YR4/4) moist; few coarse distinct yellow mottles; light clay; common medium pebbles, andesite; moderate 2-5 mm polyhedral; dry; very firm.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations[#] meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500[+]	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.6	0.07	0.002																	
0.00-0.10	6.4	0.05	0.002					23	14.0	8.40	0.28	0.61	1	.118	.87	.056	3.70	20	0.43	5.4
0.20-0.30	6.3	0.03	0.001					28	13.0	14.0	0.59	0.29	2	.045	.794	.034	6.50	29	0.35	4.9
0.50-0.60	7.2	0.03	0.001	10	18	18	53	44	22.0	21.0	0.94	0.32	2	.023	.74	.025	6.80	27	0.39	6.0
0.80-0.90	7.4	0.02	0.001	37	27	13	26	55	33.0	21.0	0.88	0.15	2	.039	.56	.019	7.00	20	0.67	6.2
1.10-1.20	7.6	0.02	0.001	42	28	17	18	54	35.0	18.0	0.77	0.13	1	.043	.559	.019	6.30			6.1

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	5.8	0.35	68		1	147	113	3.9	6.1

[#] alcoholic cations at pH 8.5
[+] -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: NEARA
Site No: 1557
AMG reference: 438 350 mE 7 025 100 mN
Great soil group: Prairie soil
Principal profile form: Dd1.12
Australian soil classification: Melanic, Eutrophic, Black Chromosol
Surface coarse fragments: common large pebbles, subrounded andesite
Substrate material: andesite
Slope: 6%
Landform element hillslope
Landform pattern: undulating low hills
Vegetation:
Structural form:
Dominant species: *Eucalyptus crebra, E.tereticornis, Corymbia intermedia, Heteropogon contortus, Bothriochloa bladhii*

Profile morphology:

Condition of surface soil when dry: firm

Horizon	Depth (m)	Description
A1	0-0.14	Black (10YR2/1) moist; clay loam; strong 5-10 mm subangular blocky; moderately moist; moderately weak. Clear to –
B21t	0.14-0.40	Very dark greyish brown (10YR3/2) moist; medium clay; few large pebbles, subrounded andesite; moderate 10-20 mm prismatic; moderately moist; moderately firm; few medium manganiferous nodules. Gradual to –
B22t	0.40-0.60	Dark greyish brown (10YR4/2) moist; medium clay; few small pebbles, subrounded andesite; strong 10-20 mm lenticular; moist; moderately firm; few medium manganiferous nodules. Gradual to –
BCt	0.60-0.80	Brown (10YR4/3) moist; sandy light medium clay; moderate 5-10 mm platy; moderately moist; moderately weak; common medium manganiferous nodules.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations[#] meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500[+]	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.0	0.06	.002																	
0.00-0.10	6.1	0.03	.001	24	19	21	35	16	10.0	4.90	0.21	0.68	1	.099	.532	.045	3.90	19	0.38	5.1
0.20-0.30	6.9	0.03	bq	11	10	12	68	26	16.0	8.60	0.77	0.21	3	.031	.357	.024	5.20	27	IS	5.9
0.50-0.60	7.7	0.07	.003	11	15	15	59	32	19.0	12.0	1.30	0.16	4	.017	.477	.014	4.20	25	IS	6.7

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	2.6	0.18	17	7	0.38	96	45	1.3	1.9

[#] alcoholic cations at pH 8.5
[+] -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **DEER (alkaline variant)**
Site No: S4
AMG reference: 449 968 mE 7 019 497 mN
Great soil group: Prairie soil
Principal profile form: Db1.13
Australian soil classification: Melanic, Eutrophic, Brown Chromosol

Substrate material: andesite
Slope: 10%
Landform element hillcrest
Landform pattern: undulating rises
Vegetation:
Structural form: softwood scrub
Dominant species: *Ficus species, Flindersia australis, Lantana camara, Chloris species, Sporobolis creber*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	**Depth (m)**	**Description**
A1	0-0.0.26	Dark brown (7.5YR3/2) moist; clay loam; strong <2mm granular; moderately moist; very weak; many 1-2mm roots. Gradual to –
B21t	0.26-0.57	Brown (10YR4/3) moist; medium clay; very few small pebbles, andesite; strong 10-20 mm angular blocky; moderately moist; very firm; very few fine manganiferous soft segregations; few 1-2mm roots. Gradual to –
B22t	0.57-0.80	Brown (10YR4/3) moist; light medium clay; few medium pebbles, andesite; strong 10-20 mm angular blocky; moderately moist; moderately strong; manganiferous; few 1-2mm roots. Gradual to –
BCt	0.80-1.15	Brown (10YR4/3) moist; clay loam; many medium pebbles, andesite; moderate 5-10 mm subangular blocky; dry; moderately firm; very few medium calcareous concretions, few medium calcareous soft segregations.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.7	0.17	0.001																	
0.00-0.10	6.8	0.15	0.001	23	22	22	30	19	14.0	4.0	0.15	1.10	1	.103	2.53	.071	2.70	17	0.37	5.6
0.25-0.35	7.4	0.17	0.001	10	19	18	48	37	28.0	8.60	0.42	0.38	1	.032	1.51	.032	4.70	20	0.64	6.5
0.50-0.60	7.6	0.17	0.001	14	22	20	41	41	30.0	10.0	0.63	0.27	2	.032	1.3	.029	4.30	20	0.67	6.6
0.80-0.90	8.2	0.22	0.001	49	26	8	14	36	26.0	9.40	0.86	0.16	2	.043	.58	.02	4.30	13	0.56	7.4
1.10-1.20	8.4	0.26	0.001	33	22	9	33	45	30.0	13.0	1.30	0.22	3	.039	.90	.023	5.80	20	0.63	7.8

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	4.5	0.52	58		1.4	109	52	1.5	10

alcoholic cations at pH 8.5
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **JIMNA**
Site No: 1106
AMG reference: 446 472 mE 7 006 906 mN
Great soil group: Brown Clay
Principal profile form: Ug5.32
Australian soil classification: Self-mulching, Mottled, Brown Vertosol

Substrate material: andesite
Slope: 5%
Landform element hillslope
Landform pattern: undulating rises
Vegetation:
Structural form: woodland
Dominant species: *Corymbia tessellaris, Cynodon dactylon, Bothriochloa decepiens*

Profile morphology:

Condition of surface soil when dry: periodic cracking, self-mulching

Horizon	**Depth (m)**	**Description**
A1	0-0.15	Dark brown (7.5YR3/2) moist; light clay; strong 2-5 mm granular; moderately moist; very weak; very few fine manganiferous nodules. Clear to –
B21	0.15-0.50	Brown (7.5YR4/3) moist; common medium distinct brown mottles; light medium clay; strong 5-10 mm prismatic; moderately moist; moderately firm; few medium ferro-manganiferous nodules. Gradual to –
BC	0.50-0.70	Yellowish grey (2.5Y5/2) moist; light medium clay; common medium pebbles, angular igneous rock (andesite); moderately moist; moderately weak.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	7.3	0.04	.002																	
0.00-0.10	7.3	0.04	.001	21	19	22	40	18	9.20	7.90	0.40	0.59	2	.086	.267	.036	2.55	17	0.52	5.6
0.20-0.30	7.7	0.06	.002	20	12	13	56	24	11.0	12.0	0.95	0.10	4	.046	.163	.025	3.19	23	0.51	6.0
0.50-0.60	8.5	0.16	.011	19	14	17	51	47	22.0	23.0	2.30	0.05	5	.038	.166	.015	4.33	24	0.64	7.2

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	1.75	0.13	17	10	1.2	67	61	2.1	0.88

alcoholic cations at pH 8.5
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **D'AGUILAR**
Site No: 2026
AMG reference: 444 350 mE 7 037 400 mN

Great soil group: no suitable group
Principal profile form: Um5.11
Australian soil classification: Haplic, Mellic, Brown Kandosol Leptic Rudosol

Surface coarse fragments: many cobbles, angular igneous rock (unidentified)

Substrate material:
Slope: 20%
Landform element hillslope
Landform pattern: rolling hills
Vegetation:
Structural form: open forest
Dominant species: *Eucalyptus crebra, E. fibrosa spp. fibrosa, Lophostemon contortus, Lantana camara, Acacia species, Cymbopogon refractus, Sporobolis creber*

Profile morphology:

Condition of surface soil when dry: loose

Horizon	Depth (m)	Description
A1	0-0.10	Dark brown (7.5YR3/2) moist; sandy clay loam; fragments, igneous rock (unidentified); weak granular; dry; very weak. Gradual to –
B	0.10-0.20	Brown (7.5YR4/3) moist; sandy clay loam; fragments, igneous rock (unidentified); weak structure; dry; very weak. Gradual to –
BC	0.20-0.40	Strong brown (7.5YR5/6) moist; sandy loam; weak structure; dry; very weak.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	5.7	0.07	.005	–	–	–	–	10	6.1	3.1	0.32	0.59	3	–	–	–	–	–	–	4.8

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	2.2	0.12	27	10	0.63	43	37	0.04	1.5

aqueous cations at pH 7.0
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **BURRUNDON**
Site No: 2593
AMG reference: 443 070 mE 6 988 260 mN

Great soil group: Solodic soil
Principal profile form: Dy3.43
Australian soil classification: Magnesic, Mottled-Mesonatric, Grey Sodosol

Substrate material: rhyolite
Slope: 10%
Landform element hillslope
Landform pattern: steep hills
Vegetation:
Structural form: open forest
Dominant species: *Eucalyptus exserta, E.melanophloia, Cynodon dactylon*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A1	0-0.08	Dark greyish brown (10YR4/2) moist; fine sandy loam; weak 5-10 mm granular; moderately moist; moderately weak. Clear to –
A2e	0.08-0.21	Greyish brown (10YR5/2) moist, white (10YR8/2) dry; fine sandy loam; few large pebbles, subrounded rhyolite; massive; moderately moist; moderately weak. Abrupt to –
B21t	0.21-0.45	Dark grey (10YR4/1) moist; common medium distinct grey mottles, very few medium distinct yellow mottles; medium clay; moderate 10-20 mm angular blocky; moderately moist; moderately firm.

depth	1:5 soil/water			particle size				exchangeable cations[#]					ESP	total elements			moistures		disp.	pH
metres	pH	EC	Cl	%				meq/100g					%	%			%		ratio	CaCl2
		dS/m	%	@105C										@65C			@105C		R1	
				CS	FS	SIL	CLA	CEC	Ca	Mg	Na	K		P	K	S	ADM	1500[+]		
B† 0-0.10	6.5	0.06	.003																	
0.00-0.10	6.6	0.06	.003	2	69	17	14	3	1.10	1.30	0.23	0.76	7	.015	2.66	.019	0.60	5	0.73	5.1
0.22-0.30	7.5	0.17	.010	1	38	12	48	14	0.60	10.0	2.50	0.64	18	.01	2.31	.019	2.30	19	0.90	6.3
0.35-0.45	8.2	0.31	.030															16		7.1

depth	organic C %	total N %	extractable P mg/kg	extractable SO4-S	extractable K meq/100g	DTPA-extractable elements mg/kg			
metres			bicarb.	mg/kg	HCl	Fe	Mn	Cu	Zn
B† 0-0.10	1.4	0.1	9	6	0.5	173	12	0.11	1.6

[#] aqueous cations at pH 7.0
[+] -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **ESK**
Site No: 2594
AMG reference: 443 080 mE 6 988 000 mN

Great soil group: Lithosol
Principal profile form: Uc1.
Australian soil classification: Leptic Rudosol

Surface coarse fragments: abundant cobbles, subangular rhyolite

Substrate material: rhyolite
Slope: 30%
Landform element hillslope
Landform pattern: rolling hills
Vegetation:
Structural form: open forest
Dominant species: *Eucalyptus exserta, Lantana camara, Cynodon dactylon*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A1	0-0.12	Greyish brown (10YR5/2) moist, fine sandy loam
R	0.12-0.20	fragments, rhyolite

depth	1:5 soil/water			particle size				exchangeable cations					ESP	total elements			moistures		disp.	pH
metres	pH	EC	Cl	%				meq/100g					%	%			%		ratio	CaCl2
		dS/m	%	@105C										@65C			@105C		R1	
				CS	FS	SIL	CLA	CEC	Ca	Mg	Na	K		P	K	S	ADM	1500[+]		
B† 0-0.10	5.9	0.03	.001	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–	4.9

depth	organic C %	total N %	extractable P mg/kg	extractable SO4-S	extractable K meq/100g	DTPA-extractable elements mg/kg			
metres			bicarb.	mg/kg	HCl	Fe	Mn	Cu	Zn
B† 0-0.10	1.5	0.08	6	5	0.33	35	33	0.05	1.2

[+] -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **PINCH**
Site No: 1556
AMG reference: 427 080 mE 6 994 330 mN

Great soil group: Brown Podzolic
Principal profile form: Db2.12
Australian soil classification: Haplic, Eutrophic, Brown Chromosol

Surface coarse fragments: common boulders, rounded granite

Substrate material: granodiorite
Slope: 15%
Landform element hillslope
Landform pattern: rolling low hills
Vegetation:
Structural form: predominantly cleared
Dominant species: *Corymbia intermedia, C.citriodora, Eucalyptus crebra, Cynodon dactylon, Heteropogon contortus*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A11	0-0.15	Dark brown (7.5YR3/2) moist; coarse sandy loam; weak 5-10 mm subangular blocky; moderately moist; very weak. Gradual to –
A12	0.15-0.30	Dark brown (7.5YR3/3) moist; coarse sandy loam; weak 5-10 mm subangular blocky; moderately moist; very weak. Clear to –
B21t	0.30-0.50	Strong brown (7.5YR4/6) moist; coarse sandy light clay; common small pebbles, subrounded granite; moderate 10-20 mm angular blocky; moderately moist; moderately firm; common coarse manganiferous nodules. Gradual to –
B22t	0.50-0.90	Yellowish brown (10YR5/4) moist; common medium prominent yellow mottles; sandy light medium clay; few small pebbles, subrounded granite; strong 10-20 mm prismatic; moderately moist; moderately firm; few coarse manganiferous nodules. Gradual to –
B23t	0.90-1.20	Yellowish red (5YR4/6) moist; coarse sandy light clay; many small pebbles, subrounded granite; moderate 5-10 mm platy; moderately moist; moderately firm; few fine manganiferous nodules.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.4	0.03	.001																	
0.00-0.10	6.2	0.02	bq	40	40	10	11	4	2.60	0.83	0.07	0.27	1	.024	1.17	.019	0.70	5	0.44	5.3
0.20-0.30	6.5	0.01	.001	43	38	7	13	3	2.30	0.82	0.06	0.26	2	.015	1.19	.011	0.50	5	0.73	5.4
0.50-0.60	7.1	0.02	.001	29	28	8	35	10	6.40	3.10	0.21	0.09	2	.015	1.09	.011	1.40	13	0.53	6.2
0.80-0.90	7.6	0.03	.001	29	28	6	37	15	10.0	5.30	0.38	0.07	2	.014	.939	.008	1.80	14	0.50	6.7
1.10-1.20	7.6	0.02	.001	30	29	6	35	16	11.0	5.60	0.41	0.06	3	.014	.936	.009	1.80			6.5

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	1.4	0.09	7	4.0	0.27	51	14	0.36	0.87

alcoholic cations at pH 8.5
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **GILLA**
Site No: 868
AMG reference: 425 730 mE 6 996 050 mN

Great soil group: no suitable group
Principal profile form: Dy3.42
Australian soil classification: Bleached, Eutrophic, Brown Chromosol

Substrate material: granodiorite
Slope: 14%
Landform element hillslope
Landform pattern: rolling low hills
Vegetation:
Structural form: woodland
Dominant species: *Eucalyptus tereticornis, E.crebra, E.melanophloia Angophora subvelutina, Corymbia intermedia, Heteropogon contortus, Aristida queenslandica*

Profile morphology:

Condition of surface soil when dry: firm

Horizon	Depth (m)	Description
A1	0-0.15	Dark brown (7.5YR3/2) moist; coarse sandy clay loam; weak <2mm granular; dry; very weak. Clear to –
A2e	0.15-0.45	Brown (10YR5/3) moist, light grey (10YR7/2) dry; coarse sandy loam; massive; dry; loose. Clear to –
B21t	0.45-0.75	Yellowish brown (10YR5/4) moist; common medium distinct brown mottles; sandy clay; few medium pebbles, angular granodiorite; strong 20-50 mm angular blocky; moderately moist; moderately firm; very few fine manganiferous soft segregations. Gradual to –
B22t	0.75-1.25	Yellowish brown (10YR5/4) moist; sandy clay; common medium pebbles, angular granodiorite; strong 10-20 mm subangular blocky; moderately moist; moderately firm; very few fine manganiferous soft segregations.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	6.5	0.03	2																	
0.00-0.10	6.4	0.03	1	45	38	4	12	4	2.80	0.98	0.02	0.26	0	.052	1.5	.019	0.58	4	0.62	5.4
0.20-0.30	7.0	0.02	0	46	40	9	7	2	1.40	0.71	0.04	0.19	2	.031	1.58	.009	0.41	3	0.69	5.8
0.50-0.60	7.2	0.02	3	36	31	0	43	5	3.30	1.60	0.09	0.33	2	.028	1.9	.01	1.22	9	0.72	6.1
0.80-0.90	7.2	0.02	9	39	31	6	24	7	4.00	2.10	0.16	0.25	2	.035	1.95	.008	1.37	9	0.78	6.3
1.10-1.20	7.3	0.02	14	42	32	5	20							.033	1.87	.008	1.15			6.2

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	1.1	0.1	21	4	0.46	53	10	0.24	1.1

aqueous cations at pH 7.0
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **BIARRA**
Site No: 2455
AMG reference: 426 150 mE 6 991 560 mE

Great soil group: no suitable group
Principal profile form: Dy2.31
Australian soil classification: Mottled, Eutrophic, Brown Chromosol

Surface coarse fragments: very few large pebbles, angular granodiorite

Substrate material: granodiorite
Slope: 11%
Landform element hillslope
Landform pattern: rolling hills
Vegetation:
Structural form: open woodland
Dominant species: *Eucalyptus crebra, Corymbia citriodora, Cynodon dactylon, Bothriochloa decepiens*

Profile morphology:

Condition of surface soil when dry: firm to hard setting

Horizon	Depth (m)	Description
A1	0-0.15	Very dark grey (10YR3/1) moist; coarse sandy loam; weak; moderately moist; very weak. Gradual to –
A2j	0.15-0.25	Yellowish brown (10YR5/4) moist, light brownish grey (10YR6/2) dry; coarse sandy loam; massive; moderately moist; very weak. Clear to –
B2	0.25-0.50	Brown (10YR5/3) moist; few medium distinct brown mottles; coarse sandy light medium clay; many medium pebbles, subrounded granite; moderate 10-20 mm angular blocky; moist; moderately weak. Gradual to –
C	0.50-0.65	Fragments, granite; moderately moist; very weak.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH CaCl2
B† 0-0.10	5.9	0.03	.001																	
0.00-0.10	6.1	0.05	.001	42	40	8	10	4	2.90	1.20	0.05	0.28	1	.026	1.7	.021	0.90	5	0.49	5.2
0.25-0.30	6.4	0.03	.001	36	23	4	37	15	8.10	6.30	0.62	0.41	4	.012	1.34	.014	3.00	15	0.72	5.0
0.50-0.60	7.2	0.03	.001	47	30	5	19	16	8.90	6.20	0.86	0.17	5	.009	1.66	.017	1.90	10	0.75	5.7

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	1.4	0.11	12	5	0.42	177	6.0	0.09	1.1

aqueous cations at pH 7.0
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **REBEL**
Site No: MFM S19
AMG reference: 423 000 mE 6 996 000 mN

Great soil group: Red podzolic soil
Principal profile form: Dr4.22
Australian soil classification: Haplic, Eutrophic, Red Chromosol

Substrate material: granodiorite
Slope: 12%
Landform element hillslope
Landform pattern: rolling hills
Vegetation:
Structural form: open forest
Dominant species: *Angophora floribunda, A. leiocarpa, Eucalyptus tereticornis, Corymbia tessellaris*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A1	0-0.15	Dark reddish brown (5YR 3/2); sandy clay loam; massive; dry weak. Gradual to –
A2	0.15-0.25	Reddish brown (5YR 4/4); sandy clay loam; massive; dry weak. Clear to –
B21t	025-0.35	Dark red (2.5YR 3/6) medium clay; weak angular blocky 20-50 mm; dry very firm. Gradual to –
B22t	0.35-0.55	Red (2.5YR 4/6); medium clay; moderate angular blocky 20-50 mm; dry very firm. Clear to –
C	0.55-0.80	Yellowish red (5YR 4/6); sandy loam; massive.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH CaCl2
B† 0-0.10	6.0	0.09	.001																	4.9
0.00-0.10	6.5	0.09	.001	36	37	7	20	7	5.3	1.6	0.07	.36	1	.037	1.89	.038	1.8	8	0.64	5.5
0.10-0.20	6.7	0.05	.001	35	34	6	25	7	5.2	1.4	0.07	.25	1	.030	1.79	.035	1.9	9	0.63	5.6
0.25-0.30	6.8	0.04	.001	25	18	5	50	9	6.4	1.7	0.12	.32	1	.028	1.25	.038	3.6	17	0.53	5.8
0.40-0.50	7.4	0.04	.001	21	13	9	55	10	7.5	2.0	0.17	.23	2	.023	.997	.029	4.3	21	0.56	6.3
0.70-0.80	7.9	0.03	.001	54	22	9	13	11	9.3	1.8	0.21	.08	2	.024	1.43	.020	2.6	9	0.90	6.7

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	1.6	0.09	4		0.34	40	21	0.64	0.98

aqueous cations at pH 7.0
+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **IVORY**
Site No: 2466 (same as MFM S11)
AMG reference: 4333 900 mE 7 000 100 mN
Great soil group: Earthy sand
Principal profile form: Uc5.23
Australian soil classification: Basic, Paralithic, Orthic Tenosol

Substrate material: granodiorite wash
Slope: 6%
Landform element footslope
Landform pattern: rolling low hills
Vegetation:
Structural form: woodland
Dominant species: *Eucalyptus tereticornis, E.crebra, E.tessellaris, Angophora leiocarpa*

Profile morphology:

Condition of surface soil when dry: firm.

Horizon	**Depth (m)**	**Description**
A1	0-0.15	Dark greyish brown (10YR4/2); loamy coarse sand; massive; moist; moderately weak. Gradual to –
A31	0.15-0.40	Brown (10YR4/3); loamy coarse sand; massive; dry; very firm. Gradual to –
A32	0.40-0.55	Brown (10YR4/3); clayey coarse sand; massive; dry; moderately firm. Gradual to –
B1	0.55-0.95	Yellowish brown (10YR5/4); clayey coarse sand; massive; dry; moderately firm. Gradual to –
B2	0.95-1.20	Brown (7.5YR5/4); clayey coarse sand; very few large pebbles, angular granite; massive; dry; moderately firm.

depth	1:5 soil/water			particle size				exchangeable cations[#]					ESP	total elements			moistures		disp.	pH
metres	pH	EC	Cl	%				meq/100g					%	%			%		ratio	$CaCl_2$
		dS/m	%	@105C										@65C			@105C		R1	
				CS	FS	SIL	CLA	CEC	Ca	Mg	Na	K		P	K	S	ADM	1500[+]		
B[†] 0-0.10	6.4	0.07	.001																	
0.00-0.10	6.8	0.02	.001	72	15	12	4	3	2.2	0.92	0.04	0.25	1	.027	2.39	.029		2	0.66	
0.20-0.30	6.2	0.01	.001	67	18	11	6	2	1.2	0.49	0.09	0.16	5	.020	2.44	.019		2	0.72	
0.50-0.60	6.5	0.01	.001	62	22	9	4	2	1.2	0.52	0.07	0.08	4	.019	2.59	.017		2	0.96	
0.80-0.90	6.8	0.01	.001	58	18	12	9	3	1.6	1.2	0.08	0.15	3	.016	2.60	.017		4	0.99	
1.10-1.20	6.9	0.01	.001	58	19	11	9	4	1.7	1.6	0.09	0.21	2	.017	2.40	.017				

depth	organic C %	total N %	extractable P mg/kg	extractable SO4-S	extractable K meq/100g	DTPA-extractable elements mg/kg			
metres			bicarb.	mg/kg	HCl	Fe	Mn	Cu	Zn
B[†] 0-0.10	1.3	0.08	4		0.41	23	32	0.36	0.63

[#] aqueous cations at pH 7.0
[+] -1500 kPa (-15 bar) using pressure plate apparatus
[†] refers to bulking of a number of surface samples prior to analysis

Soil profile class: **ESKVALE**
Site No: 2459
AMG reference: 428 070 mE 7 016 980 mN
Great soil group: Solodic soil
Principal profile form: Db1.42
Australian soil classification: Eutrophic, Subnatric, Brown Sodosol
Surface coarse fragments: few large pebbles, angular chert

Substrate material: chert
Slope: 5%
Landform element hillslope
Landform pattern: undulating low hills
Vegetation:
Structural form: cleared
Dominant species: *Eucalyptus crebra, Cynodon dactylon, Sporobolis creber*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	**Depth (m)**	**Description**
A1	0-0.10	Very dark grey (10YR3/1) moist; silty clay loam; weak; moderately moist; moderately weak. Gradual to –
A2e	0.10-0.20	Greyish brown (10YR5/2) moist, white (10YR8/2) dry; silty clay loam; massive; moderately moist; moderately weak. Clear to –
B2t	0.20-0.40	Strong brown (7.5YR4/6) moist; very few medium faint red mottles; light medium clay; moderate coarse columnar parting to strong 10-20 mm angular blocky; dry; very firm. Gradual to –
BCt	0.40-0.60	Yellowish brown (10YR5/8) moist; common medium pebbles, angular chert; dry; very firm.

depth	1:5 soil/water			particle size				exchangeable cations[#]					ESP	total elements			moistures		disp.	pH
metres	pH	EC	Cl	%				meq/100g					%	%			%		ratio	$CaCl_2$
		dS/m	%	@105C										@65C			@105C		R1	
				CS	FS	SIL	CLA	CEC	Ca	Mg	Na	K		P	K	S	ADM	1500[+]		
B† 0-0.10	5.7	0.08	.001																	
0.00-0.10	5.4	0.07	.001	13	30	29	27	7	3.60	2.80	0.20	0.32	3	.053	.701	.027	1.52	10	0.68	4.5
0.20-0.30	5.9	0.09	.008	9	20	18	55	15	3.30	9.20	2.10	0.23	14	.019	1.25	.011	2.57	17	0.82	4.5
0.50-0.60	6.7	0.39	.054	10	18	17	55	21	4.80	11.0	5.40	0.22	25	.017	1.63	.01	3.10	17	0.89	5.7

depth	organic C %	total N %	extractable P mg/kg	extractable SO4-S	extractable K meq/100g	DTPA-extractable elements mg/kg			
metres			bicarb.	mg/kg	HCl	Fe	Mn	Cu	Zn
B† 0-0.10	2.2	0.18	12	9	0.36	154	25	0.49	1.8

[#] aqueous cations at pH 7.0
[+] -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class: **HORSE**
Site No: 2596
AMG reference: 427 990 mE 7 014 340 mN
Great soil group: no suitable group
Principal profile form: Dy3.41
Australian soil classification: Bleached-Sodic, Brown Chromosol

Substrate material: chert
Slope: 10%
Landform element hillslope
Landform pattern: rolling low hills
Vegetation:
Structural form: woodland
Dominant species: *Eucalyptus melanophloia, E.tereticornis, Corymbia tessellaris, Lantana camara, Chloris gayana, Melinis repens*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	**Depth (m)**	**Description**
A1	0-0.20	Very dark grey (10YR3/1) moist; clay loam, fine sandy; few large pebbles, subangular chert; weak 5-10 mm subangular blocky; moderately moist; moderately weak. Clear to –
A2e	0.20-0.30	Pale brown (10YR6/3) moist, very pale brown (10YR8/3) dry; clay loam, fine sandy; many large pebbles, subangular chert; massive; moderately moist; moderately weak. Abrupt to –
B21t	0.30-0.60	Brown (10YR5/3) moist; common medium distinct red mottles, few medium distinct pale mottles; medium clay; moderate 10-20 mm angular blocky; moist; moderately firm. Clear to –
B22t	0.60-0.80	Light brownish grey (2.5Y6/2) moist; medium clay; few medium pebbles, subangular chert; weak 10-20 mm angular blocky; moist; moderately firm.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations[#] meq/100g ECEC	Ca	Mg	Na	K	Exch. Al meq/100 g	Exch. acid meq/100 g	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500[+]	disp. ratio R1	pH $CaCl_2$
B[†] 0-0.10	5.9	0.03	.001																			
0.00-0.10	6.1	0.03	.001	16	30	23	31	11	6.20	3.50	0.06	0.79			1	.063	1.87	.033	1.90	15	0.46	5.1
0.20-0.30	6.4	0.03	.001	12	31	23	33	7	4.20	2.50	0.13	0.36			2	.029	1.67	.012	1.10	12	0.76	5.2
0.50-0.60	6.1	0.04	.002	4	13	19	63	15	5.50	8.00	0.70	0.34			5	.023	3.05	.009	2.60	20	0.73	4.7
0.75-0.85	5.5	0.07	.007	15	9	16	59	12	2.20	8.10	1.20	0.31	3.1	3.5	10	.022	3.3	.008	2.70	16	0.60	4.2

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO_4-S meq/100g	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B[†] 0-0.10	1.7	0.09	17	5	0.5	113	10	0.84	1.2

[#] aqueous cations at pH 7.0
[+] -1500 kPa (-15 bar) using pressure plate apparatus
[†] refers to bulking of a number of surface samples prior to analysis

Soil profile class: **FREEMAN**
Site No: 2461
AMG reference: 430 090 Me 7 014 770 mN
Great soil group: no suitable group
Principal profile form: Dr3.11
Australian soil classification: Eutrophic, Subnatric, Red Sodosol

Substrate material: chert
Slope: 14%
Landform element hillslope
Landform pattern: rolling hills
Vegetation:
Structural form: woodland
Dominant species: *Eucalyptus crebra, E.melanophloia, E.tereticornis Heteropogon contortus, Aristida queenslandica*

Surface coarse fragments: common large pebbles, angular chert

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	**Depth (m)**	**Description**
A1	0-0.15	Very dark greyish brown (10YR3/2) moist; clay loam, fine sandy; very few medium pebbles, angular chert; weak 2-5 mm granular; moderately moist; very weak. Abrupt to –
B21t	0.15-0.35	Dark red (2.5YR3/6) moist; light medium clay; strong 5-10 mm subangular blocky; moderately
B22t	0.35-0.70	Yellowish red (5YR4/6) moist; common medium distinct grey mottles; light medium clay; very few large pebbles, angular chert; strong 10-20 mm angular blocky; moderately moist; very firm. Diffuse to –
B23t	0.70-1.30	Strong brown (7.5YR5/6) moist; common medium distinct red mottles, very few medium distinct grey mottles; light medium clay; strong 5-10 mm subangular blocky; moderately moist; very firm.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations[#] meq/100g ECEC	Ca	Mg	Na	K	Exch. Al meq/100 g	Exch. acid meq/100 g	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500[+]	disp. ratio R1	pH $CaCl_2$
B[†] 0-0.10	6.2	0.06	.001																			
0.00-0.10	6.1	0.07	.001	14	30	20	33	15	8.30	5.40	0.13	0.72			1	.055	.735	.039	2.16	13	0.48	5.1
0.20-0.30	6.0	0.07	.004	6	14	12	69	26	8.40	15.0	1.70	0.43			7	.017	.976	.016	4.46	23	0.68	4.6
0.50-0.60	5.4	0.14	.016	5	12	13	70	27	7.80	15.0	2.70	0.48	1.1	1.4	10	.02	1.11	.013	4.50	23	0.83	4.4
0.80-0.90	5.2	0.15	.016	5	16	14	63	29	7.60	16.0	2.90	0.51	1.1	1.5	10	.013	1.03	.026	5.00	23	0.95	4.0
1.10-1.20	5.0	0.15	.018	6	18	17	59						1.2	2.1		.017	1.11	.013	4.60			3.9

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO_4-S mg/kg	extractable K meq/100g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B[†] 0-0.10	3.0	0.17	14	7	0.66	116	21	1.0	1.7

[#] aqueous cations at pH 7.0
[+] -1500 kPa (-15 bar) using pressure plate apparatus
[†] refers to bulking of a number of surface samples prior to analysis

Soil profile class:	**NOON**	**Substrate material:**	siltstone
Site No:	2460	**Slope:**	8%
AMG reference:	425 840 mE 7 016 150 mN	**Landform element**	hillslope
		Landform pattern:	rolling hills
Great soil group:	Non-calcic brown soil	**Vegetation:**	
Principal profile form:	Dr2.22	**Structural form:**	woodland
Australian soil classification:	Haplic, Eutrophic, Red Chromosol	**Dominant species:**	*Eucalyptus crebra, Bothriochloa decepiens, Aristida queenslandica*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A1	0-0.10	Very dark brown (10YR2/2) moist; sandy clay loam; weak; moderately moist; very weak. Gradual to –
A2	0.10-0.20	Brown (7.5YR4/3) moist; sandy clay loam; weak; moderately moist; very weak; very few fine manganiferous soft segregations. Clear to –
B2t	0.20-0.50	Dark red (2.5YR3/6) moist; light medium clay; few large pebbles, angular siltstone; strong 5-10 mm subangular blocky with moderate 5-10 mm prismatic; moderately moist; moderately firm; very few fine manganiferous soft segregations.
BCt	0.50-0.70	Yellowish red (5YR4/6) moist; light medium clay; fragments, siltstone; weak platy; moderately moist; moderately firm.

depth	1:5 soil/water			particle size				exchangeable cations[#]					ESP	total elements			moistures		disp.	pH
metres	pH	EC	Cl	%				meq/100g					%	%			%		ratio	$CaCl_2$
		dS/m	%	@105C										@65C			@105C		R1	
				CS	FS	SIL	CLA	CEC	Ca	Mg	Na	K		P	K	S	ADM	1500[+]		
B† 0-0.10	6.2	0.06	.001																	
0.00-0.10	6.0	0.09	.001	21	43	15	19	11	5.60	4.30	0.13	0.68	1	.055	1.5	.021	1.64	9	0.70	5.1
0.20-0.30	6.6	0.02	bq	16	27	8	49	20	9.00	11.0	0.20	0.29	1	.029	.958	.017	3.57	17	0.39	5.4
0.50-0.60	7.2	0.03	.002	37	28	6	31	21	11.0	9.50	0.27	0.19	1	.045	.845	.011	3.35	12	0.50	6.00

depth	organic C %	total N %	extractable P mg/kg	extractable SO4-S	extractable K meq/100g	DTPA-extractable elements mg/kg			
metres			bicarb.	mg/kg	HCl	Fe	Mn	Cu	Zn
B† 0-0.10	2.2	0.17	22	6	0.76	79	16	0.63	3.2

[#] aqueous cations at pH 7.0
[+] -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class:	**WELTON**	**Substrate material:**	siltstone
Site No:	1568	**Slope:**	30%
AMG reference:	429 028 mE 7 014 425 mN	**Landform element**	hillcrest
		Landform pattern:	rolling hills
Great soil group:	Lithosol	**Vegetation:**	
Principal profile form:	Um1.23	**Structural form:**	open forest
Australian soil classification:	Leptic Rudosol	**Dominant species:**	*Eucalyptus siderophloia, E. melanophloia, Corymbia intermedia, Rhynchelytrum repens, Heteropogon contortus*

Profile morphology:

Condition of surface soil when dry: hard setting

Horizon	Depth (m)	Description
A1	0-0.10	Dark brown (7.5YR3/2); clay loam; few medium pebbles, angular; weak 5-10 mm angular blocky; moderately moist; moderately weak.
BC	0.10-0.20	Brown (10YR4/3) moist; clay loam; abundant large pebbles, angular siltstone; weak structure; moderately moist; moderately weak.

depth	1:5 soil/water			particle size				exchangeable cations[#]					ESP	total elements			moistures		disp.	pH
metres	pH	EC	Cl	%				meq/100g					%	%			%		ratio	$CaCl_2$
		dS/m	%	@105C										@65C			@105C		R1	
				CS	FS	SIL	CLA	CEC	Ca	Mg	Na	K		P	K	S	ADM	1500[+]		
B† 0-0.10	6.6	0.05	.001	–	–	–	–	14	10	3.5	0.09	0.73	1	–	–	–	–	–	–	–

depth	organic C %	total N %	extractable P mg/kg	extractable SO4-S	extractable K meq/100g	DTPA-extractable elements mg/kg			
metres			bicarb.	mg/kg	HCl	Fe	Mn	Cu	Zn
B† 0-0.10	2.5	0.17	31	5	0.77	33	12	0.47	1.2

[#] aqueous cations at pH 7.0
[+] -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class:	**BUNYA**	**Substrate material:**	phyllite
Site No:	2462	**Slope:**	4%
AMG reference:	447 600 mE 7 039 270 mN	**Landform element**	hillslope
		Landform pattern:	rolling mountains
Great soil group:		**Vegetation:**	
Principal profile form:	Dr3.31	**Structural form:**	open forest
Australian soil classification:	**Magnesic, Mottled-Subnatric, Red Sodosol**	**Dominant species:**	*Eucalyptus crebra, Eucalyptus tereticornis, Gomphocarpus physocarpus, Paspalum dilatatum, Imperata cylindrica*

Profile morphology:

Condition of surface soil when dry: firm

Horizon	**Depth (m)**	**Description**
A1	0-0.09	Black (10YR2/1) moist; clay loam, fine sandy; moderate 2-5 mm granular; moderately moist; moderately weak. Gradual to –
A21	0.09-0.20	Dark greyish brown (10YR4/2) moist; clay loam, fine sandy; weak; moderately moist; moderately weak. Gradual to –
A22j	0.20-0.35	Brown (7.5YR5/2) moist; clay loam, fine sandy; weak 5-10 mm angular blocky; moderately moist; moderately firm. Clear to –
B21t	0.35-0.70	Dark reddish brown (2.5YR3/4) moist; common medium distinct grey mottles; medium clay; very few large pebbles, subrounded quartz; strong 5-10 mm subangular blocky with weak 10-20 mm prismatic; moderately moist; moderately firm; very few fine manganiferous nodules. Diffuse to –
B22t	0.70-1.10	Strong brown (7.5YR4/6) moist; medium clay; strong 10-20 mm lenticular; moderately moist; moderately firm. Gradual to –
C	1.10-1.20	Fragments, phyllite; moderately moist; moderately weak.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g ECEC	Ca	Mg	Na	K	Exch. Al meq/100 g	Exch. acid meq/100 g	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.09	6.0	0.15	.004																			
0.00-0.09	5.8	0.07	.003	6	33	39	23	10	6.90	2.10	0.28	0.39	0.1	0.1	3	.062	.134	.039	2.30	12	0.48	4.9
0.20-0.30	5.7	0.02	.001	5	31	39	24	6	0.83	1.80	0.32	0.20	2.3	2.5	5	.017	.097	.026	1.70	9	0.84	4.1
0.50-0.60	5.6	0.03	.003	2	12	21	66	23	0.28	6.00	1.50	0.23	11.6	14.6	7	.009	.191	.010	4.60	26	0.57	3.8
0.80-0.90	5.1	0.04	.005	1	11	22	65	26	0.13	6.60	2.00	0.24	12.8	16.8	8	.006	.199	.008	4.70	25	0.71	3.5
1.10-1.20	5.3	0.05	.005	4	18	28	48						11.9	16.9		.006	.358	.009	5.00			3.5

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO_4-S mg/kg	extractable K meq/100 g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	5	0.40	26	15	0.75	273	24	0.71	3.5

\# aqueous cations at pH 7.0
\+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

Soil profile class:	**YEDNIA**	**Substrate material:**	phyllite
Site No:	S6	**Slope:**	2%
AMG reference:	445 900 mE 7 039 100 mN	**Landform element**	hillcrest
		Landform pattern:	steep mountains
Great soil group:	Lithosol	**Vegetation:**	
Principal profile form:	Um1.41	**Structural form:**	very tall open forest
Australian soil classification:	Leptic Rudosol	**Dominant species:**	*Eucalyptus crebra, E.sideroxylon, E.umbra, Acacia species, Alphitonia excelsa, Xanthorrhoea* species
Surface coarse fragments:	common medium pebbles, angular platy phyllite		

Profile morphology:

Condition of surface soil when dry: firm

Horizon	**Depth (m)**	**Description**
A1	0-0.10	Dark greyish brown (10YR4/2); loam; common medium pebbles, angular tabular phyllite; weak granular; dry; moderately weak; common roots.
A3	0.10-0.25	Dark greyish brown (10YR4/2); clay loam; common medium pebbles, angular tabular phyllite; weak granular; dry; moderately weak.
C	0.25-	Yellowish brown (10YR5/4); clay loam; many large pebbles, angular tabular phyllite.

depth metres	1:5 soil/water pH	EC dS/m	Cl %	particle size % @105C CS	FS	SIL	CLA	exchangeable cations# meq/100g CEC	Ca	Mg	Na	K	ESP %	total elements % @65C P	K	S	moistures % @105C ADM	1500+	disp. ratio R1	pH $CaCl_2$
B† 0-0.10	5.4	0.08	.004																	4.5
0.00-0.10	5.6	0.06	.004	48	15	15	23		7.2	3.7	0.27	0.50	2	.07	2.27	.034	2	10	0.55	4.6
0.15-0.25	5.8	0.06	.005						8.8	4.4	0.37	0.29	3							4.6

depth metres	organic C %	total N %	extractable P mg/kg bicarb.	extractable SO4-S mg/kg	extractable K meq/100 g HCl	DTPA-extractable elements mg/kg Fe	Mn	Cu	Zn
B† 0-0.10	5.5	0.27	63		1	129	33	0.45	8.0

\# alcoholic cations at pH 8.5
\+ -1500 kPa (-15 bar) using pressure plate apparatus
† refers to bulking of a number of surface samples prior to analysis

APPENDIX 4

SOIL ATTRIBUTE LEVELS BY SOIL PROFILE CLASS (SPC)

For an explanation of the following *land use limitation*, refer to Section 6.1.

Workability (K1 to K4):	Table 25
Soil reaction (pH1 to pH3):	Table 28
Soil water availability (M1 to M4):	Table 24
Depth categories (D1 to D5):	Table 32
Nutrient deficiency (N1 to N16):	Table 27

[Note that nutrient deficiency ratings are based on a combination of *available* P (bicarb.), *extractable* S (sulfate-sulfur) and *extractable* K]

Subsoil sodicity categories:

1. non-sodic ESP <6%
2. sodic ESP 6-15%
3. strongly sodic ESP >15%

Total element status is based on bulked 0-0.10 m samples and the ratings of Bruce and Rayment (1982):

Total N (nitrogen) %
1. > 0.50
2. 0.25 – 0.50
3. 0.15 – 0.25
4. 0.05 – 0.15
5. < 0.05

Total K (potassium) %
1. >3
2. 1 – 3
3. 0.5 – 1
4. 0.1 – 0.5
5. < 0.1

Total P (phosphorus) %
1. > 0.10
2. 0.05 – 0.10
3. 0.02 – 0.05
4. 0.005 – 0.02
5. < 0.005

Total S (sulfur) %
1. > 0.10
2. 0.05 – 0.10
3. 0.02 – 0.05
4. 0.005 – 0.02
5. < 0.005

SPC (or mapping unit)	Work-ability	Soil reaction (pH)	Subsoil Sodicity	Total element status				Nutrient deficiency	Soil water availability (m) for various depth categories			
				Total N	Total P	Total K	Total S		D1	D2	D3	D4, D5
Bd	K3	pH2	3	4	4	2	4	N13	M3	M3	M4	M4
Bi	K2	pH3	2	4	3	2	3	N11	M2	M3	M4	M4
Bm	K3	pH3	3	4	4	2	4	N13	M3	M3	M4	M4
Bp	K3	pH2	3	4	2	2	3	N9	M3	M3	M4	M4
BP(rp)	K3	pH2	3	4	2	2	3	N9	M3	M3	M4	M4
Bp-Wt	K3	pH2	3	4	2	3	3	N9	M3	M3	M4	M4
Br	K3	pH2	2	3	1	2	2	N5	M1	M2	M3	M4
Br(rp)	K3	pH2	2	3	1	2	2	N5	M2	M2	M3	M4
Bs	K4	pH2	3	3	3	3	3	N5	M2	M2	M3	M4
Bs(gp)	K4	pH2	3	4	3	3	3	N5	M2	M3	M3	M4
Bs-Sp	K4	pH2	3	4	3	3	3	N5	M3	M3	M4	M4
Bu	K3	pH3	3	3	3	2	3	N5	M3	M3	M4	M4
Ca	K3	pH1	2	3	2	1	3	N1	M1	M2	M3	M4
Ca-Lv	K3	pH1	2	3	2	2	3	N1	M2	M2	M3	M4
Cb	K3	pH2	2	3	2	4	2	N5	M1	M2	M3	M4
Cb-Bs	K4	pH2	3	3	3	4	3	N5	M2	M2	M3	M4
Cl	K3	pH1	1	4	3	2	3	N9	M3	M3	M3	M4
Cr	K1	pH1	1	4	2	2	3	N5	M3	M4	M4	M4
Cr(rp)	K1	pH1	1	4	2	2	3	N5	M3	M4	M4	M4
De	K2	pH1	1	2	1	2	3	N1	M2	M2	M3	M4
Dg	K4	pH1	1	3	2	2	3	N5	–	–	M4	M4
Du	K4	pH2	2	3	3	3	3	N5	M2	M2	M3	M4
Dw	K3	pH2	2	3	3	3	3	N1	M2	M2	M3	M4
Ek	K4	pH1	1	4	4	2	4	N13	–	–	M4	M4

SPC (or mapping unit)	Work-ability	Soil reaction (pH)	Subsoil Sodicity	Total element status				Nutrient deficiency	Soil water availability (m) for various depth categories			
				Total N	Total P	Total K	Total S		D1	D2	D3	D4, D5
Ev	K3	pH1	3	3	3	3	3	N5	M3	M4	M4	M4
Fm	K3	pH1	2	3	2	3	3	N1	M2	M2	M3	M4
Fs	K3	pH1	1	4	3	3	4	N13	–	–	M4	M4
Gh	K3	pH1	1	4	2	2	4	N5	M3	M3	M4	M4
Gi	K3	pH2	2	4	2	2	4	N11	M3	M3	M4	M4
Gk	K4	pH1	1	2	3	2	3	N1	–	–	M4	M4
Gl	K2	pH1	1	3	2	2	3	N1	M2	M3	M4	M4
Gl(rp)	K2	pH1	1	3	2	2	3	N1	M3	M3	M4	M4
Gl-Gy	K2	pH1	1	4	2	3	3	N1	M3	M3	M4	M4
Gl-Hy	K2	pH1	1	4	2	3	3	N1	M3	M3	M4	M4
Gl-Md	K2	pH1	1	3	2	2	3	N1	M2	M3	M4	M4
Gy	K3	pH2	2	3	2	2	4	N5	M2	M3	M4	M4
Hb	K2	pH1	1	4	3	4	3	N15	M3	M4	M4	M4
Hcf	K4	pH1	1	3	2	2	3	N5	M3	M3	M4	M4
Hcs	K4	pH1	1	3	1	2	2	N1	M2	M2	M3	M4
Hff	K4	pH1	1	3	2	3	3	N1	M3	M3	M4	M4
Hfs	K4	pH1	1	3	2	2	2	N1	M3	M3	M4	M4
Hgf	K4	pH1	1	4	2	2	4	N11	M3	M3	M4	M4
Hmf	K4	pH1	1	3	2	2	3	N1	M3	M3	M4	M4
Hnf	K4	pH1	1	3	2	3	3	N1	M2	M3	M4	M4
Hns	K4	pH1	1	2	1	2	3	N1	M2	M2	M3	M4
Hrf	K4	pH1	1	4	4	2	4	N13	M3	M3	M4	M4
Hs	K3	pH3	3	4	2	2	3	N5	M3	M3	M4	M4
Hy	K2	pH1	1	4	2	3	3	N5	M3	M4	M4	M4
Iv	K1	pH1	1	4	3	2	3	N13	M4	M4	M4	M4
Jm	K3	pH2	1	4	2	4	3	N9	M1	M2	M3	M4
Kp	K3	pH1	1	3	2	2	3	N9	M3	M3	M4	M4
Le	K3	pH1	1	2	1	3	2	N5	M2	M2	M3	M4
Le-Na	K2	pH1	1	3	2	3	3	N5	M2	M3	M4	M4
Lv	K2	pH1	1	2	2	2	3	N1	M2	M2	M3	M4
Md	K2	pH1	1	3	2	2	3	N1	M2	M3	M4	M4
Md-Hy	K2	pH1	1	3	2	3	3	N1	M3	M3	M4	M4
Mo	K3	pH2	3	3	2	2	3	N5	M3	M3	M4	M4
Mo-Dg	K3	pH1	3	3	3	3	3	N5	M3	M3	M4	M4
Mo-Dw	K3	pH2	2	3	3	3	3	N5	M3	M3	M4	M4
Na	K2	pH1	1	3	2	3	3	N1	M2	M2	M3	M4
Nn	K3	pH1	1	4	3	2	3	N1	M3	M3	M3	M4
Ot	K3	pH3	3	3	3	4	3	N9	M3	M3	M4	M4
Ot(gp)	K3	pH3	3	3	3	4	3	N9	M3	M3	M4	M4
Ot(rp)	K3	pH3	3	3	3	4	3	N9	M3	M3	M4	M4
Pd	K3	pH3	3	3	3	3	3	N5	M3	M3	M4	M4
Ph	K2	pH1	1	4	3	2	4	N15	M3	M3	M4	M4
Rb	K3	pH1	1	4	3	2	3	N15	M3	M3	M4	M4
Rb-Ph	K3	pH1	1	4	3	2	4	N15	M3	M3	M4	M4
Sp	K3	pH2	3	4	2	3	3	N9	M3	M3	M4	M4
Sp(gp)	K3	pH2	3	4	2	3	3	N9	M3	M3	M4	M4
Sp(rp)	K3	pH2	3	4	2	3	3	N9	M3	M3	M4	M4
St	K3	pH3	1	4	1	4	3	N1	M3	M3	M4	M4
Tu	K3	pH3	3	2	2	3	2	N9	M3	M3	M4	M4
Wl	K4	pH1	1	3	3	3	3	N1	–	–	M4	M4
Wt	K3	pH2	2	3	2	3	3	N9	M3	M3	M4	M4
Wt(rp)	K3	pH2	2	3	2	3	3	N9	M3	M3	M4	M4
Wt-Gh	K3	pH1	2	3	2	3	3	N9	M3	M3	M4	M4
Yb	K2	pH1	1	4	3	2	3	N13	M3	M4	M4	M4
Yn	K4	pH1	1	3	2	2	3	N1	–	–	M4	M4

APPENDIX 5

SUITABILITY CLASSIFICATION BY SOIL PROFILE CLASS (SPC)

SPC	No. UMAs	TOTAL AREA (ha)	SUITABILITY FOR:					AG. LAND CLASS:				
			Dryland sown pastures	Dryland crops	Irrigated pastures	Irrigated small crops	Tree and vine crops	A	Bh	Bi	C1	C2
Bd	7	627	22	–	77	–	604	–	604	–	23	–
Bi	1	130	–	–	–	–		–	–	–	–	130
Bp	90	14065	5 371	–	5 725	768	11 159	–	11 218	768	548	1 531
Bp(rp)	6	966	–	–	–	–	48	–	48	–	–	919
Bp–Wt	7	893	865	–	893	4	865	–	861	4	28	–
Br	12	513	502	317	502	328	445	317	185	11	–	–
Br(rp)	1	13	13	–	13	–	–	–	–	–	13	–
Bs	38	1477	1 471	1 274	1 274	1 274	6	1 274	–	–	197	6
Bs(gp)	20	1182	1 120	254	254	357	–	254	–	103	763	62
Bs–Sp	2	254	254	–	–	–	–	–	–	–	254	
Bu	16	1596	–	–	20	–	55	–	55	–	20	1 521
Ca	8	1168	926	346	926	346	926	346	580	–	–	242
Ca–Lv	3	108	36	–	36	–	36	–	36	–	–	71
Cb	33	2213	2 213	2 165	2 165	2 165	–	2 165	–	–	47	–
Cb–Bs	2	52	52	52	52	52	–	52	–	–	–	–
Cr	33	399	399	–	399	360	360	–	–	360	39	–
Cr(rp)	5	53	33	–	33	–	33	–	33	–	–	21
De	6	394	–	–	101	–	27	–	27	–	101	266
Dg	3	55	–	–	–	–	–	–	–	–	–	55
Dw	39	2851	1 715	–	1 777	36	1 049	–	1 049	36	1 022	744
Ek	1	74	–	–	–	–	–	–	–	–	–	74
Ev	52	1808	404	–	404	70	646	–	640	70	96	1 001
Fs	1	15	–	–	–	–	–	–	–	–	–	15
Gh	11	195	–	–	43	–	5	–	5	–	43	147
Gi	7	557	287	–	287	98	394	–	297	98	–	163
Gk	1	10	–	–	–	–	–	–	–	–	–	10
Gl	127	3156	3 156	3 156	3 156	3 156	3 150	3 156	–	–	–	–
Gl(rp)	3	35	20	–	20	–	6	–	6	–	20	9
Gl–Gy	1	2	2	–	2	2	2	–	–	2	–	–
Gl–Hy	2	160	160	–	160	160	160	–	–	160	–	–
Gl–Md	1	149	149	149	149	149	149	149	–	–	–	–
Gy	27	958	958	913	945	931	401	913	14	18	13	–
Hb	8	1587	–	–	142	90	1 587	–	1 497	90	–	–
Hcf	50	14251	–	–	–	–	–	–	–	–	–	14 251
Hcs	2	826	–	–	–	–	–	–	–	–	–	826
Hff	22	12259	–	–	–	–	–	–	–	–	–	12 259
Hfs	2	670	–	–	–	–	–	–	–	–	–	670
Hgf	12	1205	–	–	–	–	–	–	–	–	–	1205
Hmf	6	4047	–	–	–	–	–	–	–	–	–	4 04
Hnf	42	15919	–	–	–	–	–	–	–	–	–	15 919
Hns	7	9696	–	–	–	–	–	–	–	–	–	9 696
Hrf	5	2162	–	–	–	–	–	–	–	–	–	2 162
Hs	5	153	–	–	15	–	13	–	13	–	15	124
Hy	74	1201	1 201	–	1 187	1 086	1 032	–	1 086	–	115	–
Iv	5	297	–	–	230	151	297	–	146	151	–	–
Jm	1	84	84	–	84	84	–	–	–	84	–	–
Kp	3	174	–	–	–	–	174	–	174		–	–
Le	33	3649	669	–	835	50	1 156	–	1 156	46	491	1 952

APPENDIX 5 (continued)

SPC	No. UMAs	TOTAL AREA (ha)	SUITABILITY FOR:					AG. LAND CLASS:				
			Dryland sown pastures	Dryland crops	Irrigated pastures	Irrigated small crops	Tree and vine crops	A	Bh	Bi	C1	C2
Le-Na	3	1031	1 031	-	1 031	-	136	-	136	-	895	-
Lv	4	246	150	-	150	-	23	-	23	-	126	96
Md	69	2197	2 197	2 197	2 197	2 197	2 138	2 197	-	-	-	-
Md-Hy	1	34	34	-	34	34	34	-	-	34	-	-
Mo	42	4466	81	-	566	-	788	-	687	-	485	3 293
Mo-Dg	1	517	-	-	-	-	-	-	-	-	-	517
Mo-Dw	3	746	712	-	712	-	712	-	712	-	-	34
Na	17	2018	1 396	26	1 396	66	40	26	36	40	1 330	586
Nn	8	124	41	-	41	5	47	-	42	5	22	55
Ot	21	1802	1 446	-	1 400	10	-	-	-	10	1 436	357
Ot(gp)	7	459	418	-	225	-	-	-	-	-	418	41
Ot(rp)	5	626	502	-	488	-	-	-	-	-	502	124
Pd	9	780	85	-	245	36	75	-	40	36	209	495
Ph	1	54	-	-	-	-	-	-	-	-	-	54
Rb	2	211	-	-	211	-	134	-	134	77	-	-
Rb-Ph	3	129	-	-	129	-	129	-	129	-	-	-
Sp	189	8755	8 381	-	7 739	7 530	284	-	-	7 530	892	334
Sp(gp)	11	434	434	-	180	180	-	-	-	180	255	-
Sp(rp)	3	37	12	-	12	-	-	-	-	12	-	25
St	2	202	-	-	-	-	184	-	184	-	-	18
Tu	27	1821	503	-	743	123	609	-	609	123	496	593
Wt	24	1300	965	-	1 104	448	645	-	645	448	139	68
Wt(rp)	3	251	-	-	160	-	-	-	-	-	160	92
Wt-Gh	1	58	-	-	-	-	58	-	58	-	-	-
Yb	3	196	-	-	40	30	187	-	156	31	9	-
TOTALS			40 465	10 848	40 704	22 373	31 008	10 848	22 236	11 537	11 299	76 882

APPENDIX 6

LABORATORY METHODS USED TO ANALYSE SAMPLES

all analyses carried out at the Department of Natural Resources Analytical Centre, Natural Sciences Precinct, Indooroopilly, Queensland.

	Analyte		Method Code	Reproducability %	Limit of Quantitation	Unit	Analysis description	Method used	Drying conditions
	pH	1	IEC-S4A1	5	0.1	–	pH (H2O)	Aqueous 1:5, electrode	Air dry
	EC	1	IEC-S3A1	7	0.01	mS/cm	Electrical conductivity	Electrical conductivity	Air dry
	Cl	1	IEC-S5A2	10.4	6	mg/kg	Chloride (Cl) extr.	Aqueous, 1:5 soil:water	Air dry
Moistures	ADMC	1	IEC-S2A1	5	0.4	%	Air dry moisture content	Air dry moisture content	Air dry
	15B	1		7	0.3	15 Bar	15 Bar	15 Bar, pressure plate	24 H @ 105 degrees Celsius
Particle size	CS	1	IEC-S2Z2	5	1	%	Coarse sand fraction	Coarse Sand Fraction	Oven dry 105 degrees Celsius
	FS	1	IEC-S2Z2	5	1	%	Fine Sand Fraction	Fine sand fraction	Oven dry 105 degrees Celsius
	SIL	1	IEC-S2Z2	5	1	%	Silt Fraction	Silt fraction	Oven dry 105 degrees Celsius
	CLA	1	IEC-S2Z2	5	1	%	Clay fraction	Clay fraction	Oven dry 105 degrees Celsius
Alcoholic cations	CEC	2	IEC-S15C1	5	1	meq/100g	Cation Exchange	Cation exch. capacity pH 8.5	Air dry
	Ca	1	IEC-S15C1	10	0.18	meq/100g	Calcium	Exch. alcoholic NH4Cl pH 8.5	Air dry
	Mg	1	IEC-S15C1	8.7	0.31	meq/100g	Magnesium	Exch. alcoholic NH4Cl pH 8.5	Air dry
	Na	1	IEC-S15C1	6.8	0.091	meq/100g	Sodium	Exch. alcoholic NH4Cl pH 8.5	Air dry
	K	1	IEC-S15C1	6.8	0.015	meq/100g	Potassium	Exch. alcoholic NH4Cl pH 8.5	Air dry
Aqueous cations	ECEC	1	IEC-S15J	5	1	meq/100g	Effective cation exch. capacity	Exch. (Ca+Mg+Na+K+Al+H)	Air dry
	Ca	2	IEC-S15A1	10	0.18	meq/100g	Calcium	Exch. aqueous NH4Cl pH 7	Air dry
	Mg	2	IEC-S15A1	8.7	0.31	meq/100g	Magnesium	Exch. aqueous NH4Cl pH 7	Air dry
	Na	2	IEC-S15A1	6.8	0.091	meq/100g	Sodium	Exch. aqueous NH4Cl pH 7	Air dry
	K	2	IEC-S15A1		0.015	meq/100g	Potassium	Exch. aqueous NH4Cl pH 7	Air dry
Exchangeable	Al	1	IEC-S15G	8	0.5	meq/100g	Aluminium	Exchangeable Aluminium	Air dry
	Acid	1	IEC-S15G	8	0.5	meq/100g	Exchangeable acidity	Exchangeable acidity	Air dry
Dispersion	R1	1	IEC-S2Z1	6	0.1	–	Dispersion ratio	Aqu. Silt+Clay/Total Silt+Clay	Air dry
Totals	P	3	IEC-S9A1	6.1	0.001	%	Phosphorus	Total P pressed powder, XRF	Vacuum – moisture free
	K	3	IEC-S17A	3.5	0.003	%	Potassium	Total K pressed powder, XRF	Vacuum – moisture free
	S	3	IEC-S10A	12.2	0.002	%	Sulfur	Total S pressed powder, XRF	Vacuum – moisture free
DTPA extractable	Fe	1	IEC-S12A	6	3	mg/kg	Iron	0.005M DTPA extractable, ICP	Air dry
	Mn	1	IEC-S12A	6	1	mg/kg	Manganese	0.005M DTPA extractable, ICP	Air dry
	Cu	1	IEC-S-12A	6	0.1	mg/kg	Copper	0.005M DTPA extractable, ICP	Air dry
	Zn	1	IEC-S12A	6	0.1	mg/kg	Zinc	0.005M DTPA extractable, ICP	Air dry
Others	OC	1	IEC-S6A1	5	0.01	%	Organic Carbon (OC)	Org. Carbon, colorimetry Walkley & Black	Air dry
	pH (CaCl2)		IEC-S4B1			0.1	pH (CaCl2)	1:5, soil:0.01M CaCl2	Air dry
	N	1	IEC-S7A2	6	0.2	%	Nitrogen	Total N, kjeldahl, colorimetry	Air dry
	P	1	IEC-S9B2	20	1	mg/kg	Phosphorus	0.5M NaHCO3 extr. colorimetry	Air dry
	K	5		5	0.2	meq/100g	Potassium	0.005M HCl extractable, flame	Air dry
	SO4-S	1	IEC-S10B3	11.5	0.6	mg/kg	Sulfate sulfur	0.01M Ca(H2PO4)2 extr. ICP	Air dry
	NO3-N	1	IEC-S7B1		0.65	mg/kg	Nitrate nitrogen	Aqueous 1:5, colorimetry	Air dry