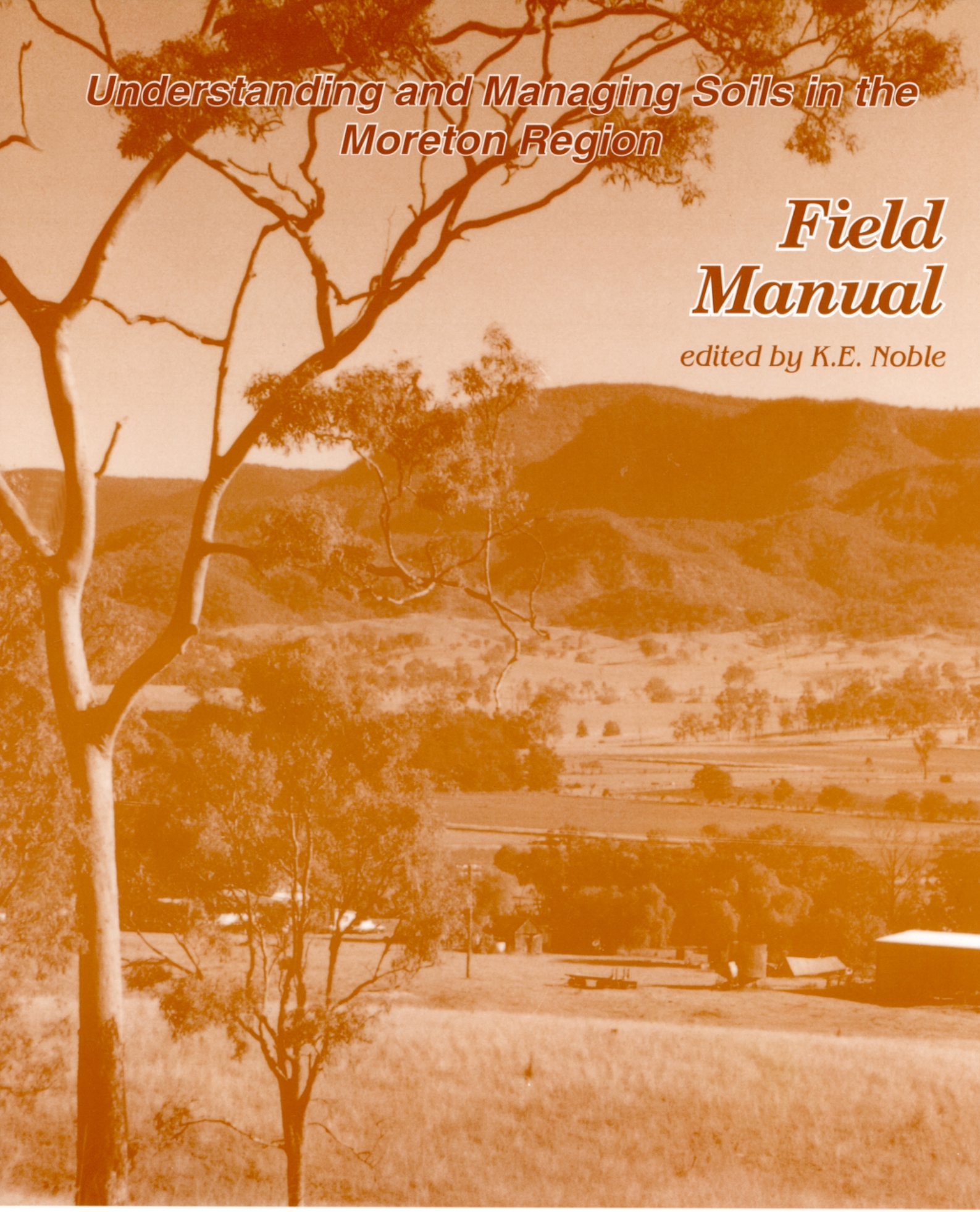
Understanding and Managing Soils in the Moreton Region

Field Manual

edited by K.E. Noble



NATIONAL LANDCARE PROGRAM

DPI QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

Queensland Government Technical Report

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Understanding and Managing Soils in the Moreton Region

Field Manual

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Edited by K E Noble

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1. INTRODUCTION

The Land Management Manuals Project is a Department of Primary Industries 'self-help' initiative to aid decision making for sustainable land management and planning. This is achieved by increasing the awareness and aiding the understanding of land resources information within the community. The project is jointly funded by the Department of Primary Industries and the National Landcare Program.

What is a Land Management Manual?

A Land Management Manual is a collation of currently available land resource data, combined with local knowledge and experience, primarily concerning soils and their management.

The preparation of the Manual involved a series of local producer workshops to obtain practical soil management information. This procedure ensured that the existing land resource information and its interpretation were up-to-date.

What area does the Manual cover?

The Manual discusses the attributes and limitations of the soils used for primary production for some 1.57 million hectares in the shires of Kilcoy, Esk, Pine Rivers, Gatton, Laidley, Moreton, Redland, Beaudesert, Albert and Boonah.

The region is bounded to the north by the summit of the Brisbane and part of the Conondale Ranges, and to the east by Moreton Bay, excluding the city areas of Brisbane, Ipswich, Logan and the Gold Coast. The western boundary follows the summit of the Blackbutt Range and along the summit of the Great Dividing Range. The southern boundary follows the Queensland-New South Wales border, along the summit of the McPherson Range (see Map 1).

The major towns in the area are Kilcoy, Toogoolawah, Esk, Samford, Petrie, Gatton, Lowood, Laidley, Boonah, Beaudesert, Cleveland and Nerang.

The project area and its relationship to Manuals in surrounding regions are shown in Map 1.

Why have a Land Management Manual?

Running a successful rural enterprise, over a long period of time, is dependent on the correct use of the available resources. Decision making should be determined by the ability of the resource to produce - not on historical practices which in some cases have led to resource degradation.

This Manual is designed to increase the awareness of the capabilities of the soils within the 10 shires of the Moreton Region, and in so doing, minimise potential land degradation. It brings together the currently available resource data and practical management information in a format which is easy to understand and use.

The Manual provides a handy tool for users to identify and evaluate their soils. The consideration of soils information is essential when developing long-term strategies for property management or for local planning.

What does the Manual contain?

The Land Management Manual package has three major parts contained within a ring-binder.

- The ***Field Manual:*** the core and most important component of the package. It provides a summary of the region's soil and land characteristics, and provides recommendations for appropriate management and use. This section of the Manual also provides information on identifying the soils. Various visual aids are provided for this purpose, including maps, tables, summary sheets and landscape and soil photographs. Farmers and graziers will find the summary sheets that contain land use and management information for their soils particularly useful. An increased knowledge of soils and their behaviour helps decision making on optimising production on different soils while minimising land degradation.

- The ***Resource Information:*** a reference document that provides a regional overview and places the soils information within this context. To support the information contained in the Field Manual, this document explains local land resource-related aspects in more detail. Land use problems encountered from local experience, and the solutions implemented are also dealt with.

- The ***Land Resource Areas (LRAs) map:*** a full colour map showing the distribution of Land Resource Areas or landscapes (**not** soils) within the Region.

Who should use the Manual?

The following list illustrates the range of potential users of the Manual. Although the list only gives one example per user, the range of possible uses is more extensive.

Present landholders	- to re-assess the potential of their property
New landholders	- to assess the realistic potential of their property
Potential landholders	- to assess the realistic potential of a property
Property Management Planning (PMP) groups	- for resource-based property planning
Landcare groups	- for resource-based planning over large areas
Planners/consultants	- to assess property and land potential
Extension staff	- for sound advice on property potential
Educators	- for education on soils and their sound use
Land valuers	- for property potential and valuation
Rural banks	- for informed decision making
Local authorities	- for shire development plans
Dept. of Transport	- for better road construction and erosion control
Queensland Rail	- for erosion control
SEQEB	- for erosion control on line construction
Telstra	- for erosion control on line installation

2. USING THE FIELD MANUAL

To use this Manual it is essential to understand the two major notions that are the basis of the soils information. These are the **'Land Resource Area (LRA)'** and the **'Soil Groups'**. Although they are both defined elsewhere, it is important to re-emphasise these concepts here.

The whole landscape is divided into 15 LRAs (or landscape units) which appear on the map in the back pocket. These landscape units help to reduce the complexity of the landscape to easily-handled proportions. These landscape units (or LRAs) contain a number of different soil groups, which because of scale ***are not mapped separately***. Each Soil Group has a defined range of distinguishing properties, i.e. they have similar profiles with similar horizon sequences, have developed from similar parent materials, and have many similar physical and chemical properties. However, they may occur on a range of different topography and have other land characteristics such as drainage, soil depth or stoniness which may influence management on these areas.

The *Field Manual* can be used by all those involved in rural land use or with an interest in sustainable land management, to answer a range of land use issues at various scales. For example, they can be used by landholders to assist them in realising their property's potential; by Landcare groups and others involved with regional land management issues such as catchment planning; by extension officers dealing with land and water use issues; by Local Authorities for regional and strategic planning and for the protection of good quality agricultural land; and by others such as planners, consultants, agribusiness representatives, land valuers, prospective property buyers, bankers, school teachers and students.

A key component of the manual is the map of regional landscape units (LRAs). This LRA map enables a farmer to relate the information on regional features contained in the Manual, to on-farm features. This helps in the identification of potential problem areas, and therefore the need for managing within these known limitations. Alternatively, this information will also enable farmers to identify previously untapped land use options, or highlight areas where degradation will occur with inappropriate management.

The steps to make the link between the broad regional picture as presented on the LRA map, and the Soil Groups identified at the property level are set out below. In summary the steps in using this manual are:

- establishing a specific Land Resource Area (LRA);
- determining the relevant Soil Group; and
- seeking the relevant land use and management information.

Table 2.1 *Brief description of LRAs*

LRA	Brief description
Coastal Plains 1a	Alluvial plains, swamps, dune systems and tidal flats near the coast. Often paper bark, cabbage tree palm, *Banksia spp*, mangroves, saltmarsh or Eucalypt open forest
Fine Textured Alluvial Plains 1b	Broad alluvial plains along rivers and creeks draining volcanics (mainly basalt) and some metamorphic rock types. Remnant blue gum woodland
Mixed Alluvial Plains 1c	Alluvial plains and terraces derived from a variety of sedimentary, metamorphic, granitic and volcanic rocks supporting blue gum, ironbarks, Moreton Bay ash, with some swamp tea tree. Scattered throughout the region
Red Volcanics 2a	Undulating plains, plateaus and hillslopes with krasnozems derived from basalt supporting mixed rainforest and Eucalypt open forest. Mainly around Cleveland, Mount Tamborine and Beechmont; small pockets at Rosevale and Benarkin
Basaltic Uplands 2b	Steep mountains, hills and rises on basalt, andesite, dolerite and gabbro supporting Eucalypt open forest to woodland; some mixed rainforest
Volcanic Peaks 3a	Steep hills and mountains of trachyte or rhyolite with shallow soils, solodics and earthy sands (stony) supporting Eucalypt open forest and softwood scrub
Southern Intrusives 3b	Undulating hills and rises on syenite and dolerite mainly in the Kalbar area supporting Eucalypt open forest to woodland
Northern Mixed Volcanics 3c	Rolling hills to steep mountains north of Lowood based on mixed volcanic, sedimentary and metamorphic rocks supporting Eucalypt open forest to woodland; some mixed rainforest
Metamorphic Hills 4	Rolling hills to steep mountains of various metamorphic rock types supporting Eucalypt open forest to woodland with some mixed rainforest, mainly in the east and north
Granite Hills 5	Rolling hills and mountains based on granitic rocks supporting Eucalypt open forest; mainly scattered in the north of the region
Forest Walloons 6a	Rises and steep to undulating hills based on fine sedimentary rocks supporting Eucalypt open forest to woodland; mainly in the southwest but scattered elsewhere
Scrub Walloons 6b	Undulating to steep hills on sedimentary rocks supporting softwood scrub, generally with brigalow. Scattered throughout the region
Marburg Forest 7a	Undulating hills and rises to steep hills and mountains on various sedimentary rocks types supporting Eucalypt open forest with some softwood scrub
Helidon Forest 7b	Undulating to steep hills on various sedimentary rocks supporting Eucalypt open forest to woodland
Marburg Scrub 7c	Rolling low hills to steep hills on sandstone supporting softwood scrub, with or without brigalow; mainly in the west of the region

Step 4. Continue to compare the information until a reasonable match is found. Matching descriptions does not imply that they must be 'identical', but rather that they should be similar in most aspects.

Step 5. Each area of your property can be mapped out as a management unit on a property plan. Where there is a change of topography, soil, drainage, erosion, geology, vegetation etc., which would necessitate a change in management practices, a new management unit or 'land type' should be identified and mapped out.

Step 6. Refer to the summary information on land use limitations, suitability and best management practices for the selected soil group.

As you gain knowledge of the land resources, it will be possible to identify both the LRAs and Soil Groups using the summary information from the *Field Manual*.

Table 2.2 *Relationship of Soil Groups to LRAs*

LRA		Soil Groups	
		Dominant Soil Groups	**Associated Soil Groups**
1a	Coastal Alluvial Plains	Humic Gleys[1]	Coarse Structured Clays, Humus Podzols, Soloths
1b	Fine Textured Alluvial Plains	Alluvial Black Earths, Alluvial Loams[2]	Sandy Alluvials, Alluvial Red-Brown Earths, Grey Clays
1c	Mixed Alluvial Plains	Coarse Structured Clays, Soloths, Red Podzolics, Alluvial Loams	Sandy Alluvials, Alluvial Red-Brown Earths, Sandy Solodics, Earthy Sands, Red Earths, Loamy Solodics, Tea Tree Clays
2a	Red Volcanics	Krasnozems[3]	
2b	Basaltic Uplands	Lithosols	Shallow Hillside Soils[4], Shallow Clays and Clay Loams[5]
3a	Volcanic Peaks	Lithosols, Shallow Clays and Clay Loams	Soloths, Sandy Solodics, Loamy Solodics, Earthy Sands (stony), Red Earths
3b	Southern Intrusives	Red Podzolics, Shallow Clays and Clay Loams[5], Lithosols, Shallow Hillside Soils[4]	Red Earths, Soloths
3c	Northern Mixed Volcanics	Shallow Hillside Soils[4], Lithosols, Shallow Clays and Clay Loams[5]	Sandy Solodics, Loamy Solodics, Grey Clays, Brown Clays
4	Metamorphic Hills	Red Podzolics, Yellow Podzolics, Lithosols	Shallow Hillside Soils[4], Soloths, Red Earths
5	Granite Hills	Earthy Sands, Red Podzolics, Yellow Podzolics, Lithosols	Soloths, Sandy Solodics, Yellow Earths
6a	Forest Walloons	Loamy Solodics, Soloths, Grey Clays, Brown Clays, Red Podzolics	Lithosols, Shallow Clays and Clay Loams[5], Sandy Solodics
6b	Scrub Walloons	Grey Clays, Brown Clays	Loamy Solodics, Red Podzolics
7a	Marburg Forest	Sandy Solodics, Loamy Solodics, Soloths, Red Podzolics, Yellow Podzolics	Grey Clays, Shallow Hillside Soils[4], Lithosols, Brown Earths
7b	Helidon Forest	Red Earths, Red Podzolics, Yellow Podzolics, Lateritic Podzolics	Yellow Earths, Lithosols, Earthy Sands
7c	Marburg Scrub	Sandy Solodics, Red Podzolics	Brown Earths, Grey Clays, Red Earths, Earthy Sands, Soloths, Shallow Hillside Soils[4], Loamy Solodics

1. Solonchaks are salty, minor soils associated with Humic Gleys
2. Alluvial Loams include Deep Prairie Soils
3. Xanthozems are yellow clays associated with Krasnozems in poorly drained areas
4. Shallow Hillside Soils include Non-Calcic Browns
5. Shallow Clays and Clay Loams include Shallow Prairie Soils and Rendzinas (see Glossary for more information)

3. SOIL SUMMARY SHEETS

READ THIS IN CONJUNCTION WITH A SET OF SOIL SUMMARY SHEETS

The following sheets provide summary information about each Soil Group and its associated land use suitability and management. Soil and site descriptions presented here are directly relevant to decisions on land use and management. A set of limitations to land use has been deduced from these descriptions and local experience. Recommendations are also given for crop and pasture suitability, irrigation and earthworks.

It must be emphasised that comments regarding best management practices are based on local knowledge and experience. The soil information is provided to enable the landholder or manager to consider this information and its implications when making any land management decisions.

Soils information

The sheets provide photographs of a typical landscape and an example soil profile. These are accompanied by summary information on the example soil's characteristics and chemical and physical properties.

Landscape description: summarises the soil's position within these landscapes and their likely locations. The vegetation usually associated with each soil is also given. It should also be noted that vegetation descriptions are not diagnostic for each Soil Group. However, they can generally be used as a guide or indicator of the occurrence of a particular Soil Group or to the presence of some important properties that are related to certain soils, e.g. soils with deep sandy surfaces.

Soil characteristics: it must be stressed that this comprises a photograph and description of an ***example*** soil profile for the named Soil Group. The range of distinguishing soil features, including chemical and physical attributes of the named soil which are relevant to land use, are briefly summarised. These general soil features will also aid in the identification of a given Soil Group.

The soil description is simplified from the profile descriptions contained in Appendix 3 of the *Resource Information*, but is detailed enough to identify the soil. Soil colour, structure and types of segregations are defined in the Glossary.

Statements are made on the availability of nutrients in the top 10 cm of the soil at the *sampling site only*. The general ratings used for the interpretation of soil chemical analyses are given in Table 3.1.

Surface soil and subsoil pH values are given for each soil. Further explanation of pH is given in the Glossary.

Salinity and sodicity within the profile are based on the chemical analyses of the soil samples taken for each example soil. Salinity is based on the electrical conductivity (EC) value and relates to inherent salinity (that is, the presence of salts in the profile). Sodicity relates to the exchangeable sodium percentage (ESP) value. These terms are defined in the Glossary.

An estimate is given of the plant available water capacity (PAWC) within the rooting zone, or the ability of the soil to retain moisture for use by the crop or pasture. Section 4.5 of the *Resource Information* gives a more detailed discussion of the soil chemical and physical properties.

Table 3.1 *Ratings used for interpretation of soil analyses*

		Ratings				
Soil Test	**Units**	**Very low**	**Low**	**Medium**	**High**	**Very high**
Cl	(%)	<0.01	0.01-0.03	0.03-0.06	0.06-0.20	>0.20
P_{ACID}	(mg/kg)	<10	10-20	20-40	40-100	>100
P_{BICARB}	(mg/kg)	<10	10-20	20-40	40-100	>100
Extr. K	(m.eq%)	<0.1	0.1-0.2	0.2-0.5	0.5-1.0	>1.0
Cu	(mg/kg)	<0.1	0.1-0.3	0.3-5	5-15	>15
Zn pH >7	(mg/kg)	<0.3	0.3-0.8	0.8-5	5-15	>15
pH <7	(mg/kg)	<0.2	0.2-0.5	0.5-5	5-15	>15
Mn	(mg/kg)	<1	1-2	2-50	50-500	>500
Total N	(%)	<0.05	0.05-0.15	0.15-0.25	0.25-0.5	>0.5
Org. C	(%)	<0.5	0.5-1.5	1.5-2.5	2.5-5.0	>5.0
Total P	(%)	<0.005	0.005-0.02	0.02-0.05	0.05-0.10	>0.10
Total K	(%)	<0.1	0.1-0.5	0.5-1.0	1.0-3.0	>3.0
Total S	(%)	<0.005	0.005-0.02	0.02-0.05	0.05-0.10	>0.10
PAWC	(mm)	<50	50-100	100-150	150-200	>200
Dispersion ratio			<0.6	0.6-0.8	>0.8	

pH Ratings	
extremely acid	<4.5
very strongly acid	4.5 - 5.0
strongly acid	5.1 - 5.5
medium acid	5.6 - 6.0
slightly acid	6.1 - 6.5
neutral	6.6 - 7.3
mildly alkaline	7.4 - 7.8
moderately alkaline	7.9 - 8.4
strongly alkaline	8.5 - 9.0
very strongly alkaline	>9.0

Land use information

The land use information has been compiled from local knowledge and experience.

Land use limitations: includes aspects important to soil management.

Land use suitability: the most suitable uses for the particular Soil Group are presented. It must be understood that the ultimate decision on land use rests with the land manager who must take into consideration current climatic and economic conditions.

Best management practices: lists important recommendations for responsible land management which allow optimal land use with minimum land degradation. Commonly recommended crops and pastures are listed.

These recommendations are based on the known inherent properties of the soils and the limitations they present to any land use.

UNDERSTANDING AND MANAGING SOILS IN THE MORETON REGION

SOIL SUMMARY SHEETS

Land Management Manual Program

ALLUVIAL BLACK EARTHS

Brief Description

Deep, dark, cracking and self-mulching clays on alluvial flats.

Landform and distribution

- Flat to gently undulating alluvial plains (slopes 0% - 3%). Widespread in the Fine Textured Alluvial Plains LRA on sediments derived mainly from basalt.
- Major occurrences are associated with the Lockyer Creek and its tributaries, Warrill Creek, Cressbrook Creek and the Logan and Albert Rivers.

Warrill Creek alluvial plain, near Kalbar, May 1994

Vegetation

Mainly cleared. Formerly blue gum woodland. Occasionally Moreton Bay ash.

Near Warrill View

Soil Profile Description

Depth (m)	Description
0.00 to 0.15	Very dark grey, light medium clay; strong fine blocky structure; pH 7.5. Clear change to:
0.15 to 0.30	Black, medium clay; strong blocky structure; pH 8.0. Gradual change to:
0.30 to 0.80	Black, medium clay; strong blocky structure; moderate amounts of soft carbonate; pH 9.5 Gradual change to:
0.80 to 1.20	Black, medium clay; coarse blocky structure; moderate amounts of soft carbonate pH 9.5.

General Soil Features

- Surface: Dark grey/dark brown, light to heavy clay, self-mulching and seasonally cracking. Strongly structured. Occasional gilgai development. Medium acid (pH 6.0) to moderately alkaline (pH 8.0).
- Subsoil: Dark grey to black, medium to heavy clay. Strongly structured, blocky or lenticular. Moderately alkaline (pH 8.0) to very strongly alkaline (pH 9.5). Calcium carbonate (lime) commonly present. Ma ybe sodic at depths > 0.60 m (a site investigation would be required to determine this).
- Internal drainage generally slow (depends on the depth of clay and the nature of the underlying materials).
- Plant available water capacity in the root zone is high (150 – 200 mm).
- N – medium to high, P – high to very high, K – high, Cu – medium, Zn – medium.

Current Development

Extensively developed for agriculture, including a wide range of dryland and irrigated crops and pastures.

ALLUVIAL BLACK EARTHS

Land Use Limitations

Drainage — Slow drainage may cause waterlogging and restrict the growth of some crops. Black earths with higher clay contents are particularly prone to waterlogging.

Soil structure — Structural problems and plough pans may develop if cropped continuously. Workability difficult immediately after rain or irrigation, or when dry.

Frosts and flooding — Local frosts and flooding may occur, depending on the site.

Erosion — Erosive flooding may be a high risk in some locations. Surface runoff can be high, particularly following irrigation.

Land Use Suitability

These soils are suitable for a wide range of agricultural uses.

Crops — These soils are suitable for most grain, fodder and small crops. However, some crops may be susceptible to waterlogging e.g. beans, carrots and potatoes. (Potato quality may also be reduced by soil cracking). Tree and vine crops are generally not recommended due to the slow drainage and the likelihood of frosts in the Moreton Region.

Pastures — These soils are ideal for pasture development and a wide range of species is suitable for both irrigated and dryland grazing strategies (*see pasture species chart*).

Irrigation — All irrigation strategies are suitable. The broad alluvial plains generally have extensive aquifers, however the supply varies in quantity and quality. Poor to marginal quality water should not be used for agricultural purposes as salinity problems may develop.

Earthworks — The high clay content and cracking nature of these soils are major limitations for earthworks. Broad based banks are recommended to reduce the effect of cracking. Allow for 30% settlement.
Septic systems: Limited suitability due to poor drainage. Alternative sewage treatment systems are recommended (e.g. composting and aerated types).
Roads and tracks: Limited suitability. Constantly used tracks should be formed, to reduce the collection of run on water in wheel tracks.
Dams: Suitability varies depending on the depth of clay and the permeability of the subsoil. Compaction should be carried out at suitable moisture levels to prevent tunnelling.

Planning Guidelines — On sites suitable for cropping, these soils would generally be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993), provided the following best management practices are adopted.

Best Management Practices

Cropping

- Where intensively developed, a coordinated drainage strategy is required comprising of subsurface drains, diversion banks and crop layout design.
- To reduce soil compaction, avoid trafficking, cultivation and harvesting when wet.
- To maintain soil structure and reduce erosion, adopt practices such as minimum tillage, stubble mulching and chemical weed control. Include cover crops in crop rotations and retain crop residues. A period under pasture in the rotation is also recommended to enhance soil organic matter.
- Nitrogen is a common deficiency if intensively utilised (and occasionally zinc, potassium and sulfur).
- Land levelling and bedding will improve irrigation efficiency and root zone drainage.

Grazing

- Maintain adequate surface cover at all times. Adjust stocking rates to suit seasonal rainfall variations and the type of market, etc.
- Suggested stocking rates are:

Clear native pasture	*1 AE/4 ha*
Improved pasture, dryland	*1 AE/4 ha*
Sown pasture, irrigated	*1 AE/0.5 to 1 ha*

ALLUVIAL LOAMS

Brief Description

Deep, freely drained loamy soils associated with watercourses (also called *deep prairie soils*, *chernozems*).

Landform and distribution

- Flat to gently undulating levees and terraces associated with watercourses (slopes 0% - 3%).
- Widely distributed throughout the Moreton Region in the Fine Textured Alluvial Plains and Mixed Alluvial Plains LRAs.

Vegetation

- Mostly cleared. Remnant woodland may include blue gum, gum-topped box, Moreton Bay ash, rough-barked apple, broad-leaved apple, silky oak, bottle brush and tea tree.
- Introduced species such as lantana, camphor-laurel

Wivenhoe Pocket, January 1993

On alluvial plain, Wivenhoe Pocket

Soil Profile Description

Depth (m)	Description
0.00 to 0.50	Very dark brown, clay loam; moderate blocky structure; pH 6.5. Diffuse change to:
0.50 to 1.00	Brown, clay loam (sandy); weak blocky structure. Diffuse change to:
1.00 to 1.30	Brown, clay loam (sandy); weak blocky structure; pH 7.2.

General Soil Features

- *Surface*: Dark brown, sandy clay loam to light clay. Well structured and friable. Slightly acid (pH 6.2) to mildly alkaline (pH 7.7).
- *Subsoil*: Dark brown to brown, clay loam to medium clay. Well structured and friable. Very well drained. Moderately alkaline (pH 8.0) to neutral (pH 7.0). Non sodic. No carbonate present.
- Plant available water capacity in the root zone is medium (100 – 150 mm).
- N – low to medium, P – high, K – high to very high, Cu – medium, Zn – medium.

Current Development

These soils are used for a wide range of cropping and horticultural enterprises as well as dairying.

ALLUVIAL LOAMS

Land Use Limitations

Soil surface	Becomes cloddy after cultivation and may become hardsetting if compacted by continual cropping. May be stony in upstream locations.
Flooding and Frosts	Seasonal flooding on lower terraces. Local frosts may occur.
Erosion	Moderate risk of rill and sheet erosion on unprotected surfaces depending on the size and velocity of the overland flow. Susceptible to streambank erosion.

Land Use Suitability

These are the premium cropping soils of the region. Their free drainage and moderate clay content provide flexibility in the choice of crops and crop management practices. Following rain or irrigation, management and harvesting operations can be carried out several days earlier than for the heavier alluvial black earths.

Crops	All crops are suitable. Tree and vine crops may be suitable, depending on the degree of flood and frost risk.
Pastures	These soils are ideal for pasture development and a wide range of species are suitable for both irrigated and dryland grazing strategies (*see pasture species chart*).
Irrigation	Most irrigation strategies are suitable. The broad alluvial plains generally have extensive aquifers, however, the supply varies in quantity and quality (poor to marginal quality water should not be used). Flood irrigation is not recommended because of the high permeability of these soils.
Earthworks	Suitable for most earthworks operations. Allow for 30% settlement. *Septic systems*: Limited suitability due to proximity to watercourses. Contact your local authority for advice. Alternative sewage treatment systems are recommended (e.g. composting and aerated types).
Planning Guidelines	On sites suitable for cropping, these soils would generally be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993), provided the following best management practices are adopted.

Best Management Practices

Cropping

- Use minimum tillage and retain stubble residues. Include green cover crops in crop rotations. Avoid trafficking, cultivation and harvesting when wet to reduce soil compaction.
- Some additions of nitrogen and sulfur may be required.
- Avoid summer cultivation in flood prone sites (in these areas maintain a cover of lucerne or other suitable pasture species).
- Do not cultivate within 20 m of the stream bank.

Grazing

- Monitor pasture use to ensure that adequate surface cover is maintained at all times (paying particular attention to retaining the more productive pasture species). Stocking rates need to be adjusted for seasonal variations and type of market, etc.
- Spell pastures when flowering and seeding. Control woody weeds.
- Suggested stocking rates are:

Clear native pasture	1 AE/4 ha
Improved pasture, dryland	1 AE/2 ha
Sown pasture, irrigated	1 AE/1 to 2 ha

ALLUVIAL RED-BROWN EARTHS

Brief Description

Brown loamy surface soils overlying reddish brown to brown clay subsoils on alluvial flats.

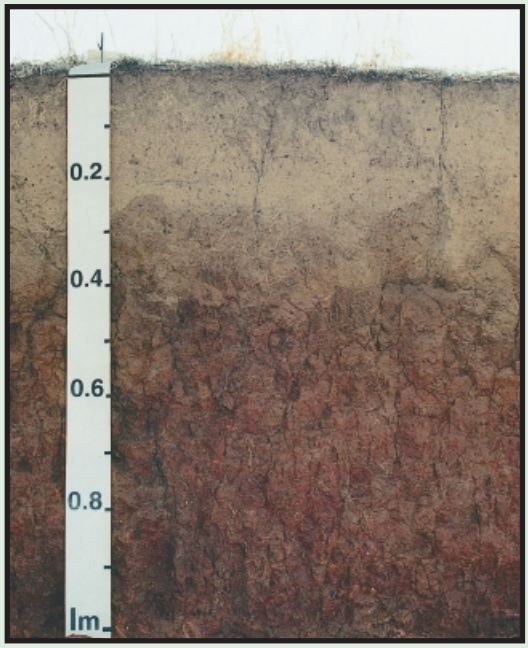
Landform and distribution

- Flat to gently undulating levees and terraces along creek lines (slopes 0% - 3%).
- On alluvium derived from mixed coarse sediments (Mixed Alluvial Plains LRA).

Beer Creek Levee, NW of Esk, May 1994

Vegetation

- Woodland of blue gum, broad-leaved apple, Moreton Bay ash, swamp mahogany.
- Generally cleared



NE of Togoolawah

Soil Profile Description

Depth (m)	Description
0.00 to 0.10	Dark brown, sandy clay loam; strong fine granular structure; pH 5.8. Gradual change to:
0.10 to 0.35	Brown, sandy clay loam; weak fine granular structure; pH 6.8. Clear change to:
0.35 to 0.55	Reddish brown, light medium clay; strong blocky structure; pH 7.0. Gradual change to:
0.55 to 1.00	Strong brown, medium clay; strong blocky structure; distinct red and yellow mottles; pH 7.0.

General Soil Features

- Clear to gradual boundary between the loamy surface soils and the clay subsoil. Distinguished from solodics by the nature of the subsurface layer which is not bleached (but may be pale) and the neutral, non sodic subsoil.
- *Surface*: Brown to dark grey, sandy clay loam to clay loam (sometimes sandy). Firm to hardsetting. Medium acid (pH 52.8) to neutral (pH 6.6).
- *Subsoil*: Brown to reddish brown, light to medium clay (sometimes sandy). Moderate to strong blocky structure. Sometimes mottled at depth. Mildly alkaline (pH 7.5) to neutral (pH 7.0). Layering sometimes evident in deep subsoil.
- Plant available water capacity in the root zone is low (50 – 100 mm) to medium (100 – 150 mm). Generally well drained.
- N – low, P - medium to high, K – medium to high, Cu – medium, Zn – medium.

Current Development

Grazing, opportunity cropping.

ALLUVIAL RED-BROWN EARTHS

Land Use Limitations

Soil surface	Structure declines after prolonged cultivation (seals and becomes hardsetting).
Erosion	Susceptible to streambank, rill and sheet erosion (in bare areas).
Flooding and frosts	Subject to occasional flooding. Frosts are likely, depending on the site.

Land Use Suitability

These are some of the better soils of the mixed, coarse alluvium, although their use is restricted at the property level by their limited areal extent (generally being confined to narrow alluvial levees and terraces). The optimum use of these soils is for the grazing of native and improved pastures.

Pastures	These soils produce good quality native pastures and are ideal for pasture development. A wide range of species are suitable for both dryland irrigated application (*see pasture species chart*).
Crops	Most crops are suitable, depending on the risk of flooding.
Irrigation	Suitable for most irrigation strategies. The quantity and quality of available water supply is critical (poor to marginal quality water should not be used).
Earthworks	Suitable for most earthworks depending on site characteristics. Allow for 30% settlement. Not suitable for septic systems.
Planning Guidelines	On sites suitable for cropping, these soils would generally be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993), provided the following best management practices are adopted.

Best Management Practices

Grazing

- Monitor pasture use to ensure that adequate surface cover is maintained (paying particular attention to retaining the more productive pasture species). Adjust stocking rates for variations in season and type of market, etc. Pastures should be spelled when flowering and seeding. Control woody weeds.
- Suggested stocking rates are:

Clear native pasture	1 AE/4 ha
Improved pasture, dryland	1 AE/2 ha
Sown pasture, irrigated	1 AE/1 to 2 ha

Cropping

- Do not cultivate within 20 m of streambank.
- Avoid summer cultivation in flood prone sites (in these areas maintain a cover of lucerne or other suitable pasture species).
- Use minimum tillage and retain stubble residues. Include green cover crops in crop rotations. Reduce soil compaction by avoiding trafficking, cultivation and harvesting when wet.

BROWN CLAYS

Brief Description

Brown cracking clays with self-mulching surfaces. Strongly alkaline subsoils that are brown to reddish brown.

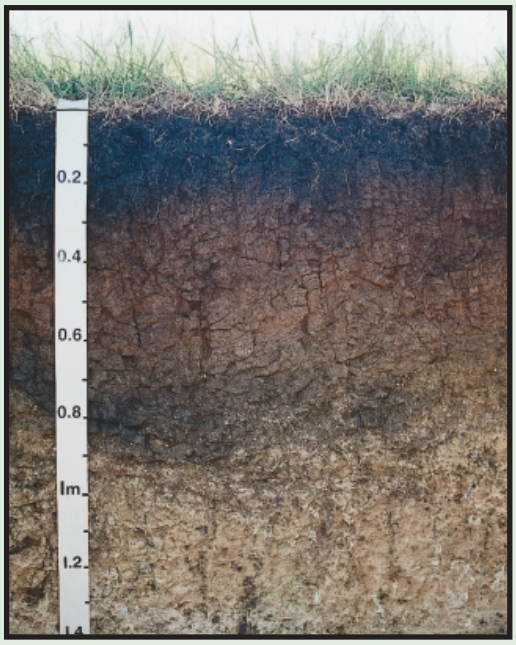
Landform and distribution

- Mid to lower slope positions of undulating low hills. Slopes 3 to 8%.
- Widespread in undulating country associated with fine grained sedimentary rock material (Forest Walloon and Scrub Walloon LRAs).

Vegetation

Mostly cleared. Woodland/open forest of blue gum and narrow-leaved ironbark and patchy occurrences of Moreton bay ash and silver-leaved ironbark.

Mutdapilly, May 1994



On Walloon Sandstone, Mutdapilly

Soil Profile Description

Depth (m)	Description
0.00 to 0.10	Dark grey, light medium clay; strong blocky structure; pH 6.0. Gradual change to:
0.10 to 0.25	Dark brown, heavy clay; strong blocky structure; pH 6.5. Clear change to:
0.25 to 0.60	Brown, medium heavy clay; strong lenticular structure; pH 7.0. Gradual change to:
0.60 to 0.85	Brown, medium clay; strong coarse lenticular; pH 9.5. Clear change to:
0.85 to 1.10	Yellow, medium clay; massive. Gradual change to:
1.10 to 1.50	Pale brown, light medium clay (weathered sandstone); pH 9.5.

General Soil Features

- *Surface*: Dark, light to medium clay. Medium to strongly self-mulching and cracking. Strong granular to blocky structure. Slightly acid (pH 6.1) to neutral (pH 7.0).
- *Subsoil*: Brown to reddish brown, medium to heavy clay. Strong lenticular structure. Moderately alkaline (pH 8.0) to strongly alkaline (pH 9.0), often with carbonate (line). Generally shallower than the grey clays, with bedrock often encountered at about 0.80 m. May be saline and sodic at depth.
- Plant available water capacity in the root zone is high (150 – 200 mm).
- N – medium to high, P – low to medium, K – high to very high, Cu – medium, Zn – medium.

Current Development

Grazing and forage crops.

BROWN CLAYS

Land Use Limitations

Soil structure	Workability difficult immediately after rain or irrigation, or when soil is dry. Surface may become hardsetting with cultivation.
Drainage	Slow drainage may cause waterlogging in some locations.
Erosion	Highly erodible (if bare or cultivated) on slopes greater than 3%.
Water availability	Water supplies required for development are very limited.
Salinity	May be saline at depth. Saline outbreaks may occur on lower slopes.
Fertility	Phosphorus generally low.

Land Use Suitability

The optimum use of these soils is for the grazing of native and improved pastures.

Pastures	These soils are ideal for pasture development and a wide range of species are suitable (*see pasture species chart*).
Crops	Suitable for a variety of dryland crops. Irrigation water is generally in short supply. Not suitable for tree/vine crops due to frosts and poor drainage.
Earthworks	The cracking nature of these soils is a limitation for earthworks. Broad based banks are recommended for all earthworks to reduce the effect of cracking. Allow for 30% settlement. *Septic Systems:* Limited suitability in certain locations due to poor drainage. Alternative sewage treatment systems (e.g. composting and aerated types) need to be considered. *Roads and tracks:* Generally suitable. *Dams*: Availability of suitable sites is limited. Suitability varies depending on the depth of clay and the permeability of the subsoil. To prevent leaks, it is essential to achieve adequate compaction using appropriate compaction equipment, working with soil at the correct moisture content. Dams should be fenced to avoid damage by stock.
Planning Guidelines	On sites suitable for cropping, these soils would generally be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993), provided the following best management practices are adopted.

Best Management Practices

Grazing

- Monitor adequate surface cover at all times. Stocking rates need to be carefully monitored and adjusted for seasonal variations and the type of market, etc.
- Suggested stocking rates are:

Clear native pasture	1 AE/5 ha
Improved pasture, dryland	1 AE/2 ha

Cropping

- If cropping, use minimum tillage and maintain maximum surface cover. Include green cover crops and stubble retention strategies in crop rotations. Pasture rotations are recommended for long-term soils stability and maintenance of organic matter.
- Do not cultivate on slopes greater then 8%. Soil conservation measures and crop management strategies will be required to control erosion on sloping sites. These could include contour banks, stubbles mulching and crop rotations.

BROWN EARTHS

Brief Description

Friable, well drained loamy soils that are brown, yellowish brown or reddish brown.

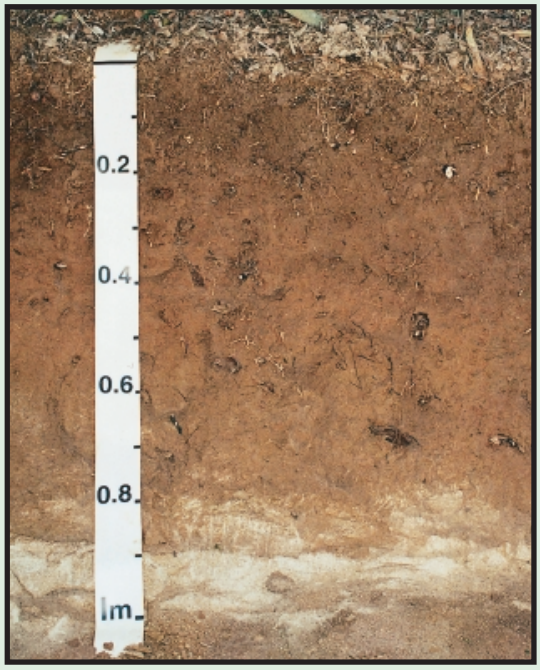
Landform and distribution

- Mid to upper slope positions of rolling, rounded hills (slopes 5 to 20%).
- Generally restricted to the Ma Ma Creek component of the Marburg sandstones (Marburg Scrub LRA) in the central-west of the region.

Woodlands Road, Woodlands, December 1993

Vegetation

- Softwood scrub, largely cleared. Brigalow may or may not be present. Vines are prominent. Other trees present include crow's ash, broad-leaved leopard wood, red ash, white cedar and scrub wilga.
- Introduced species include lantana and African boxthorn.



On Ma Ma Creek Sandstone, Woodlands

Soil Profile Description

Depth (m)	Description
0.00 to 0.20	Dark brown, clay loam; sandy; moderate granular structure; pH 7.0. Clear change to:
0.20 to 0.40	Brown, light clay (sandy); weak blocky structure; pH 7.0. Gradual change to:
0.40 to 0.65	Yellowish red, light medium clay (sandy); weak blocky structure; pH 7.0. Gradual change to:
0.65 to 0.80	Brown, light clay (sandy); massive; pH 7.0. Clear change to:
0.80+	Weathered sandstone; pH 7.2.

General Soil Features

- These soils have an earthy (porous, rough), appearance, with loamy textures and a gradually increasing clay content with depth.
- *Surface*: Brown, sandy loam to clay loam, granular or blocky structure. Neutral (pH 7.0) to slightly acid (pH 6.4).
- *Subsoil*: Light to medium clay (usually sandy). Yellowish brown to reddish brown. Weak to strong blocky structure. Medium acid (pH 6.0) to mildly alkaline (pH 7.5). Free carbonate may be present at depth.
- Plant available water capacity in the root zone is low (50 – 100 mm.
- N – low, P - high, K – high to very high, Cu – medium, Zn – medium.

Current Development

These soils have been extensively cropped in the past but much of the area is severely degraded and has been returned to grazing. Minor areas are used for horticultural crops.

BROWN EARTHS

Land Use Limitations

Erosion	Highly erodible on all slopes if bare or cultivated.
Water availability	Water supplies required for development are very limited.
Soil surface	May seal and become hardsetting with continuous cultivation. Susceptible to compaction.
Fertility	Undeveloped soils have moderate to high fertility, but this declines rapidly with cultivation. Deficiencies in most major nutrients, especially nitrogen and phosphorus.
Plant available water	Plant available water capacity is low, especially if soils are shallower or less clayey.
Weeds	Woody weeds are a problem (e.g. lantana, sally wattle).
Salinity	May act as an intake area for saline seepages downslope (saltpans may form on the flatter land at the break of slope).

Land Use Suitability

The optimum long-term use of these soils is for the grazing of native and improved pastures.

Pastures	Ideally suited to the production of good quality native pastures. A wide range of species are suitable for pasture development (*see pasture species chart*). Leucaena based pastures and other deep rooted perennial pastures are recommended.
Crops	Not suitable for continuous, broadacre cropping. Most tree and vine crops are suitable given adequate soil depth, water supply and fertiliser additions.
Irrigation	Limited trickle irrigation from farm dams. Groundwater quantity and quality is very poor.
Earthworks	Suitable for most earthworks operations. Allow 30% settlement. *Septic systems:* Generally adequate drainage for absorption systems, but there is a danger of percolation into stream and groundwater systems. *Dams:* Special construction methods required because of shallow and porous soils.
Planning Guidelines	In certain instances (e.g. lower slopes and on colluvial fans) these soils may be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993), provided the following best management practices are adopted.

Best Management Practices

Grazing

- Maintain an adequate surface cover at all times, paying particular attention to retaining the more productive pasture species.
- Use reduced tillage and planting techniques when introducing improved pasture species.
- Spell pastures when flowering and seeding.
- Adjust stock numbers to the amount of summer pasture growth. Suggested stocking rate is 1 AE/5 ha for both native and improved pastures.

Cropping

- Maintain maximum surface cover to reduce erosion and retain organic matter.
- Use minimum or zero tillage.
- For tree crops, mounding to obtain adequate soil depth, and groundcover crops, such as grazing peanuts, are recommended.
- Use trickle irrigation only, for maximum water usage and to minimise erosion and accessions to the watertable.
- Do not cultivate on slopes greater than 10%. Soil conservation measures and crop management strategies are required to control erosion on sloping land. These could include contour banks, stubble mulching and crop rotations.

COARSE STRUCTURED CLAYS

Brief Description

Deep coarse structured cracking clays, usually with gilgai. Brownish grey to yellowish grey subsoils.

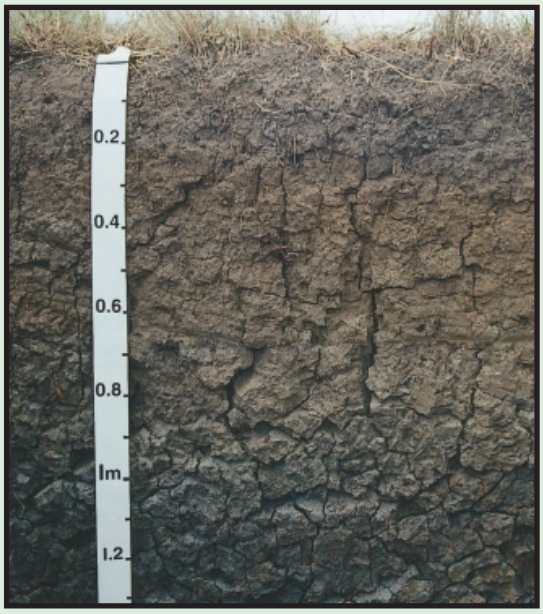
Landform and distribution

- Widely distributed on local creek flats and elevated terraces of older alluvium (Mixed Alluvial Plains LRA). Slopes up to 6%.
- Typical occurrences are on the higher terraces of the Logan river and on local creek flats in the Lockyer Valley.

Undullah Road, 2 km NW of Woodhill, February 1993

Vegetation

- Grassy open forest to woodland of gum-topped box and blue gum. Also present may be swamp mahogany, Moreton bay ash, bloodwood, grey gum, grey ironbark and narrow-leaved ironbark.
- Occasionally brigalow scrub.



On high terrace of Logan River

Soil Profile Description

Depth (m)	Description
0.00 to 0.10	Dark brown, medium clay; strong blocky structure; pH 6.5. Clear change to:
0.10 to 0.25	Dark brown, sandy clay; strong blocky structure; pH 6.0. Clear change to:
0.25 to 0.65	Brown, medium clay; moderate coarse blocky structure, faint orange mottles; pH 6.0. Gradual change to:
0.65 to 1.40	Grey, heavy clay; moderate coarse lenticular structure, distinct orange mottles; pH 5.5.

General Soil Features

- *Surface*: Dark brown to dark grey, clay loam to medium clay, blocky structure. Seasonal cracking. Gilgai usually present. Often self-mulching, occasionally hardsetting. Sometimes a shallow sandy layer may be present (due to wash from surrounding sandstone hills). Strongly acid (pH 5.2) to slightly acid (pH 6.2).
- *Subsoil*: Medium to heavy clay; grey, yellow-grey, brown or blue-grey; very coarsely structured. May be either strongly alkaline (pH 8.5) or extremely acid (pH 4.2) to strongly acid (pH 5.2).
- Medium to high salinity and strongly sodic at depths greater than about 0.50 m.
- When effective rooting depth is reduced by high subsoil salinity, plant available water capacity may be low (< 100 mm) to medium (100 – 150 mm). Otherwise high (> 150 mm).
- N – low to medium, P – very low to medium, K – low to medium, Cu – medium, Zn – medium.
- Dominance of magnesium in the subsoil indicates cation imbalance and increased dispersion tendency.

Current Development

Grazing. Provides valuable source of feed during dry spells. Sugar cane is grown in the vicinity of Alberton. In the past, these soils have been used for dairying.

COARSE STRUCTURED CLAYS

Land Use Limitations

Drainage	Poor internal and external drainage. Frequent waterlogging after rain. Some areas may be seasonally inundated.
Subsoil	Subsoil is highly saline and strongly sodic.
Plant available water	Often low, as effective rooting depth is reduced by high subsoil salinity.
Soil Structure	Coarse surface structure makes workability difficult. Very sticky when wet. Susceptible to compaction.
Erosion	Moderate to high risk of sheet and gully erosion on sloping sites.
Fertility	Generally low levels of nitrogen, phosphorus and potassium. Where these soils are strongly acid, chemical toxicities (aluminium and manganese) may be a problem.

Land Use Suitability

The optimum use of these soils is for the grazing of native pastures.

Pastures	In some locations (e.g. better drained areas with less gilgai), native pastures may be oversown with a legume or other pasture species (*see pasture species chart*). Not suitable for irrigation.
Crops	In better drained areas, short-term forage crops may be grown. In certain locations, and with careful management, may also be suitable for sugar cane.
Earthworks	Limitations due to waterlogging, high clay content and cracking nature of these soils. Allow for 30% settlement. Broad based banks are recommended to reduce the effect of cracking. ***Septic systems:*** Unsuitable. Alternative sewage treatment systems (e.g. composting and aerated types) are advised by most local authorities. ***Road and tracks:*** Limited suitability. ***Dams:*** Suitable only for stock water (if below ground level). To prevent leaks, it is essential to achieve adequate compaction using appropriate compaction equipment, working with soil at the correct moisture content. Dams should be fenced to avoid damage by stock.
Planning Guidelines	These soils would **not** generally be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993). Exceptions may be where crops of local significance are grown (e.g. in the Rocky Point Sugar Mill area).

Best Management Practices

Grazing

- Manage stock to maintain the more productive pasture species and ensure adequate surface cover at all times.
- Adjust stock numbers to suit the amount of summer pasture growth. Pastures should be spelled when flowering and seeding.
- A suggested stocking rate for cleared native pasture is 1 AE/4 ha.

Cropping

- Adopt practices such as minimum tillage, stubble mulching and chemical weed control to maintain soil structure and reduce erosion. Include cover crops in crop rotations and retain crop residues.
- To reduce soil compaction, avoid trafficking, cultivation and harvesting when wet.
- Land levelling may be required.

EARTHY SANDS

Brief Description

Deep sandy soils showing very little texture change with depth.

Landform and distribution

- Mid to lower slopes in low hilly country. Slopes 2 to 10% (modal 6%).
- Not widespread, restricted to localised occurrences in the Granite Hills and Helidon Forest LRAs and on local creek flats in the Mixed Alluvial Plains LRA.

Vegetation

Grassy open forest with a range of species including blue gum, rusty gum, broad-leaved apple, rough-barked apple, Moreton Bay ash and narrow-leaved ironbark.

Biarra Road, SW of Toogoolawah, May 1994

On granite, near Toogoolawah

Soil Profile Description

Depth (m)	Description
0.00 to 0.15	Dark greyish brown, coarse loamy sand; massive structure; pH 6.5.
0.15 to 0.40	Brown, coarse loamy sand; massive structure; hard when dry; pH 6.5.
0.40 to 0.55	Brown, coarse clayey sand; massive structure; moderately hard when dry; pH 6.5.
0.55 to 0.95	Yellowish brown, clayey sand; massive structure; pH 7.0.
0.95 to 1.20	Yellowish brown, clayey sand; massive structure; pH 7.0; a few coarse rock fragments.

General Soil Features

- Deep coarse sand. Brown, reddish brown to yellow with a slightly darker surface layer.
- Massive structure. The small quantity of clay present partially cements the sand particles together, giving the sand an ‘earthy’ or dusty appearance.
- The surface sets hard, but permeability is relatively high.
- Slightly acid (pH 6.1) to neutral (pH 7.0).
- Plant available water capacity in the root zone is low (50 – 100 mm).
- N – low, P – very low, K – medium, Cu – medium, Zn – medium.

Current Development

Grazing of native pastures, turf farming, limited horticulture, sand extraction.

EARTHY SANDS

Land Use Limitations

Plant Available Water	Plant available water capacity is low (even considering deep rooting depths).
Water Availability	Water supplies required for development are very limited.
Fertility	Nutrient status is very low, especially phosphorus and nitrogen.
Erosion	Highly erodible on slopes if groundcover is inadequate.
Soil Surface	Hard setting, restricts soil/seed contact inhibiting germination.

Land Use Suitability

The optimum long-term use of these soils is for the grazing of native pastures.

Pastures	Given suitable conditions, native pastures may be oversown with a legume or other pasture species *(see pasture species chart)*. Leucaena based pastures may also be suitable.
Crops	With adequate water supply and fertiliser additions, these soils are suitable for a range of small crops, and tree and vine crops e.g. grapes, avocados, mangoes, sweet potatoes.
Earthworks	Suitable for most earthwork operations. Allow for 30% settlement. *Septic systems*: Generally adequate drainage for absorption systems, but there is a danger of percolation into stream and groundwater systems. *Dams*: Difficulty obtaining suitable sites, and prone to leakage due to high permeability of the soils.
Planning Guidelines	Where irrigation water is available, these soils have potential for particular crops of local significance, and as such may be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993), provided the following best management practices are adopted.

Best Management Practices

Grazing

- Maintain adequate surface cover at all times, paying particular attention to the productive pasture species. Adjust stock numbers to the amount of summer pasture growth.
- Suggested stocking rate is 1 AE/5 ha for both native and improved pastures.

Cropping

- Minimise surface disturbance during crop establishment.
- Maintain an adequate surface cover at all times to reduce erosion and conserve organic matter. Specific groundcover species (e.g. grazing peanuts) are useful to maintain surface cover in tree cropping systems.
- Use trickle irrigation for maximum water usage, and to minimise erosion and accessions to the water table.
- Do not cultivate on slopes greater than 8%. Soil conservation measures and crop management strategies will be required to control erosion on sloping sites, including contour banks and crop rotations.

GREY CLAYS

Brief Description

Grey cracking clays with self-mulching surfaces.

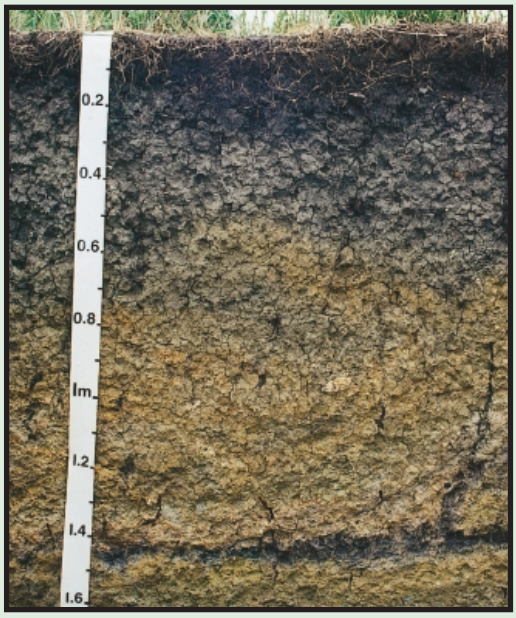
Landform and distribution

- Widespread in undulating low hills associated with the Forest Walloons and Scrub Walloons LRAs (for example in the Kalbar area). Slopes 3 to 10%.
- Also on broad crests and lower slopes of steep hills south of Gatton (Marburg Forest LRA). Slopes up to 25%.

Obum Obum Road, Kalbar, February 1995

Vegetation

- Brigalow/softwood scrub; occasionally with belah.
- Occasionally open forest consisting of Moreton Bay ash, silver-leaved ironbark and narrow-leaved ironbark.



On Walloon sediments, Kalbar

Soil Profile Description

Depth (m)	Description
0.00 to 0.20	Brownish black, light clay; strong, blocky structure; pH 6.5. Gradual change to:
0.20 to 0.60	Grey, light medium clay; strong blocky structure; pH 7.5. Gradual change to:
0.60 to 0.80	Grey, medium clay; strong coarse lenticular structure; soft carbonate (lime). Clear change to:
0.80 to 1.10	Yellowish grey, light medium clay; strong blocky structure; soft carbonate; pH 10.0.
1.10 to 1.40	Yellowish grey, light medium clay; faint mottles, carbonate nodules; pH 9.0.
1.40 to 1.60	Yellowish brown, light clay; massive; strongly mottled (weathered mudstone).

General Soil Features

- *Surface*: Dark, light to medium clay (may be clay loam in virgin sites). Strong granular to blocky structure. Slightly acid (pH 6.3) to neutral (pH 7.0), Medium to strongly self-mulching and cracking. In some locations, gilgai may be present.
- *Subsoil*: Grey to yellow, sometimes mottled, medium to heavy clay. Strong blocky to lenticular structure. Moderately alkaline (pH 8.0) to very strongly alkaline (pH 9.5). Varying amounts of soft and concretionary lime below about 0.30 m and occasionally weathered rock fragments and iron/manganese concretions. Grades into weathered parent rock (mudstone) at depths of usually more than 1 m. Salinity levels are generally high (especially under brigalow), peaking at about 1 m depth. Sodic to strongly sodic at depths greater than about 0.50 m.
- Plant available water capacity in the root zone is medium (100 – 150 mm) if the subsoil is high in salt; otherwise high (> 150 mm).
- N – medium to high, P – high to very high, K – medium to very high, Cu – medium, Zn – medium.

Current Development

- Widely used for a range of irrigated small crops (such as carrots, potatoes and onions) and irrigated winter forage crops. Rainfed summer crops are also grown successfully.
- Also grazing on improved pastures (including dairying).

GREY CLAYS

Land Use Limitations

Soil structure	Workability difficult immediately after rain or irrigation, or when soil is dry. Surface structure degrades if cropped continuously.
Erosion	Highly erodible on slopes >2%.
Subsoil	Usually sodic below about 0.50 m. Salt levels are often high.

Land Use Suitability

These soils are suited to a wide range of agricultural uses.

Crops	A wide range of crops are suitable. Generally not suitable for tree and vine crops.
Pastures	These soils are ideal for pasture development and wide range of species is suitable for both irrigated and dryland grazing strategies *(see pasture species chart)*.
Irrigation	Suitable for irrigation. Low volume systems minimise the erosion risk and are less likely to interact with the saline watertable causing saline outbreaks on lower slopes.
Earthworks	The cracking nature of these soils is a limitation for earthworks. Broad based banks are recommended for all earthworks to reduce the effect of cracking. Allow for 30% settlement. *Septic systems*: Limited suitability in certain locations due to poor drainage. Alternative sewage treatment systems (e.g. composting and aerated types) may need to be considered. *Roads and tracks*: Limited suitability. Constantly used tracks should be formed to reduce the collection of run on water in wheel tracks. *Dams*: Suitability varies depending on the depth of clay and the permeability of the subsoil. To prevent leaks, it is essential to achieve adequate compaction using appropriate compaction equipment, working with soil at the correct moisture content. Dams should be fenced to avoid damage by stock.
Planning Guidelines	These soils would generally be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993), provided the following best management practices are adopted.

Best Management Practices

Cropping

- Maintain maximum surface cover and practice reduced tillage.
- Rotate intensively cultivated crops with broadacre field crops and legumes to improve soil structure and fertility. A period under pasture in rotation is also recommended to enhance long-term soil stability and maintain soil organic matter.
- Do not cultivate on slopes greater than 10%. Soil conservation measures and crop management strategies will be required to control erosion on sloping sites. These could include contour banks, stubble mulching and crop rotations.
- Avoid trafficking, cultivation and harvesting when wet, to reduce soil compaction.

Grazing

- Maintain adequate surface cover at all times. Adjust stocking rates to suit seasonal rainfall variations and the type of market, etc.
- Suggested stocking rates are:

Clear native pasture	1AE/5 ha
Improved pasture, dryland	1 AE/5 ha
Sown pasture, irrigated	1 AE/2 ha

HUMIC GLEYS

Brief Description

Poorly drained soils with thick, friable, dark coloured surface soils high in organic matter. Subsoils are pale grey with strong rusty mottling. Permanently saturated at depth.

andform and distribution

- Flat coastal plains (slopes < 1%). Occasionally occurs in the poorly drained sections of narrow valleys floors.
- Main occurrences are in the Jacobs Well/Woongoolba area and SE of Nerang (Coastal Plains LRA).

Vegetation

Mostly cleared. Formerly open forest of blue gum, paper barked tea tree, pink bloodwood and swamp sheoak.

Woongoolba - Jacobs Well Road, September 1992

On coastal alluvium, Jacobs Well

Soil Profile Description

Depth (m)	Description
0.00 to 0.40	Very dark brown, sandy clay loam; weak blocky structure; pH 9.0. Clear change to:
0.40 to 0.70	Greyish brown, light clay (very sandy); massive; prominent orange mottling; pH 5.5. Gradual change to:
0.70 to 1.20	Grey, medium clay (sandy); massive; coarse rusty mottling; pH 5.0.

General Soil Features

- Soil properties are determined largely by drainage pattern and presence of high watertable. May be sandy or clayey throughout. May have a uniform texture profile or a strong texture contrast.
- *Surface*: Thick (0.25 to 0.40 m), organically stained (humic) layer. Loam to medium clay. Granular to blocky structure. Very strongly acid (pH 4.5) to medium acid (pH 6.0).
- *Subsoil*: Pale grey and strongly mottled (orange to red). Below the mottled zone, the subsoil is bluish grey and permanently waterlogged; however the watertable fluctuates, periodically rising almost to the surface. Sandy loam to heavy clay. Massive to coarse prismatic structure. Extremely acid (pH 4.0) to strongly acid (pH 5.5).
- Plant available water capacity in the root zone is medium (100 – 150 mm) in the clayey soils, and low (50 – 100 mm) in the sandy soils. However, the drainage efficiency and watertable depth influence plant growth more than plant available water capacity.
- N – medium to high, P – low to high, K – medium to high.

Current Development

Extensively utilised for sugar cane. Soil usually formed into raised beds with a system of channels to improve drainage. Some areas of grazing.

HUMIC GLEYS

Land Use Limitations

Drainage	External and internal drainage are poor, soils are subject to short-term flooding to various degrees. The watertable is always relatively high.
Fertility	Where these soils are strongly acid, chemical toxicities (aluminium and manganese) may be a problem.
Soil surface	Tends to crust, which reduces infiltration and creates poor soil-seed contact.
Salinity	Generally low, but medium to high salt levels in some areas close to tidal water.
Subsoil	Acid sulfate conditions. Exposure of subsoil may release sulfuric acid.

Land Use Suitability

Following drainage, these soils are suitable for a wide range of agricultural uses.

Crops	Water tolerant, shallow rooted crops are most suited to these poorly drained soils. High seasonal watertable restricts crop growth in the summer months. Sugar cane is grown successfully where drainage is provided.
Pastures	With adequate drainage and suitable fertiliser additions, these soils are suitable for the sowing of improved pastures. See *pasture species chart* for the range of suitable species. Native pastures are sparse or absent on these soils.
Earthworks	Allow for 30% settlement. *Septic systems*: Not suitable due to poor drainage and permanently high watertable. Alternative sewage treatment systems are recommended (e.g. composting and aerated types). *Roads and tracks*: Suitable except in low lying positions.
Planning Guidelines	These soils would **not** generally be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993). Exceptions may be where crops of local significance are grown (e.g. in the Rocky Point Sugar Mill area).

Best Management Practices

Cropping

- Implement surface and shallow subsurface drainage to lower the watertable (paying attention to possible acid sulfate occurrence).
- Reduce cultivation to minimise soil structure decline. Use pasture rotations for long-term soil stability and maintenance of organic matter levels.
- N and P additions generally required for sustainable production.

Grazing

- Maintain adequate surface cover at all times, paying particular attention to maintaining the more productive pasture species.
- Spell pastures when flowering and seeding.
- Adjust stock numbers to the amount of summer pasture growth. A suggested stocking rate is 1 AE/2 ha for improved pastures.

HUMUS PODZOLS

Brief Description

Loose, grey and pale sands overlying dark, cemented sands. Watertable is permanently high.

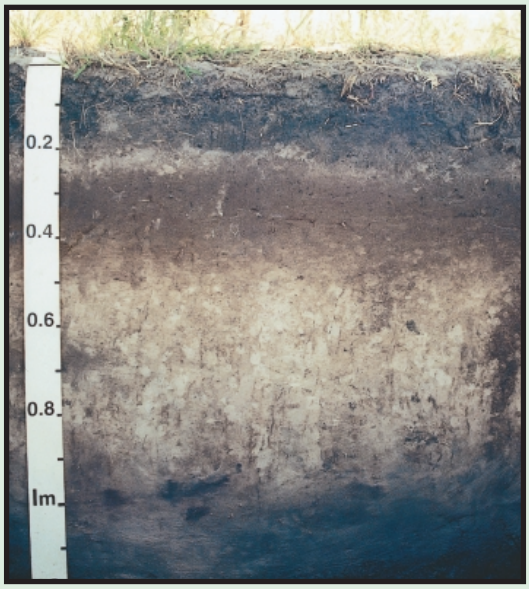
Landform and distribution

- Flat coastal plains (slopes 0 – 2%). Relict coastal dune and beach ridge deposits.
- Limited distribution on coastal lowlands in the vicinity of Jacobs Well and the Pimpama River (Coastal Plains LRA).

Vegetation

- Open forest of paper barked tea tree with cabbage tree palm, cork bark, pink bloodwood and swamp messmate.
- Tall shrubland of wallum banksia with emergent swamp messmate.
- A range of understorey shrub species is present and bracken fern is widespread.

Jacobs Well, December 1992



On estuarine deposits at Jacobs Well

Soil Profile Description

Depth (m)	Description
0.00 to 0.25	Very dark grey, sandy loam to clayey sand; weak granular structure; pH 5.5. Clear change to:
0.25 to 0.45	Dark brown, loamy sand; single grain; pH 6.0. Clear change to:
0.45 to 0.80	Light grey sand; single grain; pH 6.0. Gradual change to:
0.80 to 1.10	Grey sand, massive; pH 6.0. Gradual change to:
1.10 to 1.30	Black, clayey sand; cemented; pH 6.0.

General Soil Features

- *Surface*: Dark grey organic coloured sand to about 0.30 m. Loose, single grain to very weak granular structure. Extremely acid (pH < 4.0) to strongly acid (pH 5.5).
- *Subsoil*: Pale grey, structureless sand. Deeper in the profile (at about 0.80 to 1 m) the sane becomes black, massive and cemented (coffee rock). Extremely acid (pH 4.0) to medium acid (pH 6.0). Permanently saturated below about 1 m, but the watertable fluctuates, occasionally rising almost to the surface. A seasonally perched watertable (above the coffee rock) may also occur.
- Plant available water capacity in the root zone is often very low (< 50 mm); however the water available to plant depends on the depth to the watertable. The coffee rock is impenetrable to plant roots.
- N – low to medium, P – low to very low, K – low.

Current Development

Sugar cane, sand extraction, turf farming, grazing and mixed enterprises. Some conservation reserves.

HUMUS PODZOLS

Land Use Limitations

Drainage	Poor external drainage. Frequently high watertables restrict internal drainage.
Plant Available Water	Plant available water capacity is very low in the surface sand (this depends on depth to the watertable). Plant rooting depth is limited by the depth to coffee rock.
Fertility	Very low nutrient status. As these soils are strongly acid, chemical toxicities (e.g. aluminium and manganese) may be a problem.
Erosion	Susceptible to wind erosion after cultivation.

Land Use Suitability

These soils have limited suitability for agricultural development. Remnant wallum vegetation growing on these soils has high conservation value.

Crops	Water tolerant, shallow rooted crops are most suited to these poorly drained soils. High seasonal watertable may restrict crop growth in the summer months. Sugar cane is grown successfully where drainage is provided. Heavy applications of nitrogen, phosphorus, potassium and trace elements are required for agricultural production.
Pastures	Limited suitability for improved pastures. Native pastures are sparse or absent on these soils.
Earthworks	Allow for 30% settlement. *Septic systems*: Limited suitability due to poor drainage and fluctuating watertable. Alternative sewage treatment systems are recommended (e.g. composting and aerated types). *Roads and tracks*: Suitable except for low lying positions.
Planning Guidelines	These soils are **not** considered to be *good quality agricultural land* except where they occur in the vicinity of the Rocky Point Sugar Mill and are available for sugar cane production, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993).

Best Management Practices

Cropping

- Reduce cultivation to retain organic matter. Use pasture rotations for long-term soil stability. Organic matter additions (e.g. ‘mill mud’) will increase moisture holding capacity.
- Implement subsurface drainage to lower the watertable, if necessary.

Grazing

- Maintain conservative stocking rates and ensure an adequate surface cover at all times.
- A suggested stockingr ate is 1 AE/8 ha.

KRASNOZEMS

Brief Description

Deep, red, strongly structured clays that are friable and highly permeable.

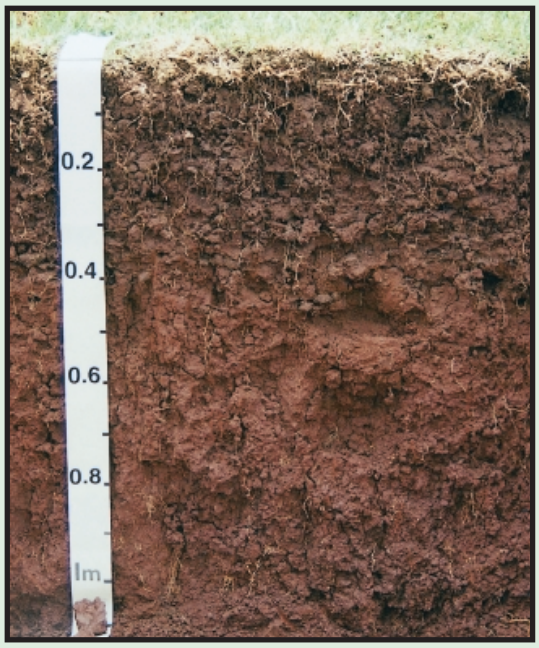
Landform and distribution

- Undulating rises to rolling low hills (slopes 3 – 40%). Associated with areas of weathered basalt (Red Volcanics LRA).
- Krasnozems are the 'red soils' characteristic of the Redlands area and the plateaus of Tamborine Mountain and Beechmont. Also occurs near Mt French.

North Tamborine, January 1991

Vegetation

- Mainly cleared. In the Redlands area the original vegetation was eucalypt open forest dominated by scribbly gum and pink bloodwood.
- On the plateaus, species include flooded gum, tallowwood and brush box with small areas of rainforest.



On basalt plateau, Beechmont

Soil Profile Description

Depth (m)	Description
0.00 to 0.20	Reddish brown, light clay; strong blocky structure; pH 6.5. Gradual change to:
0.20 to 0.50	Red, light medium clay; strong blocky structure; pH 6.0. Gradual change to:
0.50 to 1.10	Red, light medium clay; moderate blocky structure; pH 5.0.

General Soil Features

- Deep soils (often more than 5 m) with gradual horizon boundaries and gradual increase in clay content with depth.
- *Surface*: Reddish brown clay loam to light clay. Strong granular to blocky structure. Loose. Strongly acid (pH 5.5) to slightly acid (pH 6.5).
- *Subsoil*: Dark red, medium to heavy clay. Strong fine to medium blocky structure. Varying amounts of ironstone gravel and rock fragments throughout the profile. Very strongly acid (pH 4.8) to medium acid (pH 6.0). Poorly drained, seepage areas may have yellow subsoils (also called *xanthozems*).
- Plant available water capacity in the root zone is high (150 – 200 mm).
- N – medium to high, P – low to very low, K – medium to high, Cu – medium,, Zn – medium.

Current Development

Intensive horticulture, small crops and tree crops, dairying, conservation parks.

KRASNOZEMS

Land Use Limitations

Soil surface	Surface structure breaks down under cultivation to become cloddy and hardsetting; a plough pan may develop.
Fertility	Fertility is variable in natural state and declines rapidly after development. Deficiencies in most nutrients, especially phosphorus and sulfur.
Erosion	Highly erodible on cultivated slopes greater than 3%.

Land Use Suitability

These soils are suited to a wide range of agricultural uses.

Crops	All crops are suitable.
Pastures	These soils are ideal for pasture development and a wide range of species is suitable for both irrigated and dryland applications (see pasture species chart). Sward forming grasses e.g. kikuyu are recommended if not irrigating.
Irrigation	These freely drained soils are suitable for most types of irrigation, which is required for good yields of most crops.
Earthworks	Suitable for most earthwork operations. Allow for 30% settlement. *Septic systems*: Generally adequate drainage for absorption systems, but there is a danger of percolation into stream and groundwater systems. *Dams*: Special construction techniques required because of highly permeable subsoil.
Planning Guidelines	On sites suitable for cropping, these soils would generally be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993), provided the following best management practices are adopted.

Best Management Practices

Cropping

- Maintain maximum surface cover to maintain soil structure and reduce erosion. Maintain grass swards in orchards. Avoid trafficking and cultivation when wet to reduce soil compaction.
- Rotate intensively cultivated crops with broadacre field crops and legumes to improve soil structure and fertility. A period under pasture in the rotation is also recommended to enhance long-term soil stability and maintain soil organic matter.
- Where irrigating, use water efficiently to reduce erosion and minimise accessions to the watertable. Low volume systems are recommended e.g. spray, trickle.
- Regular additions of fertiliser are required to maintain productivity. These soils quickly convert applied phosphorus to forms unavailable to the plant. Lime application required on average every three to five years. Soil analysis to 15cm is recommended to determine nutrient status and lime requirement.
- Do not cultivate on slopes greater than 10%. Soil conservation measures and crop management strategies are required to control erosion on sloping land. This could include contour banks, stubble mulching and crop rotations.

Grazing

- Maintain adequate surface cover at all times. Stocking rates need to be carefully monitored and adjusted for seasonal variations and the type of market, etc.
- Suggested stocking rates are:

Clear native pasture	1AE/5 ha
Improved pasture, dryland	1 AE/2 ha
Improved pasture, irrigated	1 AE/2 ha

LATERITIC PODZOLICS

Brief Description

Deep sands overlying strongly mottled clay subsoils. Prominent subsurface layer of ironstone gravel.

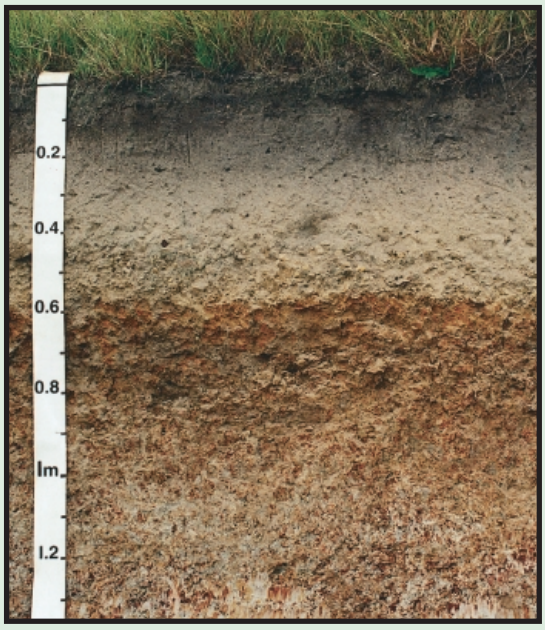
Landform and distribution

- Undulating low hills (about 6%). Often on crests and upper slopes.
- Common on the coarse grained sandstone of the Helidon Forest LRA.

Vegetation

Eucalypt open forest with a wide range of species. Common are spotted gum, scribbly gum, narrow-leaved ironbark, white mahogany, white stringybark, pink bloodwood and small-fruited grey gum.

Koplick Road, Park Ridge, November 1993



On Woogaroo Sandstone, Park Ridge

Soil Profile Description

Depth (m)	Description
0.00 to 0.25	Dark clayey sand; weak fine blocky structure to massive; pH 5.5. Clear change to:
0.25 to 0.40	Yellowish brown, loamy sand; very pale when dry; massive; pH 6.0. Clear change to:
0.40 to 0.60	Yellowish brown, loamy sand; abundant ironstone nodules and iron impregnated sandstone gravel; pH 5.5. Abrupt change to:
0.60 to 0.80	Dark yellowish brown, medium clay; reddish mottles, moderate blocky structure; some red ironstone nodules; pH 5.5. Clear change to:
0.80 to 1.00	Light grey, light medium clay; distinct orange and yellow brown mottles; pH 5.5.
1.00 to 1.40	Light grey, medium clay; fine sand increasing with depth; distinct orange mottles decreasing with depth; massive; pH 5.0.

General Soil Features

- Distinguished from the red and yellow podzolics by the deeper sandy surfaces, large amounts of ironstone gravel in the lower part of the sandy layer and the presence of mottling in the upper part of the subsoil.
- *Surface soil*: Deep sand (up to 1 m), weakly structured to structureless (massive or single grain). Loose to hardsetting surface. Dark brown grading to pale yellowish brown with depth. Abundant ironstone nodules and/or iron impregnated sandstone in the lower part of the sand. Strongly acid (pH 5.2) to slightly acid (pH 6.5).
- *Subsoil*: Light grey to yellowish brown, medium to heavy clay. Strong red to orange mottling throughout. Weak to moderate blocky structure. Medium acid (pH 6.0) to very strongly acid (pH 4.5).
- Plant available water capacity in the root zone is low (50 – 100 mm).
- N – very low, P – low to very low, K – low to medium, Cu – low to very low,, Zn – medium.

Current Development

Grazing, timber reserves, some pine plantations. Occasional cropping.

LATERITIC PODZOLICS

Land Use Limitations

Fertility	Generally low nutrient status with deficiencies of nitrogen, phosphorus and potassium as well as trace elements.
Plant Available Water	Plant available water capacity is low.
Drainage	Good surface drainage but poor drainage into the mottled clay subsoil.
Soil surface	Can become hardsetting, especially if exposed, reducing infiltration rate and increasing runoff. May be stony.
Erosion	Highly erodible on slopes greater than 2%. Prone to sheet erosion.

Land Use Suitability

The optimum long-term use of these soils is for the grazing of native pastures.

Pastures	Under suitable conditions, native pastures may be oversown with a legume or other pasture species (*see pasture species chart*). Leucaena based pastures may also be suitable.
Crops	In some locations, with adequate water supply and suitable fertiliser additions, these soils may be suitable for some horticulture and small crops.
Irrigation	Trickle irrigation for small crops only.
Earthworks	Suitable for most earthwork operations. Respread topsoil in channels after earthworks. Allow for 30% settlement. *Septic systems*: Generally adequate drainage for absorption systems, depending on the depth of surface soil (absorption test required). *Dams*: Locating suitable sites is difficult. Prone to leakage unless the base is firmly in the clay subsoil.
Planning Guidelines	On sites suitable for cropping, these soils would generally be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993), provided the following best management practices are adopted.

Best Management Practices

Grazing

- Maintain adequate surface cover at all times paying particular attention to retaining the more productive pasture species.
- Spell pastures when they are flowering and seeding.
- Adjust stock numbers to the amount of summer pasture growth. A suggested stocking rate is 1 AE/5 ha for both native and improved pastures.

Cropping

- Do not cultivate on slopes > 8%.
- Minimise surface disturbance during crop establishment and maintain adequate surface cover at all times (cover crops e.g. grazing peanuts, may be grown).
- Mound tree crops to improve drainage.
- Add fertilisers to maintain productivity.
- Implement soil conservation measures and crop management strategies to control erosion. These could include contour banks, stubble mulching and crop rotations.

LITHOSOLS

Brief Description

Very shallow soils overlying weathering rock. Often stony and gravelly.

Landform and distribution

- Ridge crests and upper slopes (slopes up to 50%).
- Widespread in hilly and mountainous topography associated with a range of LRAs (2b, 3a, 3b, 4, 5, 6a, 7a, 7b). Less common on sedimentary material.

Vegetation

Open forest to woodland with a range of species including spotted gum, narrow-leaved ironbark, grey ironbark, blue gum, broad-leaved apple and rose sheoak.

Woolooman Road, Woolooman, April 1994

On Marburg Sandstone, Woolooman

Soil Profile Description

Depth (m)	Description
0.00 to 0.25	Dark brown, sandy clay loam; coarse weak blocky structure; pH 6.0. Clear change to:
0.25+	Fractured rock (sandstone) interspersed with weathering rock.

General Soil Features

- Shallow (<0.30 m). May have a sandy, loamy or clayey texture. Variable colour (depending on parent rock). Varying amounts of stone and gravel. Very little profile development except for some darkening of the surface soil due to accumulation of organic matter. Sometimes a pale subsurface layer may be present.
- The fragmented and weathering bedrock is usually highly permeable.
- Medium acid (pH 6.0) to neutral (pH 6.6).
- Plant available water capacity in the root zone is very low (< 50 mm).
- Nutrient status varies with the composition of the parent rock, but is generally low.

Current Development

Timber reserves. Limited grazing of native pastures.

LITHOSOLS

Land Use Limitations

Soil depth	Very shallow, restricting effective rooting depth.
Soil surface	Often hardsetting with large amounts of gravel or stone.
Slope	Often very steep.
Erosion	Very high erosion risk due to steep slopes and poorly structured soil.
Available water	Very little water is held in these soils for plant use.
Plant available water	Plant available water capacity is very low.
Fertility	Generally low to very low.

Land Use Suitability

These soils are not suitable for development. In their naturally vegetated state, these soils are useful as wildlife refuges/corridors.

Pastures	Native pasture will usually be of poor quality except in favourable seasons with well distributed rainfall.
Earthworks	Limited suitability for road and track construction and other earthworks. *Septic systems*: Limited suitability due to shallow depth to bedrock. Alternative sewage treatment systems (e.g. composting and aerated types) should be considered.
Planning Guidelines	**Not** *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993).

Best Management Practices

- Leave this land as undisturbed as possible, maintaining maximum surface cover at all times. Timber and other woody vegetation should be retained on ridges and steep slopes to protect against erosion and minimise accessions to the watertable.
- If used for grazing, maintain conservative stocking rates. A suggested stocking rate is 1 AE/8 ha.

LOAMY SOLODICS

Brief description

Loamy surface soils overlying hard, alkaline, clay subsoils.

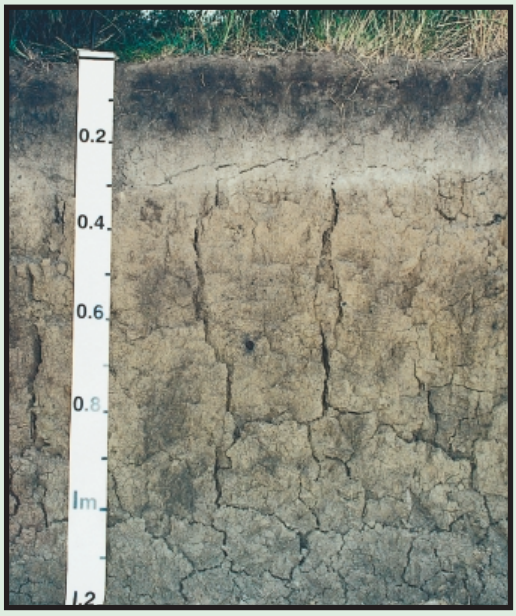
Rosewood - Warrill View Road, May 1994

Landform and distribution

- Plains and hill slopes (up to 20%)
- Widely distributed in undulatin to hilly country associated with the Fores Wallons and Marburg Forest walloons and Marburg forest LRA's and on local alluvium in the Mixed Alluvial Plain LRA

Vegetation

Open forest. Tree species include narrow-leaved ironbark, silver -leaved ironbark, Moreton Bay ash.



On Walloon Sandstone, Warrill view

Soil Profile Description

Depth (m)	Description
0.00 to 0.20	Dark greyish brown, clay loam weak blocky structure; pH 5.5. Clear change to:
0.20 to 0.30	Bleached sandy clay loam; massive; very hard when dry; traces of soft manganese nodules; pH 6.4. Abrupt change to:
0.30 to 1.00	Yellow brown, medium heavy clay; moderate medium blocky structure; pH 8.5. Gradual change to:
1.00 to 1.30	Grey medium clay; weak blocky structure; pH 9.0.

General Soil Features

- Texture contrast profiles with a very sharp boundary between the loamy surface soil and the clay subsoil.
- *Surface*: Brown to dark grey, sandy clay loam to clay loam of variable depth (0.10 to 0.40 m). Generally hardsetting. Usually a prominent bleached zone above the hard clay subsoil. Strongly acid (pH 5.4) to neutral (pH 6.6). Occasional gilgai development (on alluvial plains).
- *Subsoil*: Brown to yellow brown, medium to heavy clay, occasionally mottled. Blocky to columnar structure.Moderately alkaline (pH 8.0) to strongly alkaline (pH 9.0). Strongly sodic and dispersible. Dominance of magnesium in the subsoil increases the dispersion tendency. Sometimes contains lime. Manganese may be present.
- As rooting depth is restricted by the hard (and often saline) subsoil, plant available water capacity in the root zone is usually very low (< 50 mm).
- N – variable (low to high), P – variable (very low to high), K – medium to high, Cu – medium, Zn – medium.

Current Development

Grazing of native pastures, timber reserves, opportunistic cropping.

LOAMY SOLODICS

Land Use Limitations

Drainage	Internal drainage is impeded by the tough clay subsoil. Prone to waterlogging in wet periods.
Soil structure	Plant growth restricted by the tough clay subsoil and hardsetting surface
Erosion	Very susceptible to erosion; especially tunnel erosion and gullying (dispersible subsoil).
Fertility	Phosphorus and nitrogen levels vary, but are commonly low.
Plant available water	Plant available water capacity is very low.
Salinity	Subsoil salinity may be high.

Land Use Suitability

The surface soil is more stable and fertile than for the sandy solodics. However, the severe erosion risk combined with the other limitations listed above mean that these soils are generally unsuitable for cropping and other agricultural developments. The best use is for the grazing of native pastures.

Pastures	These soils are capable of producing good quality native pastures. Some locations (with deeper surface soils on lower slopes) may be suitable for oversowing with a legume (*see pasture species chart*). Leucaena based pastures may also be suitable on well drained sites. Nitrogen and phosphorus would generally be required (fertility analysis advised).
Crops	Limited suitability for small crops on favourable sites (low slope, ,surface soil greater than 0.30 deep).
Earthworks	Soil disturbance should be kept to a minimum. If earthworks are essential, conserve the topsoil and ensure that the subsoil is not left exposed. Do not construct drains. Allow for 30% settlement. *Septic systems*: Limited suitability due to restricted drainage into subsoil. Alternative sewage treatment systems are recommended (e.g. composting and aerated types). *Dams*: To prevent leaks, it is essential to achieve adequate compaction using appropriate compaction equipment, working with soil at the correct moisture content. Dams should be fenced to avoid damage by stock. Spread topsoil over banks to promote grass cover.
Planning Guidelines	**Not** *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993).

Best Management Practices

Grazing

- Maintain adequate cover of grass at all times. Bare soil is more easily eroded and compacted (reducing infiltration).
- Oversowing of legumes should be done with minimal soil disturbance (e.g. strip cultivation).
- Maintain as much timber cover as possible, especially on steeper slopes and ridges. Control thick regrowth if it restricts grass cover.
- Use conservative stocking rates and adjust for seasonal rainfall variation.
- Suggested stocking rates are:

Uncleared native pasture	1AE/8 ha
Cleared native pasture	1 AE/5 to 6 ha

Cropping

- Keep soil disturbance to a minimum.
- Avoid cropping. It should only be considered as a short-term option.
- Implement soil conservation measures and crop management strategies to control erosion. These could include contour banks, stubble mulching and crop rotations.

RED EARTHS

Brief Description

Red, loamy soils which are deep, porous and friable with weakly developed structure.

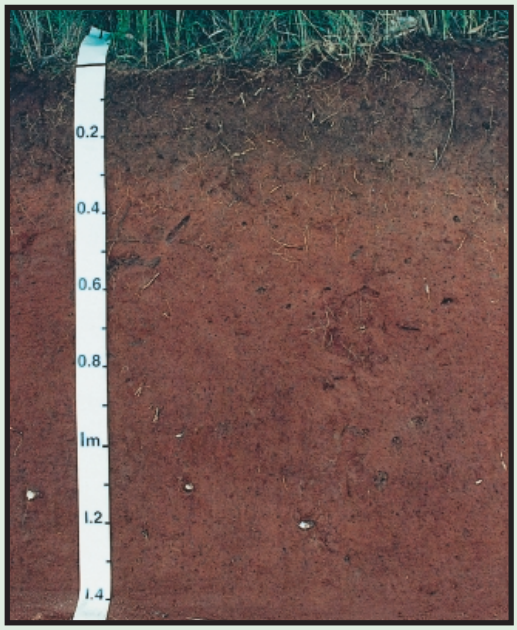
Landform and distribution

- Crests and slopes of low hills. Slopes from 2 to 20% (modal 10%).
- Widespread in the coarse-grained sediments of the Helidon Sandstone (Helidon Forest LRA).
- A minor soil group on alluvium (Mixed Alluvial Plains LRA) and in the Metamorphic Hills LRA.

Hampton Road, SW of Esk, January 1993

Vegetation

- Open forest dominated by Moreton Bay ash and narrow-leaved ironbark.
- Broad-leaved apple, swamp mahogany and blue gum also occur on lower slopes.
- Extensively cleared.



On Helidon Sandstone, Esk

Soil Profile Description

Depth (m)	Description
0.00 to 0.20	Dark reddish brown, coarse sandy loam; weak granular structure; pH 6.0. Gradual change to:
0.20 to 0.50	Dark reddish brown, coarse sandy loam; single grain; few iron/manganese nodules; pH 6.5. Gradual change to:
0.50 to 1.00	Red, coarse sandy loam; massive; pH 7.0. Gradual change to:
1.00 to 1.40	Red, coarse sandy clay loam; massive; few iron/ manganese nodules; pH 7.0.

General Soil Features

- Usually deep (ranging from 1.0 m to 5.0 m). Weak profile development with gradual increase in clay content with depth.
- *Surface*: Dark brown or reddish brown, loamy sand to sandy loam. Weak granular structure or massive. Slightly acid (pH 6.5) to strongly acid (pH 5.4).
- *Subsoil*: Red, sandy loam to sandy light clay (occasionally medium clay). Structureless (single grain to massive). Medium acid (pH 5.8) to neutral (pH 6.6). May be mottled at depth.
- Plant available water capacity in the root zone is low (50 – 100 mm).
- N – low, P – very low, K – medium, Cu – low to medium, Zn - medium.

Current Development

- Grazing. Some dryland forage cropping.
- Irrigated forage cropping and small crops where water supplies are available.

RED EARTHS

Land Use Limitations

Fertility	Nutrient status is very low, especially phosphorous and nitrogen.
Erosion	Highly erodible (if bare or cultivated) on slopes greater than 2%.
Water available	Water supplies required for development are very limited.
Plant available water	Plant available water capacity is generally low (even allowing for deep rooting depths).
Soil surface	May become hardsetting if excessively cultivated.
Salinity	May be an intake area for groundwater recharge and saline seepages on lower slopes.

Land Use Suitability

The optimum long-term use of these soils is for the grazing of improved pastures.

Crops	These soils are potentially valuable for horticulture, although significant fertiliser inputs are required (especially phosphorus and nitrogen) as well as adequate water supplies. A range of small crops and tree/vine crops are suitable e.g. melons, potatoes, tomatoes.
Pastures	These soils produce high quality native pastures. Low-key pasture development is recommended i.e. introducing legumes such as wynn cassia into native pasture. Irrigated sown pasture development is not recommended because of the quantity of water and fertiliser required.
Irrigation	The friable, highly permeable nature of these soils makes them ideal for irrigation. However to reduce erosion and conserve water supplies, irrigation is only recommended for small crops, using low volume systems e.g. spray or trickle.
Earthworks	Suitable for most earthwork operations. Allow for 30% settlement. *Septic systems*: Generally adequate drainage for absorption systems, but there is a danger of percolation into stream and groundwater systems. *Dams*: Most suitable on the lower slopes. Prone to leakage due to lack of clay. Require lining or sealing.
Planning Guidelines	Where suitable for cropping, these soils would generally be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993), provided the following best management practices are adopted.

Best Management Practices

Grazing

- Maintain an adequate surface cover at all times, paying particular attention to retaining the more productive pasture species. Pastures should be spelled when flowering and seeding.
- Adjust stock numbers to the amount of summer pasture growth. Suggested stocking rate is 1 AE/4 to 5 ha.

Cropping

- Maintain maximum surface cover to reduce erosion and retain organic matter. Use minimum or zero tillage.
- Do not cultivate on slopes greater than 8%. Soil conservation measures and crop management strategies will be required to control erosion on sloping sites. These could include contour banks, safe disposal areas for runoff, stubble mulching and crop rotations.
- A ley farming system (several years of perennial grass and legumes in the crop rotation) is recommended for the control of disease and weeds, and also to maintain soil stability and organic matter.
- Use lime where necessary, in addition to fertilisers.
- Where irrigating, use water efficiently to reduce erosion and minimise accessions to groundwater.

RED PODZOLICS

Brief Description

Brown sandy loams overlying red, well structured, clay subsoils.

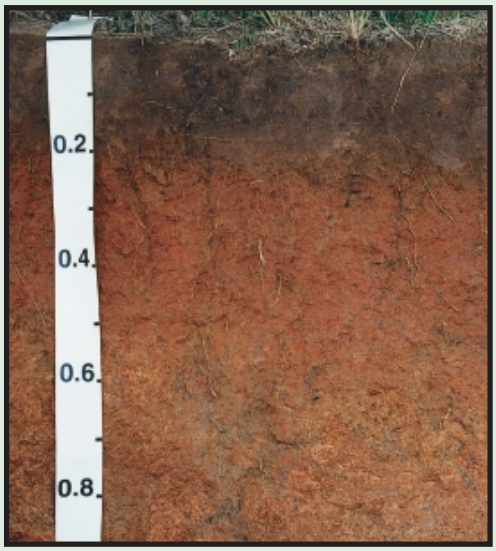
Landform and distribution

- Hillslopes ranging from gently inclined (about 6%) to steep (about 40%).
- Widespread in hilly country throughout the region. Associated with granite, metamorphic and most sedimentary rock types (common in a range of LRAs – 1c, 3b, 4, 5, 6a, 7a, 7b, 7c)

Vegetation

Grassy open forest with a wide range of species including silver-leaved ironbark, narrow-leaved ironbark, spotted gum, Moreton Bay ash, broad-leaved apple, rusty gum and pink bloodwood.

Esk-Crows Nest Road, Eskdale, December 1992



On granodiorite, Eskdale

Soil Profile Description

Depth (m)	Description
0.00 to 0.15	Dark reddish brown, sandy loam; massive; pH 7.0. Gradual change to:
0.15 to 0.25	Reddish brown, sandy clay loam; massive; pH 6.8. Clear change to:
0.25 to 0.35	Dark red, medium clay; weak blocky structure; pH 6.8. Clear change to:
0.35 to 0.55	Red, medium clay; moderate blocky structure; pH 7.5. Clear change to:
0.55 to 0.85	Yellowish red, sandy loam (decomposed granite); massive; pH 7.8.

General Soil Features

- Texture contrast profiles with a clear boundary between the surface sandy loam and the clay subsoil.
- *Surface*: Greyish brown to reddish brown, sandy loam (occasional sandy clay loam to clay loam) to between 0.10 m and 0.40 m. Loose to hardsetting. Massive and porous. The subsurface is paler in colour, but usually not bleached. Sometimes gravelly (especially in the Metamorphic Hills LRA). Strongly acid (pH 5.2) to strongly acid (pH 6.5).
- *Subsoil*: Red to reddish brown, medium to heavy clay. Sometimes mottled. Well structured and friable. Very strongly acid (pH 5.0) to slightly acid (pH 6.5). Occasionally neutral to mildly alkaline (up to pH 7.8). Variable depth (< 0.5 m to > 1.5 m). Non sodic.
- Plant available water capacity in the root zone is low (50 – 100 mm).
- N – low, P – very low, K – variable (very low to high), Cu – low to high, Zn – low to medium.

Current Development

Grazing, timber reserves. Some horticulture and small crops.

RED PODZOLICS

Land Use Limitations

Slope	Often occur on steep slopes unsuitable for agricultural development.
Erosion	Highly erodible on slopes greater than 2%. Prone to sheet erosion. On steeper slopes, there is a high risk of landslips if overcleared. Wind erosion if left bare on exposed slopes.
Fertility	Generally very low nutrient status, especially nitrogen and phosphorus. Root development and nutrient uptake may be impeded in the more acid subsoils.
Soil surface	May become hardsetting which reduces infiltration and increases runoff.
Drainage	Generally well drained. However, in mottled soils on lower slopes, temporary perched watertables may occur.
Plant available water	Plant available water capacity is low.

Land Use Suitability

The optimum long-term use of these soils is for the grazing of native pastures.

Pastures	Given suitable conditions, native pastures may be oversown with a legume or other pasture species (*see pasture species charts*). Leucaena based pastures may also be suitable.
Crops	On favourable sites (slopes < 8%, suitable soil surface and adequate depth), given adequate water supply and suitable fertiliser additions, these soils may be suitable for horticulture and small crops.
Irrigation	Trickle irrigation for small crops only.
Earthworks	Suitable for most earthwork operations. Allow for 30% settlement. *Septic systems*: Generally adequate drainage for absorption systems. Absorption test may be required. *Dams*: Difficulty obtaining suitable sites and prone to leakage due to high permeability of the soils.
Planning Guidelines	On sites suitable for cropping, these soils would generally be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993), provided the following best management practices are adopted.

Best Management Practices

Grazing

- Steep slopes should not be cleared. Maintain an adequate surface cover at all times paying particular attention to retaining the more productive pasture species.
- Spell pastures when flowering and seeding.
- Adjust stock numbers to the amount of summer pasture growth. A suggested stocking rate is 1 AE/5 ha for both native and improved pastures.

Cropping

- Do not cultivate on slopes > 8%.
- Minimise surface disturbance during crop establishment and maintain adequate surface cover at all times (groundcover crops e.g. grazing peanuts may be grown).
- Mount tree crops to achieve a minimum 1 m depth of soil.
- Add fertilisers to maintain productivity.
- Implement soil conservation measures and crop management strategies to control erosion. These could include contour banks, stubble mulching and crop rotations. Re-spread topsoil in channels after earthworks.

SANDY ALLUVIALS

Brief Description

Deep, well drained sandy soils associated with watercourses (also called *alluvial soils*).

Landform and distribution

- Levees and low terraces associated with watercourses (slopes 0 – 3%).
- Widely distributed in association with most streams, but not extensive in total area (Fine Textured Alluvial Plains and Mixed Alluvial Plains LRAs).

Vegetation

- Mostly cleared. Remnant river sheoak, blue gum and red bottlebrush.
- Introduced species such as lantana, camphor-laurel and castor-oil plant may be present.

Channel bench, Logan River between Woodhill and Kagara, March 1994

Logan River between Woodhill and Kagara

Soil Profile Description

Depth (m)	Description
0.00 to 0.08	Brown, loamy sand; single grain; pH 7.0. Abrupt change to:
0.08 to 0.12	Dark brown, sandy clay loam; massive. Abrupt change to:
0.12 to 0.20	Brown, loamy sand; pH 7.3. Abrupt change to:
0.20 to 0.38	Brown, sandy loam; single grain. Abrupt change to:
0.38 to 0.44	Dark brown, sandy clay loam; massive. Abrupt change to:
0.44 to 0.55	Brown, loamy sand; single grain. Abrupt change to:
0.55 to 0.63	Dark brown, sandy clay loam; massive; pH 7.7. Abrupt change to:
0.63 to 0.70	Brown, loamy sand; single grain. Abrupt change to:
0.70 to 0.72	Dark brown, sandy clay loam; massive; pH 7.7.
	similar pattern continues

General Soil Feature

- Very little horizon development. Characterised by the presence of distinct layers of alluvium, each layer differing in colour, texture, gravel content and thickness. These layers represent change in the original sedimentation and indicate that these are young soils. The colour of the upper layers is usually dark brown or grey and this may extend down the profile, although the lower layers are often lighter coloured.
- The texture varies markedly between profiles and often within one profile, ranging from sands and sandy loams to sandy clay. Layers of gravel and stone are more prevalent in the upper reaches of the watercourse. The more clayey soils may have a granular to blocky structure, while the more sandy soils are structureless (single grain or massive).
- Medium acid (pH 5.8) to mildly alkaline (pH 7.8).
- Plant available water capacity in the root zone depends largely on texture and varies from low (50 – 100 mm) to medium (100 – 150 mm).
- N – low, P – medium to high, K – medium to high, Cu – medium, Zn – medium.

Current Development

Grazing. Some fodder and small cropping. In most locations, use is restricted by flooding.

SANDY ALLUVIALS

Land Use Limitations

Flooding	Seasonal flooding occurs in most location.
Soil surface	Surface may become cloddy and crusting with cultivation. May be stony.
Plant available water	Low in sandy textured soils.
Erosion	Moderate risk of rill and sheet erosion on unprotected surface depending on the amount and velocity of overland flow. Susceptible to streambank erosion.

Land Use Suitability

The use of these soils is restricted by the frequency of flooding and their limited areal extent at the property level.

Crops	These soils are suitable for most winter crops. The risk of flooding limits the summer cropping potential of these soils.
Pastures	These soils are ideal for pasture development and a wide range of species is suitable for both dryland and irrigated applications (*see pasture species chart*).
Irrigation	Adequate quantity and quality of water supply are critical (poor to marginal quality water should not be used). Flood irrigation is not recommended because of the high permeability of these soils.
Earthworks	Suitable for most earthwork operations. Allow for 30% settlement. Not suitable for septic systems.
Planning Guidelines	On sites suitable for cropping, these soils would generally be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993), provided the following best management practices are adopted.

Best Management Practices

Grazing

- Monitor pasture use to ensure that adequate surface cover is maintained. Pastures should be spelled when flowering and seeding. Control woody weeds. Stocking rates need to be adjusted for seasonal variations and type of market, etc.
- Suggested stocking rates are:

Cleared native pasture	1AE/4 ha
Improved pasture dryland	1 AE/2 ha
Sown pasture, irrigated	1 AE/2 ha

Cropping

- Maintain maximum surface cover, especially in summer when erosion risk is highest.
- Do not cultivate within 20 m of stream bank.
- Use minimum tillage and retain stubble residues to improve soil structure and reduce erosion. Include green cover crops in crop rotations. Control weeds.
- Irrigation is normally required. Manage spray applications carefully to prevent stream contamination.

SANDY SOLODICS

Brief Description

Sandy surface soils overlying hard, alkaline, clay subsoils.

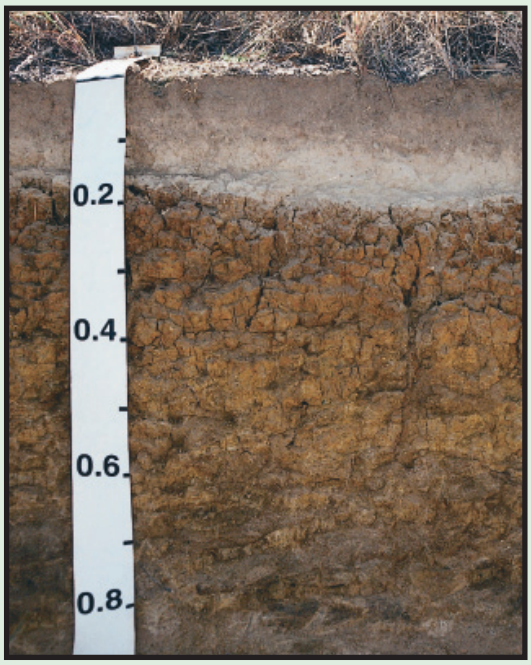
Landform and distribution

- Plains and hillslopes (0 – 20%).
- Common in undulating to hilly country associated with coarse grained sedimentary rock material (Marburg Forest and Marburg Scrub LRAs) and on local alluvium in the Mixed Alluvial Plains LRA.

Vegetation

- Grassy open forest. Species include spotted gum, narrow-leaved ironbark, silver-leaved ironbark, Moreton Bay ash and bull oak.

Forest Hill - Laidley Northern Connection Road, May 1994



On Marburg Sandstone, Forest Hill

Soil Profile Description

Depth (m)	Description
0.00 to 0.07	Dark brown, sandy loam; weak granular structure; pH 6.5. Clear change to:
0.07 to 0.17	Bleached pale brown; sandy loam; massive; hard when dry; pH 5.8. Abrupt change to:
0.17 to 0.42	Yellowish brown, medium heavy clay; strong blocky structure; faint red mottles; hard when dry; pH 6.5. Gradual change to:
0.42 to 0.60	Yellowish brown, light clay; weak blocky structure; pH 8.5. Gradual change to:
0.60 to 0.90	Brownish yellow, clayey sand (weathered sandstone); pH 9.0.

General Soil Features

- Texture contrast profiles with a very sharp boundary between the sandy surface soil and the clay subsoil.
- *Surface*: Brown to dark grey, loamy sand to sandy loam of variable depth (0.10 m to 0.40 m). Usually hardsetting. Always a prominent bleached zone above the hard clay subsoil. Strongly acid (pH 5.4) to slightly acid (pH 6.5).
- *Subsoil*: Yellow-brown to brown, light clay to heavy clay. May be mottled (yellow or grey). Blocky to columnar structure. Moderately alkaline (pH 8.0) to strongly alkaline (pH 9.0). Strongly sodic and dispersible. Dominance of magnesium in the subsoil increases the dispersion tendency. Sometimes contains lime.
- As rooting depth is restricted by the hard (and often saline) subsoil, plant available water capacity in the root zone is usually very low (< 50 mm).
- N – low, P – very low to low, K – low to medium, Cu – medium, Zn – medium.

Current Development

Grazing of native pastures. Timber reserves.

SANDY SOLODICS

Land Use Limitations

Drainage	Internal drainage is impeded by the touch clay subsoil. Prone to waterlogging .
Soil structure	Plant growth restricted by the tough clay subsoil and hardsetting surface.
Erosion	Very susceptible to erosion, including sheet erosion, tunnel erosion and gullying (dispersible subsoil).
Fertility	Very low nutrient status, especially phosphorus and nitrogen.
Plant available water	Plant available water capacity is very low.
Salinity	Subsoil salinity may be high.

Land Use Suitability

The severe erosion risk combined with the other limitations listed above means that these soils are generally unsuitable for cropping and other agricultural developments. The best use is for the grazing of native pastures.

Pastures	Pasture development is generally not appropriate. However, some more favourable locations (with deeper surface soils on lower slopes) may be suitable for the oversowing (minimum disturbance) of native pastures with a legume (*see pasture species chart*). Nitrogen and phosphorus would generally be required (fertility analysis advised).
Earthworks	Soil disturbance to be kept to a minimum. If earthworks are essential, conserve the topsoil and ensure that the subsoil is not left exposed. Do not construct drains. Allow for 30% settlement. *Septic systems*: Limited suitability due to restricted drainage into subsoil. Alternative sewage treatment systems are recommended (e.g. composting and aerated types). *Dams*: To prevent leaks, it is essential to achieve adequate compaction using appropriate compaction equipment, working with soil at the correct moisture content. Dams should be fenced to avoid damage by stock. Spread topsoil over banks to promote grass cover.
Planning Guidelines	**Not** *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993).

Best Management Practices

Grazing

- Maintain adequate grass cover at all times. Bare soil is more easily eroded and compacted which reduces infiltration.
- Oversowing of legumes should be done with minimal soil disturbance (e.g. strip cultivation).
- Maintain as much timber cover as possible, especially on steeper slopes and ridges. Control thick regrowth if it restricts grass cover.
- Use conservative stocking rates and adjust for seasonal rainfall variation.

Suggested stocking rates are:	*Uncleared native pasture*	1AE/8 ha
	Cleared native pasture	1 AE/5 to 6 ha

SHALLOW CLAYS and clay loams

Brief Description

Shallow, dark, friable clay loams and clays over weathered parent rock. This group includes *shallow prairie soils*, *shallow black earths* and *rendzinas*.

Landform and distribution

- Generally found in hilly topography in mid to upper slope positions (slopes 3-30%).
- Widely distributed throughout the Moreton region in areas associated with weathered volcanic rocks (particularly andesite, basalt and microsyenite). A dominant soil group in the Basaltic Uplands, Southern Intrusives and Northern Mixed Volcanics LRAs. Also occurs in the Forest Walloons LRA.

Vegetation

- Open forest, mostly cleared in the settled areas. Species include silver-leaved ironbark, narrow-leaved ironbark, Moreton Bay ash, blue gum, yellow box, forest sheoak and white stringybark.
- Softwood scrub or mixed rainforest with a range of species including crow's ash, silky oak and hoop pine.

General soil features

- *Surface*: Surface condition is loose to self-mulching (occasionally hardsetting). Brown to black, clay loam to medium clay, well structured. Slightly acid (pH 6.4) to mildly alkaline (pH 7.4).
- *Subsoil*: Black, brown or reddish brown clay. Strong blocky structure. Slightly acid (pH 6.4) to strongly alkaline (pH 8.5), depending on the parent rock. Bedrock at 0.3 to 0.8 m.
- Plant available water capacity in the root zone is low (50 - 100 mm), due to the shallow nature of these soils. Generally good internal drainage. The fractured bedrock is generally highly permeable.
- N – medium to high, P – medium to high, K – medium to high, Cu – medium, Zn – medium.

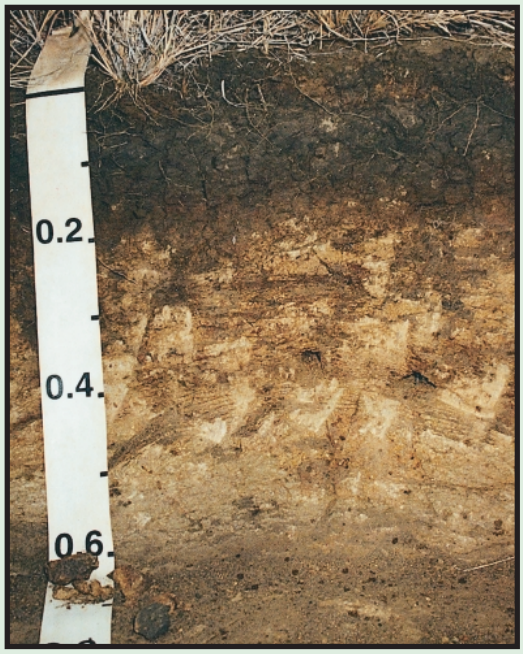
Example sites

a. Shallow prairie soils
Southern Intrusives LRA

Landform and vegetation

- Undulating low hills and rises on igneous intrusions of microsyenite. Slopes 4 to 13%
- Mostly cleared. Remnant tree species include narrow-leaved ironbark, Moreton Bay ash and blue gum.

Boonah - Fassifern Road near Kalbar, October 1994



On microsyenite, Kalbar

Soil Profile

Depth (m)	Description
0.00 to 0.07	Dark brown, light clay; fine blocky structure; pH 6.5. Gradual change to:
0.07 to 0.22	Dark brown, medium clay; strong blocky structure; pH 6.5. Gradual change to:
0.22 to 0.30	Brown, medium clay; weak blocky structure; pH 7.0. Gradual change to:
0.30 to 0.40	Yellowish brown, sandy clay loam; massive structure; pH 7.8. Gradual change to:
0.40+	Yellowish brown, clayey sand; massive (weathered microsyenite).

SHALLOW CLAYS and clay loams

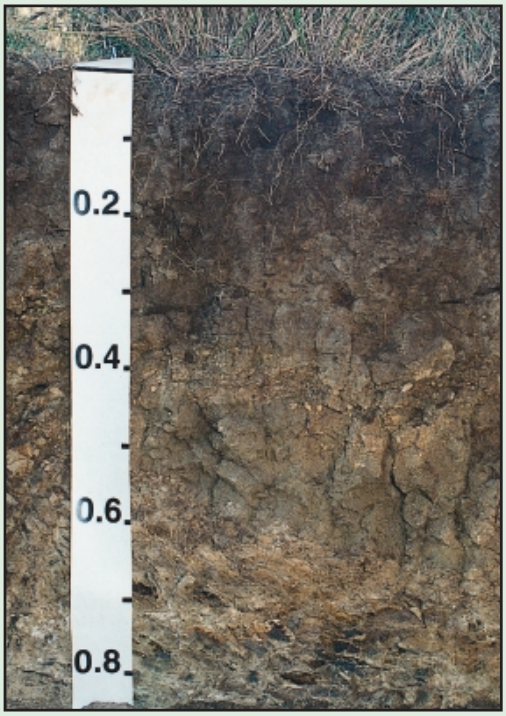
b. Shallow prairie soils

Northern Mixed Volcanics LRA

D'Aguillar Highway, west of Kilcoy, May 1994

Landform and vegetation

- Rolling low hills (slopes 10 - 30%)
- Mixed rainforest or eucalypt open forest. Remnant species include crow's ash, silky oak and fig.



On andesite, Kilcoy

Soil Profile

Depth (m)	Description
0.00 to 0.20	Dark brown, clay loam; strong granular structure; pH 6.5. Gradual change to:
0.20 to 0.50	Brown, medium clay; strong blocky structure; some gravel; pH 7.5. Gradual change to:
0.50 to 0.75	Light Brown, light medium clay; strong blocky structure; gravelly; pH 7.5. Gradual change to:
0.75+	Light brown, clay loam; weakly structured; very gravelly; pH 8.5 (weathered andesite).

SHALLOW CLAYS and clay loams

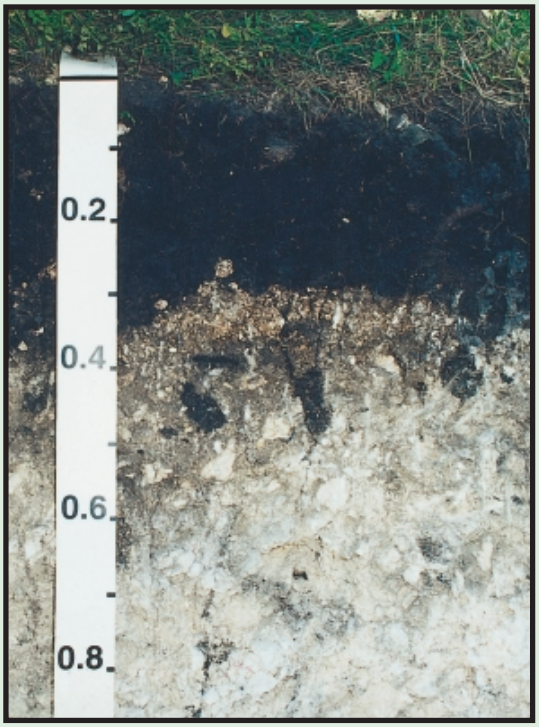
c. Rendzinas

Forest Walloons LRA

Limestone Ridge Road, south of Ipswich, May 1994

Landform and vegetation

- Undulating rises to rolling low hills.
- Open forest consisting of ironbarks, Moreton Bay ash, blue gum and broad-leaved apple.



On Limestone, Limestone Ridge

Soil Profile Description

Depth (m)	Description
0.00 to 0.10	Black, clay loam; strong granular structure; pH 7.5. Clear change to:
0.10 to 0.20	Black, light clay; strong blocky structure; pH 7.7. Clear change to:
0.20 to 0.35	Black, medium clay; strong blocky structure; pH 8.0. Clear change to:
0.35 to 0.55	Greyish brown, medium clay; weak blocky structure; pH 8.0. Gradual change to:
0.55+	Weathered limestone. (Note: coarse fragments of limestone present on surface and throughout the profile).

SHALLOW CLAYS and clay loams

Land Use Limitations

Soil depth	Shallow, often less than 0.5 m above weathered bedrock.
Soil surface	Often stony. May become hardsetting after continuous cultivation.
Plant available water	Plant available water capacity is low due to shallow soil depth.
Slope	Slopes above 15% too steep for cultivation.
Erosion	Moderate to high erosion hazard, especially on steeper slopes.
Salinity	May act as intake area for groundwater recharge, thereby contributing to salinity problems in lower land units.

Land Use Suitability

The optimum long-term use of these soils is for the grazing of native and improved pastures.

Crops	On areas with suitable depths of soil (> 0.5 m) and low slopes (< 10%), a range of grain, fodder and small crops may be grown. Some tree and vine crops may also be suitable depending on local conditions, including frost hazard.
Pastures	These soils are suitable for non-irrigated pasture development and a wide range of species is suitable (*see pasture species chart*).
Irrigation	Adequate water supply and excessive drainage are limitations. Trickle irrigation is suitable for small crops and tree crops.
Earthworks	Suitable for most earthwork operations. Remove topsoil prior to earthworks and carefully respread in the channels following the construction of waterway, diversion banks or contour banks. Allow for 30% settlement. *Septic systems*: Generally adequate drainage for absorption systems, but there is a danger of percolation into stream and groundwater systems. *Dams*: Difficulty obtaining suitable sites and prone to leakage due to shallow nature of the soils.
Planning Guidelines	Only where these soils are suitable for cropping and sown pastures would they be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993), provided the following best management practices are adopted.

Best Management Practices

Grazing

- Maintain adequate surface cover at all times paying particular attention to retaining the more productive pasture species. Pastures should be spelled when flowering and seeding.
- Control woody weeds and regrowth problems on steeper slopes (particularly in northern areas).
- Adjust stocking numbers to the amount of summer pasture growth. A suggested stocking rate is 1 AE/4 ha for both native and improved pastures.

Cropping

- Maintain maximum surface cover and control runoff.
- Implement contour banks, safe disposal areas for runoff and crop management strategies to control erosion.
- Include green cover crops and stubble retention strategies in crop rotations.
- Where irrigating, use water efficiently to minimise accessions to groundwater.
- Mound tree crops to obtain minimum 1 m depth of topsoil.

SHALLOW HILLSIDE SOILS

Brief Description

Shallow soils with loamy surfaces overlying reddishn brown well structured clays in hilly country (also called *non-calcic brown soils).*

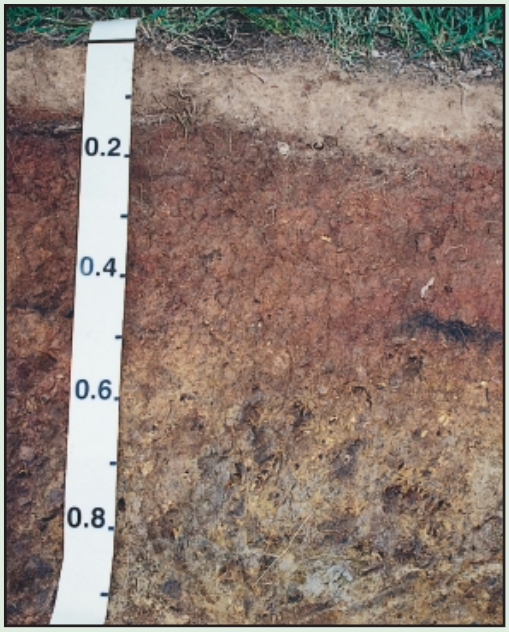
Landform and distribution

- Widespread in hilly country associated with a range of LRAs (2b, 3b, 3c, 4, 7a). Individual occurrences are often limited in areal extent.
- Mid to upper slope positions (slopes up to 40%).

Noonans Corner, Esk - Crows Nest Road, May 1994

Vegetation

- Open forest with a range of species including spotted gum, narrow-leaved ironbark, silver-leaved ironbark, blue gum, Moreton Bay ash and small-fruited grey gum. Sparse understorey.
- Brigalow and softwood species may occur.



Eskvale.

Soil Profile Description

Depth (m)	Description
0.00 to 0.15	Brown, sandy clay loam; massive; pH 6.0. Clear change to:
0.15 to 0.50	Reddish brown, medium clay, strong blocky structure, friable, coarse rock fragments increasing in abundance with depth; pH 7.0.
0.50 to 0.60	Yellowish brown, light medium clay; weak blocky structure, many coarse rock fragments; pH 7.0.
0.60+	Weathered bedrock (sandstone, possibly metamorphosed); pH 7.0.

General Soil Features

- Texture contrast profiles with a clear boundary between the loamy surface soils and the reddish brown clay subsoils. Distinguished from the podzolics and solodics by the absence of a bleached subsurface layer and a neutral to mildly alkaline subsoil.
- *Surface*: Commonly clay loam, occasionally more sandy. Usually thin, less than 0.20 m. Weakly structured to massive, hardsetting. Medium acid (pH 6.0) to neutral (pH 7.0).
- *Subsoil*: Reddish brown, light to medium clay. Well structured. 0.25 to 0.50 m thick, over permeable fractured rock. Very good internal drainage. Sometimes mottled at depth (due to weathering rather than waterlogging). Neutral (pH 6.7 to 7.2).
- Plant available water capacity in the root zone is low (50 – 100 mm).
- N – low to very low, P – low to very low, K – medium, Cu – medium, Zn – low to medium

Current Development

Grazing, timber reserves.

SHALLOW HILLSIDE SOILS

Land Use Limitations

Erosion	As these soils often occur on steep slopes, erosion is a risk if surface is disturbed.
Soil depth	Shallow depth to weathered bedrock.
Plant available water	Plant available water capacity is low.
Soil surface	Hardsetting, reduced infiltration rate. May be rocky.
Fertility	Deficient in phosphorus, nitrogen and some trace elements such as zinc.
Salinity	Acts as an intake area, saline seepages may occur in lower slopes.

Land Use Suitability

The optimum use of these soils is for grazing native pastures and for limited timber production.

Pastures	Pasture development is generally not appropriate.
Earthworks	Suitable for most earthwork operations. Allow for 30% settlement. *Septic systems*: Generally adequate drainage for absorption systems, but there is a danger of percolation into stream and groundwater systems. *Dams*: Difficulty obtaining suitable sites and prone to leakage due to shallow nature of the soils.
Planning Guidelines	**Not** *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993).

Best Management Practices

Grazing

- Maintain adequate grass cover at all times. Bare soil is more easily eroded as well as compacted (reducing infiltration).
- Maintain as much timber cover as possible, especially on steeper slopes and ridges. However, thick regrowth may need to be controlled if it restricts grass cover.
- Use conservative stocking rates and adjust for seasonal rainfall variation.

Suggested stocking rates are:	*Uncleared native pasture*	1AE/8 ha
	Cleared native pasture	1 AE/5 to 6 ha

SOLOTHS

Brief Description

Loamy sand to clay loam surface soils overlying coarsely structured, hard, clay subsoils.

Landform and distribution

- Plains and hillslopes (up to 20%).
- Widely distributed in low hilly country associated with coarse and fine grained sediments (Marburg Forest and forest Walloons LRAs) and on local alluvium in the Mixed Alluvial Plains LRA.

Vegetation

Woodland to open forest. Species include spotted gum, narrow-leaved ironbark, silver-leaved ironbark, Moreton Bay ash, bull oak and gum-topped box.

Greys Plains Road, Mount Mort, May 1994

*On Walloon Sandstone, Mount Mor***t**

Soil Profile Description

Depth (m)	Description
0.00 to 0.10	Brown, clay loam; massive; pH 5.8. Clear change to:
0.10 to 0.27	Bleached pale brown, sandy clay loam; massive; pH 6.5. Abrupt change to:
0.27 to 1.20	Greyish brown, light clay; weak blocky structure to massive; extremely hard when dry; small amounts of gravel; pH 5.8.

General Soil Features

- Texture contrast profiles with a very sharp boundary between the surface soil and the clay subsoil.
- *Surface*: Brown to dark grey, loamy sand to clay loam of variable depth (0.10 to 0.40 m). Generally hardsetting. Usually a thick bleached zone above the hard clay subsoil. Very strongly acid (pH 4.5) to slightly acid (pH 6.5). Occasional gilgai development (on alluvial plains).
- *Subsoil*: Brown, yellow-brown to red, light clay to heavy clay, often mottled. Coarse blocky to columnar structure, or massive. Very strongly acid (pH 4.5) to medium acid (pH 6.0). Strongly sodic and dispersible. Dominance of magnesium in the subsoil increases the dispersion tendency.
- As rooting depth is restricted by the hard (and often saline) subsoil, plant available water capacity in the root zone is usually very low (0 – 50 mm).
- N – low to medium, P – very low to low, K – variable (low to very high), Cu – low to medium, Zn – medium.

Current Development

Grazing of native pastures, timber reserves, some softwood plantations.

SOLOTHS

Land Use Limitations

Drainage	Very poor; internal drainage impeded by the clay subsoil. Prone to waterlogging in wet periods.
Soil structure	Plant growth restricted by the very tough, poorly structured subsoil and the hardsetting surface.
Erosion	Very susceptible to erosion; including sheet erosion, tunnel erosion and gullying (dispersible subsoil).
Fertility	Nutrient status generally very low, especially phosphorus and nitrogen.
Plant available water	Plant available water capacity is very low.
Salinity	Deep subsoil salinity may be very high; saline seeps may occur in lower slope positions.

Land Use Suitability

These soils have similar land use limitations to the solodics. However, the limitations are generally more severe, hence the soloths are often regarded as inferior to the solodics. They are unsuitable for agricultural development. The best use is for the carefully controlled grazing of native pastures.

Pastures	Pasture development is not appropriate.
Earthworks	Soil disturbance should be kept to a minimum. If earthworks are essential, conserve the topsoil and ensure that the subsoil is not left exposed. Do not construct drains. Allow for 30% settlement. *Septic systems*: Limited suitability due to restricted drainage into subsoil. Alternative sewage treatment systems are recommended (e.g. composting and aerated types). *Dams*: To prevent leaks, it is essential to achieve adequate compaction using appropriate compaction equipment, working with soil at the correct moisture content. Dams should be fenced to prevent damage by stock. Spread topsoil over banks to promote grass cover.
Planning Guidelines	**Not** *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993).

Best Management Practices

Grazing

- Maintain adequate grass cover at all times. Bare soil is more easily eroded and compacted.
- Maintain as much timber cover as possible, especially on steeper slopes and ridges. Control thick regrowth if it restricts grass cover.
- Use conservative stocking rates and adjust for seasonal rainfall variation.

Suggested stocking rates are:	*Uncleared native pasture*	1AE/8 ha
	Cleared native pasture	1 AE/5 to 6 ha

TEA TREE CLAYS

Brief Description

Coarse structured cracking clays with gilgai. Dark grey to dark brown heavy clay subsoils.

Landform and distribution

- Flat plains with some wide swampy depressions (slopes < 1%).
- Older alluvial plains and terraces (Mixed Alluvial Plains LRA).
- Not widespread but locally common south of Ipswich and in the vicinity of Jimboomba.

Vegetation

- Open scrub of swamp tea tree (*Melaleuca tamariscina subsp. irbyana*);occasionally with emergent narrow-leaved ironbark, broad-leaved ironbark, blue gum and gum-topped box.
- Considerable areas of swamp tea tree have been cleared.

Middle Road, off Cunningham Highway south of Ipswich, February 1993

On relict alluvial plain, south of Ipswich

Soil Profile Description

Depth (m)	Description
0.00 to 0.10	Very dark brown, light clay; strong blocky structure; pH 6.5. Clear change to:
0.10 to 0.40	Very dark brown, medium clay; moderate coarse blocky structure; few ironstone nodules; pH 6.0. Clear change to:
0.40 to 0.70	Very dark brown, heavy clay; moderate coarse lenticular structure; faint yellow-brown mottles; pH 5.5. Gradual change to:
0.70 to 1.30	Dark grey, heavy clay; moderate coarse lenticular structure; faint orange mottles. Clear change to:
1.30+	Bedrock (rounded boulders).

General Soil Features

- *Surface*: Brown to dark grey, light to medium clay. Firm to hardsetting. Coarsely structured. Seasonally cracking with normal gilgai usually present. Medium acid (pH 6.0) to neutral.
- *Subsoil*: Dark grey to greyish brown, medium to heavy clay. Coarsely structured, usually mottled. Very strongly acid (pH 4.0) to strongly acid (pH 5.5).
- Medium to high salinity and strongly sodic at depths greater than about 0.50 m.
- Plant available water capacity in the root zone is low (< 100 mm) to medium (100 – 150 mm).
- N – low to medium, P – very low, K – low to medium, Cu – medium, Zn – medium.
- Dominance of magnesium in the subsoil indicates cation imbalance and increased dispersion tendency.

Current Development

Bush reserves, grazing native pastures. In the past, the tea tree branches were harvested and used for shade material and the bark was used in plant nurseries.

TEA TREE CLAYS

Land Use Limitations

Drainage	Poor internal and external drainage. Frequently waterlogged, usually inundated for considerable periods after substantial rain.
Subsoil	Subsoil is highly saline and strongly sodic.
Plant available water	Often low, as effective rooting depth is reduced by high subsoil salinity.
Soil structure	Coarse surface structure. Very poor workability. Sticky when wet, very hard when dry.
Fertility	Generally low levels of nitrogen, phosphorus and potassium. Strong subsoil acidity may also induce some chemical toxicities (e.g. aluminium and manganese).

Land Use Suitability

These soils are not suitable for agricultural development. If vegetated, these areas are useful as wildlife reserves/corridors or buffer zones. Swamp tea tree has a restricted distribution in SE Queensland and remnants have high conservation value.

Pastures	If already cleared, these soils may have some use for the grazing of native pastures. Pasture development is not appropriate.
Earthworks	Severe limitations due to persistent waterlogging, high clay content and cracking nature of these soils. Allow for 30% settlement. *Septic systems*: Unsuitable. Alternative sewage treatment systems (e.g. composting and aerated types) would be required by most local authorities. *Roads and tracks*: Limited suitability. *Dams*: Suitable for stock water only (if below ground level). To prevent leaks, it is essential to achieve adequate compaction using appropriate compaction equipment, working with soil at the correct moisture content. Dams should be fenced to avoid damage by stock.
Planning Guidelines	These soils would **not** generally be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993). Exceptions may be where crops of local significance are grown (e.g. in the Rocky Point Sugar Mill area).

Best Management Practices

Grazing

- Maintain conservative stocking rates and ensure an adequate surface cover at all times.
- A suggested stocking rate is 1 AE/8 ha.

YELLOW EARTHS

Brief Description

Yellow, loamy soils which are porous and friable with weakly developed structure.

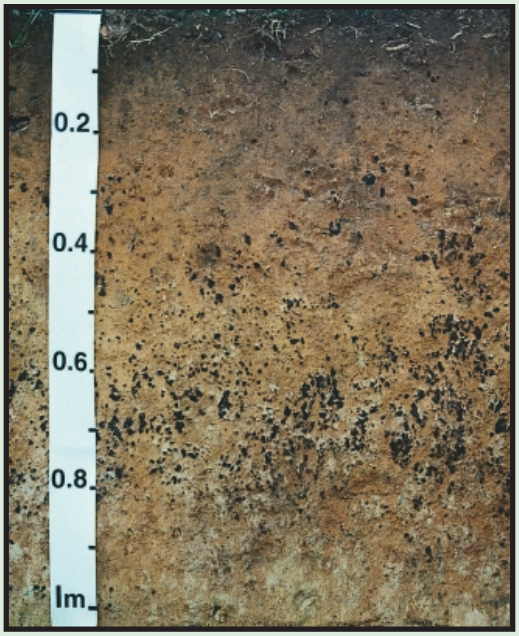
Landform and distribution

- Slopes and depressions associated with low hills. Slopes range up to 20%.
- Associated with red earths in the Helidon Forest LRA. Although they occur on the same slopes as red earths and in all landscape positions, their presence normally indicates a wetter moisture regime (e.g. more subsoil seepage water).

Hampton Road, SW of Esk, January 1993

Vegetation

- Open forest dominated by Moreton Bay ash and narrow-leaved ironbark.
- Broad-leaved apple, swamp mahogany and blue gum are also common.
- Extensively cleared.



On Helidon Sandstone, Esk

Soil Profile Description

Depth (m)	Description
0.00 to 0.10	Brown, sandy loam; fine granular structure; pH 6.0. Clear change to:
0.10 to 0.35	Yellowish brown, fine sandy clay loam; massive; few coarse iron/manganese nodules; pH 6.0. Gradual change to:
0.35 to 0.60	Yellowish brown, fine sandy light clay; massive; few coarse iron/manganese nodules; pH 6.5. Gradual change to:
0.60 to 0.80	Yellowish brown, fine sandy light clay; massive; pale mottling; coarse iron/manganese nodules; pH 7.0. Gradual change to:
0.80 to 1.20	Reddish yellow, light clay (coarse sandy); massive; distinct pale mottling; few coarse fragments of sandstone; few iron/manganese nodules; pH 7.0.

General Soil Features

- Not as deep as the red earths (usually less than 2m to parent rock). Gradual increase in clay content with depth.
- *Surface*: Brown, sandy loam. Weakly structured to massive. In some locations, a prominent bleached subsurface layer occurs. Slightly acid (pH 6.5) to strongly acid (pH 5.4).
- *Subsoil*: Yellowish brown, sandy clay loam to light clay (occasionally medium clay). Structureless (single grain or massive). Commonly mottled. Prominent accumulations of iron/manganese nodules. Slightly acid (pH 6.5) to medium acid (pH 5.8).
- Plant available water capacity in the root zone is low (50 – 100 mm).
- N – low to very low, P – very low, K – low to medium, Cu – medium,, Zn – low to medium.

Current Development

Grazing. Some dryland forage cropping.

YELLOW EARTHS

Land Use Limitations

Fertility	Nutrient status is very low, especially phosphorus and nitrogen.
Water Availability	Water supplies required for development are very limited.
Plant available water	Plant available water capacity is low (even considering deep rooting depths.
Soil surface	May become hardsetting if excessively cultivated.
Erosion	Highly erodible (if bare or cultivated) on slopes greater than 2%.
Drainage	Imperfect drainage through the profile at certain times of year. The mottled sub soils and iron/manganese nodules indicate extended periods of seasonal saturation.
Salinity	May be an intake area for groundwater recharge and saline seepages on lower slopes.

Land Use Suitability

The optimum long-term use of these soils is for the grazing of native and improved pastures.

Crops	These soils are potentially valuable for horticulture, although significant fertilizer inputs are required (especially phosphorus and nitrogen) as well as adequate water supplies. A range of small crops are suitable e.g. melons, potatoes, tomatoes. The periodic subsoil wetness is a limitation for tree and vine crops (which would require hilling).
Pastures	These soils produce high quality native pastures. Low-disturbance pasture development is recommended i.e. introducing legumes such as wynn cassia into native pastures. Irrigated sown pasture development is not recommended because of the quantity of water and fertilizers required.
Earthworks	Suitable for most earthwork operations. Allow 30% settlement. *Septic systems*: Generally adequate drainage for absorption systems, but there is a danger of percolation into stream and groundwater systems. *Dams*: Most suitable on the lower slopes. Prone to leakage due to lack of clay. Require lining or sealing.
Planning Guidelines	On sites suitable for horticulture, these soils would generally be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993), provided the following best man agement practices are adopted.

Best Management Practices

Grazing

- Maintain an adequate surface cover at all times paying particular attention to retaining the more productive pasture species.
- Spell pastures when they are flowering and seeding.
- Adjust stock numbers to the amount of summer pasture growth. A suggested stocking rate is 1 AE/4 to 5ha for both native and improved pastures.

Cropping

- Minimise soil disturbance during crop establishment. Maintain maximum surface cover to reduce erosion and retain organic matter.
- Do not cultivate on slopes greater than 8%. Soil conservation measures and crop management strategies will be required to control erosion on sloping sites. These could include contour banks, stubble mulching and crop rotations.
- Use a ley farming system (several years of perennial grass and legumes in the crop rotation) for control of disease and weeds, and also to maintain soil suitability.
- Lime when necessary, in addition to fertilizers.
- Use trickle irrigation on small crops only.

YELLOW PODZOLICS

Brief Description

Brown sandy loams overlying yellow, well structured, clay subsoils.

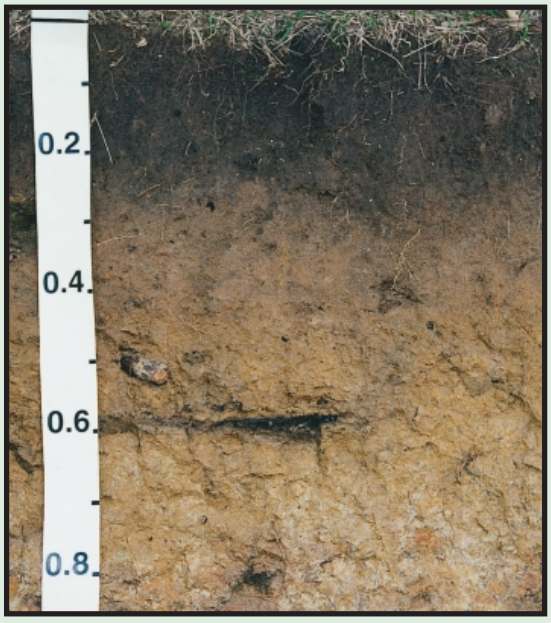
Landform and distribution

- Gently undulating rises to rolling hills. Slopes range from 2 to 20%. Often in mid to lower slope positions; flat ridges and minor depressions.
- Widespread in hilly country throughout the region. Associated with granite, metamorphic and most sedimentary rock types (LRAs 4, 5, 7a, 7b).

Esk-Crows Nest Road, Eskdale, May 1994

Vegetation

Grassy open forest with a wide range of species including silver-leaved ironbark, narrow-leaved ironbark, spotted gum, Moreton Bay ash, broad-leaved apple, rusty gum and swamp mahogany.



On granodiorite, Eskdale

Soil Profile Description

Depth (m)	Description
0.00 to 0.20	Dark brown, sandy loam; strong fine granular structure; pH 6.5. Clear change to:
0.20 to 0.30	Dark yellowish brown, coarse sandy loam; massive; pH 6.8. Gradual change to:
0.30 to 0.45	Yellowish brown, sandy loam; massive; pH 6.0. Clear change to:
0.45 to 0.65	Yellowish brown, coarse sandy light medium clay; strong coarse blocky structure; few faint red and grey mottles, pH 6.5. Clear change to:
0.65 to 0.90	Brownish yellow, coarse sandy medium clay; distinctly mottled red and grey; strong blocky structure; pH 7.0.

General Soil Features

- Texture contrast profiles with a clear boundary between the surface sandy loam and the clay subsoil.
- *Surface*: Greyish brown to dark brown, sandy loam (occasionally sandy clay loam to clay loam) to between 0.10 m and 0.40 m. Loose to hardsetting. Massive and porous. The subsurface is paler in colour, but usually not bleached. Strongly acid (pH 5.2) to slightly acid (pH 6.5).
- *Subsoil*: Yellow to yellowish brown, medium to heavy clay. Usually mottled. Well structured and friable. Strongly acid (pH 5.2) to slightly acid (pH 6.5). Occasionally neutral to slightly alkaline. Variable depth (< 0.5 m to > 1.5 M). Non sodic.
- Plant available water capacity in the root zone is low (50 – 100 mm).
- N – low, P – very low, K – medium, Cu – low to medium, Zn – low.

Current Development

Grazing, timber reserves. Some horticulture and small crops.

YELLOW PODZOLICS

Land Use Limitations

Drainage	Poorly drained subsoil results in waterlogging after heavy rain.
Fertility	Generally low nutrient status, especially nitrogen and phosphorus and trace elements. Root development and nutrient uptake may be impeded in the more acid subsoils.
Soil surface	Tends toward hardsetting which reduced infiltration rate and increases runoff.
Erosion	Highly erodible on slopes greater than 2%. Prone to sheet erosion. Wind erosion if left bare on exposed slopes.
Plant available water	Plant available water capacity is low.

Land Use Suitability

The optimum long-term use of these soils is for the grazing of native pastures.

Pastures	Under suitable conditions, native pastures may be oversown with a legume or other pasture species (*see pasture species chart*). Leucaena based pastures may also be suitable.
Crops	In some locations, with adequate water supply and suitable fertiliser additions, these soils may be suitable for some horticulture and small crops. Deep rooted crops are restricted in areas with poor subsoil drainage.
Irrigation	Trickle irrigation for small corps only.
Earthworks	Suitable for most earthwork operations. Re-spread topsoil in channels after earthworks. Allow for 30% settlement. *Septic systems*: Limited suitability due to extended waterlogging at certain times during the year. Alternative sewage treatment works (e.g. composting and aerated types) are recommended. *Dams*: Suitable, but return topsoil to dam walls and maintain spillway vegetation.
Planning Guidelines	On sites suitable for cropping, these soils would generally be assessed as *good quality agricultural land*, in accordance with State Planning Policy 1/92: Development and Conservation of Agricultural Land (DHLGP, 1992) and associated Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993), provided the following best management practices are adopted.

Best Management Practices

Grazing

- Do not clear steep slopes. Maintain adequate surface cover at all times, paying particular attention to retaining the more productive pasture species.
- Spell pastures when flowering and seeding.
- Adjust stock numbers to the amount of summer pasture growth. A suggested stocking rate is 1 AE/5 ha for both native and improved pastures.

Cropping

- Do not cultivate on slopes > 8%.
- Minimise surface disturbance during crop establishment and maintain adequate surface cover at all times (cover crops e.g. grazing peanuts may be grown).
- Mound tree crops to improve drainage.
- Add fertilisers to maintain productivity.
- Implement soil conservation measures and crop management strategies to control erosion. These could include contour banks, stubble mulching and crop rotations.

GLOSSARY

A horizon	See *Soil horizon*
A_2 horizon	See *Subsurface soil, Bleach*
Acid clay	Clay subsoils of low pH that occur under brigalow-belah vegetation
Acid soil	A soil giving an acid reaction throughout most or all of the soil profile (precisely, below a pH of 7 0, practically, below a pH of 6 5) Generally speaking, when the pH drops below 5 5 the following specific problems may occur - aluminium toxicity, manganese toxicity, calcium deficiency and/or molybdenum deficiency Such problems adversely affect plant growth and root nodulation, which may result in a decline in plant cover and increase in erosion hazard See *pH*
Adult Equivalent	The feed requirements of a 450 kg non-lactating beast
AE	See *Adult Equivalent*
Aeolian sediments	See *Sedimentary rocks*
Alkaline soil	A soil giving an alkaline reaction throughout most or all of the soil profile (precisely, above a pH of 7 0, practically, above a pH of 8 0) Many alkaline soils have a high pH indicated by the presence of calcium carbonate, and are suitable for agriculture However, others are problem soils because of salinity and/or sodicity Soils with a pH above 9 5 are generally unsuitable for agriculture See *pH*
Alluvial plain	A plain formed by the accumulation of alluvium on a floodplain over a considerable period of time, this accumulation may be still occurring at present (recent alluvium) or may have ceased (relict alluvium)
Alluvium (pl alluvia)	Deposits of gravel, sand, silt, clay or other debris, moved by streams from higher to lower ground
B horizon	See *Soil horizon*
Backplain	Large alluvial flat occurring some distance from the stream channel, often characterised by a high water table and the presence of swamps or lakes
Basalt	See *Volcanic rocks*

Bleach Subsurface soil (A_2 horizon) that is white, near white or much paler than adjacent soil layers. It occurs in varying proportions:

conspicuous bleach - 80% or more of the layer is white or almost so, when the soil is dry.

sporadic or partial bleach - the bleaching occurs irregularly through the subsurface layer, or as blotches or, as nests of bleached grains of soil material often at the interface of the surface and subsoil layers.

C material Layer(s) below the B horizon which may be weathered parent material, not bedrock, little affected by soil-forming processes.

Chernozems A Great Soil Group with black, organically rich surface. Clay content increasing gradually with depth to a brown to dark brown calcareous subsoil. Similar to black earths but have a lower clay content, are more porous and are friable. Drainage is superior to black earths (Stace et al., 1968).

Chlorotic An abnormal yellow colour of a plant.

Clays Soils with a uniform clay texture throughout the surface soil and subsoil.

- *cracking* Clay soils that develop vertical cracks when dry.

- *non-cracking* Clay soils that do not develop vertical cracks when dry.

Colluvium (pl. colluvia) Slope deposits of soil and rock material.

Colour See *Soil colour*.

Concretion (in soil) See *Segregation*.

Consistence (of soil) Refers to the degree of resistance to breaking or deformation when a force is applied.

Crabholes See *Gilgai - crabhole*.

Cracking clays See *Clays, cracking*.

Deep weathering The process by which earthy or rocky materials are slowly broken down into finer particles and soil by chemical processes over a long period of time. The chemical alteration of the rocks involved:

- leaching of the calcium-rich cement which previously bound the constituent particles together to form the rocks;
- a progressive transformation of feldspar minerals, clay minerals and labile fragments to form a new matrix of kaolinite white clay;
- the alteration of iron-rich minerals to form iron oxides (red colour); and
- mobilising and recrystallising of silica produced from the breakdown of minerals; more resistant quartz grains were relatively unaffected.

Dispersion — The process whereby soils break down and separate into their constituent particles (clay, silt, sand) in water. Dispersible soils tend to be highly erodible and present problems for earth works. Dispersion is associated with sodicity levels. See *Sodicity*. The dispersion ratio, R1, and its interpretation are discussed in Section 4.5.4.

Dissection — The process of streams or erosion cutting the land into hill, ridges and flat areas.

Drainage (soil profile) — The rate of downward movement of water through the soil, governed by both soil and site characteristics. Categories are as follows:

- Very poorly drained: free water remains at or near the surface for most of the year;
- Poorly drained: all soil horizons remain wet for several months each year;
- Imperfectly drained: some soil horizons remain wet for periods of several weeks;
- Moderately well drained: some soil horizons remain wet for a week after water addition;
- Well drained: no horizon remains wet for more than a few hours after water addition; and
- Rapidly drained: no horizon remains wet except shortly after water addition.

Dry sclerophyll forest — Trees, typically found in low rainfall areas, with tough leaves (e.g. eucalypts) which help to reduce water loss.

Duplex soil — See *Texture contrast soil*.

Duricrust — A cemented layer at or near the surface resulting from the concentration of breakdown products of rock weathering.

Earths — Soils with a sandy to loamy (including clay loam) surface soil, gradually increasing to a loamy to light clay subsoil.

- *massive* — Earths in which the subsoil is not arranged into natural soil aggregates and appears as a coherent, or solid mass.

- *structured* — Earths in which the subsoil is arranged into natural soil aggregates which can be clearly seen.

Effective rooting depth (ERD) — Depth to which most plant feeder roots will penetrate. This is taken here to be the depth either to which salts have been leached and have therefore accumulated, or to an impeding layer. This represents the long-term depth of wetting.

Electrical conductivity (EC) — A measure of the conduction of electricity through water, or a water extract of soil. The value can reflect the amount of soluble salts in an extract and therefore provide an indication of soil salinity.

Erodibility (soil)	The susceptibility of a soil to the detachment and transportation of soil particles by erosive agents. It is a function of the mechanical, chemical and physical characteristics of the soil, and is independent of the other factors influencing soil erosion such as topography, land use, rainfall intensity and plant cover. It may be changed by management.
Erosion hazard	The susceptibility of a parcel of land to the prevailing agents of erosion. It is dependent on a combination of climate, landform, soil, land use and land management factors.
ESP	Exchangeable sodium percentage. See *Sodicity*.
Feldspar	Any of a group of alkaline aluminium silicate minerals. An important part of igneous rocks, such as granite.
Feldspathic sandstones	Sandstones with less than 25% feldspar grains.
Gilgai	Surface microrelief associated with soils containing shrink-swell clays. Characterised by the presence of mounds and depressions.
- *crabhole*	Irregularly distributed small depressions and mounds, separated by a more or less continuous shelf. Vertical interval usually less than 0.3 m. Horizontal interval usually 3-20 m, surface almost level.
- *linear*	Long, narrow, parallel, elongate mounds and broader, elongate depressions more or less at right angles to the contour; usually in sloping lands.
- *melonhole*	Large depressions, usually greater than 3 m diameter and deeper than 0.3 m, which have a sub-circular or irregular shape and are separated by elongate mounds or set in an almost level surface.
- *normal*	Small, irregularly distributed mounds and sub-circular depressions, usually with less than 0.3 m vertical interval between the mound tops and bottom of depressions.
Gradational texture profiles	Soil profiles with a gradual increase in texture (i.e. more clayey) as the profile deepens.
Granite/granitic rocks	Coarse-grained, *igneous* rock formed well below the Earth's surface in which quartz constitutes up to 50% of the minerals. Other minerals included are feldspars and micas.
Gypsum	A naturally occurring soft crystalline material which is a hydrated form of calcium sulphate. Gypsum contains approximately 23% calcium and 18% sulfur. It is used to improve soil structure and reduce crusting in hard setting clayey soils.
Hard setting	Surface soil that becomes hard and apparently structureless on the periodic drying of the soil.

Horizon See *Soil horizon*, also *Soil horizon boundary*.

Humic gleys A Great Soil Group consisting of soils with dark coloured topsoils over mottled grey subsoils. These soils are frequently flooded and have high watertables (Stace et al., 1968).

Humus podzols A Great Soil Group consisting of sandy soils with waterlogged subsoils and an acid to very strongly acid reaction trend. These soils have a dark A_1 horizon of organic matter accumulation, a light grey or whitish A_2 horizon, and a dark grey to black humic B horizon (Stace et al., 1968).

Igneous rocks Rock crystallised from molten rock material (magma). It may be extruded to the Earth's surface (*volcanic*) or cool at variable depths below the surface (intrusive, and plutonic).

Infiltration The movement of water through the soil surface. Soils with a high infiltration capacity allow more rain to enter the soil than soils with a low capacity. Runoff will occur when the rate of rainfall exceeds the soil's infiltration capacity. Surface soil structure and texture are important determinants of the infiltration capacity of a soil.

Kaolinisation Breakdown of minerals (particularly feldspars) under intense weathering to form kaolinite clay (china clay). See also *Laterite*.

Krasnozems A Great Soil Group consisting of red, strongly structured, clay soils. They have gradational texture profiles, with an acid to neutral reaction trend (Stace et al., 1968).

Laterite A profile formed by intense weathering. Many deeply weathered profiles termed 'lateritic' exhibit a distinct series of layers including a surface duricrust, ironstone and mottled and pallid (kaolinised) zones. The word laterite is used for any profile in which ironstone is a major feature. See *Duricrust*.

Lateritised rocks Rocks which have been partially or completely weathered to laterite.

Levee A very long, very low, nearly level ridge immediately adjacent to a stream channel, built up by over-bank flow.

Lithosols A Great Soil Group consisting of shallow, stony or gravelly soils which are usually found on steep slopes (Stace et al., 1968).

Local relief The altitude difference between the base and crest of slopes in undulating or hilly areas.

Massive earths See *Earths, massive*.

Massive structure See *Soil structure, apedal*.

Melonholes	See *Gilgai - melonhole.*
Metamorphic rocks	Rocks that were originally igneous or sedimentary that have been physically and/or chemically altered by high temperatures and/or pressures beneath the Earth's surface.
Mineralisation	The breakdown of soil organic matter and crop and animal residues by micro-organisms to inorganic (available) forms.
Mottle	Spots, blotches or streaks of subdominant colours different from the main soil colour.
Mycorrhizae	Soil fungi which act as rootlets and increase the amount of nutrients (particularly phosphorus and zinc) available to plants. Fallowing, excessive tillage and soil fumigation can cause mycorrhizae to die out. Plants growing with mycorrhizae are generally healthier and more resistant to disease, particularly root rots.
Nodules (in soil)	See *Segregation.*
Non-calcic brown soil	A Great Soil Group with dark grey to red-brown A1 horizon of loamy sand to clay loam of weak blocky structure overlying a neutral to slightly alkaline B horizon of reddish-brown to red clay with moderate to strong blocky structure. Carbonates and an A2 horizon are both absent (Stace et al., 1968).
Non-cracking clays	See *Clays, non-cracking.*
Pans	A hard and/or cemented soil horizon e.g. cultivation pan.
Permeability	The capacity for transmission under gravity of water through soil or sediments.
Plant available water capacity (PAWC)	The quantity of water held in a soil that can be extracted by plant roots. It is expressed as millimetres of plant available water within the root zone.
pH	A measure of the acidity or alkalinity of a soil. A pH of 7.0 indicates neutrality, higher values indicate alkalinity and lower values indicate acidity. Each unit change in pH represents a 10-fold change in either the acidity or alkalinity of the soil. For example, a pH of 5.0 is 10 times more acid than a pH of 6.0. Soil pH affects the amount of different nutrients that are soluble in water and therefore the amount of nutrient available to plants.
Podzolics	A Great Soil Group consisting of texture contrast soils with distinct or bleached subsurface horizons overlying subsoils which have higher clay contents and iron and manganese deposits. These soils have an acid reaction trend (Stace et al., 1968).

Porosity (of soil) The degree of pore space in a soil (i.e. the percentage of the total space between solid particles). The extent and type of soil porosity indicates the ease with which water, air and roots can move through the soil. Without sufficient pores of the right size, soil is unproductive because plant roots cannot move through the soil easily, air and water movement are poor, and there is insufficient water for plant growth.

There are two types of pores. Macropores are large pores, greater than 0.03 mm in diameter, and most can be seen by the naked eye. They include the spaces between soil aggregates caused by cultivation, shrinking and cracking, channels made by roots of plants, and earthworm and other animal and insect tunnels. Macropores are vitally important in allowing water and air to move freely, but provide little water for plant uptake because they are readily drained.

Micropores are small pores less than 0.03 mm in diameter occurring mainly within aggregates. Water drains through them very slowly so they act as water reservoirs for plant roots.

Prairie soils A Great Soil Group consisting of soils with thick, dark A horizons, mildly acid to mildly alkaline reaction trend, and soil depths generally less than 1 m (Stace et al., 1968).

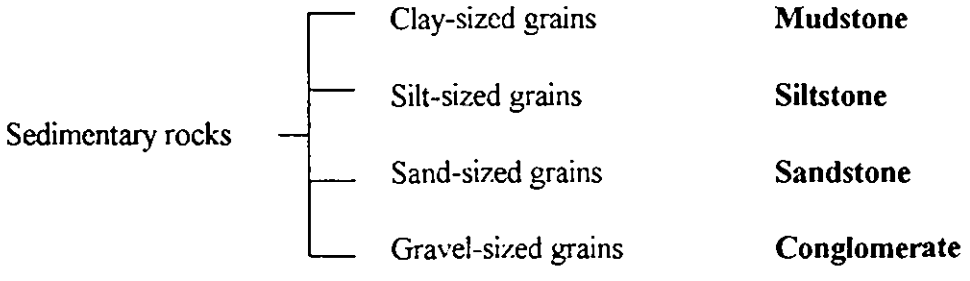
Rendzinas A Great Soil Group consisting of shallow to very shallow soils formed from limestone. They are dark coloured clay loams or light clays with a neutral to alkaline reaction trend (Stace et al., 1968).

Salinity The presence of sufficient soluble salts to adversely affect plant growth and/or land use. The main salt involved is sodium chloride, but sulfates, carbonates and magnesium salts occur in some soils. It is expressed as a level of electrical conductivity (EC). See *Electrical conductivity.*

Sands Soils with a uniform sand (including sandy loam) texture throughout the surface soil and subsoil.

Sedimentary rocks Rocks formed from the accumulation of material which has been weathered and eroded from pre-existing rocks, then transported and deposited as sediment by wind (aeolian) or water (fluvial, marine).

Sedimentary rocks have been classified according to grain size and constituent minerals:



Sandstone is further subdivided on the basis of the dominant minerals making up the clasts (solid inclusions) or the matrix which cements the clasts together:

Sandstone

- 90% or more of grains are quartz: **Quartzose sandstone**
- less than 75% of grains are quartz: **Labile sandstone**
- 25% or more of grains are feldspar: **Arkose sandstone**
- less than 25% of grains are feldspar: **Feldspathic sandstone**

Segregation

Discrete accumulations of minerals in the soil because of the concentration of some constituent, usually by chemical or biological action. Segregations are described by their nature, abundance and form.

1) nature

for example, calcareous (carbonate), gypseous (gypsum), manganiferous (manganese) and ferromanganiferous (iron-manganese).

2) abundance

very few (trace or occasional)	<2%
few (slight)	2-10%
common (light)	10-20%
many (moderate)	20-50%
very many (heavy)	>50%

3) form

concretions	- spheroidal formations (concentric in nature).
nodules	- irregular rounded formations (not concentric or symmetric). Can have a hollow interior.
fragments	- broken pieces of segregations.
crystals	- single or complex clusters of visible crystals.
soft segregations	- finely divided soft segregations accumulated in the soil through chemical action with water. They contrast with surrounding soil in colour and composition but are not easily separated from the soil as separate bodies.

Self-mulching

A condition of well-structured surface soil, notably of clays, in which the aggregates fall apart naturally as the soil dries to form a loose mulch of soil aggregates.

In cultivated soils, ploughing when wet may appear to destroy the surface mulch which, however, will re-form upon drying.

Sodicity

A characteristic of soils (usually subsoils) containing exchangeable sodium to the extent of adversely affecting soil stability, plant growth and/or land use. It is measured as a percentage of the cation exchange capacity of the soil.

The classes are defined as follows:

non-sodic	- less than 6%
sodic	- between 6% and 15%
strongly sodic	- more than 15%

Sodic or strongly sodic soils would be dispersible and may be improved by the addition of gypsum.

Soft segregations (in soil)

See *Segregation.*

Soil colour

The colour of soil material is determined by comparison with a standard Munsell soil colour chart. The colours are described for moist soils unless otherwise stated.

Soil depth

The following depth ranges are used in this manual to describe the soil surface and soil profile depths.

1) soil surface

thin	0-15 cm
moderately thick	15-30 cm
thick	30-60 cm
very thick	>60 cm

2) soil profile

shallow	0-30 cm
moderately deep	30-60 cm
deep	60-90 cm
very deep	>90 cm

Soil horizon

A layer of soil material within the *soil profile* with distinct characteristics and properties produced by soil-forming processes, and which are different from those of the layers above and/or below. The three main horizons are: A (topsoil); B (subsoil); C (see C material).

Soil horizon boundary

Boundaries between horizons take many forms. The terms used in the soil descriptions of the Field Manual soil photographs and Appendix 3 (Resource Information) are:

Sharp - less than 5 mm wide; **Abrupt** - 5 to 20 mm wide;
Clear - 20 to 50 mm wide; **Gradual** - 50 to 100 mm wide;
Diffuse - more than 100 mm wide.

Soil profile

A vertical cross-sectional exposure of a soil, from the surface to the parent material or *Substrate*.

Soil reaction trend

The general direction of the change in pH with depth.

Soil structure — The arrangement of natural soil aggregates that occur in soil; structure includes the distinctness, size and shape of these aggregates.

1) distinctness

- *strong* — The natural soil aggregates are quite distinct in undisplaced soil; when displaced more than two-thirds of the soil material consists of aggregates (i.e. well structured).
- *moderate* — Natural soil aggregates are well formed and evident but not distinct in undisplaced soil; when displaced more than one-third of the soil material consists of aggregates (i.e. moderately structured).
- *weak* — The natural soil aggregates are indistinct and barely observable in undisplaced soil; when displaced up to one-third of the soil material consists of soil aggregates (poorly structured).

2) size

- *coarse* — The natural soil aggregates are relatively large; an average size of 20 mm or more is coarse for the purposes of this manual.
- *medium* — The average size of the natural soil aggregates is between fine and coarse.
- *fine* — The natural soil aggregates are relatively small; an average size of 5 mm or less is fine for the purposes of this manual.

3) shape

- *apedal* — There are no observable natural soil aggregates (structureless); the soil may be either a coherent mass (massive) or a loose, incoherent mass of individual particles such as sand grains (single grain).
- *blocky* — The natural soil aggregates have the approximate shape of cubes with flat and slightly rounded sides.
- *prismatic* — The natural soil aggregates have the approximate shape of elongated blocks.
- *columnar* — The natural soil aggregates are like those of *prismatic* but have domed tops.
- *polyhedral* — The natural soil aggregates are irregular, many sided and multi-angled.
- *lenticular* — The natural soil aggregates are like large vertical lens shapes with curved cracks between the aggregates.
- *platy* — The soil particles are arranged around a horizontal plane and bounded by relatively flat horizontal faces.

Soil texture

The coarseness or fineness of soil material as it affects the behaviour of a moist ball of soil when pressed between the thumb and forefinger. It is generally related to the proportion of clay, silt and sand within a soil. Texture classes used in this manual are defined primarily by the total clay content:

	Group	Clay content (%)
Coarse	Sand Loamy sand Sandy loam	less than 5 5 to 10 10 to 20
Medium	Loam Sandy clay loam Clay loam	≈ 25 20 to 30 + sand 30 to 35
Fine	Sandy clay Light clay Medium clay Heavy clay	35 to 40 + sand 35 to 40 40 to 50 more than 50

Solodic soils

Soils with strong texture contrast between A horizons and sodic B horizons which are not strongly acid.

Solonchaks

Highly saline soils with little profile development associated with coastal and estuarine areas which are frequently inundated by sea-water. They are usually grey-brown to greyish medium to heavy clays and may have distinct mottles (Stace et al., 1968).

Soloths

A Great Soil Group consisting of soils with a strong texture contrast, abrupt boundary between A and B horizons, a prominent bleached A_2 horizon, and clay B horizons with coarse blocky or columnar structure. They have an acid to neutral reaction trend (Stace et al., 1968).

Structural formation

Vegetation grouping based on attributes of the tallest layer e.g. ***class*** *(of vegetation)* growth form, crown separation and height.

Structured earths

See *Earths, structured.*

Subsoil

Soil layers below the surface with one of the following attributes:
- a larger content of clay, iron, aluminium, organic material (or several of these) than the surface and subsurface soil;
- stronger colours than those of the surface and subsurface soil above, or the *substrate* below. The B horizon.

Substrate

The material below the soil profile which may be the parent material or may be unlike the material from which the soil has formed; substrate which is not parent material for the soil above may be layers of older alluvium, rock strata unrelated to the soil or the buried surface of a former landscape.

Subsurface soil — Soil layers immediately under the surface soil which usually have less organic matter, paler colours and may have less clay than the surface soil. The A_2 horizon.

Surface crust — Distinct surface layer, often laminated, ranging in thickness from a few millimetres to a few tens of millimetres, which is hard and brittle when dry and cannot be readily separated from and lifted off the underlying soil material.

Surface soil — The soil layer extending from the soil surface down which has some organic matter accumulation and is darker in colour than the underlying soil layers. The A horizon.

Terrace — Any long, relatively level or gently sloping surface, generally narrower than a plain and bounded by a steeper ascending slope on one edge and a steeper descending slope on the other. Often associated along the margin and above the level of a body of water e.g. stream or lagoon.

Texture — See *Soil texture*.

Texture contrast soil — A soil in which there is a sharp change in soil texture between the A and B horizons (surface and subsoil) over a distance of 10 cm or less. Also known as a duplex soil.

Uniform clays — See *Clays*.

Volcanic rocks — Igneous rocks which have cooled from magma extruded to the Earth's surface. The size of the rock crystals depends on its duration of cooling - rapid cooling forms very fine crystals or even volcanic glass.

- *acid* — Contain 10% or more quartz and proportions of magnesium, iron and calcium. Usually light coloured.

- *basic* — Basalt or basaltic rocks containing minimal or no quartz. Usually dark coloured because of a high proportion of iron and manganese minerals.

- *intermediate* — Contain less than 10% quartz and mixed amounts of other minerals that are intermediate between the typical acid and basic igneous rocks.

Waterlogged — An area in which all the pores in the soil have filled with water. Excess water may lie on the surface of the soil. All the air in the pores has been displaced by water, so no oxygen is available to plant roots or for soil microbial activity. If waterlogging continues for a long period, plants die. Under waterlogged conditions, nitrate, the most available form of nitrogen, breaks down and is lost as a gas.

Workability — The ease or otherwise of working the soil with machinery.

Xanthozems A Great Soil Group consisting of yellow, strongly-structured acid clays with moderate horizon differentiation. They have gradational texture profiles, typically a clay loam surface and medium to heavy clay subsoil. They are closely associated with krasnozems and mainly occur on poorly drained slopes (Stace et al., 1968).