NSW DEPARTMENT OF
PRIMARY INDUSTRIES

SOILpak – southern irrigators - Readers' Note

This document is part of a larger publication. The remaining parts and full version of the publication can be found at:

http://www.dpi.nsw.gov.au/agriculture/resources/soils/guides/soilpak/south-irrig

Updated versions of this document can also be found at the above web address.

PART A. INTRODUCTION

Chapter A1. Introduction

Southern Irrigation SOILpak aims to provide a range of best soil management practices to optimise crop and pasture yields. Soils used for irrigation in southern NSW are varied, and this manual identifies five main soil groups. Crop enterprises are also varied. The major irrigated farming systems considered in this manual are (a) rice/rice rotations, (b) summer cropping (excluding rice), (c) winter cropping, and (d) pastures.

SOILpak concentrates on the skills needed to:

- assess the condition of the soil with emphasis on the cultivation layer (0–10 cm) and the soil profile (0–100 cm)
- understand the management options for maintaining or improving soil condition for a particular crop or pasture system.

SOILpak does not aim to make the final decision for irrigators. Instead it provides soil management options which can assist irrigators to develop successful soil management strategies.

Good soil management has economic benefits. Poor soil management can lead to large yield losses and unnecessary input costs. Sound soil management also improves the condition of the environment through the control of processes such as rising watertables, salinisation and soil structural decline.

INTENDED AUDIENCE

SOILpak is intended for:

- irrigators who want to learn more about how to manage their soil
- consultants and extension officers who wish to become more skilled in advising their clients on soil management.

YOU CHOOSE

Those chapters that contain a list of management options have a step-by-step procedure to guide you towards a decision. You will be asked which of several circumstances best describe your situation. Each circumstance is matched with a list of possible options.

Given your resources and economic situation, it will be up to you to decide which option best suits your needs. Your decision must take account of soil type, crop type, water and equipment availability.

Weather is an over-riding factor in all farming operations. Remember when following any plans or guidelines, that the weather may not allow them to be realised.

There is no doubt about the value of soil assessment — it is highly recommended. However the final decision about which soil management option to select is the responsibility of the irrigators and their advisers.

OVERVIEW OF CONTENTS

The manual is subdivided into five sections, with several chapters within these sections, as well as a glossary of terms in the appendices.

The remainder of **Section A** presents key soil terminology encountered in the manual, and a description of an ideal soil for rice and non rice crops, so that you can form a picture of what to aim for.

Description of the five main soil groups of the Riverina landscape and their limitations are also presented.

Section B offers help for a range of situations where you may need a quick solution to a soil management problem, without long explanations.

Section C concentrates on the diagnosis of the soil condition. Other chapters may refer you back to Section C.

Section D provides soil management information on the four major farming systems practiced in southern NSW; rice rotation systems, summer cropping/double cropping rotation systems, winter crop rotation systems, and pasture based farming systems.

Section E provides more detailed information on a number of soil problems, and ways of minimising or overcoming these problems through improved practices. Irrigation scheduling is also explained in this section.

The appendices include a glossary of terms.

The manual caters for two distinct types of irrigators:

- those wanting an overview and/or quick help
- those wanting measures of soil condition and details of options for overcoming soil management problems.

To deal with a specific problem it is not necessary to read the entire manual — refer to the index for guidance. If you encounter words or terms that you're unfamiliar with — remember to use the glossary at the back of the manual.

Chapter A2. Read this first! (some useful soil terms)

COMPONENTS OF SOIL

- **soil is made up of solid, liquid and gas components**
- **solid part ⟶ mineral particles**
- **liquid part ⟶ water**
- **gas part ⟶ air**

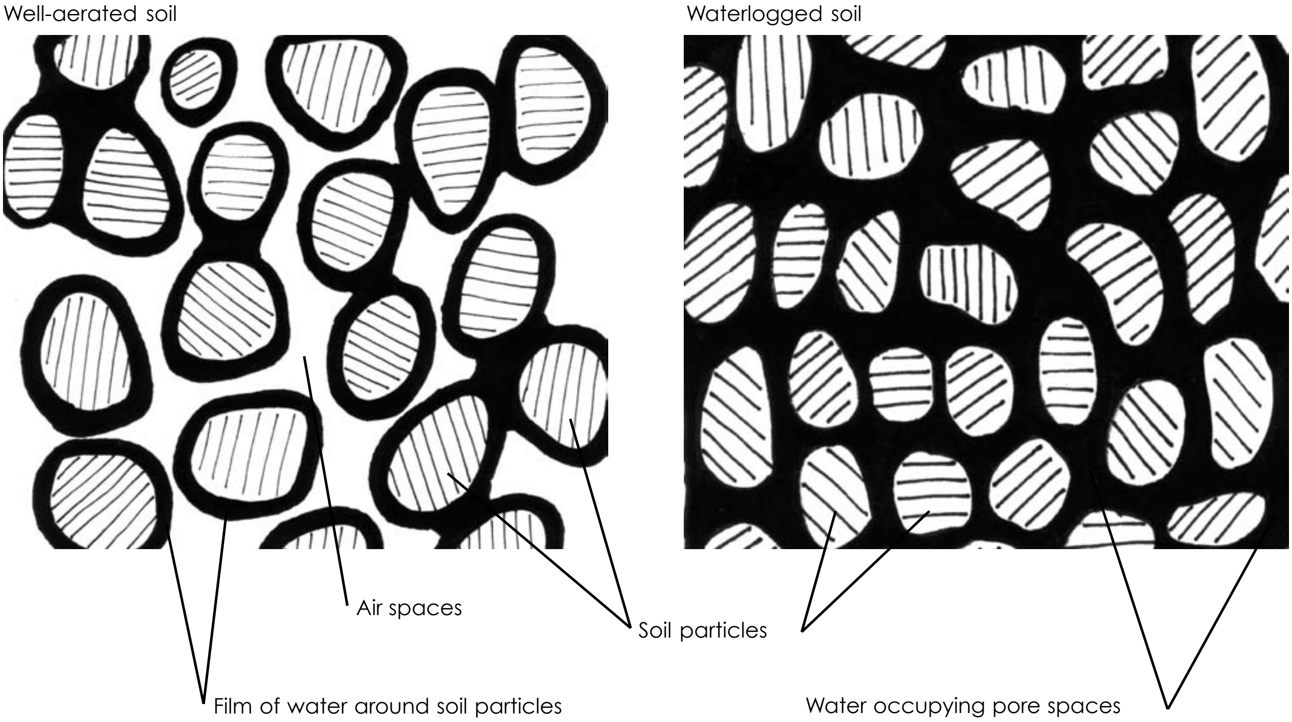
Soil is a mixture of solid, liquid and gas components.

1) The **solid components** are minerals derived originally from weathering rocks, and organic materials derived from plants and microorganisms. In the Riverine Plain of South-eastern Australia much of the mineral elements of the soil have been transported to the area by the action of prior streams or rivers. These prior streams are no longer active, but once dominated the landscape, bringing in huge quantities of weathered rock, forming the basis of the soil. In parts of the plain, clay transported into the area by wind also makes a significant contribution to the soils.

2) The **liquid component** of the soil is made up of water, with varying amounts of nutrients and other soluble substances dissolved within it. The water and nutrients are used by plants to grow. Water may be lost by evaporation to the atmosphere or by deep drainage through the soil. Water that is drawn out of the soil by plants and released into the atmosphere is called *transpiration*.

3) The **gas component** refers to the air contained in the soil. Soil is generally porous, containing many air spaces. The oxygen in air in the soil is required for growth of most plants. When the soil becomes saturated with water, with no air left in the pores, the soil is said to be *waterlogged*. (see Figure A1).

Figure A1. Well-aerated and waterlogged soil



TEXTURE

- **soil particles are grouped into 5 main size ranges: gravel, coarse sand, fine sand, silt and clay**
- **a soil with a relatively even mix of particle sizes is called a 'loam'**

Texture is a measure of the behaviour of a small handful of soil when moistened with water, worked into a ball and then pressed out between thumb and forefinger. It is used as a guide to the proportions of gravel, coarse sand, fine sand, silt and clay in a soil. Texture is important because it affects the movement and availability of water, air and nutrients in soil.

The word 'loam' refers to a relatively even mix of particle sizes in a soil. For example, a sandy loam is a soil with a mix of particle sizes, however coarse sand is dominant. Likewise clay loam, has a mix of particle sizes, but more clay than a loam textured soil.

A simple test to describe soil texture is described in the diagnosis section in *Chapter C4: Soil texture.*

STRUCTURE

- **soil particles are held together to form soil units called aggregates**
- **aggregate size and shape, and the air spaces between, largely determine structure**
- **a well structured soil has many small aggregates, and a good balance of large and small pores**
- **small pores act as water storage areas for plants**
- **large pores allow relatively easy movement of air, water and plant roots**

Soil structure refers to the arrangement of sand, silt and clay particles and organic matter, and the spaces between them. Individual soil particles and organic matter usually stick together to form aggregates (similar to a clod), leaving air spaces or pores between the aggregates. It is rare for soil particles to exist as single units in the soil (except in sands). Therefore the soil generally consists of many distinct soil aggregates. The size and shape of these aggregates varies. The arrangement and size of these aggregates along with the pores or spaces between aggregates, is known as *structure*.

A well-structured soil has many small aggregates. It has ample space within and between aggregates to allow good penetration of water, air and plant roots (transmission pores), yet also has adequate small pores to store water for use by plants (water storage pores).

Individual soil aggregates may have differing shapes. Some aggregate shapes indicate better soil structure from a plant growth point of view. Some shapes are given below in Figure A2.

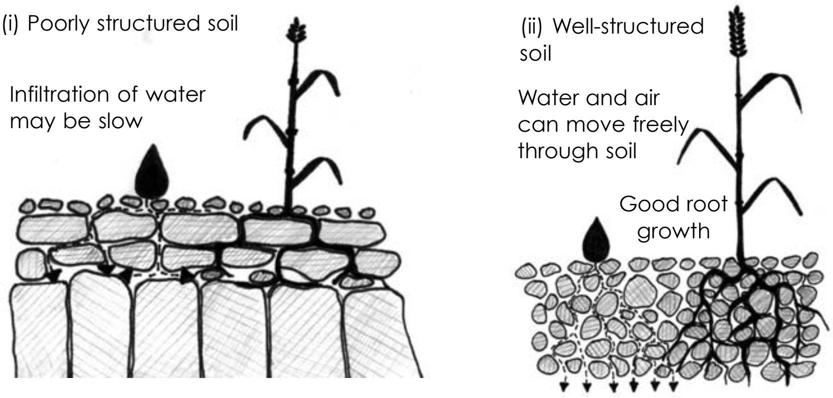
Crumb type aggregates allow good plant growth due to good water and air movement. Soils with crumb structure allow good root growth since the soil is less compact than other structure types. Blocky structure is also generally favourable for plant growth.

Structure can be rated as good or bad from a plant growth point of view. Poor structure does not allow good movement of water and air and hence plant growth is poor. Soil that consists of large blocks having few pores or air spaces is said to have a 'massive' structure. Soils with

Figure A2. Some different aggregate shapes

platey structure (like small plates) are also likely to have restricted air and water movement. These conditions are poor for the growth of most plants (see Figure A3). Rice is an exception, since it grows under waterlogged conditions and has no need for oxygen supply from the soil.

Figure A3. Well-structured and poorly structured soil



SLAKING

- **when water is applied to most soils, the clods 'melt' or breakdown; this process is called slaking**
- **microaggregates are the smallest structural units in the soil**
- **after irrigation or rainfall a slaking or dispersing soil may becomes hard and compact on drying; this condition is often called hardsetting**

When water is applied to most soils, the aggregates within that soil tend to 'melt', or break down. This results in soil clods disintegrating into very small fragments of the original clod. These small aggregates are often referred to as *microaggregates*. This is process is called *slaking*, and it is common in most soils.

Slaking may result in problems such as surface crusting and hardsetting, particularly in soils with a loamy topsoil, such as the red-brown earths. Soils low in organic matter are likely to slake excessively.

Most clay soils that swell upon wetting and crack upon drying are less likely to form severe surface crusts.

DISPERSION

- **when water is applied to clay soils with high sodium contents, and low soluble salts, the aggregates may break down into individual particles; this is called dispersion**
- **dispersive soils are generally poorly structured**
- **gypsum is often applied to dispersive soils to improve their structure**

Dispersion is the process following slaking, in which soil microaggregates further break down into their component particles (sand, silt and clay) on the application of water.

Clay dispersion occurs due to high levels of sodicity, i.e. high amounts of sodium 'bound' to clay particles, and low levels of soluble salts. Dispersion increases when sodicity is high and organic matter levels are low. Soil disturbance, especially cultivating soils when too wet, will increase dispersion.

Gypsum, a type of salt containing calcium, is often applied to sodic clay soils. Gypsum acts by increasing the level of soluble salts and replacing sodium with calcium on the clay. The combination of these two factors reduces swelling and prevents dispersion, therefore helping to maintain soil structure. Organic matter, which helps bond soil particles together, also assists in reducing dispersion.

INFILTRATION AND PERMEABILITY

- **infiltration refers to the movement of water into a soil**
- **permeability refers to the ability of a soil to allow the movement of water and air through it**
- **soils of low permeability are well suited to rice, but not to other crops**

Infiltration refers to the entry of water into the soil. A soil with low infiltration is one in which water does not enter very quickly, and a shallow wetted zone may result following rainfall or irrigation.

Permeability is the soil characteristic that governs the rate of air and water movement through it. Permeability and infiltration rate are influenced by the size and distribution of pores in the soil. The more porous a soil, the higher the infiltration rate and its permeability.

Soils with low permeability are well suited to rice growing since movement of water into the watertable is low. On the other hand, the same soils are not well suited for crops other than rice. This is because water entry is restricted, resulting in low water storage at each irrigation. Waterlogging is also likely on these soils due to poor internal drainage. Low permeability is often associated with poorly structured soils, usually due to slaking and dispersion.

ORGANIC MATTER

- **organic matter is made up of living and dead plant and animal matter**
- **organic matter strongly influences soil structure, particularly in loamy and sandy soils**
- **soil organic matter (as measured in a soil test) is the humus content of the soil, and does not include plant residue, trash etc.**

Organic matter in soils consists of all living and dead plant and animal matter. Organic matter includes seeds, leaves, roots, earthworms and manure, as well as bacteria, fungi and humus.

Soil structure is highly dependent on organic matter content, particularly in loamy and sandy textured soils. The higher the organic matter content of loamy soils, the better their structure.

Organic matter tends to be concentrated on the soil surface and in the upper part of the topsoil, since this is where most plant material is found. Dead plant material decays to become a dark-coloured material called humus, which causes the darker layer of topsoil in many soils.

ACIDITY/pH

- **soils below pH 7 are acid**
- **soils above pH 7 are alkaline**
- **growth and yield is reduced in most plants if the soil pH(CaCl2) is below 5**
- **soil acidification is increased by many agricultural practices**

The pH scale

Soil pH is a measure of how acid or alkaline the soil is. The standard method of measuring soil pH in the laboratory is with a suspension made from air-dry soil mixed with five times its weight of a dilute solution (0.01M) of calcium chloride ($CaCl_2$). The result is designated $pH_{(CaCl2)}$.

Distilled water is sometimes used in place of calcium chloride, in which case results are reported as $pH_{(water)}$. Values of $pH_{(CaCl2)}$ are about 0.5–0.8 lower than $pH_{(water)}$.

Acidity

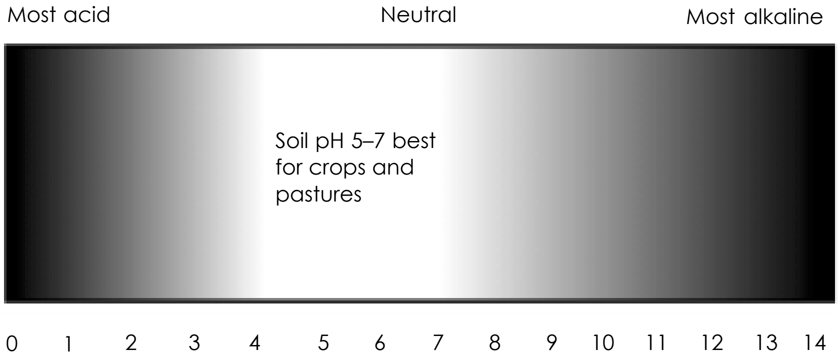
Soil pH of 7 is regarded as neutral. All soils below pH 7 are acid. However, the growth and yield of most plants are unaffected until $pH_{(CaCl2)}$ goes below about 5.

As pH levels drop below 5 and soil acidity increases, plant growth and yield decline. Yields can be affected directly by acidity or indirectly by changing the availability of some important nutrients. For example, as pH decreases below 6, availability of phosphorus and sulfur may decrease. At the same time, aluminium and manganese become more available and may cause yield reductions through aluminium and manganese toxicity. At pH levels above 7 other elements such as zinc may become less available to plants.

Many soils are naturally acid, but agricultural practices have contributed to the increasing acidification of many neutral to slightly acid soils. These practices include:

- use of some ammonium fertilisers, particularly ammonium sulphate:
- production of legumes that fix nitrogen, if that nitrogen is leached, rather than being taken up by plants:
- removal of nutrients in the form of produce.

Figure A4. The pH scale (values measured in 0.01 M ($CaCl_2$)



* values measured in 0.01 M $CaCl_2$

BULK DENSITY

- **bulk density is the mass of oven dry soil per unit of volume, expressed in megagrams per cubic metre (1 megagram is equivalent to one tonne)**
- **bulk densities generally range from 1.0–2.0 Mg/m^3**
- **high bulk densities can restrict root development and plant growth**

Bulk density is defined as the mass of oven-dry soil per unit volume. Soils with high bulk density have a smaller volume of pore spaces. Very high bulk density is therefore undesirable for plant growth, since infiltration, aeration (supply of air to roots) and root development are likely to be below optimum.

Bulk density is expressed in megagrams (tonnes) per cubic metre. Bulk density values range from:

less than 1.0 for topsoils high in organic matter

1.0–1.4 for well-aggregated loamy soils

1.2–2.0 for sands and compacted subsoil horizons in clay soils

The bulk densities of the subsoils of most Riverina soils range from 1.4–1.8.

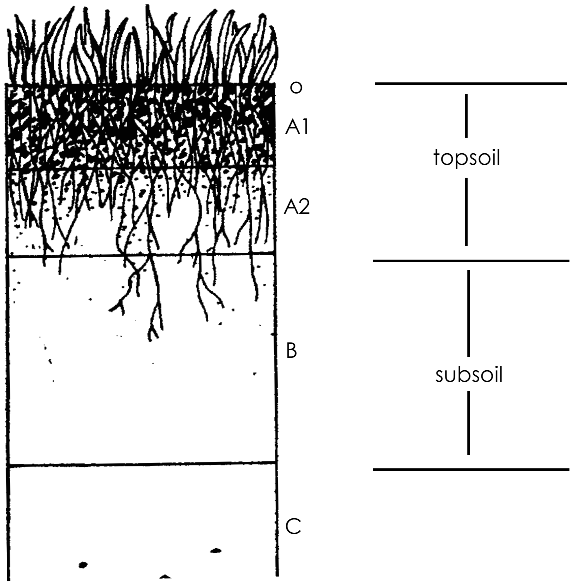
Soil layers with a high bulk density are often very hard when dry. Compacted soil layers have a high bulk density and are often referred to as having high soil strength.

THE SOIL PROFILE

A soil profile is a vertical section of the soil. It allows you to examine the layers of the soil from the surface soil down to the rock or sediments from which the soil was formed (parent material). In the Riverine environment most soils have parent material consisting of sediments or soil particles carried into the area by wind or water.

The layers in the soil are called horizons. These horizons are obvious in some soils because changes in soil appearance are abrupt as you look down the soil profile. However in many other soils the change is more gradual and horizons are hard to distinguish.

Figure A5. The soil profile



O horizon (surface organic litter)

This is the layer of organic matter sitting on top of the soil. It tends to be deepest in undisturbed forest environments.

A_1 horizon (topsoil)

This is the surface layer of the topsoil. It has the most organic matter and biological activity of any of the horizons. The decayed organic matter (humus) darkens the soil colour.

A_2 horizon (topsoil)

This layer is similar in texture to the surface layer, but is generally not as dark due to less organic matter. It may not be present in all profiles. Sometimes it has a pale bleached appearance and is less well structured. Bleaching is an indication of periodic waterlogging above a relatively impermeable subsoil.

B horizon (subsoil)

This horizon usually has more clay than the topsoil. In clay soils, the difference in clay content between the A and B horizons is less than those for other soils, such as red-brown earths.

C horizon (weathering rock)

This layer is not present in most Riverina soils.

Chapter A3. The ideal soil

A benchmark is provided to assess the suitability of soils for different cropping enterprises in the Murray and Murrumbidgee valleys. This chapter presents an ideal soil for the production of pastures and crops other than rice, and for rice.

FEATURES OF AN IDEAL SOIL FOR PASTURES AND CROPS OTHER THAN RICE

The features of an ideal soil for the production of non-rice crops and pasture include:

- friable seed bed protected by plant residues/organic mulch
- well structured topsoil with optimal porosity
- adequate topsoil depth
- subsoil with adequate water entry and rapid air entry
- subsoil of optimal bulk density
- near neutral pH
- adequate nutrition
- low sodicity and optimal salinity

Soils used for non-rice crops and pastures need porosity that allows adequate infiltration of irrigation water to meet plant water requirements. An ideal soil is able to store large quantities of water which is readily available to plants. This is especially important for summer crops and some pasture species which have a high water requirement. This characteristic allows longer intervals between irrigations. It also delays the onset of drought stress in non-irrigated crops.

The ideal subsoil must be well structured to allow adequate internal drainage in order to prevent waterlogging. The subsoil should be of optimal density to allow unrestricted root growth. It should have low sodicity, and also have optimal salinity to prevent dispersion and to allow adequate drainage.

Optimum growth of non-rice crops and pasture species requires specific pH, salinity and nutrition levels in the soil. Each crop/pasture species has its own specific requirement for nutrients and tolerance of pH and salinity. The optimal levels depend on the crop or pasture species grown.

There are many different species grown under irrigation in southern NSW. For the nutritional requirements of each plant species, refer to district sowing guides. Information on the pH requirements and salinity tolerance limits of the most common crops and pasture plants grown in southern NSW are provided in Chapters B5 and B6.

FEATURES OF AN IDEAL SOIL FOR RICE PRODUCTION

The features of an ideal soil for rice production include:

- surface soil which can be easily cultivated
- topsoil which is non-dispersive and non-saline
- non-saline sodic subsoil at least 3 m deep

The seedbed of an ideal rice soil should be firm and well aggregated and range from 5–7 cm in depth. Clod size should range from 1–5 cm. To ensure good seedling establishment, the clods should not slake or disperse, thus reducing rice seed burial, wind damage due to poor anchorage, and muddy water.

The surface cover of plant residue should be less than 5% for cultivated seedbeds.

Good rice soils are slightly acidic to slightly alkaline, the optimum pH range being 5.5–8. Rice has a low tolerance to salinity in both the soil and flood water. Ideally the root zone should be non-saline, and the soil salinity of the subsoil less than 3 dS/m (EC_{se}).

The texture of the subsoil should be a medium to heavy clay. Ideally the subsoil should be sodic and of low salinity so that some soil dispersion occurs. This ensures that the soil has poor internal drainage and accessions to the watertable are minimised.

A soil suitable for rice growing must have a specific depth of clay in the profile. Soils for rice growing should meet the rice soil suitability criteria, as recommended by the Department of Land and Water Conservation and local irrigation authorities (see Chapter B7: *Is my soil suitable for rice growing?*).

Chapter A4.
Soils of the Riverine Landscape

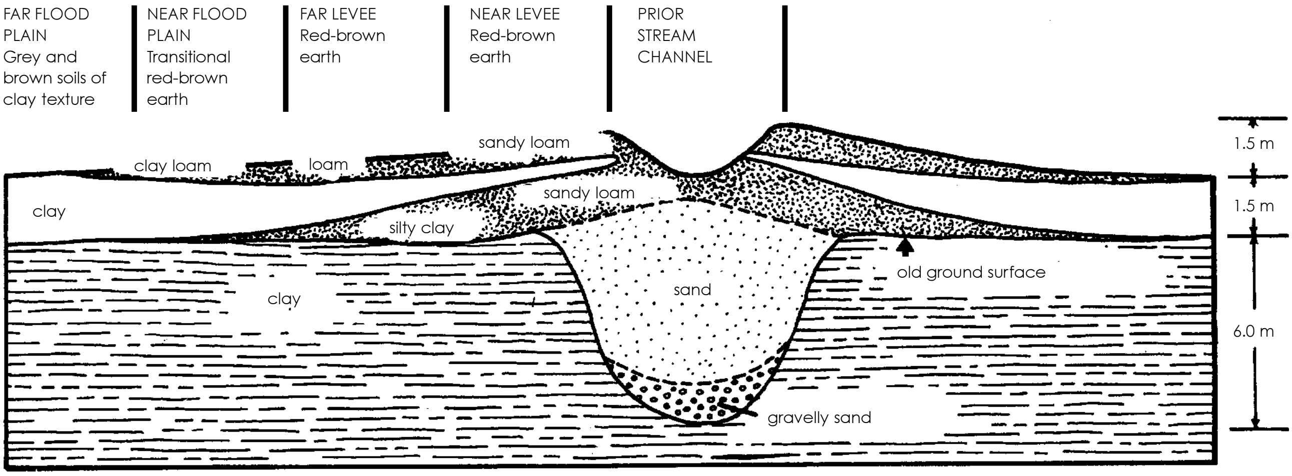
The five main soil groups recognised in the Riverine landscape are:

Sandhill soils
Red-brown earths
Transitional red-brown earths
Non self-mulching clays
Self-mulching clays

SOIL FORMATION IN THE RIVERINE LANDSCAPE

The soils of the Riverine Plain are formed upon sediments from ancient rivers that once dominated the area, along with clay materials carried into the area by wind. These ancient rivers are often referred to as prior streams. The general relationship between prior streams and soil types is shown in Figure A6.

Figure A6. Relationship between prior stream and soil type



From M. Stannard, Water Resources Commission of NSW (1976). Original drawing by G. G. Chapman, CSIRO, Griffith, NSW.

It can be seen from Figure A6, that the further the soil is away from the prior stream towards the far flood plain:

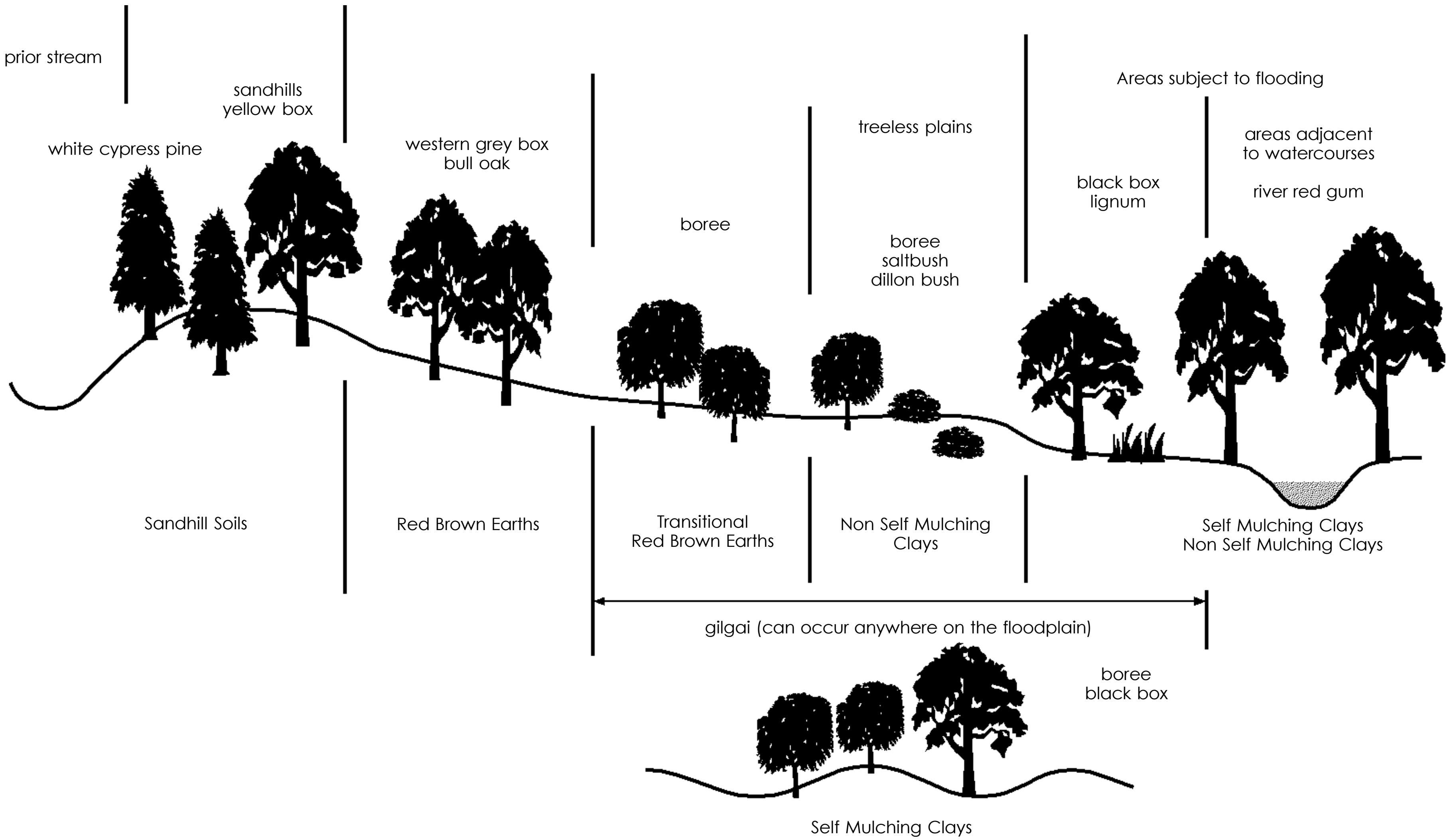
- the loam topsoil becomes thinner
- the topsoil becomes more clayey in texture.
- depth of clay subsoil increases.

- **sandhills occur close to prior streams, however prior streams may exist with no associated sandhills**
- **self-mulching soils occur in gilgai areas and in low lying areas that often flood**

In this generalised diagram, there is no indication of the occurrence of sandhill soils. Sandhills are generally associated with the prior streams and occur as a ridge, usually to one side of the prior stream. However prior streams can occur without the associated sandhills.

Self-mulching and non self -mulching soils occur on the levee and flood plain areas. These are soils of clay texture in the subsoil. Self-mulching refers to clay soils that are well structured or ‘crumbly’ in the topsoils, and in some well into the subsoil as well. They are mostly found in the far levee near existing streams and watercourses.

Figure A7. The soil/vegetation association of the riverine landscape



Most of the levee and flood plain soils are non self-mulching, consisting of the red-brown earths on the levee areas, the heavier transitional red-brown earths on the near flood plain, and the non self-mulching clays of the far flood plain (the latter is often referred to as the treeless plains).

Vegetation may help in identifying soil groups and soil types, since soil, vegetation and local topography are all related. This is illustrated in Figure A7.

In reality soils usually change gradually with distance from the prior stream, not abruptly as indicated in the above figures. This is the reason why it is sometimes difficult to place a soil into one of the groups shown. To help you identify your soil, a brief description of the soils in each group is given. Some photos have been included to provide examples of soils in each group.

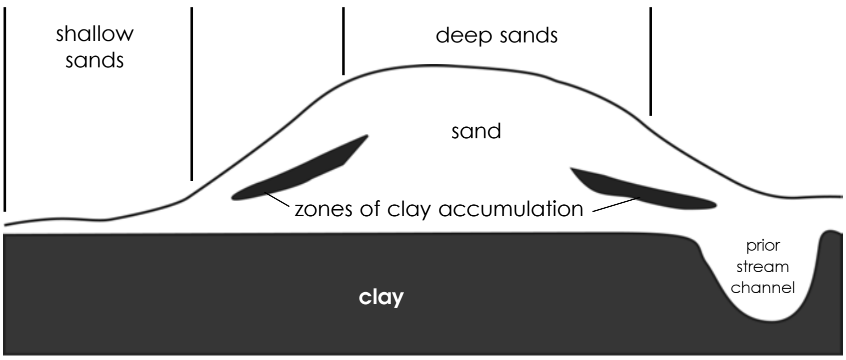
SOILS OF THE RIVERINE LANDSCAPE

SANDHILL SOILS

- **sandhill soils have a topsoil of loose sand greater than 15 cm in depth**
- **deep sands have loose sand to a depth of 2 m or greater, with no obvious subsoil, or bleached layers**
- **shallow sands have a shallower topsoil overlying a clay subsoil; a bleached layer in the lower topsoil is usually present**

Texture: Sandhill soils have a loose sandy topsoil which is greater than 15 cm deep. Deep sands occur in more elevated areas of the sandhill formation where the sandy topsoil is at least 2 m deep. In lower areas of the sandhill formation the depth of sandy topsoil decreases and a shallow clayey-sand subsoil is present. In some areas thin clay bands may be present in deep sands, and are thought to have originated from wind blown clay material. Bands of loam to clay may also develop at depth due to the leaching of clay materials out of the topsoil.

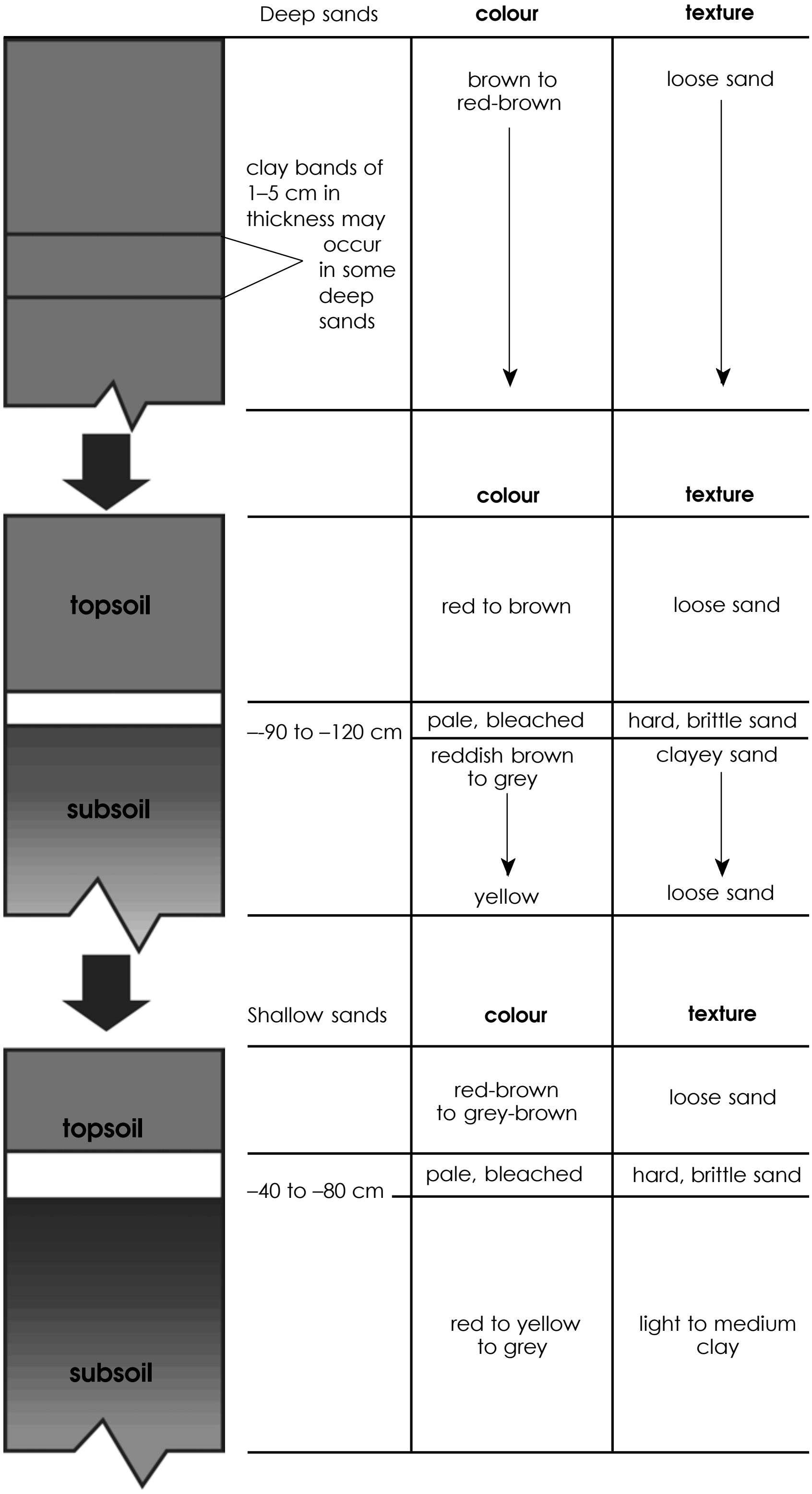
Figure A8. Depth of sandhill soils in relation to position (diagramatic representation)



Colour: The colour of the topsoil is generally brown to red-brown, but some shallow sands may be grey-brown. The subsoils, where present, vary from red to yellow to grey. Yellow and grey colours indicate heavier, poorly drained subsoils, and a bleached layer of overlying topsoil indicates periodic waterlogging. Generalised sandhill profiles are shown in Figure A9.

- **sandhill soils (especially deep sands) have low water holding capacity and poor nutrient retention**
- **sandhill soils are well drained, except where an impermeable clay or cemented layer is within the root zone**
- **a bleached layer indicates periodic waterlogging caused by a perched water table overlying an impermeable layer**
- **sandhills may be prone to erosion**

Figure A9. Generalised sandhill soil profiles



Topography: Sandhill soils are associated with the prior stream channel, and usually occur as a ridge to one side of the stream (Figure A6).

Vegetation: Vegetation on sandhill soils is predominantly White Cypress Pine, with some Grey Box and Yellow Box towards the extremities of the sandhills.

Soil types of the sandhill soil group:

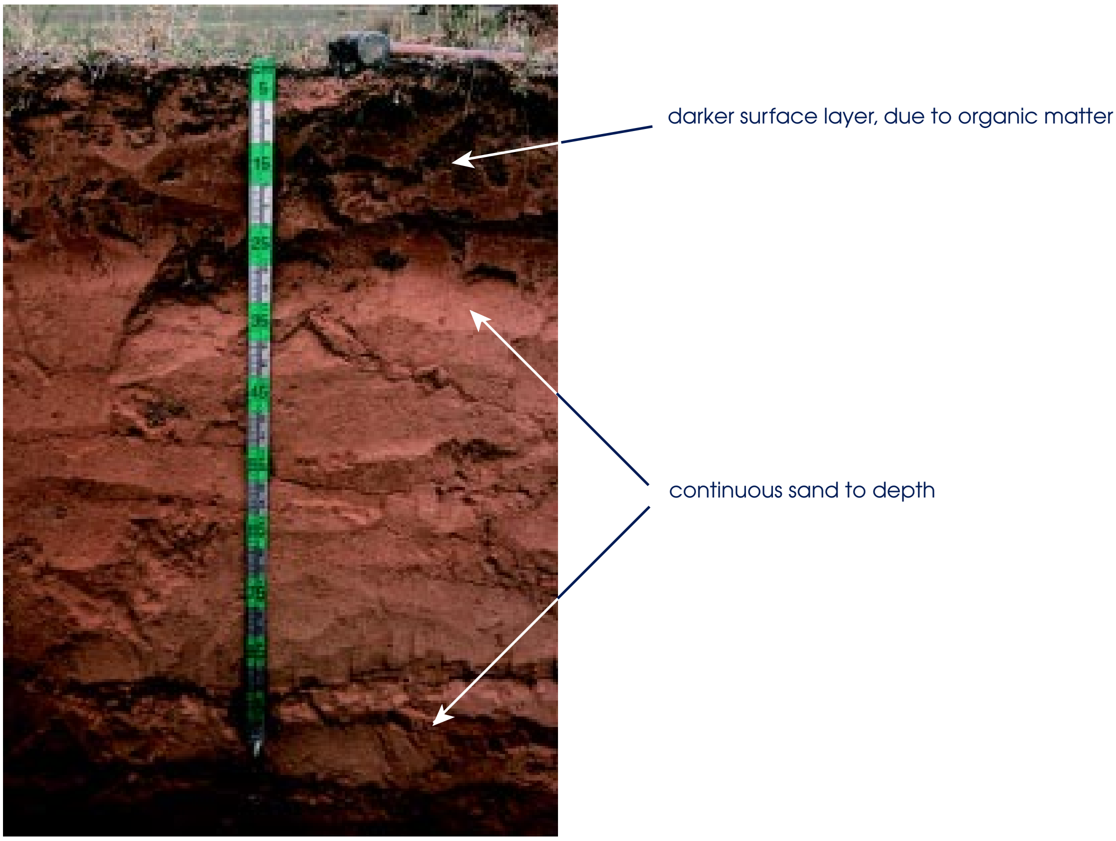
Banandra sand
Banna sand
Boona sand, sandy loam
Danberry sand, sandy loam
Eulo sand
Hyandra sand
Jurambula sand
Mycotha sand
Pullega sand, sandy loam
Purdanima sand
Sandmount sand
Teningerie sand
Tubbo sand
Utona sand
Wamoon sand
Wetuppa sand, sandy loam
Whymoul sand
Yambil sand
Yandera sand
Yarangery sand

Examples of sandhill soils: See following colour insert

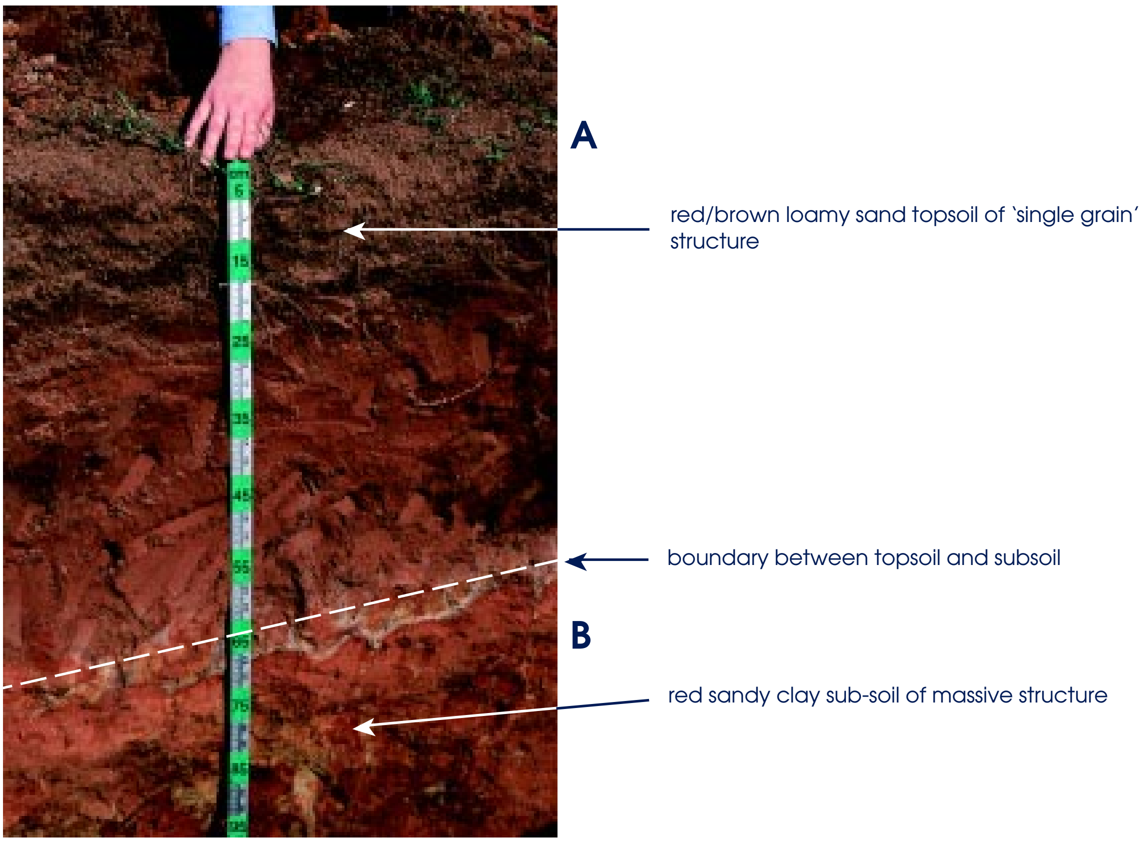
EXAMPLES OF SOIL TYPES

Sandhill soils

1. Sandmount sand (deep sand)

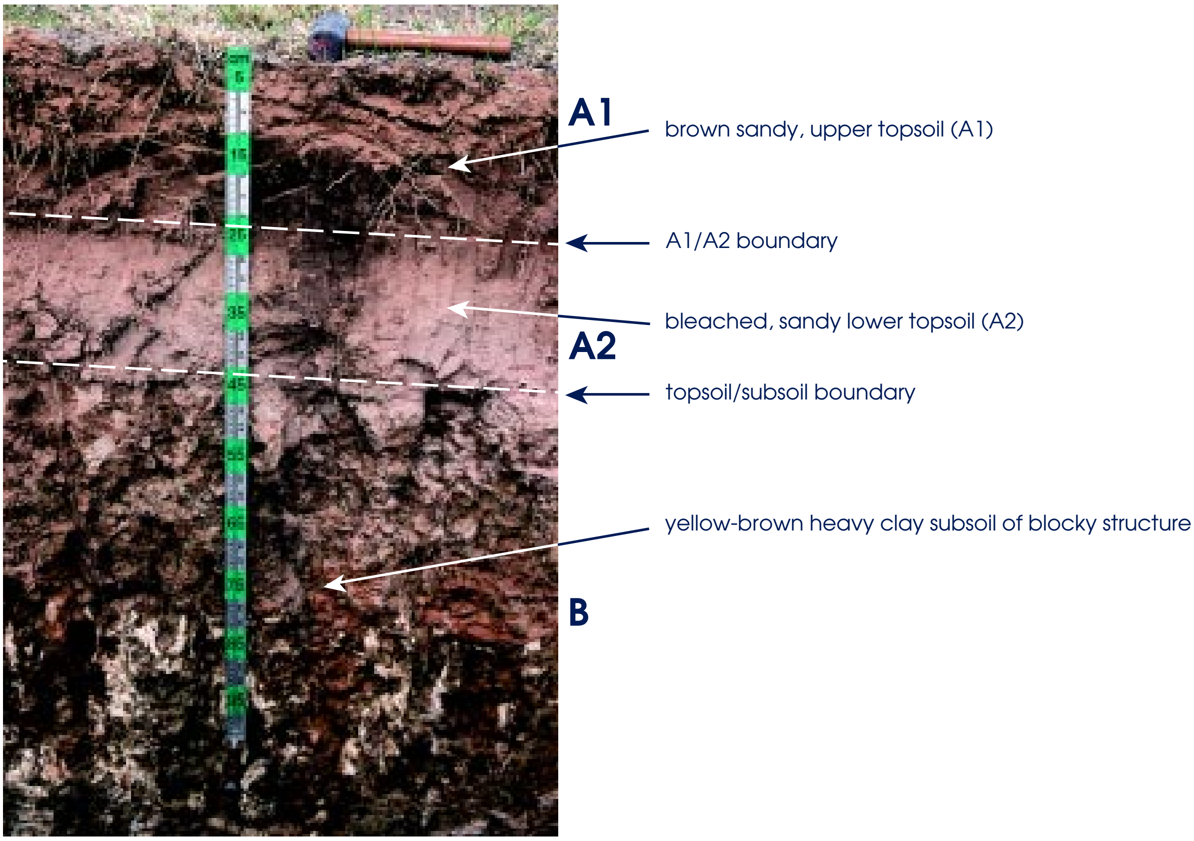


2. Wamoon sand (intermediate depth sand)



Sandhill soils

3. Danberry sand (shallow sand)



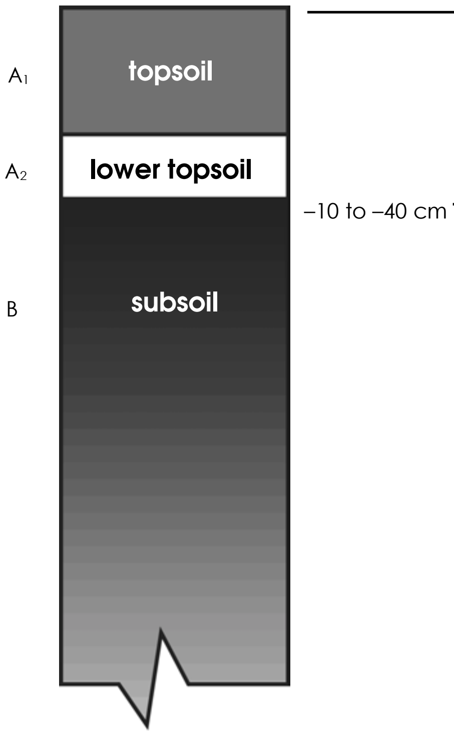
RED-BROWN EARTHS

- **red-brown earth soils have a topsoil of sandy-loam to light clay loam overlying a clay subsoil**
- **the lighter (coarser) textured topsoil is between 10 and 40 cm thick and varies in colour from red to grey/brown.**
- **the lower topsoil is called the A2 horizon, and it may be bleached**
- **subsoil varies in colour from yellow to red to grey**

Texture: Red-brown earths (RBEs) have a sandy-loam to clay-loam topsoil overlying a clay subsoil. Because of this contrast in soil texture, red-brown earths are also called duplex soils. The thickness of the topsoil varies from 10 to 40 cm, with a depth of 10–15 cm being most common.

Colour: The colour of the topsoil varies from red to brown to light grey-brown. Clay subsoils vary in colour from yellow to red to grey. Subsoils may be a patchy mixture of colours, which is referred to as mottling. There may also be a bleached layer of topsoil, immediately above the subsoil, which indicates periodic waterlogging. A generalised RBE profile is presented in Figure A10.

Figure A10. A generalised red-brown earth profile



	colour	texture	structure
A1	red-brown to light grey	sandy-loam to loam	massive to sub-angular blocky
A2	pale, bleached*	as above*	massive*
B	red to grey ↓ yellow to olive-brown to grey	light to heavy clay ↓ often coarser than upper subsoil	angular blocky ↓ massive

* The pale lower layer of topsoil (A_2 horizon) is not found in all red-brown earths.

Topography: Red-brown earths occur on the near levee of the prior stream system (Figure A6).

Vegetation: The natural vegetation most likely to be found on areas of red-brown earths are the Western Grey Box, Yellow Box and White Cypress Pine. The Yellow Box is found in sandy well drained RBEs, often over prior streams. Sandier RBEs are usually found in more elevated positions of the landscape and are favoured by the White Cypress Pine.

Soil types of the red-brown earth group:

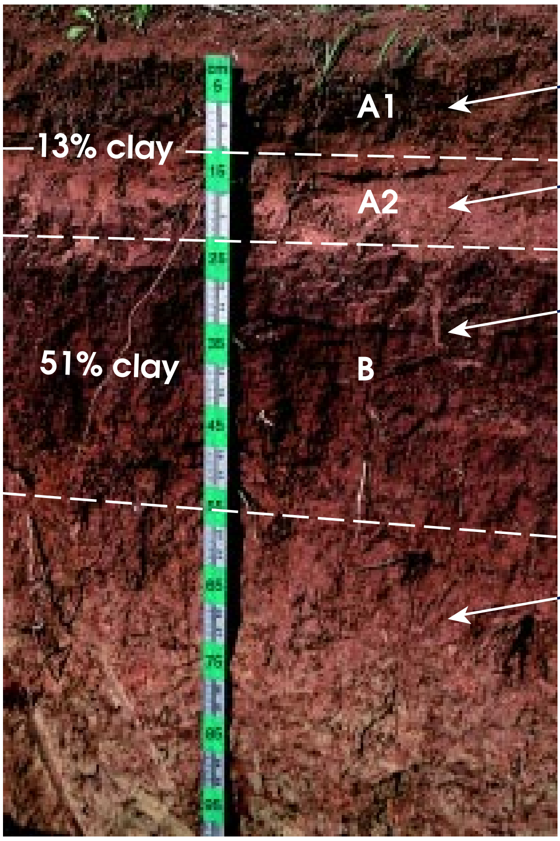
Ballingal loam
Barooga loam
Beelbangera loam
Beremagad sandy loam
Bibul clay loam, loam
Birganbigil clay loam, loam, sandy loam
Bundure loam
Bunnaloo loam
Burraboi sandy gravelly loam
loam,
Camerooka sandy loam
Cobram loam, sandy loam
Conargo sandy loam
Deniboota sandy loam, loam
Finley sandy loam, loam
Fivebough sandy loam
Griffith loam, clay loam
Hanwood loam, loam
Jondaryan loam, clay loam
Katunga gravelly loam
Lake View loam
Leeton clay loam
Merungle loam
Mirrool loam
Moira loam
Naringaningalook loam
Stanbridge sandy loam, loam
Tharbogang loam
Thulabin clay loam, loam, sandy loam
Tulla loam
Wakool sandy loam
Willimbong loam
Womboota loam

Examples of red-brown earths: See following colour insert.

EXAMPLES OF SOIL TYPES

Red-brown earths

1. Thulabin sandy loam



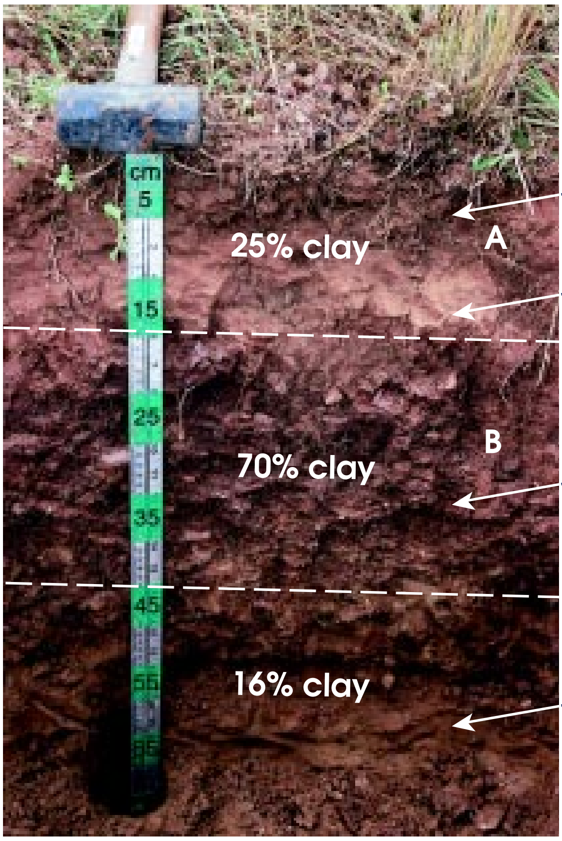
red-brown sandy loam of single grain structure

pale sandy loam of massive structure

reddish brown sandy clay of blocky structure

yellow-red medium clay of massive structure

2. Bunnaloo loam



red-brown loam topsoil

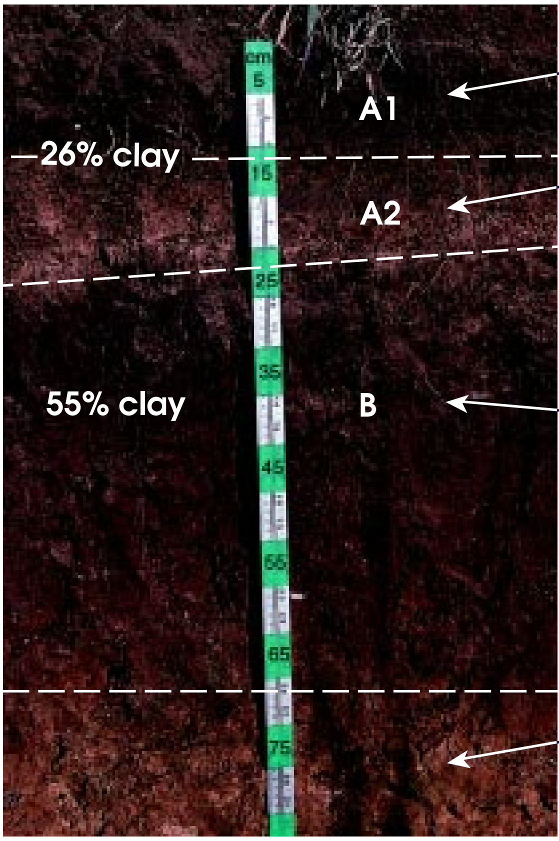
pale lower topsoil

heavy clay subsoil

sandy loam subsoil

Red-brown earths

3. Mundiwa loam (deep topsoil phase)



brown loam topsoil, has a fine many-sided type structure

pale loam topsoil of weak to massive structure

red/brown medium clay subsoil of weak blocky structure

yellow/brown medium clay subsoil of massive structure

TRANSITIONAL RED-BROWN EARTHS

- **transitional red-brown earths differ from red-brown earths by having:**
  — shallower and usually more clayey topsoils
  — more clayey, deeper subsoils
- **growth problems plants experience in transitional red-brown earths are similar to those for red-brown earths, but are more common and more severe due to the shallower topsoils and more clayey texture of transitional red-brown earths.**

Texture: Transitional red-brown earths (TRBEs) are a specific subgroup of red-brown earths and are formed from finer sediments than the red-brown earths. This means they generally have a higher clay content than the red-brown earths. TRBEs have a shallow clay loam topsoil of 5-10 cm depth, overlying a clay subsoil.

Colour: The colours of the topsoil and subsoil are much the same as those described for red-brown earths, with red-brown being the most common colour. Figure A11 illustrates a generalised TRBE profile.

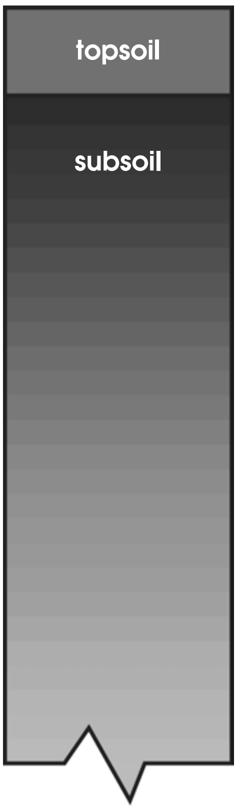
Subsoil characteristics: The subsoil of transitional red-brown earths is either sodic or non sodic. Based on this, transitional red-brown earths are divided into two groups:

Sodic TRBEs have dispersive (sodic) clay subsoils which are dense and less permeable than that of non-sodic TRBEs.

Non-sodic TRBEs have non-dispersive (non-sodic) clay subsoils, and are well structured and more permeable to water than sodic TRBEs.

Sodic TRBEs are more common than non-sodic TRBEs.

Figure A11. A generalised transitional red-brown earth profile



	colour	texture	structure
topsoil (0 to –5 to –10 cm)	red to brown to grey	clay loam	massive
subsoil	red to grey ↓ yellow to olive-brown to grey	medium to heavy clay ↓ light to heavy clay	angular-blocky ↓ angular-blocky ↓ massive

Topography: Transitional red-brown earths are usually found on the near floodplain (Figure A6). However, they also occur in association with self-mulching soils in gilgai complexes. TRBEs are located on the shelf or slightly depressed areas of the gilgai complex.

Vegetation: The natural vegetation most likely to be found on transitional red-brown earths include Boree, Western Grey Box and Black Box. Western Grey Box is found in better drained TRBEs, while the Black Box occurs in poorly drained areas, often in a gilgai formation.

Soil types of the transitional red-brown earth group:

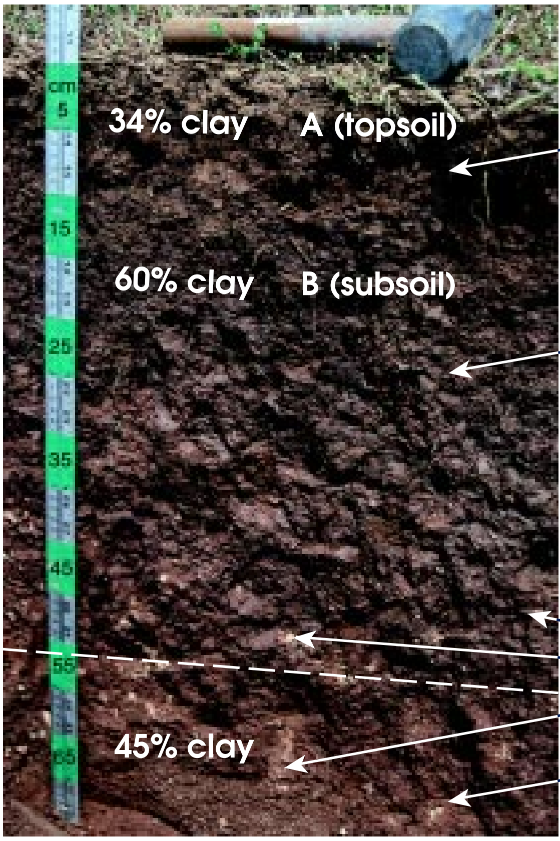
Beremegad loam	Mundiwa clay loam	Wongal clay loam
Coree clay loam	Tilga sandy clay loam	Yallakool clay loam
Dahwilly sandy loam	Tomara loam	Yarraman clay loam, clay
Marah loam	Tulla clay loam	Zara loam
Morago clay loam	Tuppal clay loam	
Muckatah clay loam	Wilbriggie clay loam	

Examples of transitional red-brown earths: See following colour insert.

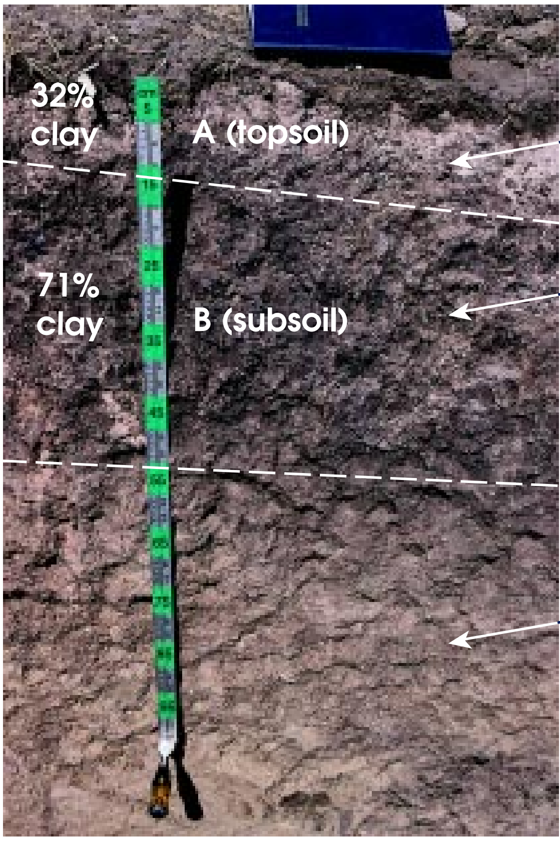
EXAMPLES OF SOIL TYPES

Transitional red-brown earths

1. Willbriggie clay loam

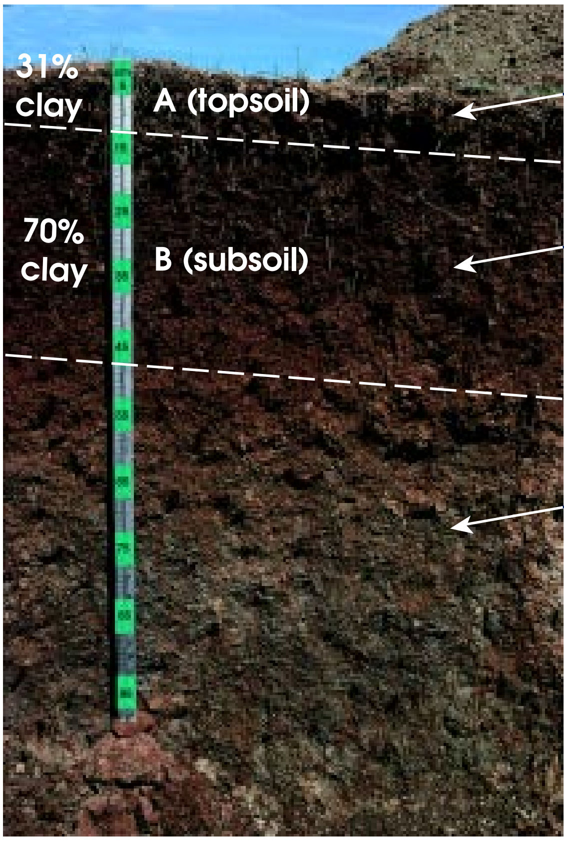


2. Coree clay loam



Transitional red-brown earths

3. Mundiwa clay loam

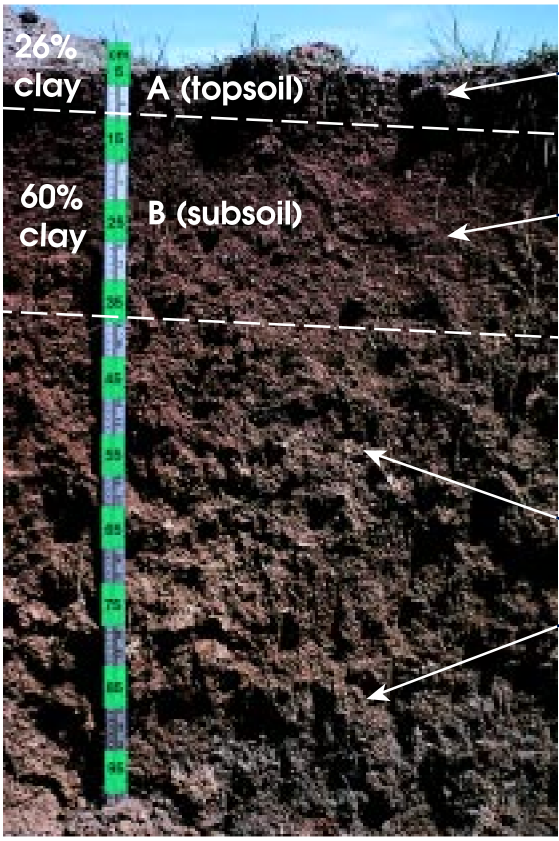


red-brown clay loam topsoil of hardset/ massive structure

red heavy clay subsoil of weak blocky structure

grey heavy clay subsoil of massive structure

4. Birganbigil loam



red-brown loam topsoil of platy/hardset structure

red heavy clay subsoil of blocky structure

heavy clay subsoil varying in colour from red to grey, structure is massive.

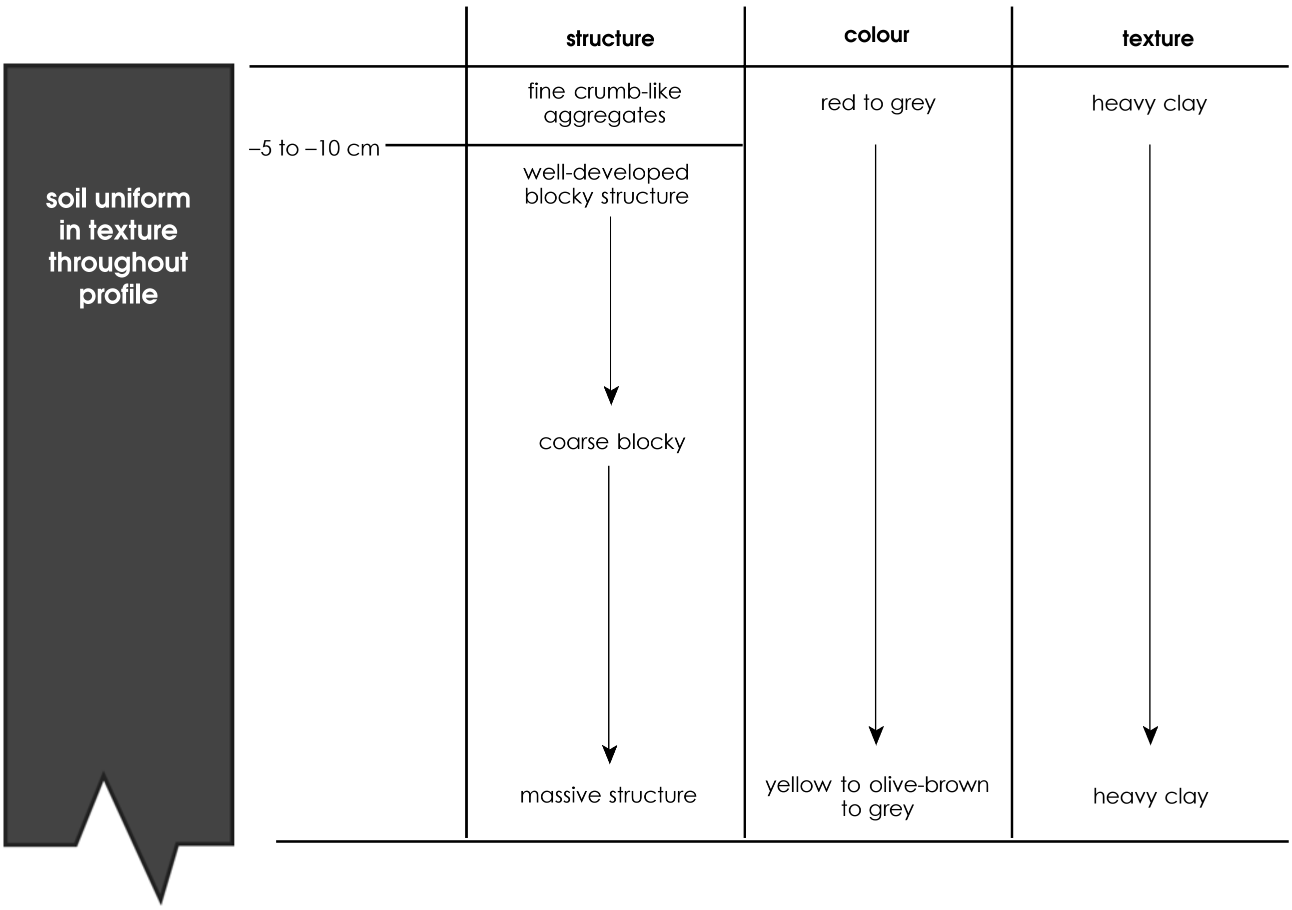
SELF-MULCHING CLAYS

- **self-mulching clay soils are uniform in clay content**
- **they have a crumbly, well-developed surface structure**
- **they often occur as the 'mound' in gilgai formations**
- **self-mulching clay soils have good structure in most situations**
- **they are prone to compaction, especially when wet**
- **self-mulching clays have comparatively few problems compared to other soil groups, but they can be 'leaky' under rice**

Texture: Self-mulching clays (SMCs) have a uniform heavy clay texture in both the topsoil and subsoil. The self-mulching surface soil is composed of small aggregates which are friable (easily cultivated) when dry. The aggregates remain stable when wet, thus maintaining soil structure. SMCs are formed by extensive swelling and shrinking brought about by wetting and drying.

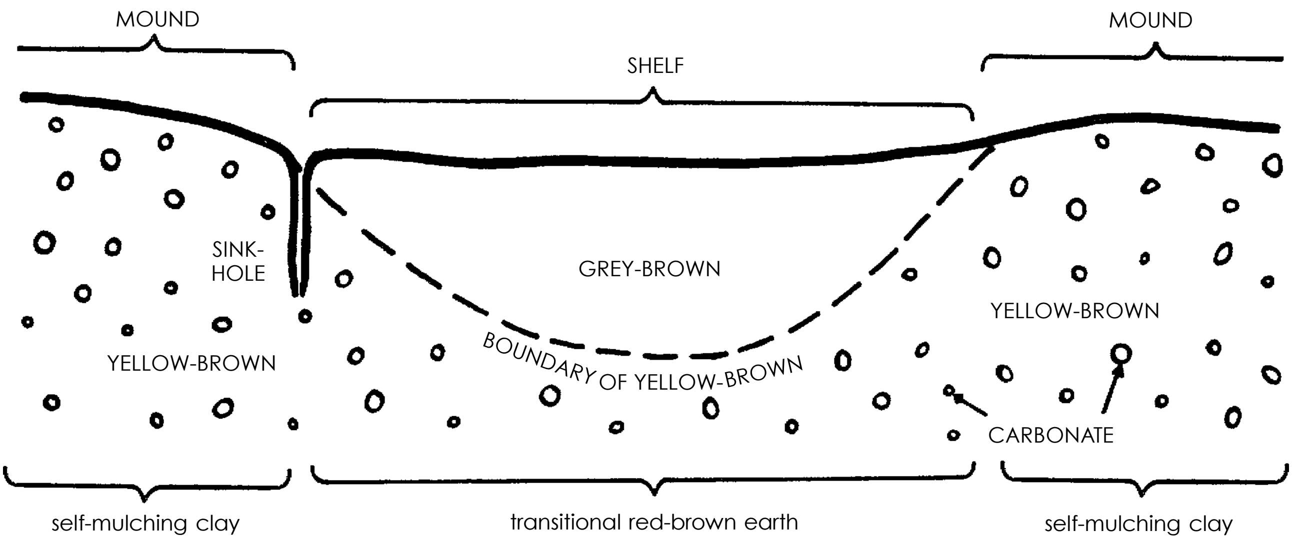
Colour: The colour of the self-mulching clay soils ranges from reddish brown to grey, and colour may tend to become more yellow with depth. Lime nodules may also be present throughout the soil profile. Properties of a generalised SMC profile are given in Figure A12.

Figure A12. A generalised self-mulching clay profile



Topography: Self-mulching clays are found on the far flood plain and also in gilgai formations across the near and far floodplains (Figure A6). They occur as the mound or 'puff' in the gilgai complex (Figure A13). Areas having more than 50% mound as a proportion of the total area are usually considered to be SMCs.

Figure A13. Typical gilgai formation in relation to soil type (Stace *et al.* 1968)



Normal gilgai of the Riverine Plain, taken near Leeton.

Vegetation: The associated vegetation most likely to be found on areas of self-mulching clay are Boree and Black Box.

Soil types of the self-mulching clay group:

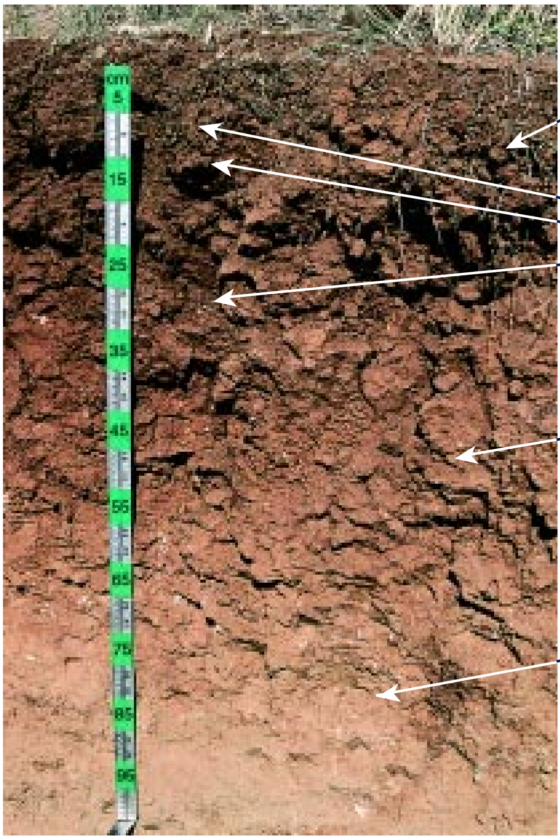
Coleambally clay	Gundaline clay	Wunnamurra clay
Gogeldrie clay	Niemur clay	Yooroobla clay

Examples of self-mulching clays: See following colour insert.

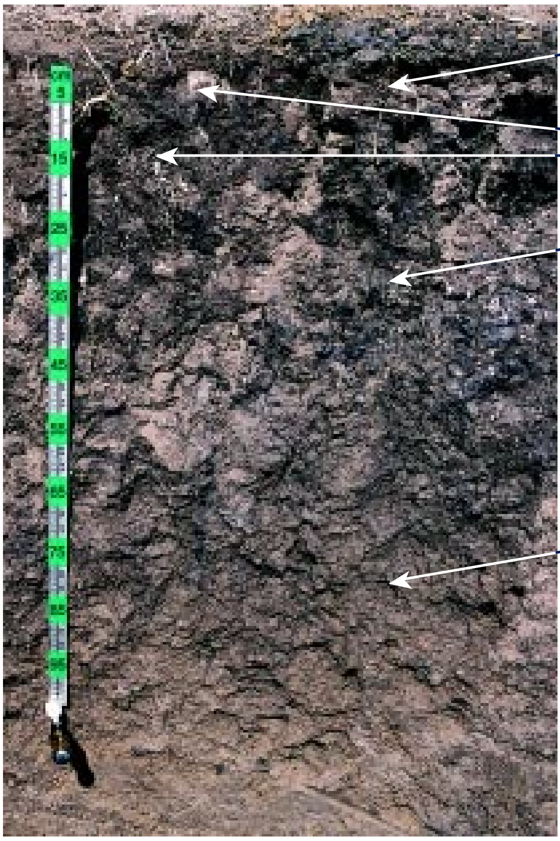
EXAMPLES OF SOIL TYPES

Self-mulching clays

1. Yooroobla clay



2. Wunnamurra clay



Self-mulching clays

3. Self-mulching clay surface

4. Non self-mulching clay surface

Note that both surface soils are dry and have not been cultivated for months; the self-mulching clay will often have a loose surface soil even when uncultivated. A thin fragile crust may form at the surface of self-mulching soils, while non self-mulching clays will usually form a strong thick surface crust, or be hardset at the surface.

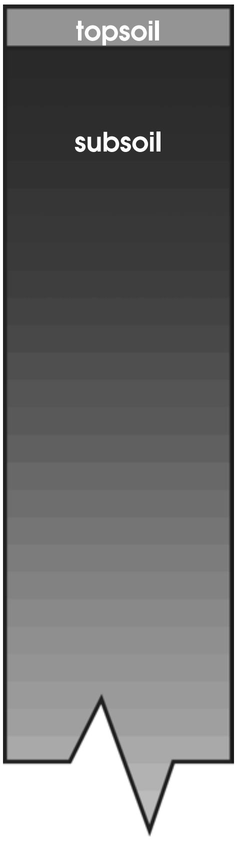
NON SELF-MULCHING CLAYS

- **non self-mulching clay soils often have a shallow crust-like topsoil**
- **they are poorly structured and are usually dispersive**
- **they are found in the far flood plain areas**

Texture: The shallow topsoil of a non self mulching clay (NSMC) is usually less than 5 cm in depth. The topsoil ranges in texture from a clay loam to a light clay, whilst the underlying subsoil is a dense heavy clay. These soils are generally sodic and poorly structured, causing them to swell and disperse on wetting and set hard on drying. Both infiltration and permeability are poor due to their texture and propensity to disperse.

Colour: The colour at the surface varies from brown to grey. Brown NSMCs usually have better surface drainage, while the grey coloured clays generally indicates poor drainage. The colour of deep subsoils range from brown to grey to yellow.

Figure A14. A generalised non self-mulching clay profile



	colour	texture	structure
topsoil (—1 to –5 cm)	brown to grey	loam to light clay	massive
subsoil (top)	brown to grey	heavy clay	angular blocky to massive
subsoil (bottom)	yellow to grey	medium to heavy clay	massive

Topography: Non self-mulching clays occur in the far floodplain area of the landscape (Figure A6). These areas are typically very flat and hence drainage is poor.

Vegetation: The natural vegetation most likely to be found on areas of non self-mulching clay are Boree, Black Box (in poorly drained areas), Dillon Bush and Cotton Bush.

Soil types of the non self-mulching clay group:

Billabong clay	Morago clay	Tulla clay loam
Colimo clay	Moulamein clay	Wandook clay
Coree clay	Niemur clay	Wilbriggie clay
Crommelin clay	Noorong clay	Yallakool clay
Goolgumbla clay	Riverina clay	

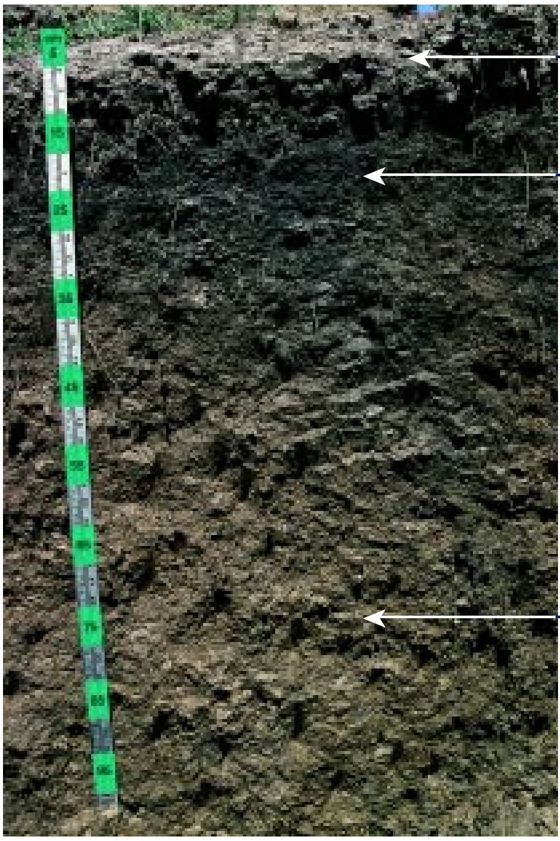
Examples of non self-mulching clays: See following colour insert.

EXAMPLES OF SOIL TYPES

Non self-mulching clays

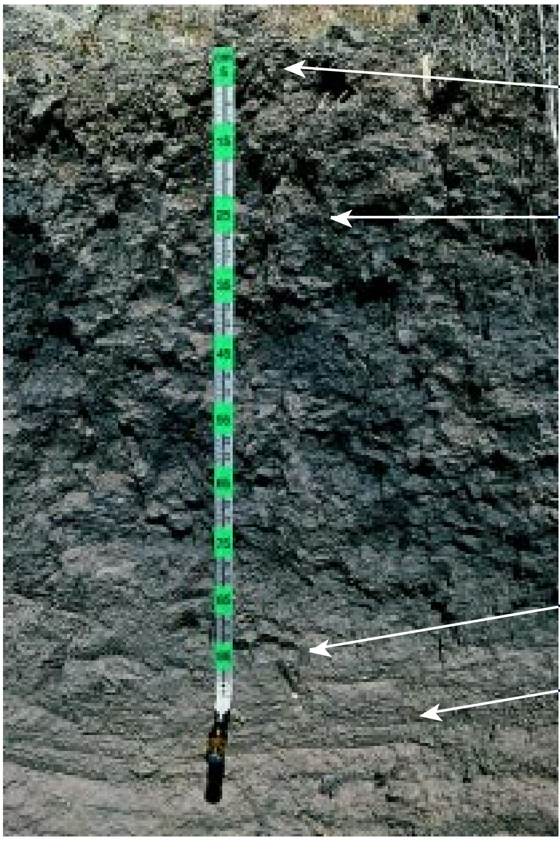
1. Billabong clay

2. Riverina clay



Non self-mulching clays

3. Wandook clay



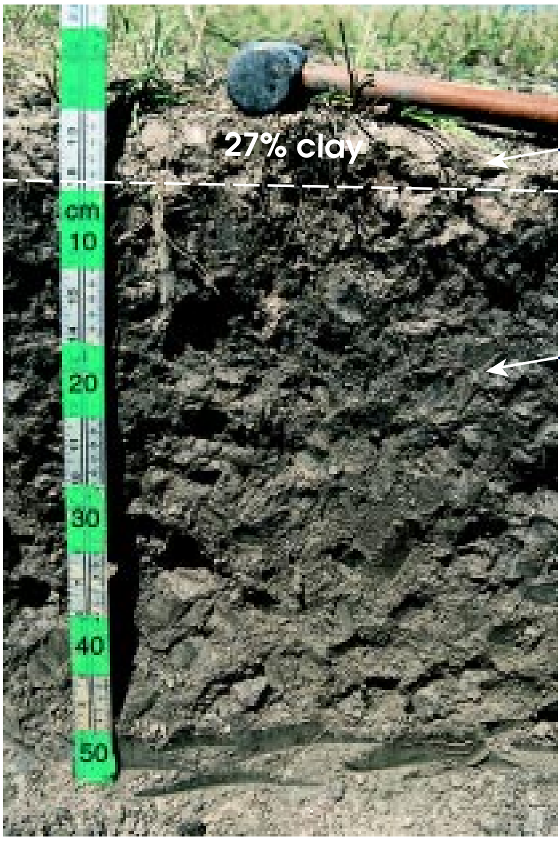
thin light clay loam crust that cracks on drying

blocky structured dark grey, heavy clay

lime nodules

massive, brown medium clay

4. Moulamein clay



hardset sandy clay loam

massive grey heavy clay

Chapter A5. Soil limitations to crop production

SANDHILL SOILS

1. Dense subsoil: A dense clay subsoil, characteristic of the shallow sands, restricts the deep drainage of water and will result in the development of a perched watertable. Perched watertables and waterlogging are common in shallow sands with a clay subsoil. Soil management problems arising from a dense subsoil are:

- waterlogging
- poor aeration

2. Sandy topsoil: Due to the sandy texture of the topsoils, several soil management problems occur:

- low water holding capacity leading to the need for frequent irrigation
- high permeability resulting in deep drainage and possibly recharge to the watertable
- low nutrient storage capacity, with nutrient deficiencies likely to arise
- low ability to resist a change in pH (low buffering capacity)
- soil loss due to wind erosion, especially where soil is left bare

RED-BROWN EARTHS

1. Hardsetting: Hardsetting results from structural instability of the topsoil upon wetting (slaking and/or dispersion). It frequently occurs in soils with a high content of fine sand and/or silt which are low in organic matter. Many of these soils were formerly well structured before excessive cultivation damaged their structure. The surface layer of topsoil of hardsetting red-brown earths sets hard upon drying, showing very little structure and few cracks. Management problems associated with this are:

- reduced seedling emergence
- reduced infiltration

2. Dense subsoil: Subsoils of red-brown earths are generally high in clay content and have high bulk density. A high bulk density is more likely when the subsoil is sodic. Management problems caused by heavy dense subsoils include:

- low permeability to water, limiting the depth of wetting and resulting in the development of a perched watertable and subsequent waterlogging
- poor aeration
- high mechanical resistance to root growth

TRANSITIONAL RED-BROWN EARTHS

(i) Non-sodic TRBEs

1. Hardsetting/crusting: Management problems associated with a hardsetting topsoil are the same as for red-brown earths.

2. Compaction: The subsoils of non sodic TRBE are prone to compaction. Traffic and/or tillage under moist conditions, and heavy stocking rates, are likely to cause compaction. Soil management problems associated with compaction are:

- low permeability to water in the compacted layer, restricting drainage and causing waterlogging
- poor aeration in the compacted layer
- high strength of the compacted layer will impede root growth

(ii) Sodic TRBEs

1. Hardsetting/crusting: Management problems associated with a hardsetting topsoil are the same as for the red-brown earths.

2. Sodic clay subsoils: Sodic clay subsoils are poorly structured, are prone to dispersion and have high bulk density. This results in the following management problems:

- poor aeration
- low permeability to water resulting in poor internal drainage and waterlogging
- high strength, offering mechanical resistance to root growth

SELF-MULCHING CLAYS

1. Compaction: These soils are normally well structured, and structure can be maintained even with frequent cultivations, provided the soil is not too wet. Compaction in self-mulching clays mainly occurs from tillage, traffic or livestock on moist soil. These soils face the same management problems as compacted non-sodic transitional red-brown earths.

2. Permeability: Despite their high clay content, permeability and internal drainage can still be good due to the stability of soil structure of most self-mulching clay soils. Rice growing is therefore inadvisable in many of these soils due to their high water use, which could result in accessions to the water table.

NON SELF-MULCHING CLAYS

1. Sodicity: Sodicity causes dispersion of non self-mulching clay soils, aggravating their poor structure and high bulk density. These soils become soft and ‘spewy’ when wet, and they set hard when dry. The following management problems arise:

- low infiltration and permeability reduces depth of wetting, and results in poor water storage at each irrigation.
- poor aeration
- poor internal drainage and waterlogging
- high soil strength impedes root growth, unless quite moist
- surface crusting prevents seedling emergence
- ‘muddy water’ with early season irrigation reduces the establishment and early growth of rice

Note that a complete list of all the soil types identified in the main irrigation districts of the Riverine Plain is found in Appendix 2.