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Landscapes and soils of the Northam district

D N. Sawkins

Department of Agriculture and Food

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Landscapes and soils of the Northam district
LANDSCAPES AND SOILS OF THE NORTHAM DISTRICT

Developed and compiled by:
Doug Sawkins
Department of Agriculture and Food, Western Australia
Narrogin Office

March 2010

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Copies of this document are available in alternative formats upon request.
3 Baron-Hay Court, South Perth WA 6151
Tel: (08) 9368 3333
Email: enquiries@agric.wa.gov.au
www.agric.wa.gov.au
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I am particularly indebted to Kerry Coyle for editing this bulletin as a favour at a time when I had few options.

Developed and compiled by Doug Sawkins, Department of Agriculture and Food, Western Australia, Narrogin office, March 2010.
Introduction

The agricultural areas of Western Australia are very diverse, with a wide range of landscapes, soils and associated native vegetation.

This bulletin was designed as an induction course for Department of Agriculture and Food employees who have been recently posted to the department’s district offices, but the information is fundamental for many who work in these districts.

This Bulletin provides readers with principles underlying the formation of local landscapes and soils, and information needed to identify landscapes and their associated soils. The emphasis is on field application.

It provides a basis for developing a more detailed knowledge of:

- local soils and land capability
- salinity and hydrology
- local farming systems
- landcare and nature conservation.

Table 1 Areas covered in this series (see also Figure1)

<table>
<thead>
<tr>
<th>District</th>
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<td>Albany</td>
<td>Denmark, Plantagenet, Albany, Cranbrook</td>
</tr>
<tr>
<td>Katanning</td>
<td>Wagin, Tambellup, Broomehill, Gnowangerup, Kojonup, Katanning, Woodanilling, Dumbleyung, West Arthur, Kent</td>
</tr>
<tr>
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<td>Kulin, Lake Grace, Kondinin, Kent</td>
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<td>Merredin</td>
<td>Mount Marshall, Yilgarn, Bruce Rock, Mukinbudin, Westonia, Koorda, Trayning, Narembeen, Merredin</td>
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<tr>
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<td>Gingin, Chittering, Dalwallinu, Dandaragan, Victoria Plains, Moora</td>
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<td>Brookton, Pingelly, Cuballing, Williams, Narrogin, Wandering, Corrigin, Wickepin.</td>
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<tr>
<td>Three Springs</td>
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Each bulletin has been designed as a self-learning module that contains the following components:

1. Two articles
   These describe the development and distribution of the soils, landscapes and soil landscape systems in the district.
2. Decision aids for use in the field
   - Indicator vegetation guide that is useful for quickly understanding soil type variations from remnant pre-European vegetation.
   - Other decision aids to help you identify landscape types, land units and common soil types in the district.

3. A half-day documented field tour to provide field examples of the information covered in the lectures, and specific stops to give practice in using the decision aids.

4. Case studies
   These are areas in the district that have been displayed as a map with photographs of numbered points to illustrate the soils and landscape. These real-life examples show the diversity of landscapes that make up the soil landscape systems in the district, and explain the variations that occur. Distances are shown so that you can visit each area with the document as a guide.

5. Appendixes with supporting information, a glossary and references.
   To get the best value from this course, I recommend that you refer to the ‘Soil guide: a handbook for understanding and managing agricultural soils’, WA Department of Agriculture Bulletin no. 4343.

Figure 1 Areas covered in this Bulletin series with reserves shown in green
Landscape development in the Northam district

In this article, you will be introduced to factors influencing soil and landscape development in the Northam district.

You will notice in Figure 2 that the landscape becomes more subdued to the east, and can be divided into three distinct drainage zones.

The western part has distinct north-west/south-east patterns in ridges and valleys, and relatively few large waterways. This is called the Darling Range Zone (DRZ), and is the broad uplifted plain of the Darling Range and its eroded margins. Grey and brown gravelly soils and sheet ironstone are common.

To the east is the Ancient Drainage Zone (ADZ), where the landscape is more subdued with frequent yellow sandy gravel uplands and wide, flat drainage systems with salt lakes. In many years run-off does not reach the sea.

Between the two is the Rejuvenated Drainage Zone (RDZ). This zone has an active drainage system with north–south flowing branches of the Avon River that meet at Northam and break through the Darling Range to join the Swan River. The landscape is more dissected, often with variable soils formed from dissected laterite profiles and underlying crystalline rock. The sandplain north of Meckering and Cunderdin is bordered on the north, east and south sides by ancient drainage valleys, but has aeolian soils and upper valleys consistent with the RDZ further west.

Figure 2 Drainage zones in the Northam district
Another obvious feature in the Northam district is the strange orientation of the rivers. Sudden changes in river direction are an indication that geology and earth movements have significantly influenced landscape development. For example:

- From Koorda the salt lake system snakes around in a ‘Z’ fashion before reaching Northam. The Salt River system after Quairading drains water from the Yilgarn (Merredin) and Lockhardt (Lake Grace) district with water coming north from as far south as Pingrup. It then goes north to Northam as the Avon River.

- The Mortlock north branch (Goomalling) drains almost north–south (with a drainage pattern that goes as far north as Dalwallinu).

A number of factors and processes have interacted to develop the landscapes and soils (see Figure 3).

**Geology and tectonic movement**

There are marked differences in the underlying rocks, which weather and erode in distinctive ways. Differential weathering of rock types, faulting and geological uplift have had large effects on landscape relief and soil type.

The geology of southern Western Australia is dominated by the Yilgarn Craton, an ancient and relatively stable area of granites and gneiss (a metamorphic banded granite-like rock).
You will notice in Figure 4 that many features such as faults, dykes, major rock formations and waterways trend NW/SE, E/W or NE/SW. The north-west alignment of major rock bands of the Yilgarn Craton reflects its formation over many hundreds of million years as ‘rafts’ of land on tectonic plates collided to form bands of gneiss that were intruded by granites. Stresses associated with these events caused cracking and intrusion of the dolerite dykes that occur throughout the craton.

In the Northam district there are few sedimentary rocks as in the Perth basin. Igneous rocks include granite, dolerite, gabbro, quartz and metamorphic rocks such as gneiss, migmatite and banded ironstone that are the parent materials for wind and waterborne deposits, laterites and a range of soils. Outcrops are relatively common in dissected (rejuvenated) areas.

Figure 5 shows a range of soils formed directly from felsic (acidic) rocks in WA. These have relatively high amounts of quartz, and weather to sandy surfaced soils. They are mainly granites but include other igneous rocks such as felsic gneisses. Gneisses are metamorphosed igneous rocks that vary in their dark mineral content, ranging from granitic to quite mafic.

Mafic gneisses, as well as greenstones, dolerites and gabbros tend to form more clayey soils. Figure 6 shows a range of mafic (basic) rocks which typically contain large proportions of ‘dark’ minerals and high levels of calcium and iron. They typically weather to red-brown/brown clay loam to clay soils with alkaline and often calcareous subsoils.
Figure 5  **Felsic (quartz rich) rocks and soils**

Figure 6  **Mafic rocks and soils**
The Jimperding metamorphic belt is a band of very mixed and often mafic rocks that runs NNW to SSE through Northam along the Avon valley. In the rest of the Northam district, narrow bands of mafic soil formed on dolerite dykes occur throughout the district.

About 150 million years ago, processes commenced that culminated in the separation of Australia from Antarctica and India. These caused extensive faulting as well as uplifts on the south and west of the Yilgarn Craton, which in turn caused marked changes to slope and drainage patterns. I will discuss this in the next section.

Native vegetation

In Western Australia, there is a very close relationship between soil types and the pre-European vegetation, with vegetation and associated soils often forming complex mosaics in the landscape.

There is considerable evidence (Verboom, WH and Pate, JS (2003)) that plants can engineer soil conditions to deny water and nutrients to competitors. Plants and associated microorganisms create horizons in many of our soils, particularly through root secretions. Common examples in the district are:

- laterite formation by many members of the Proteaceae family and *Allocasuarina* genus (tammas) that control access to soil phosphorus in well-drained acidic situations.
- ‘wodjil’ acacia highly acidic yellow sandy earth and gravel soils in the eastern and north eastern wheatbelt with highly acid subsoils
- mallee duplex soils with silica ‘seals’ and/or dense clay on or above the subsoil that generally restrict understorey access to stored water. The mallees themselves use their roots to store and access water using a process called hydraulic redistribution. Surface water may also be transmitted directly to these storage zones via macro pores which arise when roots shrink during heavy rain
- lime deposits in subsoils of alkaline soils assist in soil water storage and may control access to soil phosphorus
- plants such as brown mallet that create water-repellent topsoils and can direct water by their shape and bark characteristics into the subsoil.

Laterites are soils in which iron and aluminium have accumulated in the profile, usually as gravels. Figure 7 depicts a common type of laterite profile. An old laterite developed on granite usually has a sandy surface overlying small round gravel then a layer of blocky ironstone followed by mottled clay and then a pallid zone, sometimes referred to as ‘pipe clay’. Saprock is a zone of partially weathered bedrock that is quite permeable for groundwater movement.
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Topsoil: sand with varying amounts of gravel

Reticulite: ferricrete that can be indurated or gravelly

Mottled zone: mottled sandy clay to clay loam

Pallid zone: pale sandy clay to clay loam

Saprock: partially weathered rock

Basement rock

Figure 7 Typical laterite profile (Soilguide 1998) and a composite profile image (not to scale)

Most laterite formation involves plants and bacteria, which accounts for the observations that different laterites occur under different populations of plants and that laterite is still forming where there is sufficient rainfall.

Figure 8 Gravel and reticulite formation

The following factors are required for laterite development:

1. Plants with proteoid roots and associated bacteria: These secrete organic molecules of low molecular weight carboxylates (LMCs) which form a compound with phosphorus (and iron and other minerals such as aluminium and silica) that is soluble in water and can be absorbed by plant roots. Most of the plants with proteoid roots are Proteaceae (most noticeably dryandras, banksias and hakeas), and Casuarinaceae—tammas and
sheoaks). Bacteria use excess LMCs as food and so precipitate the minerals. Gradually iron becomes depleted near the soil surface and accumulates further down as ferricretes. Minerals are also mined using chelation, and uplifted and concentrated in the upper regolith by plant hydraulic lift. This is a primary reason why very sandy materials can have stony ferricretes over sandy lower layers, and why lateritic pallid zones occur.

![Figure 9 Plants on laterites at the Darling Range (left) and Kukerin (right)](image)

2. Low phosphate soils: *Proteaceae* and *Casuarinaceae* have a competitive edge over other vegetation in these soils. In more fertile soils other species are often more competitive.

3. Leaching (acidic) soil conditions: Many proteaceous plants and associated bacteria function best in acid to neutral soil conditions. Laterites will not form on poorly drained or alkaline soils (the LMCs involved are deactivated by calcium). This explains why most laterites are found on well-drained ridges and slopes or in valleys that have good internal drainage.

4. Enough rainfall to move the dissolved minerals down the soil: Rainfall is required to move the chelated iron down the soil profile. If not, the iron would remain near the surface and the deeper laterite layers would not form. Typical laterite profiles are more common in higher rainfall areas of the district, such as the Darling Range.

Laterites in the district vary due to:

1. The type of parent material—for example, grey sandy laterites (see Figure 10) commonly formed by lateritisation of quartz-rich igneous rocks and sandy deposits: Examples in the Northam district occur in the ancient river deposits at West Kokeby (West Kokeby soil landscape system) and the Kauring sandy laterites (Mulcahy & Hingston 1961) in the Morbinning and Walrerming soil landscape systems in the east of the district. Mafic laterites have darker, heavier, more iron-rich ferricrete with more clay in the soil matrix. Mafic laterites are often found on ridges or spurs, and can have a major influence on landscape development (Verboom & Galloway 2004). More information on mafic and sandy landscapes can be found in the landscape recognition guide.
2. Stage of laterite formation: Some laterites are very old but others have formed more recently with less well-developed profiles that may lack a pallid or mottled zone. In Figure 11, the young laterite has loamy gravel over reddish-brown clay then weathering dolerite.

Dolerite often weathers to red-brown loamy duplex and clay, but lateritisation can't start until the soil becomes neutral. The much older profile in the Darling Range on the right has a 'pink' zone in contrast to the pallid zone of the adjacent granitic profile. This profile is a truncated laterite on a mid slope where erosion has removed most of the original overlying gravel.
3. Geology and climate create situations that favour particular vegetation associations that in turn create soil types which give them a competitive advantage: In the north and east of the district, the present climate may favour wodjil yellow sandplain. These have acidic yellow loamy sands with Acacia and Proteaceae heath often with gravelly rises that support tamma heath.

The term ‘wodjil’ refers to at least three species of stiff-leaved acacia that become more common to the east. Wodjils and soils with highly acidic subsoils are less common in the Northam district but increase further east.

In a study near Dowerin, Verboom & Pate (2003) found that gravel and yellow loamy sand soils formed spiral patterns that transcend topography, and are characteristic of species competition. Radiometric imagery is explained in more detail in the Merredin bulletin of this series.

![Figure 12 Digital aligned ternary radiometrics model of the Elashgin catchment (Verboom & Pate 2003)](image)

Figure 13 shows a change in soil type exposed in a road cutting. Before the land was cleared, a eucalypt plant community was probably invading the tamma gravel. As it invaded, the eucalypt community was creating a duplex soil and ‘overprinting’ the existing soil.

![Figure 13 Soil type change from laterite to sandy duplex at Meenaar](image)
Figure 14 shows a general grouping of the main laterite types in the Northam district that generally corresponds to soil landscape systems discussed in the next section. There is a general trend from deep stony laterites in the Darling Range though grey sandy laterites to yellow sands of the eastern wheatbelt.

Darling Range laterites have been forming continuously for the longest time, due to higher rainfall, and can have very deep pallid zones. The lateritic topsoil tends to be more gravelly and often without the grey sandy surface of laterites further east. This is due to biological activity in the forest soils which mixes the topsoil.

Grey sandy laterites further east have grey sandy gravel or sand-over-gravel topsoils, with areas of deep pale spillway sand in hollows.

Pale sands and sandy gravels from old river deposits are derived from ancient river sands of an extinct river in the west Kokeby area.

Eucalypts with associated hard-setting or duplex soils tend to dominate in areas that do not favour laterite development. These include fertile soils, alkaline soils, and situations with restricted water movement through the soil, such as winter waterlogged, and heavy textured and poorly structured soils, particularly in very low rainfall areas.
Climate

Climate changes cause changes in landscape and native vegetation. In the past 6 million years our climate has fluctuated greatly. In wetter times the landscape tended to be more stable. Soils formed faster and were more protected by dense vegetation. Plants favouring laterite development flourished on stable well-drained areas, probably with plants favouring duplex soils in lower slope areas.

During arid phases, the soil was barer and subject to erosion by flash floods. Sandplain development was favoured at the expense of gravels, particularly in the E/NE agricultural areas of Western Australia. Aridity may also have been associated with very strong winds and lower sea levels due to water being tied up as ice. Lower sea levels increased slope to the sea, which favoured water erosion. Winds moved materials out of dry rivers and lakes inland forming lakeside sand and loamy soils. Some lateritic sandplain and duplex soils formed on this material when the climate became wetter again.

In low rainfall areas, salts and clays have accumulated in the valleys where there was insufficient rainfall to flush salts out of the system in rivers or groundwater.

![Figure 15 Climate changes and landscape consequences](image)

Soil movement processes

Soil particles are sorted and transported by the following processes.

Wind. Deep aeolian sands can also be found adjoining major trunk valleys (usually on the eastern side) in the east of the district.
These commonly have banksia, native pine and woody pear vegetation. These deposits are relatively recent, being blown from exposed valley floors (probably playa lakes) in arid times, possibly as recently as 20,000 to 100,000 years ago. Youngest deposits are uniform deep sands but older deposits have lateritic profiles. Examples are the Philips and Walyerming soil landscape system sandplains that will be described in the next section. Calcareous aeolian loams with red morrel vegetation become common in trunk valleys in the north-east of the district.

Colluviation is the most widespread process with soil movement down slopes and on to valleys in both arid and wet climates. The soil moves downslope by raindrop action, biological activity such as burrowing, by flash floods or just gravity acting on loose soil. Colluvial soils are very common, although the materials moved by colluviation differ.

Figure 17 shows a reddish-brown loam at York derived from decomposing metamorphic rocks. Downslope the loamy layer can be expected to become deeper and finer, with fewer rock fragments.

Alluvial processes were quite extensive in the major valleys more than 15 million years ago when the climate was wetter but these deposits are largely buried now by loamy sediments originating from redistributed materials sweeping down from uplands.

Recent alluvial soils are confined mainly to flat trunk valleys of the ADZ (Belka shallow alkaline duplex soils) and Avon River terrace loams.
In reality it is difficult to distinguish between alluvial and colluvial processes and there is also evidence of mixing of products from more than one mode of action.

Soil profiles can also reveal complex sequences of differentiation where differing profiles overlay or overprint each other.

Duplex soils are very common in waterways, valleys and lateritic slopes.

In the Avon Valley where soils have often formed from mafic rocks (brown loamy duplexes often with alkaline subsoils) are common but elsewhere there is a mixture of sandy and loamy duplexes, usually with grayish topsoil.

These duplexes tend to have acidic to neutral subsoils in higher rainfall areas (for example, Morbinning series) with calcareous alkaline duplexes (for example, Belka series) more common in ADZ valleys where the climate has favoured accumulation of salts in valley subsoils.

Valley duplex soils are frequently susceptible to waterlogging, particularly those with shallow sandy topsoils and dense sodic subsoils that can inhibit root penetration.

Figure 18 Duplex soils: Deep sandy duplex (A); Sandy duplex with alkaline subsoil (B); Alkaline shallow loamy duplex (C)
Lateritic soils frequently merge into duplexes, as shown in figures 13 and 19. Figure 19 shows variation in a sandy duplex soil from a gravelly spur on an upper slope east of Tammin. Note the increase in depth of sand and underlying alkaline sandy clay with lime nodules. The soils in Figure 13 can be seen at stop 4 of the field trip.

Interaction between factors discussed in this article has resulted in the complex landscapes we see today.
Soil landscape systems in the Northam district

Soil surveys conducted for much of the district have characterised the main soils and grouped soil and landscape information into units often referred to as land units (or land surfaces.)

A land unit has single soil types or a group of soil types that correspond to broad topographical features such as valley floor, hill slopes and sandplain, or to a sequence of soils to each other. Land units are useful for understanding the landscape at paddock to farm level.

More recently the Department of Agriculture and Food, Western Australia has introduced a hierarchical classification system. Information is stored in a database to provide a uniform method of classification and information storage (Schoknecht et al. (2004)). The relationship between the mapping methods is shown in figures 1 and 2.

![Diagram showing relationship between soil landscape systems and land units](image_url)

Figure 20 Relationship between soil landscape systems and land units
Soil landscape systems (also called systems here for brevity) consist of a range of land units. Different systems often contain the same land units but in differing proportions.

Systems are more useful for gaining an overview of major landscape areas in the district, particularly for areas where there are large differences in the proportion of land surfaces (for example, areas of different laterite types, differences in geology, or more or less dissected).

This section is an introduction to the main upland systems in the form of a greatly simplified story about the development of the geology and geomorphology of the district.

In reality, the situation is more complex, with unclear dates and often with events (for example, the uplift of the Darling Range) occurring as stages over long periods rather than as a single event. However, this approach helps us appreciate the factors that led to the development of the systems.

First consider the crystalline bedrock that underlies the district. Most of the district, particularly in the east, is underlain by granitic and felsic gneiss rocks.

The Jimperding metamorphic belt is an area of ancient rock that is most evident in the Avon Valley. This belt is synonymous with the Jelcobine system. It has a lot of mafic gneisses and other metamorphic rocks that have formed red loam and clay soils, with some residual mafic laterites. Erosion-resistant rocks such as banded ironstones, quartzites and quartz veins form sharp ridges that often trend in a NW/SE direction.
We will now start our ‘story’.

Australia was once a part of a supercontinent called Gondwana. When this split about 150 million years ago, processes started that culminated in the separation of Australia from Antarctica and India. The extensive faulting and marginal uplifts that resulted from the rift caused marked changes to drainage patterns.

As the tectonic plate containing India gradually separated from Western Australia, west-flowing rivers deposited sediments from the Yilgarn Craton into a valley that is now the Swan coastal plain. There was also a rift developing on the south coast between Australia and Antarctica. The median watershed is a major ridge that separated rivers to the east that flowed south from those in the Northam district that flowed west.

Figure 23 depicts possible ancient river systems in the late Cretaceous period. In the image on the left, blue lines indicate present-day trunk valleys, and purple lines show paleorivers that are now extinct. At this time the Darling Range did not exist and most rivers in the Northam district flowed west, with rivers further east flowing south. Evidence of these rivers can be found in river sediments with water-washed boulders south-west of Calingiri, in uplifted sand-filled extinct river systems north of New Norcia and south-west of Beverley.

In the east of the district, paleorivers flowed south to the coast. As a consequence of the gradual separation of Antarctica, there was an east–west uplift (a ‘marginal swell’) just inland from the south coast called the Jarrahwood axis. This, and a major fault WSW through Merredin and Kellerberrin, resulted in a change of slope and a reversal of the former south-flowing rivers. These apparently then broke through the median watershed at the Caroline gap south-west of Kellerberrin to form the Salt River and joined the paleoriver that in turn joins the present day Helena River to Perth.

About 30 million years ago a similar marginal swell east of the Darling Fault caused the uplift of the Darling Range. This and associated faults interrupted the westerly flowing river systems. The Yilgarn Craton to the west also tilted slightly up to the west, reducing the grade in river systems in the Ancient Drainage Zone (ADZ) and infilling to create the present broad
sluggish valleys. The Darling Range rose in a series of events that may still be occurring today. The right diagram in Figure 23 shows multiple sandy channels in the Darling Range west of Beverley where the paleoriver changed its course as the Darling Range rose (Salama 1997).

Present-day Avon River Median watershed Chin Smith lineament Paleoriver
Present day trunk valley (often in paleochannel but flow direction may have changed)

Figure 23 Inferred paleorivers before (left) and after (right) the Jarrahwood axis uplift and subsequent reversal of south-flowing paleorivers

Figure 24 shows the broad valleys (Wallambin and Kellerberrin systems—see the soil landscape system précis) and main upland systems of the ADZ. You will note considerable correspondence with the laterite types described in the last section.

The Tandegin system contains a lot of yellow sandplain and gravelly rises. In the Kwolyin system, the landscape has been eroded with more rock outcrops, and duplex and loamy soils derived from granitic rocks and dissected laterite.

Figure 24 Main upland systems in the ADZ
The river flowing through the Caroline Gap from Merredin and Lake Grace carried much more water than now, and was up to 70 m deeper. Subsequent uplift of the Darling Range created a large lake in the area that is now the Yenyenning Lakes.

In subsequent arid climatic phases, dry lake deposits are likely to have been the source of extensive sand sheets on uplands on the south and east sides of the Salt River. These mainly deep sandy deposits with grey deep sandy gravel uplands form the Walyerming system in the ADZ. The Narrogin bulletin in this series features the Walyerming system in the East Quairading case study.

The paleoriver flowing from Dowerin past Calingiri and New Norcia could also have been dammed by the Darling Range uplift, and later, a north–south fault that forms a ridge today on the eastern side of the north branch of the Mortlock River. Resulting sandy deposits form the Phillips system. Soils west of Bolgart are mainly grey deep sands, with a greater proportion of yellow deep sands further east. The Phillips system is featured in the Southern Brook East case study.

The Darling Range uplift was accompanied by parallel faults on the eastern side that captured rivers that were blocked by the emerging Darling Range. There is a major fault from Dalwallinu to Pingelly that follows the present Mortlock north branch which flows south, and the Avon south branch which flows north to Northam where the rivers have broken through the Darling Range to the Swan River.

Uplift on the eastern side of the fault north of Northam blocked the paleoriver flowing east from Dowerin, forcing the water to take an S-shaped path until it joins the Avon. This and other land movements initiated erosion of laterites to the underlying rock.
The Northam district is still seismically active due to movements along an ancient NW/SE-trending zone of weakness in the crust called the south-west seismic zone. The land is rising near Calingiri, Meckering and Mawson (Dentith et al. 2003). This and accompanying faults have also affected landscape development.

Figure 26 left shows the influence of faults and uplift on river direction and landscape erosion.

The Morbinning system comprises smooth and truncated grey sandy laterites on the eastern side of the ADZ. South of Northam, the grey sandy laterite landscape has gravelly uplands with frequent large breakaways, and grey sandy duplex, deep sand and gravelly sand soils. North of Northam, the system is more subdued.

Downslope, geological erosion has cut down to bedrock from which soils of the Jelcobine and Greenhills systems have formed.

The Jelcobine system contains the Avon Valley. It is very hilly and dissected with mainly fertile loamy and clay soils formed from Jimperding Metamorphic Zone rocks.

The Greenhill system further east has a more subdued topography with mainly granitic soils and is similar to the Kwolyin system in the ADZ.

Land units in the Morbinning and Greenhills systems are featured in the Mawson case study.

The Darling Range is a broad well-drained plateau that has been dissected on its east and west sides. Laterites are more developed than further east, with extensive gravelly and stony laterite uplands and, often, very deep pallid zones that are being mined for bauxite.
Figure 27 shows the main DRZ soil landscape systems.

**Dissected systems**
- Yarawindah system: mafic loamy valleys
- Clackline system: granitic sandy duplex valleys
- Boyagin system: mixed soils with plateau remnants and dissected laterites

**Gravelly upland systems**
- Darling Plateau and Wundowie systems: jarrah marri 'buckshot' gravels

**Paleochannel systems**
- Kokeby and Dale systems: deep pale sands, gravelly sands and deep sandy duplex formed from sandy paleochannels

Figure 27 DRZ soil landscape systems

The West Kokeby and Dale systems are remnants of the paleochannel complex that were stranded when the Darling Range rose and the river was diverted north along the Avon Valley.

The south-west York case study features land units in the Boyagin, Clackline, and Kokeby systems.
Figure 28 Main Northam district soil landscape systems
Appendix: Northam district soil landscape systems précis

This is a brief field guide to give you an impression of soil landscape systems in this district. You need to read the relevant land resources summary to properly understand each system.

<table>
<thead>
<tr>
<th>Ancient Drainage Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Uplands with yellow lateritic sandplain</strong></td>
</tr>
<tr>
<td>Tandegin 258ta</td>
</tr>
<tr>
<td>Sandplain dominated uplands with gravelly crests and upper slopes, and long colluvial yellow sandplain upper to lower slopes. Unlateritised surfaces occur where the laterite profile has been stripped (often below a low breakaway) contain colluvial duplex soils and soils formed from fresh rock. Underlying crystalline rock is medium- to coarse-grained granite with minor mafic phases, intruded by mafic and quartz dykes. Kwongan on sandplain, mallee scrub and eucalyptus woodlands on unlateritised country.</td>
</tr>
<tr>
<td>Kwolyin 258ky</td>
</tr>
<tr>
<td>This system is more dissected than the Tandegin system, with more granitic duplex and clay soils, and granitic domes and tors. York gum – salmon gum woodlands on duplex slopes with jam and rock sheoak thickets around rock outcrops and scattered Kwongan on sandplain patches.</td>
</tr>
<tr>
<td><strong>Grey sandy gravels with aeolian sandplain areas</strong></td>
</tr>
<tr>
<td>Walverming 258wy</td>
</tr>
<tr>
<td>This system contains soils formed from grey sandy gravels but with extensive areas blanketed by mainly yellow aeolian sands blown south-east of valleys of the Salt River system (Yenyenning Lakes). Lateritic sandy gravels, and granitic sands with shallow duplexes, occur on upper colluvial slopes, becoming deeper and more alkaline downslope. York gum – wandoo – salmon gum woodlands, kwongan heath on sandplain, acorn banksia and sandplain pear on sandy aeolian deposits.</td>
</tr>
<tr>
<td><strong>Valley systems</strong></td>
</tr>
<tr>
<td>Wallambin, Lagan 258wa258La</td>
</tr>
<tr>
<td>Salt lake chains with salt lake soil adjoining aeolian calcareous loamy earths. Mallee, red morrell woodland and saltbush–bluebush–samphire flats.</td>
</tr>
<tr>
<td>Kellerberrin 258kb</td>
</tr>
</tbody>
</table>
## Rejuvenated Drainage Zone

### Uplands

- **Morbinning (256Mb)**
  - Undulating grey sandy gravel sandplain remnants, breakaways and slopes, with grey deep sandy duplex, pale deep sand and some yellow sandy earth. Wandoo – jam – salmon gum woodland and heath.
  - South of Northam, the laterite is more fully developed with large breakaways and colluvial duplex slopes underlain by pallid zone over granite.
  - North of Northam the landscape is more subdued, and the profile tends to be shallower with grey sand over reticulite, which in turn overlies decomposing crystalline rock.
  - The crystalline rock tends to be granite, with some gneiss and dolerite intrusions.

- **Greenhills (256Gh)**
  - Undulating terrain where erosion has dissected the Morbinning system, with deep sandy duplex (grey and red), brown deep loamy duplex, bare rock and shallow loamy duplex. York gum – jam – salmon gum – wandoo, rock sheoak woodland.

- **Jelcobine (256Jc)**
  - Undulating to hilly country in the west Northam – Toodyay area, with mainly loam and duplex soils formed from fresh gneissic rocks of the Jimperding metamorphic zone.

### Aeolian sandplain

- **Phillips sandplain (256Ps)**
  - Gently undulating windblown lateritic sandplain with poorly drained seepage areas and lakes.
  - Gravelly pale deep and pale deep sands, yellow sandy earths and yellow deep sands. Heath.

### Valley systems

- **Avon Flats (256Af)**

- **Goomalling system (256Go)**
  - Poorly drained valley flats, with grey deep sandy duplex (sometimes alkaline) and saline wet soil. York gum – jam – wandoo.
Landscapes and soils of the Northam district

### Darling Range

<table>
<thead>
<tr>
<th>Lateritic plateau</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darling Plateau (255Dp)</td>
<td>Lateritic plateau in the Western Darling Range with sandy gravels, loamy gravels, deep sands and wet soils. Mainly jarrah–marri forest and woodland, with some wandoo, banksias and heath in sandy hollows.</td>
</tr>
<tr>
<td>Wundowie (253Wn)</td>
<td>Lateritic plateau with some rock outcrops, generally west of the Darling Plateau system. This system has more dissected areas with more soils formed from lower layers of the laterite profile. Residual granite, laterite and duricrust crests of the Yalanbee, Pindalup and Michibin units with deep sandy gravels, loamy gravels and shallow gravels, granite and gneiss-derived shallow sandy to clayey sands. Jarrah–marri–wandoo forest.</td>
</tr>
<tr>
<td>Julimar (253ju)</td>
<td>More mafic equivalent of the Wundowie system north-west of Toodyay, with loamy gravels, bare rock and other mixed soils.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dissected lateritic plateau</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boyagin (253By)</td>
<td>Large ironstone remnants surrounded by stripped terrain of granitic rock outcrops and fresh soils. Mainly sandy and loamy gravel soils. Gravels have jarrah–marri parrot bush forest. Loams and duplexes with York gum and wandoo, with mallet and powderbark wandoo on scarp faces.</td>
</tr>
<tr>
<td>Clackline (253Cc)</td>
<td>Associated with and more dissected than the Boyagin system. Less gravel soils and more variable soils formed from granitic and gneissic rocks. Wandoo–jarrah–marri–jam–York gum woodland.</td>
</tr>
<tr>
<td>Yarawindah (253Yh)</td>
<td>More mafic equivalent of the Clackline system north-west of Toodyay. Loamy gravel, loamy earth, loamy duplex, and some rock.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Paleochannel sandplain and deep sandy duplex soils</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Kokeby (257Wk)</td>
<td>Gently undulating sandy and swampy terrain, with pale deep sand, grey deep sandy duplex and non-saline wet soils. Partially lateritised alluvium and colluvium over old sediments associated with major drainage courses.</td>
</tr>
<tr>
<td>Dale (253Da)</td>
<td>Similar to West Kokeby System. Differs in occupying valley floors rather than mainly occurring in elevated positions.</td>
</tr>
</tbody>
</table>
Field tools

The following decision aids been developed to help you identify and integrate clues that are available to you in the field for interpreting the landscape and its soils.

In time, you will automatically recognise the association between clues that reinforce each other, and you will be able to recognise landscape changes as you travel.

Many surface clues can help—such as remnant vegetation, fragments on the surface, the shape of the landscape, topsoil colour, or man-made features such as banks, dams, roaded catchments and gravel pits.

Beware of reliance on road surface or road verge soil. Gravel has often been carted from gravel pits and spread along the road verge during road construction. Also sand may accumulate along fence lines and road reserves due to wind and water erosion.

Six field tools are supplied:

- Landscape investigation sheet
- Guide for recognising indicator remnant vegetation in the district
- Landscape recognition guide
- Northam district land mapping units and soils
- Soil texturing card for use in the field to manually texture soils
- Common soils in the Northam district
Northam District Soil/Landscape Investigation Sheet

This is a summary sheet for you to identify and integrate clues in the field for interpreting the landscape and its soils. In time you will automatically recognise the association between clues that reinforce each other, and will be able to recognise landscape changes as you travel.

Remnant vegetation is a very handy guide. However, note that there are exceptions and you can be misled by:

- introduced vegetation, particularly on roadsides and fence lines
- remnant species that have taken over as the dominant species when the original vegetation was cleared or has degraded over time. Rock sheoak (*Allocasuarina huegeliana*), roadside tea tree (*Leptospermum erubescens*) and jam (*Acacia acuminata*) are common volunteer species
- grazing that leaves only hardy species.

![Figure 28 Dense volunteer rock sheoak (left); original wandoo rock sheoak vegetation (right)](image)

You can also gain clues from weeds such as perennial veldt grass that invades roadside sands, and tagasaste or pine plantations on poor sands, and barley grass on saline soils.

The decision aid also provides information to help you recognise clues such as landscape dissection and other surface clues. Landscape dissection and position in the landscape indicate likely soil forming materials and features like susceptibility to salinity or waterlogging.

Surface clues include rock outcrops, fragments on the surface, and man-made structures like dams, roaded catchments and clusters of windmills.
### Table 2 Northam District Soil/Landscape Investigation Sheet

<table>
<thead>
<tr>
<th>Drainage zone</th>
<th>Indicator vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># see Indicator vegetation guide (page 31)</td>
</tr>
</tbody>
</table>

| Where are you in the landscape? | Using the Landscape recognition guide (page 41), look around and see where you are relative to other features. Are you near a ridge, breakaway or valley, in a dissected, lateritic or aeolian area or a trunk valley? Is the area you are on a sandy or mafic surface (or a mixture)? Using the Northam district land unit guide (page 50) can you recognise the land unit you are in and possible soil types? |

| Fragments on the surface | Granite or gneiss, quartz, mafic rock, silcrete, saprock, sedimentary rock, laterite gravel or reticulite, mottled or pallid zone rocks, lime nodules |

**Other clues** (e.g. dams, sand or gravel pits, road cuttings, rock outcrops, erosion, salinity or waterlogging)

| Your conclusion on the landscape and soil(s) | Dig a hole, texture the soil (page 71) and identify the soil from the common soils list (page 72) |
Indicator vegetation of the Northam district

DRZ = Darling Range Zone; RDZ = Rejuvenated Drainage Zone; ADZ = Ancient Drainage Zone

Salmon gum (*E. salmonophloia* RDZ and ADZ) and gimlet (*E. salubris* ADZ) are common on clay, clay loam soils and loamy duplex soils on slopes and valleys. Salmon gums often dominate on loamy duplex and deep loam soils, and gimlets on heavier clay soils. Below, note gimlet’s darker bark and fluted stem in the salmon gum – gimlet woodland.

Wandoo (*E. wandoo*) and Inland Wandoo (*E. capillosa*) have a similar appearance. Wandoo occurs in the west of the district from gravels in association with jarrah and marri to duplex soils. When dominant, it often indicates deep or grey sandy duplex and gravelly duplex soils. With other vegetation on gravelly uplands, wandoo usually becomes more dominant when the soil becomes more duplex. Inland, wandoo occurs east of Northam, mainly on upland sandy duplex soils and shallow soils over pallid zone. It tends to have more orange shades and dark spots on the trunk than wandoo.
Salmon gum – wandoo woodland is common on shallow sandy duplex valleys in the ADZ and RDZ. Salmon gums dominate on very shallow sandy duplex, clay or calcareous duplex soils, with wandoo being more common on sandy duplexes in deeper sandy duplexes, and rock sheoak on very deep sandy duplex patches.

Shiny leaves and layered foliage of the salmon gum distinguish it from the dull-leafed wandoos with ‘bunchy’ foliage.

Brown mallet (*E. astringens*, left) occurs in the southern edge of the district, but also extends east to Corrigin. Note the brown scaly bark and characteristic Y-shaped mallet branch structure. **Powder bark wandoo** (*E. accedens* right) occurs in the DRZ on breakaways and stony ridges. It can be distinguished from wandoo by its powdery smooth bark, and much brighter white/seasonally pink bark. Wandoo bark is generally steel grey/yellow. Both are typical of water-repellent soils and can occur together.

**Tree** – single trunk, with branches that usually start more than 1 m above the ground and occupy about half of the tree’s height. If the main trunk is damaged, many branches can resprout from the base or stems (epicormic growth). Examples include salmon and York gums, wandoo, marri and jarrah.

**Mallet** – single trunk with relatively steep angled branches and a more or less terminal crown that occupies less than half of the plant. Mallets are sensitive to fire and do not recover if the main trunk is lost. Examples include mallets and gimlet. Mallets often occur as pure or massed stands.

**Mallee** – multi-stemmed trees usually less than 10 m high. Several stems come from a lignotuber that can replace them when one or more are lost. Mallees that have not had to regenerate may have a single stem but also have the basal ‘mallee root’.
York gum (*E. loxophleba*) is widespread except for the Darling Range, usually in dissected landscapes with frequent igneous rock outcrops where it is often accompanied by jam, rock sheoak and sometimes salmon gum or wandoo. York gum can also be found on major valley floors, particularly below mafic uplands.

On slopes, York gum most commonly indicates duplex or loamy soils formed over fresh igneous rocks, with jam dominating on shallow soils and salmon gum on alkaline soils. In major valleys it may indicate loamier textured soils from more mafic rocks upslope.

Rough-barked *E. loxophleba* subsp. *loxophleba* (shown below) is found over most of the district.

A subsp. *loxophleba*/*York gum mallee intergrade that has a rough stocking bark is found on mafic red-brown loams and clays in the east of the district. This grades to a very similar looking tree subsp. *supralaevis* north and east of Ballidu.

Red morrel (*E. longicornis*) is a tree that occurs on:

- soils formed on mafic rock uplands in the RDZ and ADZ. Red-brown stony and loamy gravels grading to gravelly loams with alkaline subsoils
- aeolian loamy soils usually on the west and southern sides of trunk valleys in the ADZ.

York gum can be distinguished from red morrel by its generally rougher bark and more branching form.

Several species of trees and mallees with a stocking of rough bark occur on alkaline valley soils (often aeolian loams), and red-brown clay loam soils north and east of Harrismith. These include Yorrel (*E. yilgarnensis* (syn Beard *E. gracilis* and *E. myriadena* (syn Beard *E. ovularis*)).

These species all have shiny leaves and rough bark but can be differentiated from the York gum by narrower leaves and smaller fruit.
Mallees are found mainly in the RDZ and ADZ. A few species (mottlecah *Eucalyptus macrocarpa*, white mallee *E. albida*, *E. incrassata* and *E. phaenophylla*) occur with sandplain and gravel heath.

Mallee-dominant vegetation more commonly indicates duplex or shallow soils (for example, sandy duplex near breakaways, and rocky or hard-setting areas). Apart from a few easily identifiable species like mottlecah, it is difficult to associate the many species with soil type without species identification keys. In these areas, you can gain an idea of land management groups by noting the type of understorey in conjunction with landscape clues such as slope, rock fragments and topsoil features.

**Mottlecah** (*E. macrocarpa*) is commonly found in yellow sandy soils (loamy sands, sand over gravel) and some pale gravelly sands. **White mallee** (*E. albida*) also occurs on grey sandy laterites in the east of the district.

Dense mallee on hard-setting shallow grey loamy duplex soil below a breakaway

Red-flowering mallee (*E. erythronema*) on grey deep sandy duplex north of Meckering
Jarrah (*E. marginata*) occurs in the gravelly uplands in the DRZ and western RDZ. It indicates very gravelly and sandy gravelly soil, often with ironstone ridges associated with marri and dryandras but can also occur on deep pale sands.

Marri (*Corymbia calophylla*) occurs on gravelly rises and slopes in the DRZ and western RDZ, often down slope of jarrah or dryandra ironstone ridges. It may be with jarrah on gravelly rises or wandoo on gravelly duplex soils. It generally grows on better-water-holding soils than jarrah but can occur on deep grey sand over gravel.

Manna wattle (*Acacia microbotrya*) may be mistaken for jam, as they often occur together. However, unlike jam, manna wattle can occur on a wide range of soils, including lateritic gravels and sands. Manna wattle has broader sickle-shaped leaves and ball-shaped flowers in late autumn.

Jam (*Acacia acuminata*) often occurs with York gum and rock sheoak, and can dominate in shallow granitic and mafic soils, with another less common wattle (*Acacia saligna*). Sometimes it can be scattered in lower slope sandy duplex soils in dissected landscapes. Jam has slender, pointed glossy leaves and rod-shaped flowers in spring.
**Wodjil** is a name for a number of stiff-leaved acacias that are common on acidic soils in the eastern and north-eastern wheatbelt. The wodjil (left) is *Acacia neurophylla*.

Yellow ‘wodjil’ sandplain heath (below) occurs in the north-east of the Northam district. It has a range of plant species with acacias, tammas, sandplain mallees and hakeas being most prominent. Gravels usually occur on rises but sands can be found on ridges, upper and lower slopes.

The image below shows a yellow sandplain slope near Merredin.

**Melaleucas** occur in all zones and many landscape positions. They often dominate the understorey on winter wet and shallow duplex soils. The plants shown below are from the *Melaleuca uncinata* group that are common in waterways and around rocks.

Booree type melaleucas occur in ADZ salt lake chains.

Broombush (*Melaleuca uncinata* group) is common around rocks and in waterways but is also found in lateritic soils.

Melaleuca scrub in a Darling Range waterway.
Sheoaks (small trees) and Tammas (mainly shrubs) have needle type foliage with separate male (pollen) and female ('nut') plants. Salt sheoak (*Casuarina obesa*) favours saline and wet areas, but the others are *Allocasuarina* species that indicate well drained sandy or gravelly soils. Rock sheoak (*Allocasuarina huegeliana*) is widespread. Before agriculture, it was mainly on granitic sandy surfaced soils, sandy gravels and deep sandy duplex soils. However it has colonised many different well drained soils on roadsides. Sheoak (*Allocasuarina fraseriana*) is a similar tree that occurs on Darling Range sandy/sandy gravel soils. Black tamma (*Allocasuarina acutivalvis*) occurs mainly on mafic and yellow stony and shallow gravels, in the east of the district. Tamma, the most common tamma (*Allocasuarina campestris*) occurs with black tamma, but tends to be more common in deeper or loamier gravels and yellow earths.
Sandy soil vegetation

Roadside tea tree (*Leptospermum erubescens*) is common on well drained sandy surfaced soil. Tea trees are common on deep grey sands, but are colonising species that have spread on well drained disturbed areas.

Christmas tree (*Nuytsia floribunda* left) an indicator of deep grey sandy soils, with sheoak (*Allocasuarina fraseriana* right) that occurs on Darling Range sands and sandy gravels.

Sandplain cypress (*Actinostrobus arenarius*) often occurs in sandy soil, particularly yellow aeolian deep sands with Acorn banksia and woody pear

Woody Pear (*Xylomelum angustifolium*) occurs mainly on smooth slopes and crests and in dunes adjoining salt lakes and old drainage lines. It often occurs with banksias, sandplain cypress, roadside tea tree and sandplain heath. It indicates aeolian deep yellow sands. The image on the left shows woody pear with tamma.
Proteaceous species are major components of lateritic and sandy heaths, and as understorey species are a good guide to identifying mallee duplex gravels from other duplexes. 

**Banksias** are generally a good guide to sandy gravel and deep sandy soils. 

**Grevilleas** are also noticeable in lower rainfall sandplain heath, particularly yellow sand over gravel, but also occur on other well drained upland soils. 

**Hakeas** have similar flowers to grevilleas, but have a woody fruit. They are very common on sandy gravel to shallow and loamy gravel soils, but occur on a range of soils Needle Hakea (*Hakea preissii*) occurs on red clay soils. 

**Dryandras** (now in the *Banksia* genus) with their prickly vegetation are a noticeable feature of shallow gravel and sandy gravel soils.
Unlike most Hakeas, Prickle bush hakea (*Hakea preissii*) occurs on alkaline clay soils.

Flame grevillea (*G. eriostachya*) is a feature of eastern yellow sandplain.

Hookers grevillea (*G. hookeriana*) flower and fruit.

Stinkwood (*Jacksonia sternbergiana* left) and Woolly bush (*Adenanthos sericea* right) are common on grey sandy soils.

Dryandras

Parrot bush (*Banksia sessilis*) is common on Darling Range gravels.

Prickly dryandra (*Banksia armata*) with tamma on a gravelly ridge near Southern Brook.
Landscape Recognition Guide

Long-term stability of the Yilgarn Craton and lateritisation of most uplands have produced distinctive upland landscape patterns that are to a large extent determined by slope and underlying rock types. This guide can help you recognise these patterns in the field.

This guide distinguishes three upland landscape types that usually merge into one another.

- sandy landscapes—quartz-rich granites and gneisses, sandy sediments, and rocks with an aeolian sand overlay
- mafic influence landscapes—granites and gneisses with frequent dolerite dykes or bands of rock such as mafic gneiss or banded ironstone
- Mafic landscapes—mafic gneiss, greenstone or large dolerite dyke areas.

Table 3  Landscape characteristic rules of thumb

<table>
<thead>
<tr>
<th>Sandy</th>
<th>Mafic influence</th>
<th>Mafic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Often upland plains and gentle slopes. Breakaways are generally small</td>
<td>Landscape varies according to rock composition and frequency of mafic dykes. Often mafic gravel ridges on major ridges to mafic landscapes but these are usually interspersed with felsic rock areas, particularly on slopes and valleys</td>
<td>Hilly with active drainage and mafic ironstone or mafic rock outcrops</td>
</tr>
<tr>
<td>Sandy gravel or sandy duplex upper slopes and ridges. Can include shallow grey duplex and grey clays</td>
<td>Often similar mesas and mafic ridges on major ridges to mafic landscapes but these are usually interspersed with felsic rock areas, particularly on slopes and valleys</td>
<td>Dark stony and loamy gravel mesas on ridge tops that are often only isolated residuals in a dissected landscape with rocky red and brown loam and clay soils</td>
</tr>
<tr>
<td>Deep pale sand hollows on lateritic slopes</td>
<td>Mixed loamy and sandy gravels on lateritic backslopes, often with yellow to pale sandy hollows</td>
<td>Loamy gravel to yellow loamy sand on lateritic backslopes</td>
</tr>
<tr>
<td>Valleys often grey sandy duplex soils, and sometimes deep sands</td>
<td>Variable depending on the geology. Loamy, or more frequently, shallow sandy duplex colluvial valley soils but are often shallower, with more colour and better structured subsols than sandy landscapes</td>
<td>Red-brown to brown loamy surfaced colluvial valley soils</td>
</tr>
<tr>
<td>Grey often coarse sandy surfaced soils in dissected areas, pale dam banks and often soaks and seepages</td>
<td>Variable soils in dissected areas, frequently with granitic, pallid clay dams. More shallow sandy duplex soils than sandy landscapes</td>
<td>Red-brown soils and dams in dissected areas</td>
</tr>
<tr>
<td>Frequent gravel pits on mafic laterite ridges</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

These landscapes can be further divided in dissected areas, lateritic or aeolian areas, and trunk valleys and paleochannels (see Figure 40 page 51).

Figure 29 shows an example from the Southern Brook East case study of an aeolian landscape where a sand sheet covered an undulating upland to create a smooth, sandy landscape with numerous swamps, and sluggish winter-waterlogged waterways. In the lower left of the figure, river headward incision has stripped away the sand and formed a mafic influence dissected landscape.
Landscapes and soils of the Northam district

Figure 29  Dissected and sandy aeolian landscapes east of Southern Brook

Figure 30 shows an example from the Mawson case study of a mafic influence landscape. Note how mafic soils tend to be on the rises.

Dissected mafic influence landscape

Steep slopes with soils formed from pallid zone, mafic and felsic rock  Breakaway

Smooth lateritic landscape slopes with gravel rises and sandy to loamy gravels on slopes and hollows. Truncated bowls in the laterite often have mixed pallid zone and rocky soils surrounded by breakaways.

Figure 30  Dissected and smooth lateritic landscapes at Mawson.

Sandy landscapes

These are land surfaces formed on granitic-type igneous rock, aeolian sands and West Kokeby sandy sediments. They generally have sandy (often pale) surfaced soils in an often smooth gently sloping landscape. Exceptions occur where main rivers have cut though uplands and areas like Greenhills/Mawson that are subject to geological uplift (Dentith & Featherstone 2003).

The Philips system aeolian landscape is featured in the North Meckering case study. The east Quairading case study in the Narrogin bulletin of this series covers an aeolian yellow sand area. The West York landscape example features West Kokeby system units.
31A Kwolyin system, ADZ Danberrin, Rocky Hills units. Granitic sandy duplex soils at the Caroline Gap where large granite tors have been exposed by the Salt River cutting through the Median Watershed. Other clues in this image are York gum, salmon gum, mallee vegetation, granitic dams and contour banks which all point to shallow duplex soils from igneous rocks below the rocks.

31B Greenhills system, RDZ York unit lower slope sandy duplex soils. The hills in the background mark the transition to loamy uplands of the Jelcobine system. The slope ends at a flat Mortlock unit trunk valley.

31C Greenhills system, RDZ York unit upper slope sandy duplex soils. Clues include rock outcrop on the crest, pale dam, sandy surfaced soils with weathered granite fragments.

Figure 31  Dissected granite landscapes
Figure 32  **Sandy landscape dissected laterites**

Figure 33  **Lateritic yellow sandplain**
Figure 34 Sandy aeolian landscapes

34A Meckering. Philips system, RDZ Eaton unit. Grey sandy slope below a yellow sand ridge

34B Bolgart. Philips system, RDZ Eaton unit. Grey deep sandplain

Figure 35 Land surfaces associated with the West Kokeby paleochannel

35A West Kokeby system, DRZ Kokeby unit. Sandy gravel ridge grading to deep grey sand
Mafic influence landscapes

This is where rock types are too intermixed to form distinct sandy or mafic landscapes. They are very common as basement rocks vary and dolerite dykes have intruded most underlying granites and gneisses. These dykes are frequently associated with uplands as mafic, often lateritic ridges, but soils on slopes are very variable due to sudden changes in rock type and colluvial merging of soils formed from them.

Mafic rocks generally weather more quickly than more quartz-rich igneous rocks such as granite but mafic areas commonly coincide with dissected hilly uplands that stand above surrounding granitic surfaces.

Two factors are involved.

1. The contact layer between dykes and the surrounding rock are often more erosion-resistant due to ‘baking’ by heat from the molten dyke.

2. Iron-rich laterites formed from mafic rocks are more resistant to erosion than those formed from granites. Over long periods, more rapid soil transport from granitic laterites causes these areas to become lower, leaving mafic laterite ridges. However, when the dense mafic ironstone is penetrated, rapid erosion of the underlying layers and greater run-off and soil movement from the clay soils result in steep slopes and incised waterways. Quartz-rich igneous rocks and areas that have aeolian sand sheet influence form sandy soils that create less run-off and subsequent water erosion. This and less resistant reticulite create more subdued landscapes with sandy surfaced soils and often less active waterways.

A conceptual diagram of a mafic landscape is shown in Figure 36.

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Figure 36 Diagrammatic view of a mafic influence landscape

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Ironstone
Pink clay
Loamy gravel forming on dolerite
Mafic dyke
Mixed usually shallow duplex soils on dissected slopes

Granite

Dark to yellow-brown shallow gravels grading to loamy gravel, and yellow loamy sands
Rocky red-brown loam to clay soil
Mixed soils
Mafic landscapes

These are often hilly uplands with red-brown soils that may have lateritic stony or loamy gravel residuals. Soils formed from mafic rock are often alkaline and calcareous loams, loamy duplexes and clays.
Figure 38 Mafic rock landscapes
39A Buckshot sandy loam gravel below a ridge top mafic breakaway

39B Mafic stony gravel ridge

39C Smooth lateritic upland with stony ridges, sandy and loamy gravel slopes and orange loamy duplex valley

Figure 39  Mafic laterite landscapes
Northam district land mapping units

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<td>4.7 Kokeby unit</td>
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<td>4.8 Sheahan unit</td>
</tr>
<tr>
<td>4.9 Dale unit</td>
</tr>
<tr>
<td>4.10 Maitland unit</td>
</tr>
</tbody>
</table>
1. Introduction

The Northam district contains mapping from the Northam, Bencubbin and Corrigin Land Resource Surveys, which each have differing mapping units that were incorporated into the Department of Agriculture and Food resource mapping classification as subsystems. This section contains a guide to land units that using a modified Northam Land Resource Survey (Lantzke and Fulton 1993) land unit and soil type classification that covers most of the district.

This, in conjunction with the indicator vegetation and land surface recognition guides, will enable you to understand the landscape types, land units, and associated soil types in the field.

Figure 40 and Table 3 provide a format for placing these units in the landscape.

![Simple landforms classification](image)

### 1. Dissected area
Mixed soils from truncated laterite and underlying igneous rock.

### 2. Lateritic or aeolian area
Gravels and sandplain often grading to sandy duplex downslope

### 3. Trunk valleys and paleochannels
Alluvial/colluvial duplex and heavy soils and morrel loams and West Kokeby paleochannel sandy soils

The Northam survey did not distinguish sandy soils derived from laterites from aeolian soils derived from ancient lakes and river systems that often have different vegetation and soil properties. This is particularly relevant near Quairading and north of Meckering-Cunderdin.

The guide below contains new and amended units to correct this.

It has been recognised that the extensive aeolian sandplain area with sandy duplex drainage lines to the north of Meckering has more similarities to the RDZ than the ADZ (as mapped in the Northam survey) despite the ancient drainage valleys surrounding it. As a result, this area has been reclassified as RDZ, Philips and Goomalling systems.
### Table 4 Land units within the landform classification

<table>
<thead>
<tr>
<th>Dissected landscape</th>
<th>Lateritic or aeolian uplands</th>
<th>Trunk valleys and paleochannels</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ancient Drainage Zone (ADZ)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Booraan (mainly truncated laterite)</td>
<td>Ulva (lateritic)</td>
<td>Merredin Belka Baandee</td>
</tr>
<tr>
<td>Steep rocky hills Danberrin (mainly igneous rock soils)</td>
<td>Aeolian sandplain</td>
<td>Collgar (lower slopes and minor valley floors) Nangeenan (morrel loam)</td>
</tr>
<tr>
<td><strong>Rejuvenated Drainage Zone (RDZ)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ewarts (mainly truncated laterite)</td>
<td>Quailing (lateritic)</td>
<td>Mortlock Avon</td>
</tr>
<tr>
<td>Hamersley York Steep rocky hills (mainly igneous rock soils)</td>
<td>Eaton (aeolian)</td>
<td></td>
</tr>
<tr>
<td><strong>Darling Range Zone (DRZ)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaver (mainly truncated laterite)</td>
<td>Yalanbee, Leaver, Pindalup</td>
<td>Williams Dale Maitland, Kokeby Sheehan (Kokeby paleochannel)</td>
</tr>
<tr>
<td>Michbin Steep rocky hills (mainly igneous rock soils)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 2 Ancient Drainage Zone (ADZ)

The Ulva unit (U) contains large areas of lateritic yellow sandplain and gravelly soils that occur as long, regular slopes often high up in the landscape. This unit is all that remains of the old lateritic profile that once covered most of the uplands. The Booraan unit (B) occurs on hillslopes and contains hard-setting, sandy loam over clay soils, and sandy duplex soils formed from the dissection of the lateritic profile. The Collgar unit (C) occurs on the lower slopes and contains sandy surfaced duplex soils derived from colluvial material. The Danberrin unit (D) occurs adjacent to rock outcrop and contains soils formed from the weathering of exposed bedrock. Areas of rock outcrop and steep rocky hills large enough to be mapped out are included as a separate unit, Rocky Hills (R). There are two major valley types in the ADZ. The Belka unit (Be) contains pale, sandy surfaced valleys while the Merredin unit (M) contains heavy, red and grey valley soils. The Nangeenan unit (N) contains areas of calcareous ‘morrel soils’ that often occur adjacent to salt lakes. The Baandee unit (Ba) contains the salt lake system and its associated dunes. The Walyerming unit (not in the Northam survey) occurs east of the Yenyenning lakes as yellow and pale sands (Corrigin survey 258Wy2) among mainly lateritic uplands.
Landscapes and soils of the Northam district

Figure 41 Idealised view of land units in the Ancient Drainage Zone

2.1 Ulva soil landscape unit (U)

The Ulva unit comprises a large percentage of the ADZ, particularly in the Tandegin soil landscape system. A similar unit in the Bencubbin land resource survey area is the Yelbeni unit. Further north-east is the Koorda unit with extensive sandplains and more frequent highly acid ‘acid wodjil’ soils.

The landform comprises undulating upland areas and divides with long gentle slopes. This unit can occur adjacent to the valley floor where sand has moved downslope.

Breakaways are occasionally present and often occur at the boundary between the Ulva and the Booraan units.

Table 5 Landforms, original vegetation and soils in the Ulva unit

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy and gravelly uplands</td>
<td>Tamma or sandplain mallee</td>
<td>10–15 cm loose to firm grey brown loamy sand</td>
<td>Coherent yellow clayey sand grading to a sandy loam Often contains large amounts of ironstone gravel overlying reticulite</td>
<td>Yellow gradational loamy sand</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>Wodjil scrub</td>
<td>10–15 cm firm brown loamy sand</td>
<td>Coherent yellow loamy sand to sandy loam grading to a sandy clay loam. Very acidic at depth</td>
<td>Deep yellow acid sand</td>
<td>Northam Survey*</td>
</tr>
<tr>
<td></td>
<td>Wodjil and tamma scrub</td>
<td>5–15 cm hard-setting brownish to yellowish loamy sand</td>
<td>10–25 cm coherent yellow clayey sand Often contains ironstone gravel over reticulite</td>
<td>Shallow ironstone</td>
<td>78</td>
</tr>
</tbody>
</table>

* Lantzke and Fulton 1993
2.2 Walyerming soil landscape unit

This is a new aeolian sand unit that occurs in the Walyerming system east of Quairading.

258Wy1 subsystem lateritic sands and sands over gravel, with sandplain heath and scattered wandoos

258Wy2 subsystem has deep aeolian pale and yellow sands that are usually on slopes on the east of the major salt lake chain, with Banksia sp., sandplain pear, Christmas tree and tea trees

Table 5 Landforms, original vegetation and soils in the Walyerming unit

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undulating yellow and pale sandplain</td>
<td>Christmas tree, banksia, tea tree and low scrub</td>
<td>10–15 cm loose grey sand</td>
<td>80 cm or greater loose white or pale yellow sand, occasionally overlying ironstone gravel</td>
<td>Deep pale sand</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>Banksia sp. and sandplain pear</td>
<td>10–15 cm loose, brown sand</td>
<td>70 cm or greater loose, yellow sand, sometimes overlying yellow loamy sand</td>
<td>Deep yellow sand</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Tamma or sandplain mallee</td>
<td>10–15 cm loose to firm grey brown loamy sand Often contains ironstone gravel</td>
<td>Coherent yellow clayey sand grading to a sandy loam Often contains large amounts of ironstone gravel overlying mottled zone</td>
<td>Yellow gradational loamy sand</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>Tea tree scrub</td>
<td>10–15 cm loose pale greyish brown sand</td>
<td>About 40–50 cm loose pale, overlying a gravel layer and/or mottled zone</td>
<td>Pale sand over gravel/loamy sand</td>
<td>77</td>
</tr>
<tr>
<td>Poorly drained depressions within the sandplain</td>
<td>Rushes</td>
<td>10–15 cm loose grey sand</td>
<td>Greater than 70 cm loose pale sand over sandy clay</td>
<td>Waterlogged sand</td>
<td>Northam Survey</td>
</tr>
</tbody>
</table>

2.3 Booraan soil landscape unit (B)

Hillslopes predominantly containing hard-setting, grey to brownish sandy loam over clay soils, based on dissected laterites and downslope colluvial deposits. A roughly equivalent unit in the Bencubbin land resource survey area is the Nembudding unit. This is a complex landform based on dissected laterites upslope and colluvial soils downslope. A small breakaway or dip in the landscape may separate this unit from the Ulva unit with white, weathered pallid zone or weathered rock on the soil surface and shallow soils. A common upland soil is Shallow hard-setting grey sandy loam over clay with wandoo, inland wandoo and mallee vegetation. Further downslope soils tend to be deeper with deep sandy duplex soils and wandoo and mallee vegetation (Slopes, deep sandy duplex), red brown to brown duplex soils (Slopes, brown loamy duplex) with salmon gum vegetation.
2.4 Collgar soil landscape unit (C)

Gentle lower slopes containing sandy surfaced duplex or 'mallee soils'. A similar unit in the Bencubbin land resource survey area is the Nungarin unit. This unit occurs on the gentle lower slopes and some tributary valleys. It is often found below the Booraan or Ulva unit and above a Belka or Merredin unit.

The soils are equivalent to the loamy sand valley duplex of the RDZ, but grade in the east of the district to the Collgar series grey duplex and gradational loams with an underlying silcrete hardpan that is typical of the Merredin district.

Native vegetation comprises mallee species (*E. transcontinentalis*, *E. cylindriflora*, *E. erythronema* and *E. subangusta*) with some wandoos (*E. wandoo* and *E. capillosa*) and tamma.

2.5 Danberrin soil landscape unit (D)

Areas of rocky, red and greyish brown loamy sands and sandy loams formed from freshly exposed bedrock. Rock outcrop is common. An equivalent unit in the Bencubbin land resource survey area is the Kwelkan unit.

The Danberrin unit occurs as irregular, low hills with slopes of 2–20 per cent and is found in association with, and often below areas of Steep Rocky Hills (R). It occurs on the mid and upper slopes of the landscape.
Table 9 Landforms, original vegetation and soils in the Danberrin unit

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper, mid and lower slopes often adjacent to rock outcrop</td>
<td>York gum and jam</td>
<td>15 cm loose to hard setting brown loamy sand to sandy loam</td>
<td>20–60 cm reddish brown to brown clayey sand to sandy loam over a reddish to yellowish brown structured clay and/or decomposing bedrock</td>
<td>Rocky red brown loamy sand/sandy loam</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>Jam, occasional York gum sheoak and wandoo in some areas</td>
<td>15 cm loose to hard-setting grey brown sand to loamy sand</td>
<td>Pale to yellowish brown sand to clayey sand over a structured, yellowish clay at about 50 cm overlying decomposing granitic rock</td>
<td>Brownish grey granitic soils</td>
<td>87</td>
</tr>
<tr>
<td>Upper, mid and lower slopes on dolerite dykes</td>
<td>York gum, salmon gum and needle bush</td>
<td>15 cm red brown, often self-mulching clay</td>
<td>Well-structured, dark red clay overlying decomposing dolerite rock. May contain lime at depth</td>
<td>Red brown doleritic clay loam</td>
<td>91</td>
</tr>
</tbody>
</table>

2.6 Steep Rocky Hills soil landscape unit (R)

Steep hills which contain large areas of rock outcrop. Slopes range from 10 per cent to greater than 30 per cent. This unit contains soils similar to those found on the Danberrin soil landscape unit. However, the soils contain much more rock outcrop and are generally shallower in depth.

2.7 Belka soil landscape unit (B)

Broad, flat trunk valleys of the central and eastern wheatbelt containing sand over alkaline clay soils. The valleys, up to about 3 km wide with gradients of about 1:700 to 1:1500. Natural drainage lines are ill defined and contain old stream channels or sand seams.

The Belka unit is the most common type of valley in the western part of the ADZ. It is less common further to the east where the Merredin unit dominates. In secondary valleys this unit can grade upslope into the Collgar unit.

Table 10 Landforms, original vegetation and soils in the Belka unit

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy surfaced, broad valley floors</td>
<td>Salmon gum, York gum, wandoow and some types of mallee</td>
<td>10–20 cm loose, grey brown sand</td>
<td>40–80 cm coherent, light yellow brown sand overlying a brownish, yellow calcareous structured clay</td>
<td>ADZ valley alkaline deep sandy duplex</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>Salmon gum, gimlet, York gum and some types of mallee</td>
<td>10 cm loose to firm, grey brown sand to loamy sand</td>
<td>15–40 cm coherent, light yellow brown sand to clayey sand overlying a light yellowish brown calcareous structured clay</td>
<td>ADZ valley alkaline shallow sandy duplex</td>
<td>86</td>
</tr>
</tbody>
</table>
2.8 Merredin soil landscape unit (M)

Broad, flat valleys of the eastern wheatbelt containing heavy, red and grey brown soils that sometimes contain crabholes (gilgais).

A roughly equivalent unit in the Bencubbin land resource survey is the Trayning unit.

The Merredin unit has major valley floors up to about 3 km wide with gradients of 1:250 to 1:500, and is the major valley type in the eastern part of the ADZ.

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loamy or clayey surfaced broad valley floors (sometimes with crabholes)</td>
<td>Salmon gum and gimlet</td>
<td>10–15 cm hard-setting, dark reddish brown sandy loam</td>
<td>About 30 cm structured reddish brown sandy clay overlying structured, reddish brown clay with lime nodules at depth</td>
<td>Red brown sandy loam over clay valley soil</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>Salmon gum and gimlet</td>
<td>10–15 cm hard-setting, reddish brown clay loam to light clay</td>
<td>Structured reddish brown clay with lime nodules</td>
<td>Red clay valley soil</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td>Gimlet and salmon gum</td>
<td>10–15 cm hard-setting grey clay loam to clay</td>
<td>Structured, grey brown clay with lime nodules</td>
<td>Grey clay valley soil</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>Salmon gum, gimlet and needle bush</td>
<td>10–15 cm cracking, grey to brown sandy clay loam to clay</td>
<td>Structured grey to brown clay with lime nodules</td>
<td>Grey to brown cracking clay</td>
<td>Northam Survey*</td>
</tr>
<tr>
<td>Valley floor (sometimes on lower slopes)</td>
<td>Morrel</td>
<td>20–40 cm powdery, dark reddish brown to grey sandy clay loam</td>
<td>Structured, reddish to dark yellow brown clay loam to clay with lime nodules at depth</td>
<td>Powdery surfaced calcareous soil</td>
<td>Northam Survey</td>
</tr>
</tbody>
</table>

2.9 Nangeenan soil landscape unit (N)

Areas of reddish, powdery surfaced, 'morrel soils' that often occur adjacent to salt lakes, or lower slopes fringing major valleys.

A roughly equivalent unit in the Bencubbin land resource survey area is the Kununoppin unit.

The Nangeenan unit has a limited occurrence in this district. It is found in larger areas in the eastern wheatbelt. A large area of this unit occurs just north of the district area around the Cowcowing Lakes.

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valley floor, occasionally on lower slopes</td>
<td>Morrel</td>
<td>20–40 cm powdery, dark reddish brown to grey sandy clay loam</td>
<td>Structured, reddish to dark yellow brown clay loam to clay with lime nodules at depth</td>
<td>Powdery surfaced calcareous soil</td>
<td>Northam Survey*</td>
</tr>
</tbody>
</table>
2.10 Baandee soil landscape unit (Ba)

The Baandee unit consists of salt lakes, channels, flats and associated dunes at the lowest point of the broad valley floor. This unit can be up to 3 km in width and has gradients of about 1:1500. Calcareous and gypsiferous dunes fringe the main salt lake channel. A roughly equivalent unit in the Bencubbin land resource survey area is the Wallambin unit.

Two salt lake systems occur within the district—the east branch of the Mortlock River which winds in a big arc from Meckering and Cunderdin through north Tammin to Dowerin; and the Yenyenning Lakes branch of the Avon River which occurs south-east of Beverley.

The salt lakes and drainage channels contain no vegetation. Samphire (*Halosarcia* sp.) grows on the severely waterlogged and saline areas immediately surrounding the lakes and channels. The less severe areas support saltbush (*Atriplex* sp.) and bluebush (*Maireana brevifolia*). The lunettes and dunes that occur on the margins of the salt lake system contain *Callitris* sp., salt sheoak (*Casuarina obesa*) and *Melaleuca* sp.

3. Rejuvenated Drainage Zone (RDZ)

Eight soil landscape units have been mapped in the RDZ.

The Quailing unit (Qu) occurs as an undulating, upland plateau containing areas of yellow and pale sandplain. This unit is all that remains of the old lateritic profile that once covered the uplands. The Ewarts unit (Es), which is often separated from the Quailing unit by a breakaway, occurs on the hillslopes over large areas in the east of the Zone of Rejuvenated Drainage. The soils are formed from the dissected lateritic profile and contain predominantly sand or loamy sand over yellowish clay soils.

Where rejuvenation of rivers has completely stripped away the lateritic profile, areas of soils have developed from the weathering of fresh rock. These areas have been mapped as the York unit (Y). The Avon Valley sideslopes consist almost entirely of the York unit. The Hamersley unit (H) comprises the thin, poorly drained, midslope drainage lines within the York unit. The Steep Rocky Hills (R) are associated with the York unit.
The Avon unit (A) occurs on the floodplains of the Avon, lower Mortlock and lower Dale rivers and contains a mixture of alluvial clays, loams and sands.

The Mortlock unit (Mo), which occurs upstream from the Avon unit, typically contains salinity and waterlogging-prone sand or loamy sand over clay soils.

The Eaton unit (E) comprises pale surfaced aeolian sandplain that contains poorly drained seepage areas and lakes. Two large areas of the Eaton unit occur within the study area, one north of Meckering and the other in the East Bolgart–West Goomalling area.

The idealised view of land units in the RDZ is not representative. Field examples can be found in the field tour, and Southern Brook and Mawson case studies.

### 3.1 Quailing soil landscape unit (Qu)

This unit has yellow and pale sandy and gravelly soils, often found above a breakaway as an undulating plateau on the catchment divide. It also includes deep, spillway sand areas that have moved off the plateau onto adjacent areas of hillslopes. Slopes range from 0 to 5 per cent.

North of the Goldfields Road, the Quailing unit is surrounded by fewer breakaways and often has an appearance intermediate between the Quailing unit and the pale, undulating Eaton sandplain to the north and east. The Quailing unit is most common in the Morbinning soil landscape system.

Major soils are pale sand over gravel/loamy sand, yellow gradational loamy sand, and pale deep sand. Minor soils are deep yellow sand, buckshot gravel, and waterlogged sand.

#### Table 13 Landforms, original vegetation and soils in the Quailing unit

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undulating yellow and pale sandplain often above a breakaway</td>
<td><em>Banksia</em> sp., Christmas tree, sheoak and low scrub</td>
<td>10–15 cm loose grey sand</td>
<td>80 cm or greater loose white or pale yellow sand Occasionally overlying ironstone gravel</td>
<td>Pale deep sand</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td><em>Banksia</em> sp. and sandplain pear</td>
<td>10–15 cm loose, brown sand</td>
<td>70 cm or greater loose yellow sand, sometimes overlying yellow loamy sand Coherent, yellow clayey sand grading to a sandy loam often with large amounts of ironstone gravel overlying mottled zone</td>
<td>Yellow deep sand</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Tamma, sandplain mallees and wandoo</td>
<td>10–15 cm loose to firm, grey brown loamy sand Often contains ironstone gravel</td>
<td>About 40–60 cm loose, pale sand overlying a gravel layer and/or mottled zone. Coherent, yellowish brown sand to clayey sand with large amounts of ironstone gravel overlying laterite cap rock at depth</td>
<td>Yellow gradational loamy sand</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>Tea tree scrub and wandoo.</td>
<td>10–15 cm loose, pale greyish brown sand</td>
<td>Pale sand over gravel/loamy sand</td>
<td>Pale sand over gravel/loamy sand</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>Parrot bush, grass tree, wandoo and <em>Eucalyptus macrocarpa</em></td>
<td>10–15 cm firm, brownish sand to loamy sand Large amounts of ironstone gravel</td>
<td>Coherent, yellowish brown sand to clayey sand with large amounts of ironstone gravel over laterite cap rock at depth</td>
<td>Buckshot gravel</td>
<td>79</td>
</tr>
<tr>
<td>Poorly drained seepage areas</td>
<td>Rushes</td>
<td>10–15 cm loose, grey sand</td>
<td>Greater than 70 cm loose, pale sand over sandy clay</td>
<td>Waterlogged sand</td>
<td>Northam Survey</td>
</tr>
</tbody>
</table>
3.2 Ewarts soil landscape unit (Es)

Hillslopes containing mainly sand and loamy sand over yellowish clay soils, with some gravel ridges, and some heavier soils that often occur immediately below a breakaway.

The hillsides have slopes from 2 to 10 per cent that be separated from an area of Qualing sandplain unit by a breakaway. A Mortlock valley unit or an area of the rocky York unit commonly occurs at the base of these slopes.

This unit comprises a large proportion of the RDZ in areas to the east of the Avon Valley, but is most common in the Morbinning soil landscape system. North of the Great Eastern Highway, this unit's soils contain more gravel, with the soils become more like those of the Booraan unit to the east (North Meckering).

The original vegetation comprises open woodland predominantly consisting of wandoo but also containing jam, tamma, and rock sheoak. Salmon gums and red morrel can occur on mafic areas.

The soils are very mixed, with major soils being deep grey sandy duplex, shallow sandy surfaced duplex, deep sandy surfaced duplex, yellow gradational loamy sand, slopes: brown loamy duplex, pale sand over gravel/loamy sand. Minor soils include shallow hard-setting grey sandy loam over clay, sandy loam over pinkish clay below breakaways, pale deep sand, breakaway face and ironstone cap, and loamy sand surfaced valley duplex.

Table 14 Landforms, original vegetation and soils in the Ewarts unit

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper mid and lower slopes</td>
<td>Wandoo with some jam, Tamma may occur on gravelly phases</td>
<td>10–15 cm loose to hard-setting, greyish brown loamy sand</td>
<td>Coherent, pale to yellowish brown clayey sand overlying a yellowish brown, mottled clay about 40 cm. Ironstone gravel commonly occurs above the clay</td>
<td>Slopes: deep sandy duplex (loamy sand)</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>Wandoo, sheoak and tea tree</td>
<td>10–15 cm loose, greyish brown sand</td>
<td>Greater than 45 cm loose, pale sand overlying a yellowish brown, mottled clay. Ironstone gravel commonly occurs above the clay</td>
<td>Slopes: deep sandy duplex (sand)</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>Wandoo with some sheoak, jam and tea tree</td>
<td>10–15 cm loose, greyish brown sand</td>
<td>Less than 45 cm loose pale sand overlying a yellowish brown, mottled clay. Ironstone gravel commonly occurs above the clay</td>
<td>Slopes: shallow sandy surfaced duplex</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yellow gradational loamy sand</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>Tamma and wandoo.</td>
<td>10–15 cm loose to firm, grey brown loamy sand. Often contains ironstone gravel</td>
<td>Coherent, yellow clayey sand grading to a sandy loam often with large amount of ironstone gravel overlying mottled zone</td>
<td>Slopes: brown loamy duplex</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Salmon gum, wandoo and some mallee species</td>
<td>5–15 cm hard-setting dark greyish brown to reddish brown sandy loam.</td>
<td>Massive, dark yellowish brown sandy loam to sandy clay loam overlying a structured, light yellowish brown clay at about 20 cm. Lime may be present in the clay</td>
<td>Pale sand over gravel/loamy sand</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>Wandoo and tea tree</td>
<td>10–15 cm loose, pale greyish brown sand</td>
<td>40–60 cm loose, pale sand overlying a gravel layer and/or mottled zone</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.3 York soil landscape unit (Y)

Areas of soils derived from freshly exposed rock. This unit is typified by the red soils of the Avon Valley but also includes areas of similar, but often greyer and lighter textured, soils to the east of the valley. This unit is most common in the Jelcobine and Greenhills soil landscape systems. It occurs as irregular, often hilly country where streams or rivers have dissected the lateritic profile to expose bedrock. This unit occurs on the mid and lower slopes but can occur higher up in the landscape adjacent to rock outcrop. Slopes are generally in the order of 3 to 12 per cent. The steeper, rocky hills that occur in association with the York unit are mapped separately as the Steep Rocky Hills (R) unit.

York gum and jam woodland is most common. Salmon gums grow on some of the heavier soil types while wandoo and rock sheoak generally grow on the gritty, lighter soils.

Major soils include rocky red brown loamy sand/sandy loam, brownish grey granitic soils, red brown doleritic clay loam. Minor soils include hard-setting gritty quartzitic soil, waterlogged greyish loamy sand/sandy loam, and coarse granitic sand.

Table 15 Landforms, original vegetation and soils in the York unit

<table>
<thead>
<tr>
<th>Parent material</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predominantly granite felsic gneiss and migmatite</td>
<td>York gum and jam</td>
<td>15 cm firm to hard-setting brown loamy sand to sandy loam</td>
<td>20–60 cm reddish brown to brown clayey sand to sandy loam over a reddish to yellowish brown structured clay and/or decomposing bedrock</td>
<td>Rocky red brown loamy sand/sandy loam</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>Jam, occasional York gum, sheoak and wandoo in some areas</td>
<td>15 cm loose to hard-setting grey brown sand to loamy sand.</td>
<td>Pale to yellowish brown sand to clayey sand over a structured, yellowish clay at about 50 cm overlying decomposing granitic bedrock</td>
<td>Brownish grey granitic soils</td>
<td>87</td>
</tr>
<tr>
<td>Dolerite and other fine grained, basic rocks</td>
<td>York gum, salmon gum and needle bush</td>
<td>15 cm red brown, often self-mulching clay loam</td>
<td>Well-structured, dark red clay overlying decomposing dolerite rock. May contain lime at depth</td>
<td>Red brown doleritic clay loam</td>
<td>91</td>
</tr>
</tbody>
</table>

3.4 Hamersley soil landscape unit (H)

This unit has narrow, minor drainage lines that occur predominantly within the York unit and lead down to major drainage systems such as the Avon and Dale rivers.

It has first and second order streams that occur as midslope drainage lines. Waterways are V-shaped but can have a thin, alluvial terrace up to 20 m wide. Rock outcrop is common. Some areas of this unit are saline. Gullies may form in the drainage line. Slopes of 1–6 per cent occur along the watercourse.

This unit is most common in the Jelcobine and Greenhills soil landscape systems.
Table 16 Landforms, original vegetation and soils in the Hamersley unit

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant Vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil Type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flooded gum, York gum and jam</td>
<td>10–15 cm dark greyish brown sand to sandy loam</td>
<td>Light yellowish brown sand to sandy loam overlying a brownish clay at 15–50 cm</td>
<td>Waterlogged greyish loamy sand/sandy loam</td>
<td>Northam Survey</td>
<td>88</td>
</tr>
<tr>
<td>Northam Survey</td>
<td>20–60 cm reddish brown to brown clayey sand to sandy loam over a reddish to yellowish brown structured clay and/or decomposing bedrock</td>
<td>Pale to yellowish brown sand to clayey sand over a structured, yellowish clay at about 50 cm overlying decomposing granitic bedrock</td>
<td>Brownish grey granitic soils</td>
<td>87</td>
<td></td>
</tr>
<tr>
<td>Narrow, first and second order midslope drainage lines which occur within the York unit</td>
<td>15 cm firm to hard-setting brown loamy sand to sandy loam</td>
<td></td>
<td>Rocky red brown loamy sand/sandy loam</td>
<td></td>
<td>88</td>
</tr>
<tr>
<td>Jam, occasional York gum, sheoak and in some areas wandoo</td>
<td>15 cm loose to hard-setting grey brown sand to loamy sand</td>
<td></td>
<td>Brownish grey granitic soils</td>
<td></td>
<td>87</td>
</tr>
</tbody>
</table>

3.5 Steep Rocky Hills soil landscape unit (R)

Steep sloping hills which contain large areas of rock outcrop. Generally occur on the mid and upper slopes. Slopes range from 5 per cent to greater than 30 per cent. It is common on the upper slopes of the Avon Valley, especially in the Jelcobine soil landscape system.

This unit contains soils similar to those found on the York unit. However the soils contain more rock outcrop and are generally shallower in depth.

3.6 Avon soil landscape unit (A)

Alluvial terraces and floodplains that occur adjacent to the Avon, lower Mortlock and lower Dale rivers.

This unit occurs alongside the Avon River, extending from Mount Kokeby to west of Toodyay. The Avon unit also occurs on the lower reaches of the Dale River, the Mortlock River and Wongamine and Toodyay brooks. It is also the Avon Flats soil landscape system.

The floodplains may be up to 2 km wide in upstream areas (for example, Beverley) but are much narrower downstream from Northam. The gradients of these valleys are about 1:250. This unit also includes small areas of dunes that occur immediately adjacent to the river channel. Soil salinity is rare, though the river water is quite salty. The Mortlock unit occurs further upstream from, and grades into, the Avon unit.

Major soils include red brown alluvial loam, grey alluvial clay, and orange alluvial loamy sand. Minor soils include grey alluvial self-mulching clay, yellow alluvial sand, pale valley floor sand, and loamy sand surfaced valley duplex.

Grey alluvial clay and loamy sand surfaced valley duplex soil types become far more common in the Kokeby area where the Avon unit grades into the Mortlock unit. Orange alluvial loamy sand is more common in the Northam and Toodyay areas.
Table 17 Landforms, original vegetation and soils in the Avon unit

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floodplains of the major waterways within the Avon valley</td>
<td>York gum, salmon gum and jam</td>
<td>10–15 cm of hard-setting, dark reddish brown clayey sand to sandy clay loam</td>
<td>10–50 cm of structured, reddish brown sandy loam to clay loam overlying structured, red to brown clay. Lime may occur at depth</td>
<td>Red brown alluvial loam</td>
<td>Northam Survey</td>
</tr>
<tr>
<td></td>
<td>Salmon gum, York gum and needle bush</td>
<td>10–15 cm of hard-setting dark greyish brown sandy loam to clay</td>
<td>Structured, greyish brown clay. Lime may occur at depth</td>
<td>Grey alluvial clay</td>
<td>Northam Survey</td>
</tr>
<tr>
<td></td>
<td>Flooded gum, sheoak, York gum and jam</td>
<td>10–15 cm of firm, brown, fine-grained sand to clayey sand</td>
<td>At least 40 cm of coherent, orange fine-grained sand to clayey sand. Reddish to light yellowish clay may occur at depth</td>
<td>Orange alluvial loamy sand</td>
<td>Northam Survey</td>
</tr>
</tbody>
</table>

3.7 Mortlock soil landscape unit (Mo)

Alluvial salinity and waterlogging-prone valley floors of the Mortlock River and other similar creeks that predominantly contain sand over yellowish clay soils. These valleys can be up to 2 km wide but, in their upper reaches, are often only 100 m wide. The upstream areas of this unit consist of minor creeks with a thin, alluvial terrace and the associated poorly drained lower slopes.

Valley floors have gradients of about 1:650. Small areas of dunes may occur adjacent to the river channel. Soil salinity affects up to 30 per cent of this soil landscape unit. Waterlogging is very common.

This unit comprises the Goomalling and Brookton Valley soil landscape systems.

Table 18 Landforms, original vegetation and soils in the Mortlock unit

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alluvial flats and low-lying areas adjacent to the Mortlock River and similar water courses</td>
<td>Wandoo, jam, York gum, sheoak and the occasional salmon gum in some areas Sheoak, jam and some York gum and wando Flooded gum on poorly drained areas</td>
<td>10–15cm loose to hard-setting greyish brown sand to clayey sand</td>
<td>Coherent, pale to yellowish brown loamy sand to about 40 cm overlying a structured, yellowish brown, mottled clay</td>
<td>Loamy sand surfaced valley duplex</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>Salmon gum, York gum and needle bush</td>
<td>10–15 cm loose, greyish brown sand</td>
<td>50 cm to greater than 100 cm loose, pale sand overlying a pale yellow mottled structured clay</td>
<td>Pale valley floor sand</td>
<td>Northam Survey</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10–15 cm hard-setting dark greyish brown sandy loam to clay</td>
<td>Structured, greyish brown clay. Lime may occur at depth</td>
<td>Grey alluvial clay</td>
<td>Northam Survey</td>
</tr>
</tbody>
</table>
3.8 Eaton soil landscape unit (E)

Gently undulating pale mostly aeolian sandplain with dunes in some areas. Seepage areas lakes and waterlogged deep sandy duplex waterways are common in low-lying areas.

This unit occurs in two discrete areas—in the North Meckering area; and in the East Bolgart–West Goomalling area.

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undulating pale and yellow sandplain</td>
<td>Tea tree scrub and white gum</td>
<td>10–15 cm loose, pale greyish brown sand</td>
<td>About 40–60 cm loose, pale sand overlying a gravel layer and/or a mottled zone</td>
<td>Pale sand over gravel/loamy sand</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>Christmas tree, banksia, tea tree and low scrub</td>
<td>10–15 cm loose, grey sand</td>
<td>80 cm or greater loose, white or pale yellow sand, occasionally overlying ironstone gravel</td>
<td>Pale deep sand</td>
<td>74</td>
</tr>
<tr>
<td>Tamma and wandoo</td>
<td>10–15 cm loose to firm, grey brown loamy sand. Ironstone gravel present</td>
<td>70 cm or greater loose yellow sand, sometimes overlying yellow loamy sand</td>
<td>Coherent, yellow clayey sand grading to a sandy loam often with large amounts of ironstone gravel overlying mottled zone</td>
<td>Yellow gradational loamy sand</td>
<td>76</td>
</tr>
<tr>
<td>Banksia and sandplain pear</td>
<td>10–15 cm loose, brown sand</td>
<td>Greater than 70 cm loose, pale sand to a depth of over sandy clay</td>
<td>Waterlogged sand</td>
<td>Waterlogged sand</td>
<td>Northam Survey</td>
</tr>
</tbody>
</table>

4. Darling Range Zone (DRZ)

Ten soil landscape units have been mapped within the Darling Range and West Kokeby areas.

The Yalanbee unit (Ya) comprises the undulating Darling Plateau which possesses 'buckshot gravel' or 'pea gravel soils'. The Pindalup unit (Pn) contains the shallow, minor, swampy valley floors that occur on the Darling Plateau.

The Leaver unit (L) contains gravelly, hillslope soils derived from the dissected lateritic profile. It includes the breakaway face, the steep, upper slopes and the moderately sloping, colluvial lower slopes.

The Michibin unit (Mn) occurs on the hillslopes and contains duplex soils which often have granite or other rock within the soil profile. These soils are formed from the weathering of fresh rock. Steep rocky areas and rock outcrop have been mapped as the Steep Rocky Hills unit (R). The floodplains of the major streams and brooks that have dissected the eastern part of the Darling Range Zone are mapped as the Williams unit (W).

The Kokeby, Sheahan, Dale, and Maitland units are associated with the extinct upper Helena river system west of an area from about York to Kokeby.
The Kokeby unit (K) occurs as gently undulating side slopes in both the DRZ and West Kokeby Zone. It contains pale, sandy surfaced soils with small areas of gravel ridges. The Sheahan unit (S) contains areas of deep pale sand and is especially common in the West Kokeby area. The broad valley floors containing deep sandy duplex soils that commonly occur in the West Kokeby and Dale River areas are mapped as the Dale unit (Da). The swamps and poorly drained areas that occur within the Dale unit are mapped as the Maitland unit (Ma).

Figure 43 Idealised view of land units in the DRZ

4.1 Yalanbee soil landscape unit (Ya)

The Yalanbee unit is an undulating plateau with predominantly 'buckshot gravel' soils on long, smooth slopes which have gradients ranging from one to eight per cent. It occurs high up in the landscape and is usually separated from the Leaver unit below by a breakaway. Ironstone boulders or lateritic pavement may be present on the surface.

Remnant vegetation consists of jarrah, marri and parrot bush, with powderbark wandoo in some areas.

This unit forms a major part of the Darling Plateau, Wundowie, Julimar and Udamong soil landscape systems, and to a lesser extent of the Boyagin, Clackline and Yarawindah systems.
### Table 20 Landforms, original vegetation and soils in the Yalanbee unit

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undulating upland plateau</td>
<td>Jarrah, marri, parrot bush with wandoo in some areas</td>
<td>Loose to firm, greyish brown sand to loamy sand. Abundant fine, round ironstone gravel. Non-wetting</td>
<td>Coherent, brownish yellow sandy to loamy sand gravel sometimes overlying lateritic caprock</td>
<td>Buckshot gravel</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Marri, wandoo with jarrah in some areas</td>
<td>Hard-setting, greyish brown loamy sand</td>
<td>Coherent, yellowish brown sandy loam gravel often increasing to a clay at depth</td>
<td>Yellow sandy gravel over clay</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Marri, jarrah and wandoo with a shrub layer of parrot bush, tea tree and grass tree</td>
<td>Loose, pale greyish brown sand</td>
<td>About 40–60cm loose, pale sand overlying a gravel layer and/or a massive, yellow loamy sand</td>
<td>Pale sand over gravel/loamy sand</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>Banksia, Christmas tree and tea tree with scattered marri</td>
<td>Loose, grey sand</td>
<td>80 cm or greater loose white or pale yellow sand</td>
<td>Pale deep sand</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>Banksia, jarrah, marri, tea tree and sheoak</td>
<td>Loose, brown sand</td>
<td>70 cm or greater loose, yellow sand</td>
<td>Yellow deep sand</td>
<td>75</td>
</tr>
</tbody>
</table>

### 4.2 Leaver soil landscape unit (L)

Table 20 Landforms, original vegetation and soils in the Leaver unit

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steep, upper slopes and moderately inclined, mid and lower slopes</td>
<td>Wandoon, marri and powder bark wandoo</td>
<td>Hard-setting, greyish brown to brown loamy sand. Abundant ironstone gravel</td>
<td>Coherent, yellowish brown sandy loam often increasing to a clay at depth. Abundant ironstone gravel present</td>
<td>Yellow sandy gravel over clay</td>
<td>80</td>
</tr>
<tr>
<td>Small areas found immediately below the breakaway face. Slopes are often 5–10 per cent but can be 20 per cent</td>
<td>Powder bark wandoon and wandoo</td>
<td>Shallow, grey to brownish sand loam. Usually hard-setting and non-wetting. Can have a dusty appearance</td>
<td>At about 5–15 cm a pinkish to white dispersive clay occurs (this subsoil is often exposed by erosion of the topsoil)</td>
<td>Sandy loam over pinkish clay below breakaways</td>
<td>Northam Survey</td>
</tr>
<tr>
<td>Moderately inclined mid and lower slopes</td>
<td>Marri, wandoo, jarrah and a shrub layer of parrot bush, tea tree and grass tree</td>
<td>Loose, pale greyish brown sand</td>
<td>About 40–60 cm loose, pale sand overlying a gravel layer and/or a massive yellow loamy sand</td>
<td>Pale sand over gravel/loamy sand</td>
<td>77</td>
</tr>
<tr>
<td>Moderately to steep upper slopes. Often as a spur to the sides of breakaways</td>
<td>Jarrah, marri and parrot bush with wandoo in some areas</td>
<td>Loose to firm, greyish brown sand to loamy sand. Abundant fine, round ironstone gravel present</td>
<td>Coherent, brownish yellow sandy to loamy sand gravel, sometimes overlying lateritic caprock</td>
<td>Buckshot gravel</td>
<td>79</td>
</tr>
</tbody>
</table>
Gravelly slopes and ridges found in the western part of the study area where streams and rivers have dissected the Darling Plateau.

This unit includes the breakaway face and steep upper slopes (10–30 per cent) which often occur at the top of this unit and separate it from the Yalanbee unit above; and the moderately inclined, gravelly, mid and lower slopes (2–10 per cent). In many cases the Michibin unit occurs below the Leaver unit.

This unit is found in the Darling Plateau, Wundowie, Boyagin, Julimar and Udamong soil landscape systems, and to a lesser extent in the Clackline and Yarawindah systems.

4.3 Pindalup soil landscape unit (Pn)

This unit consists of a shallow, narrow valley floor found within the Yalanbee and, occasionally, Leaver units. Gradients along the creek line are generally less than one per cent. These valleys have a concave shape with a characteristic swampy floor. The Pindalup unit often occurs upstream from the larger, more dissected Williams valley unit. About 30 per cent of this unit is affected by salinity.

The incidence of salinity is highest where there has been clearing. This unit includes the foot slopes of the adjoining units.

Table 21 Landforms, original vegetation and soils in the Pindalup unit

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shallow concave, thin valley floor found within the DRZ</td>
<td>Flooded gum and rushes White gum grows on the margins of these valleys</td>
<td>Dark grey to dark brown loamy sand to sandy loam</td>
<td>Pale to yellowish sandy loam to sandy clay loam overlying a mottled, light grey to brownish yellow, structured clay. Ironstone gravel may be present</td>
<td>Poorly drained sandy loam duplex</td>
<td>Northam Survey</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hard-setting, brownish, fine loamy sand to loam</td>
<td>Brown to yellow loam often grading into structured clay at depth</td>
<td>Alluvial loam</td>
<td>Northam Survey</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dark greyish brown sand with a loose surface</td>
<td>White to light yellowish brown sand which overlies a mottled, light yellowish brown to pale clay at about 40–70 cm. Ironstone gravel may occur</td>
<td>Dale valley deep sandy duplex</td>
<td>84</td>
</tr>
</tbody>
</table>

4.4 Michibin soil landscape unit (Mn)

Hillslopes containing soils formed by the weathering of fresh rock. Rock outcrop is common.

It is the Darling Range equivalent of the York and Danberrin units further east.

The landform comprises sideslopes (2–12 per cent) found where dissection by creeks and rivers has removed the old lateritic profile and exposed fresh rock. The upper portion of this unit is often steeper and contains more rock outcrop (very rocky and/or steep areas have been mapped out separately as the Steep Rocky Hills unit (R)).

The lower slopes are gently inclined, less rocky and contain deeper, colluvial soils.

Note: Because of their small size, some gravelly spurs belonging to the Leaver unit have been mapped within the unit.
This unit is found mainly in the Boyagin, Clackline and Yarawindah soil landscape systems.

Table 23 Landforms, original vegetation and soils in the Michibin unit

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hillslopes containing scattered rock outcrop</td>
<td>In the eastern Darling Range Zone—York gum, jam and sheoak. Further to the west—marri and wandoo</td>
<td>Firm to hard-setting brownish grey sand to loamy sand. Granitic rocks often occur on the surface</td>
<td>About 50 cm pale to yellowish brown sand to clayey sand over a structured yellowish clay overlying saprock</td>
<td>Brownish grey granitic loamy soils</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Firm to hard-setting brown loamy sand to sandy loam to depth of about 15 cm</td>
<td>Reddish brown to brown clayey sand to sandy loam to a depth of 20–60 cm overlying a reddish to yellowish brown structured clay and/or decomposing bedrock</td>
<td>Rocky red brown loamy sand/sandy loam</td>
<td>88</td>
</tr>
<tr>
<td>Hillslopes immediately adjacent to dolerite dykes</td>
<td>In the eastern Darling Range Zone—York gum and jam. Further to the west—marri and wandoo</td>
<td>Hard-setting or self-mulching red brown loam to clay</td>
<td>Well-structured, dark red clay overlying decomposing dolerite</td>
<td>Red brown doleritic clay loam</td>
<td>91</td>
</tr>
</tbody>
</table>

4.5 Williams unit (W)

Alluvial terraces and flats. This unit is generally less than 100 m wide but can be up to 500 m wide alongside major drainage lines. Slope gradients are about 1:250, but can be steeper in areas. The Michibin unit often occurs either side of a Williams valley unit. Salinity affects about 5 per cent of this unit. It is common where brooks and streams have dissected the eastern part of the Darling Range. Includes the floodplains of Talbot, Warranine and Jimperding Brooks and Mount Anvil and Flat Rock Gullies. Waterlogging is common. Rock outcrops may be present.

Table 24 Landforms, original vegetation and soils in the Williams unit

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thin, alluvial terraces of the major drainage lines within the DRZ</td>
<td>Flooded gum, jam, York gum and wandoo</td>
<td>Firm to hard-setting, greyish loamy sand</td>
<td>Coherent, pale to yellowish brown loamy sand to about 40 cm overlying a structured, yellowish brown, mottled clay</td>
<td>Loamy sand surfaced valley duplex</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dark grey to dark brown loamy sand to sandy loam</td>
<td>Pale to yellowish sandy loam to sandy clay loam overlying a mottled, light grey to brownish yellow, structured clay</td>
<td>Poorly drained sandy loam duplex</td>
<td>Northam Survey</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hard-setting, brownish, fine loamy sand to loam</td>
<td>Brown to yellow loam often grading into structured clay at depth</td>
<td>Alluvial loam</td>
<td>Northam Survey</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hard-setting, grey sandy loam to clay loam to about 10–20 cm</td>
<td>Structured, grey clay</td>
<td>Grey alluvial clay</td>
<td>Northam Survey</td>
</tr>
</tbody>
</table>
4.6 Steep Rocky Hills soil landscape unit (R)

Areas of rock outcrop and steep rocky hills. This unit is common alongside the Dale River in the West Dale area and adjacent to the Avon River west of Toodyay.

Vegetation comprises marri, jam, rock sheoak, York gum, grass tree and wandoo. This unit contains pockets of soils similar to those found on the Michibin unit. However, they contain much more rock outcrop and are generally shallower.

4.7 Kokeby soil landscape unit (K)

The landform comprises gently undulating (2–6 per cent) sandy hillsides with small areas of gravel ridges and crests. This unit is synonymous with the West Kokeby soil landscape system, and is situated above the low-lying Dale unit. This unit is featured in the South-West York case study.

Table 25 Landforms, original vegetation and soils in the Kokeby unit

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant Vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil Type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gently undulating hillslopes</td>
<td>Marri, jarrah and wandoo with a shrub layer of parrot bush, tea tree and grass tree</td>
<td>Loose pale greyish brown sand</td>
<td>About 40–60 cm loose, pale sand overlying a gravel layer and/or a massive, yellow loamy sand</td>
<td>Pale sand over gravel/loamy sand</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>White gum, marri, sheoak and tea tree</td>
<td>Loose, greyish brown sand</td>
<td>Loose, pale sand overlies a mottled, light grey to yellow clay subsoil at greater than 45 cm. Ironstone gravel may occur above the clay</td>
<td>Slopes: deep sandy duplex</td>
<td>82</td>
</tr>
<tr>
<td>Gravelly ridges on gently undulating hillslopes</td>
<td>Marri and wandoo with jarrah in some areas</td>
<td>Hard-setting, greyish brown loamy sand and Abundant ironstone gravel</td>
<td>Coherent, yellowish brown sandy loam often increasing to clay at depth. Abundant, ironstone gravel present</td>
<td>Yellow sandy gravel over clay</td>
<td>80</td>
</tr>
<tr>
<td>Hollows and depressions within gently undulating hillslopes</td>
<td>Banksia, Christmas tree and tea tree with scattered marri</td>
<td>Loose, grey sand</td>
<td>80 cm or greater loose, white to pale yellow sand</td>
<td>Pale deep sand</td>
<td>74</td>
</tr>
</tbody>
</table>

4.8 Sheahan soil landscape unit (S)

Pockets of deep, pale spillway sand derived from the dissected lateritic profile that is common on the hills slopes in the West Kokeby area.

This unit occurs in association with the Kokeby unit on the gently undulating hillslopes (1–6 per cent) in the West Kokeby Zone. It also occurs as small areas, often in depressions, within the DRZ.
Table 26  Landforms, original vegetation and soils in the Sheahan unit

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hollows and depressions on gently undulating hillslopes</td>
<td>Banksia, Christmas tree and tea tree with scattered marri Marri, jarrah and wandoo with a shrub layer or parrot bush, tea tree and grass tree</td>
<td>Loose, grey sand</td>
<td>80 cm or greater loose white or pale yellowish sand.</td>
<td>Pale deep sand</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Loose, pale greyish brown sand</td>
<td>About 40–60 cm loose, pale sand overlying a gravel layer and/or massive yellow loamy sand</td>
<td>Pale sand over gravel/loamy sand</td>
<td>77</td>
</tr>
</tbody>
</table>

4.9 Dale soil landscape unit (Da)

Broad valley floors in the West Kokeby and Dale River areas that contain sand over clay soils and pale sands.

It occurs as flats and broad tributary valleys to the Dale and Avon rivers and Talbot Brook. Slopes are usually less than one per cent. Salinity affects about 5 per cent of this unit. Low-lying areas are prone to waterlogging. The poorly drained swamps that occur within the Dale unit are mapped as the Maitland unit.

This unit is synonymous with the Dale soil landscape system.

Table 26  Landforms, original vegetation and soils in the Dale unit

<table>
<thead>
<tr>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil</th>
<th>Subsurface soil</th>
<th>Soil type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flats and broad tributary valleys to the Dale and Avon rivers and Talbot Brook</td>
<td>Wandoo, flooded gum, tea tree and rock sheoak</td>
<td>Dark greyish brown sand with a loose surface</td>
<td>About 40–70 cm white to light yellowish brown sand which overlies a mottled, light yellowish brown to pale clay. Ironstone gravel may occur above the clay layer</td>
<td>Dale valley deep sandy duplex</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Firm to hard-setting greyish loamy sand</td>
<td>About 40 cm coherent, pale to yellowish brown loamy sand overlying a structured, yellowish brown, mottled clay</td>
<td>Loamy sand surfaced valley duplex</td>
<td>83</td>
</tr>
</tbody>
</table>

4.10 Maitland soil landscape unit (Ma)

Swamps found on the broad valley floors within the Dale unit. The swampy soils have paperbark (*Melaleuca* sp.) and rushes (*Juncus* sp.) vegetation.
Soil field texture guide

The texture of a soil reflects the size distribution of mineral particles finer than 2 mm. If it is gravely, remove the gravel by sieving.

Take a sample of soil that will sit comfortably in the palm of your hand from the layer of soil to be textured.

Form a bolus (ball) of soil by moistening the sample with water and kneading it. Knead the soil for 1–2 minutes while adding more water or soil until it just fails to stick to the fingers. The soil is now ready for shearing (ribboning). Note how the bolus feels when kneading it.

Press out the soil between the thumb and forefinger to form a ribbon. The ribbon should only be 2–3 mm thick.

The behaviour of the bolus and of the ribbon determines the field texture. **Do not decide texture solely on the length of the ribbon.**

Table 27  soil texture groups

<table>
<thead>
<tr>
<th>Texture group</th>
<th>Subgroup</th>
<th>Behaviour of bolus and ribbon</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLAY</td>
<td>All clays</td>
<td>Plastic bolus like putty, smooth to touch, becomes stiffer as clay increases, forms ribbon of 50–75 mm or more</td>
</tr>
<tr>
<td></td>
<td>Clay loam</td>
<td>Coherent plastic bolus, smooth to manipulate, forms ribbon of 40–50 mm</td>
</tr>
<tr>
<td>LOAM</td>
<td>Sandy clay loam</td>
<td>Coherent bolus, feels sandy, forms ribbon of 25–40 mm</td>
</tr>
<tr>
<td></td>
<td>Loam</td>
<td>Coherent bolus, feels smooth and spongy, forms ribbon of about 25 mm</td>
</tr>
<tr>
<td></td>
<td>Sandy loam</td>
<td>Weakly coherent bolus, feels sandy, ribbon of 15–25 mm. Sand grains may be visible</td>
</tr>
<tr>
<td></td>
<td>Clayey sand</td>
<td>Clay stain on fingers, very slightly coherent bolus, ribbon of 5–15 mm</td>
</tr>
<tr>
<td>SAND</td>
<td>Loamy sand</td>
<td>Very slightly coherent bolus, dark staining of fingers, minimal ribbon of about 5 mm</td>
</tr>
<tr>
<td></td>
<td>Sand</td>
<td>Cannot form a bolus, non-coherent</td>
</tr>
</tbody>
</table>
Common soils of the Northam district

This section contains examples of common soils in the district that are derived from a list compiled by Lantzke and Fulton (1993). Some names have been changed to make them easier to identify, and a few categories have been amalgamated. Soils are very variable, particularly on dissected laterites in the RDZ where there is often a mosaic of gravels, sand over gravel over reticulite or clay and lateritic duplex soils that merge into one another. Subsoils also vary in their resistance to root penetration by crop and pasture roots and the soils and their properties listed should only be taken as a guide.

<table>
<thead>
<tr>
<th>Soil</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture legumes for soil types</td>
<td>73</td>
</tr>
<tr>
<td>Pale deep sand</td>
<td>74</td>
</tr>
<tr>
<td>Yellow deep sand</td>
<td>75</td>
</tr>
<tr>
<td>Yellow gradational loamy sand</td>
<td>76</td>
</tr>
<tr>
<td>Pale sand over gravel/loamy sand</td>
<td>77</td>
</tr>
<tr>
<td>Shallow ironstone.</td>
<td>78</td>
</tr>
<tr>
<td>Buckshot gravel</td>
<td>79</td>
</tr>
<tr>
<td>Yellow sandy gravel over clay</td>
<td>80</td>
</tr>
<tr>
<td>Slopes, shallow sandy duplex</td>
<td>81</td>
</tr>
<tr>
<td>Slopes, deep sandy duplex</td>
<td>82</td>
</tr>
<tr>
<td>Loamy sand surfaced valley duplex</td>
<td>83</td>
</tr>
<tr>
<td>Dale valley deep sandy duplex</td>
<td>84</td>
</tr>
<tr>
<td>ADZ valley grey alkaline deep sandy duplex</td>
<td>85</td>
</tr>
<tr>
<td>ADZ valley grey alkaline shallow sandy duplex</td>
<td>86</td>
</tr>
<tr>
<td>Brownish grey granitic soils</td>
<td>87</td>
</tr>
<tr>
<td>Rocky red brown loamy sand/sandy loam</td>
<td>88</td>
</tr>
<tr>
<td>Shallow hard-setting grey sandy loam over clay</td>
<td>89</td>
</tr>
<tr>
<td>Slopes brown loamy duplex</td>
<td>90</td>
</tr>
<tr>
<td>Red brown doleritic clay loam</td>
<td>91</td>
</tr>
<tr>
<td>Red brown sandy loam over clay valley soil</td>
<td>92</td>
</tr>
<tr>
<td>Red clay valley soil</td>
<td>93</td>
</tr>
<tr>
<td>Grey clay valley soil</td>
<td>94</td>
</tr>
</tbody>
</table>
Table 28  **Annual pasture legumes for common soils in the Northam district**

This table is a general guide. Check species and varietal information in ‘Pasture legumes for temperate farming systems: the ute guide’.

<table>
<thead>
<tr>
<th></th>
<th>Subclover</th>
<th>Balansa clover</th>
<th>Bladder clover</th>
<th>Eastern star clover</th>
<th>Gland clover</th>
<th>Bajerula</th>
<th>Barrel medic</th>
<th>Burr medic</th>
<th>Disc medic</th>
<th>Sphere medic</th>
<th>Serradella</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pale deep sand</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2–3</td>
</tr>
<tr>
<td><strong>Yellow deep sand</strong></td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td><strong>Yellow gradational loamy sand</strong></td>
<td>3–4</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2–3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td><strong>Pale sand over gravel/ loamy sand</strong></td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3–4</td>
</tr>
<tr>
<td><strong>Shallow ironstone</strong></td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><strong>Buckshot gravel</strong></td>
<td>2–3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2–3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><strong>Yellow sandy gravel over clay</strong></td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><strong>Slopes shallow sandy duplex</strong></td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2–3</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1–2</td>
</tr>
<tr>
<td><strong>Slopes deep sandy duplex</strong></td>
<td>2–3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Loamy sand surfaced valley duplex</strong></td>
<td>4</td>
<td>3</td>
<td>3–4</td>
<td>2</td>
<td>3–4</td>
<td>2–3</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Dale valley deep sandy duplex</strong></td>
<td>4</td>
<td>4</td>
<td>3–4</td>
<td>2</td>
<td>3–4</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>ADZ valley alkaline deep sandy duplex</strong></td>
<td>2</td>
<td>1</td>
<td>2–3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2–3</td>
</tr>
<tr>
<td><strong>ADZ valley alkaline shallow sandy duplex</strong></td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td><strong>Brownish grey granitic soils</strong></td>
<td>4</td>
<td>2</td>
<td>3–4</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>Rocky red brown loamy sand/ sandy loam</strong></td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>Shallow hard-setting grey sandy loam over clay</strong></td>
<td>1</td>
<td>2–3</td>
<td>2–3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Slopes brown loamy duplex</strong></td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>Red brown doleritic clay loam</strong></td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3–4</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td><strong>Red brown sandy loam over clay valley soil</strong></td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td><strong>Red clay valley soil</strong></td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td><strong>Grey clay valley soil</strong></td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>
Pale deep sand

WA soil group: pale deep sand

Deep, white and pale yellow sands with thin, grey topsoil. The soil profile is at least 80 cm deep before gravel or an increase in texture is encountered—‘Christmas tree and banksia sands’.

Soil series: Philip series—pale deep sand; Eaton series—pale yellow deep sand.

Vegetation: ADZ and RDZ—low scrub with emergent Banksia sp. and Christmas tree. Roadside tea tree is a common species of the low scrub. DRZ—scattered marri may also occur if ironstone gravel occurs at depth.

Acidity: High risk due to high acidification rate low productivity, high leaching very low buffering capacity) and acidic pH

Soil structure: Sandy and loose throughout the profile

Water repellence: Extremely susceptible

Waterlogging: Not a problem

Water erosion: low risk—run-off can occur from heavy rain on dry water-repellent soils

Wind erosion: Very high risk

Water availability: Low to very low

Plant rooting depth: Deep

Other: Leaching is a problem on these soils. Soaks may occur downslope of them. These soils are not suited for most agricultural annual species.

Cereals: Very low potential

Canola: Very low potential

Grain legumes: Narrow-leaf lupins: low to moderate yield potential if potassium is applied

Pastures: Usually planted to tagasaste. See page 73.
Yellow deep sand

Deep yellow sand (greater than 80 cm deep) with a brownish topsoil—’sandplain pear and banksia country’.

Soil series: Cunderdin series.

Vegetation: ADZ and RDZ—sandplain pear, banksias and native pine. DRZ—marri, banksias and rock sheoak.

**Acidity**
Very high risk due to high acidification rate (moderate productivity, leaching), and mildly acidic pH

**Soil structure**
Sandy throughout the profile

**Water repellence**
Very susceptible

**Waterlogging**
Not a problem

**Water erosion**
low risk—run-off can occur from heavy rain on dry water-repellent soils

**Wind erosion**
Very high risk

**Water availability**
Generally medium-low

**Plant rooting depth**
Deep

**Other**
Leaching is a problem on these soils. Soaks frequently occur downslope of them.

**Cereals**
Moderate yields but subject to nitrogen leaching

**Canola**
Moderate potential but dry topsoils can affect establishment.

**Pastures**
Well suited to serradellas but shallower rooted species fail in dry seasons. See page 73.

**Grain legumes**
Narrow-leaf lupins—moderate to high yield potential
**Yellow loamy sand/loamy sand over gravel**

WA soil group: yellow sandy earth

Good to very good quality yellow sandplain. These soils include deep loamy sands grading to sandy loam with depth (yellow earths), and yellow loamy sand soils that have increasing clay content with depth, and a reticulite or gravelly layer deeper than 30 cm.

**Soil series**: Tammin, Ucarty series (gravelly); Wyola, Ejanding series (no gravel).

**Vegetation**: Tamma, sandplain mallee (*E. macrocarpa and E. pyriformis*) and tussock grass (*Lepidosperma angustatum*).

**Acidity**  High risk due to high acidification rate, and acidic pH

**Soil structure**  Firm-setting surface. Very susceptible to traffic pan formation. Deep ripping gives a marked growth response in cereal crops and yield responses except in dry years.

**Water repellence**  Susceptible

**Waterlogging**  Low risk

**Water erosion**  Moderate to low risk but they are hard-setting and can have run-off, particularly on tracks. These soils can be compacted into roaded catchments.

**Wind erosion**  Moderate to high, depending on texture

**Water availability**  Generally medium

**Plant rooting depth**  Deep

**Other**  A small amount of these soils in the north-east of the district may have very acidic subsoils.

**Cereals**  High yield potential

**Canola**  Moderate to high potential. Soil acidity may reduce yields.

**Grain legumes**  Narrow-leaf lupins—high yield potential

**Pastures**  Excellent soils for subclovers (except on acidic soils), and serradellas. See page 73.

**Wyola series**  A Loose to hard-setting greyish brown to yellowish brown sand to clayey sand Usually contains small to moderate amounts of ironstone gravel. pH 6.0

**Tammin series**  B1/B2 Yellow to yellowish brown clayey sand grading to a sandy loam or sandy clay loam at depth. Large amounts of ironstone gravel often present. pH 6.5.

B  Red, orange and yellow mottled sandy clay loam to sandy clay reticulite Little or no ironstone gravel. pH 6.5
Pale sand over gravel/loamy sand

Pale sand over gravel and/or loamy sand at about 40 cm.

**Soil series:** Kauring series—ironstone gravel occurs in the subsoil. Mawson series—no ironstone gravel present in the subsoil.

**Vegetation:** ADZ and RDZ—low tea tree scrub, Christmas tree and wandoo, grading to tamma on shallow variants. DRZ—scattered marri, wandoo and low roadside tea tree scrub.

**Acidity**
High risk due to high acidification rate low productivity, high leaching very low buffering capacity), and acidic pH.

**Soil structure**
Loose sandy topsoil

**Water repellence**
Extremely susceptible

**Waterlogging**
Not a problem

**Water erosion**
Low risk, run-off can occur from heavy rain on dry water-repellent soils

**Wind erosion**
Very high risk

**Water availability**
Low to very low, but often grades into (better) shallower sand over clay or reticulite

**Plant rooting depth**
Deep

**Other**
Soaks may occur downslope from these soils. These soils are suited to deep-rooted annual or perennial agricultural plants such as tagasaste

**Cereals**
Moderately low potential generally

**Canola**
Unsuitable

**Grain legumes**
Narrow-leaf lupins—low to moderate yield potential depending on depth to subsoil if potassium is applied.

**Pastures**
Serradellas—low to moderate potential depending on depth to subsoil if potassium is applied. See page 73.

---

**A1** Loose greyish brown to light grey medium-to-coarse sand. May contain ironstone gravel. pH 6.5

**A2** Pale medium-to-coarse sand. May contain ironstone gravel. pH 7.0

**A3** Pale medium-to-coarse sand Large amounts of ironstone gravel pH 7.0

**B2** Yellow, loamy sand to sandy loam, with red and pale mottles May contain ironstone gravel. pH 7.0

**C** Red, orange and yellow mottled reticulite sandy clay loam to sandy clay. pH 6.5
**Shallow ironstone**

These soils have a shallow mantle (< 20 cm) of ironstone gravels in a grey or brown sandy matrix over dense reticulite. The soil can be found on breakaways, crests, ridges and upper slopes, and often grades into deeper lateritic sandy and gravelly soils.

**Soil series:** Wyalkatchem series.

**Native vegetation:** generally low prickly heath and tamma.

- **Acidity:** Moderate to high risk
- **Soil structure:** Generally a hard-setting sandy gravel over impermeable reticulite ironstone
- **Water repellence:** Moderate risk
- **Waterlogging:** Low risk
- **Water erosion:** Moderate to high risk as they tend to occur on uplands and can initiate run-off that can cause erosion downslope
- **Wind erosion:** Low risk
- **Water availability:** Low
- **Plant rooting depth:** Generally shallow but variable due to variable depth of gravel over the reticulite, and some plant roots can travel down old root channels and cracks in the reticulite
- **Other:** This soil has a low productivity due to shallowness and poor plant water availability.
- **Cereals:** Moderate to poor depending on depth to ironstone and cracks in the ironstone
- **Canola:** Poor
- **Grain legumes:** Not suitable
- **Pastures:** See page 73.
Buckshot gravel  

WA soil group: deep sandy gravel

Very gravelly ‘buckshot’ or ‘pea’ gravel soils that occur on the undulating plateau of the Darling Range.

**Soil series**: Yalanbee series.

**Vegetation**: Tall, open forest of jarrah, marri, the occasional wandoo and powderbark wandoo. A shrub layer of parrot bush and grass trees also occurs.

**Acidity**: These soils were originally mildly acidic but have a moderately high acidification rate due to high leaching sandy matrix soils.

**Soil structure**: Sandy throughout the profile

**Water repellence**: Very susceptible

**Waterlogging**: Not a problem

**Water erosion**: Winter moderately low, summer moderate. High run-off is common from summer storms due to the sloping landscape and water-repellent soils.

**Wind erosion**: Low

**Water availability**: Low to moderately low

**Plant rooting depth**: Deep

**Other**: High phosphate-fixing soils. Manganese deficiency in cereals is common in dry seasons. Run-off from water repellency can delay germination.

**Cereals**: Moderately low to moderate depending on soil texture and soil depth

**Canola**: Moderately low to moderate depending on soil texture and soil depth

**Grain legumes**: Moderate narrow-leaf lupin yield potential

**Pastures**: See page 73.

---

A1 Dark grey to dark brown fine-to-medium grained loose sand to loamy sand. Large amounts of fine round, ironstone gravel. Often non-wetting. pH 6.5

B2 Brownish yellow, fine-to-medium grained sand to loamy sand. Large amounts of fine, round, ironstone gravel. pH 7.0

Sheet laterite (duricrust) may occur below this soil and outcrops in places
March 2010

Yellow sandy gravel over clay WA soil group: duplex sandy gravel

Gravelly, yellow loamy sand over clay soils that occur on the dissected hillslopes within the Darling Range.

Soil series: Leaver series.

Vegetation: The dominant vegetation is wandoo and marri with the occasional jarrah and powderbark wandoo.

Acidity Moderate risk
Soil structure Firm setting to loose surfaced soil
Water repellence Very susceptible
Waterlogging Very low risk
Water erosion Moderate to high risk, particularly from summer storms on water-repellent soils
Wind erosion Moderately low risk
Water availability Moderate
Plant rooting depth Moderate to deep
Other High phosphate-fixing soils
Cereals Moderate to moderately high yield potential
Canola Moderate to moderately high yield potential
Grain legumes Narrow-leaf lupins
Pastures See page 73.

A 1 Firm dark greyish brown to dark brown loamy sand. Usually with large amounts of ironstone gravel. pH 6.0

A3/B1 Very gravelly yellowish brown to strong brown clayey sand to sandy loam. pH 6.5

B2 Strong brown to brownish yellow sandy clay loam to Moderately structured medium clay. Generally contains some ironstone gravel. pH 6.5
**Slopes shallow sandy surfaced duplex**  W.A. soil group: grey shallow sandy duplex

Shallow sand over yellowish clay soils in the RDZ.

**Soil series:** Quajabin series.

**Vegetation:** Wandoo with rock sheoak, jam and roadside tea tree.

- **Acidity:** Deeper variants with acidic topsoils are susceptible.
- **Soil structure:** Usually have a firm surface but deeper variants may have loose sand. Dense subsoils may restrict root growth.
- **Water repellence:** Susceptible.
- **Waterlogging:** Moderately high risk
- **Water erosion:** Moderate risk
- **Water availability:** Moderate to good but depends on depth of sandy layer and underlying soil structure. Water perched above the clay is an advantage in some seasons.
- **Plant rooting depth:** Depends on depth of sandy layer and underlying soil structure
- **Cereals:** Average to good. Yields can be restricted in both very dry (root restriction) and very wet (waterlogging) seasons.
- **Canola:** Average to good
- **Grain legumes:** Peas can yield well but wind erosion of stubbles is a risk. Lupins—moderate to low yields.
- **Pastures:** See page 73.
Slopes deep sandy duplex  
WA soil group: grey deep sandy duplex

Deep, often coarse, sand over yellowish clay soils in the RDZ and DRZ (Dulbelling series), and loamy sand over clay (Morbinning series, or sand over gravel over clay (Mortlock series). This soil combines Northam survey deep sandy surface duplex, loamy sand surfaced duplex and loamy sand over clay soil categories. The images below show a range of soils.

Vegetation: Wandoo, with rock sheoak being especially common on the deeper phases. Roadside tea tree occurs in some areas. Tamma becomes more common in the understorey on loamy sand duplexes, sand over gravel over clay.

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidity</td>
<td>High risk due to high acidification rate, acidic topsoil pH and low buffering capacity</td>
</tr>
<tr>
<td>Soil structure</td>
<td>Firm setting to loose surface. Moderately low response to deep ripping on loose sandy versions but types with loamy sand to 20 cm may give economic responses. Root penetration into subsoils varies.</td>
</tr>
<tr>
<td>Water repellence</td>
<td>Very susceptible</td>
</tr>
<tr>
<td>Waterlogging</td>
<td>Moderate on shallower types, particularly at the change of slope</td>
</tr>
<tr>
<td>Water erosion</td>
<td>Low to moderate risk, mainly in depressions and break of slope</td>
</tr>
<tr>
<td>Wind erosion</td>
<td>High risk</td>
</tr>
<tr>
<td>Water availability</td>
<td>Moderate to moderately low depending on clay and gravel content, and depth to clay, and ability of roots to penetrate the subsoil. Water repellence early in the growing season can also cause patchy water availability. Water perched above the clay is an advantage in some seasons.</td>
</tr>
<tr>
<td>Plant rooting depth</td>
<td>Moderate to good but depends on depth of sandy topsoil and subsoil structure.</td>
</tr>
<tr>
<td>Cereals</td>
<td>Moderate to high yields</td>
</tr>
<tr>
<td>Canola</td>
<td>Moderate to high but low water-holding topsoil may limit early growth</td>
</tr>
<tr>
<td>Grain legumes</td>
<td>Narrow-leaf lupins—moderate on deeper types</td>
</tr>
<tr>
<td>Pastures</td>
<td>See page 73.</td>
</tr>
</tbody>
</table>
Loamy sand surfaced valley duplex  WA soil group: grey deep sandy duplex

This is the same soil as the loamy sand duplex that occurs on the lower slopes or valley floor and has the potential to become waterlogged in wet years.

Soil series: Morbinning series—loamy sand over clay; ironstone gravel absent.
Mortlock series—loamy sand over clay; ironstone gravel present.

Vegetation: RDZ—wandoo with some jam, salmon gum, York gum and rock sheoak.
DRZ—wandoo, flooded gum and marri in the west.

Acidity  High risk due to high acidification rate, acidic topsoil pH and low buffering capacity
Soil structure  Firm setting to loose surfaced soil that may respond to deep ripping.
Water repellence  Susceptible
Waterlogging  Moderate to high risk
Water erosion  Low to moderate risk
Wind erosion  Moderate risk
Water availability  Moderate to moderately high depending on clay and gravel content, and depth to clay, and ability of roots to penetrate the subsoil
Plant rooting depth  Moderate, limited by waterlogging in wet seasons
Other  Pastures often stay green longer on these soils due to perched water. High crop yields are possible but frost and waterlogging increase risk.
Cereals  Moderate to high yields unless waterlogged
Canola  Moderate yields unless waterlogged
Grain legumes  Narrow-leaf lupins are risky but yield well in dry seasons.
Pastures  See page 73.

A1 Loose grey to dark greyish brown medium-to-coarse grained sand. pH 6.0

A2/A3 Light grey to light yellowish brown sand. May contain small amounts of ironstone gravel above the clay. pH 6.5.

B2 Very pale brown to yellowish brown sandy clay to medium clay. Red and orange mottles are common. Moderately structured. pH 6.5
**March 2010**

**Dale valley deep sandy duplex**  
WA soil group: grey deep sandy duplex

Pale sand over yellowish clay soils that are common on the broad valley floors in the West Kokeby/Dale area.

**Soil series:** Dale series.

**Vegetation:** The dominant vegetation is wandoo and tea trees, with flooded gum and sedges on the wetter areas.

**Acidity**  
Moderate risk

**Soil structure**  
Loose surfaced soil over dense clay subsoil

**Water repellence**  
Very susceptible but repellency is often not a problem because these soils are in water-gaining valleys

**Waterlogging**  
Very high risk

**Water erosion**  
Low risk

**Wind erosion**  
Moderate risk

**Water availability**  
The sandy topsoil has a poor water-holding capacity, and waterlogging restricts root penetration of the clay subsoil.

**Plant rooting depth**  
Limited by waterlogging in wet seasons, and depth to clay in dry seasons

**Other**  
Pastures (particularly perennials) are the best options for this soil. Drainage may reduce the waterlogging intensity.

**Cereals**  
High waterlogging and frost risk. Oats are the best adapted cereal.

**Canola**  
Not suitable

**Grain legumes**  
Not suitable

**Pastures**  
See page 73.

---

A1 Loose dark greyish brown medium-to-coarse grained sand. pH 6.0

A2 Very pale brown to light yellowish brown sand. May contain ironstone gravel. pH 6.0

B2 Very pale brown to brownish yellow sandy clay to medium clay. Abundant orange and pale mottles. Moderately structured. pH 7.0
ADZ valley alkaline deep sandy duplex  WA soil group: alkaline grey deep sandy duplex

Grey, sandy surfaced valley duplex of the ADZ. A clay layer, which is often calcareous, occurs at about 60 cm.

**Soil series:** Bungulla series.

**Vegetation:** Salmon gum, York gum, inland wandoo and some types of mallee.

**Acidity**
Despite the alkaline subsoil there is a moderately high rate of acidification of the sandy topsoil.

**Soil structure**
Firm setting to loose surfaced soil that may respond to deep ripping. The calcareous subsoil tends to allow better root penetration than wandoo and mallee duplexes.

**Water repellence**
Susceptible

**Waterlogging**
Low to moderately low risk

**Water erosion**
Low risk

**Wind erosion**
Moderate risk

**Water availability**
Moderate to moderately high depending on the clay content of the topsoil. Water perched above the clay layer can be an advantage.

**Plant rooting depth**
Moderate

**Other**
Variants with very sandy topsoils may have less reliable crop and pasture establishment in dry seasons.

**Cereals**
Moderate to moderately high yields unless waterlogged

**Canola**
Moderately low to moderate yields

**Grain legumes**
Narrow-leaf lupins are grown but can be waterlogged in wet seasons and have reduced yields due to calcareous subsoil

**Pastures**
Deeper rooted species are better adapted to this soil. See page 73.

![Soil profile diagram](image)

- **A1** Greyish brown sand to loamy sand
  - Loose to firm surface
  - pH 6.5

- **A2** Light yellowish brown sand to clayey sand
  - pH 7.0

- **B2** Pale brown to brownish yellow medium clay.
  - Faint, pale mottles may be present. Strongly structured. Calcareous (lime) segregations are often present.
  - pH 7.0 to 8.5
ADZ valley alkaline shallow sandy duplex  WA soil group: alkaline grey shallow sandy duplex

Grey, sandy surfaced valleys of the ADZ. An alkaline, often calcareous, clay layer occurs at about 10–30 cm.

**Soil series:** Belka series.

**Vegetation:** Salmon gum, York gum, gimlet, and some types of mallee.

**Acidity**  Low risk

**Soil structure**  Loose to firm setting soil. The calcareous subsoil tends to allow better root penetration than wandoo and mallee duplexes.

**Water repellence**  Moderately susceptible

**Waterlogging**  Susceptible to waterlogging in a wet season

**Water erosion**  Low risk

**Wind erosion**  Low to moderate risk

**Water availability**  Moderately high. Water perched above the clay layer can be an advantage in some years.

**Plant rooting depth**  Moderately shallow to moderate

**Other**  This soil is frequently in an area susceptible to salinity.

**Cereals**  Moderate to moderately high yields unless waterlogged

**Canola**  Moderate yields

**Grain legumes**  Peas and faba beans

**Pastures**  See page 73.

---

A1 Greyish brown sand to loamy sand
Generally loose but may be hardsetting. pH 6.5

A2 Light yellowish brown sand to clayey sand.
pH 7.0
(Note: This layer may be very thin or absent.)

B2 Light yellowish brown medium clay
Faint, pale mottles may be present. Moderately structured. Lime segregations are often present
pH 8.5
Brownish grey granitic soils

WA soil groups: grey deep sandy duplex, yellow brown deep sandy duplex, yellow brown shallow sand

Greyish sand to loamy sand over yellowish clay and/or decomposing bedrock. Often found adjacent to granitic outcrops.

Soil series: Maleballing, Boyadine series.

Vegetation: ADZ and RDZ—jam, York gum and rock sheoak. Wandoo occurs in some areas. DRZ—wandoo, marri, rock sheoak and jam.

Acidity Moderate to high risk due to high acidification rate (high productivity, low buffering capacity).

Soil structure Loose to firm setting generally well-structured soils

Water repellence Moderately to highly susceptible

Waterlogging In patches below rock outcrops or near bedrock highs

Water erosion Moderate risk, particularly adjacent to rock outcrops

Wind erosion Moderate to high risk

Water availability Moderate to moderately high, depending on depth to rock

Plant rooting depth Moderate to deep

Other These are quite productive soils except for very sandy and shallow soil over rock variants.

Cereals Generally moderate yields

Canola Moderate yields

Grain legumes Narrow-leaf lupins yield well on deeper soils, although patches can be waterlogged in wet years. Peas also yield well but summer wind erosion risk is very high.

Pastures See page 73.
Rocky red brown loamy sand/sandy loam

WA soil group: red sandy earth, red shallow loamy duplex

Rocky, red-brown to brown, loamy sand to sandy loam over clay and/or decomposing bedrock—‘York gum/jam soils’.

**Soil series:** York, Mulukine, Seabrook series.

**Vegetation:** ADZ and RDZ—York gum and jam. DRZ—marri, wandoo and jam.

**Acidity**
Moderate acidification rate but many soils now need lime due to their productivity and because they were among the first soils cleared

**Soil structure**
Generally firm setting, well-structured soils

**Water repellence**
Low to moderately susceptible

**Waterlogging**
Possibly in patches below rock outcrops or near bedrock highs

**Water erosion**
Moderate to high risk, particularly adjacent to rock outcrops

**Wind erosion**
Low to moderate risk

**Water availability**
Moderate to high, depending on depth to rock

**Plant rooting depth**
Moderate

**Other**
These are the most productive soils over a range of seasons.

**Cereals**
Moderate to high yields

**Canola**
Moderate to high yields

**Grain legumes**
Narrow-leaf lupins—moderate on sandier types. Well suited to peas, and deep loams are suitable for other pulses.

**Pastures**
Excellent subclover soils. See page 73.

---

A1 Brown to dark reddish brown medium-to-coarse grained loamy sand to sandy loam
Loose to hard-setting surface
pH 6.0

A3/B1 Reddish brown to yellowish brown clayey sand to sandy loam. Weakly structured to massive. pH 7.0

B2 Reddish brown to brown medium clay
Moderately structured. pH 7.0

C Decomposing bedrock
Shallow hard-setting grey sandy loam over clay

WA soil group: grey shallow loamy duplex

Hard-setting, hard to manage, shallow, gritty, grey sandy loam overlying clay. Often contains white decomposing granite or pallid zone on the soil surface. The surface can be non-wetting.

Soil series: Meenaar series.

Vegetation: Wandoo, some mallee species and salmon gum.

Acidity
Low risk

Soil structure
Hard-setting poorly structured topsoil (that is susceptible to surface sealing) over dense clay that inhibits root penetration. Can be boggy.

Water repellence
Very susceptible on some soils

Waterlogging
Waterlogging is a problem on lower slopes and break of slope.

Water erosion
Low risk

Water availability
Moderately low but depends on depth of topsoil and subsoil bulk density

Plant rooting depth
Shallow

Other
Soil structure can be improved by no-till cropping and avoiding grazing until pastures are well established. Test for gypsum responsiveness.

Cereals
Low (poor soil structure very wet or dry seasons) to moderate (improved structure) yield potential

Canola
Low

Grain legumes
Peas and faba beans

Pastures
See page 73.

A1 Hard-setting grey, medium-to-coarse grained loamy sand to sandy loam. Massive structure. pH 6.0

A2 Light brownish grey to yellowish brown clayey sand to sandy clay loam. pH 6.5
(Note: This layer is often absent.)

B2 Pale brown to light brownish grey sandy clay to medium clay. Moderately structured. May contain calcareous (lime) segregations. pH 6.5 (but can become alkaline at depth)

C Pallid zone or saprock (decomposing rock)
Slopes brown loamy duplex  WA soil group: brown shallow loamy duplex

Grey-brown to dull reddish, sandy loam over clay at 10–30 cm. Occurs on the hillslopes in the ADZ and DRZ.

Soil series: Booraan series.

Vegetation: Salmon gum with some gimlet, wandoo, inland wandoo, and mallee.

### Acidity
Very low risk

### Soil structure
Moderately well-structured subsoils but hard-setting topsoils are susceptible to surface compaction, particularly from heavy grazing early in the growing season

### Water repellence
Low risk

### Waterlogging
Low risk

### Water erosion
Susceptible to water erosion, particularly below rock outcrops or breakaways

### Wind erosion
Moderate risk

### Water availability
Moderate to good but there is great variability in depth to underlying rock or poorly structured clays

### Plant rooting depth
Moderate

### Other
These are potentially high yielding soils. They retain subsoil moisture well but, being on slopes, tend to receive less run-off from upslope than the Merredin series. They have moderate to high potassium levels.

#### Cereals
Excellent, except in very dry seasons

#### Canola
Possible in wet seasons

#### Grain legumes
Well suited to pulses. Faba beans, vetches, peas, chickpeas

#### Pastures
See page 73.

A1 Hard setting dark greyish brown to reddish brown loamy sand to sandy loam. pH = 6.5

B Dark greyish brown or dark reddish brown to light yellowish brown sandy loam to sandy clay loam pH 6.5 to 8.0

C Light yellowish brown to dark reddish brown medium clay. Moderately structured. May contain lime. Usually alkaline
**Red brown doleritic clay loam**  WA soil group: self-mulching cracking clay

Red to brown, heavy textured soils formed from dolerite or similar fine-grained basic rocks. Often has a self-mulching, cracking surface.

**Soil series:** Northam series.

**Vegetation:** ADZ and RDZ—York gum, salmon gum and needle bush (*Hakea preissii*). DRZ—wandoo, York gum.

<table>
<thead>
<tr>
<th>Acidity</th>
<th>Low risk.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soil structure</strong></td>
<td>Firm setting, well-structured soils</td>
</tr>
<tr>
<td><strong>Water repellence</strong></td>
<td>Not a problem</td>
</tr>
<tr>
<td><strong>Waterlogging</strong></td>
<td>Low risk but boggy areas can occur below rock outcrops or near bedrock highs</td>
</tr>
<tr>
<td><strong>Water erosion</strong></td>
<td>High risk, particularly adjacent to rock outcrops</td>
</tr>
<tr>
<td><strong>Wind erosion</strong></td>
<td>Low risk</td>
</tr>
<tr>
<td><strong>Water availability</strong></td>
<td>Moderately high</td>
</tr>
<tr>
<td><strong>Plant rooting depth</strong></td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>These are fertile and very productive soils, although yields are reduced in very dry seasons in the ADZ.</td>
</tr>
<tr>
<td>Cereals</td>
<td>Moderate to high yields</td>
</tr>
<tr>
<td>Canola</td>
<td>Moderate to high yields</td>
</tr>
<tr>
<td>Grain legumes</td>
<td>Very suitable for pulses although loose rocks make pea harvesting difficult</td>
</tr>
<tr>
<td>Pastures</td>
<td>See page 73.</td>
</tr>
</tbody>
</table>

**A1 Reddish brown sandy clay loam to medium clay.** Often self-mulching with surface cracks but can be hard-setting. pH 6.5 (Note: A transitional A3 sandy clay loam or clay loam horizon may occur.)

**B2 Reddish brown medium clay.** Strongly structured. Often contains dolerite rock. May contain lime at depth. pH 6.5 to 8.5

**C Decomposing dolerite rock**
Red brown sandy loam over clay valley soils

Red-brown, sandy loam over clay soils found on the broad valley floors of the central and eastern wheatbelt: ‘Merredin sandy loam’.

Soil series: Merredin, Kellerberrin series.

Vegetation: Salmon gum and gimlet.

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidity</td>
<td>Not a problem</td>
</tr>
<tr>
<td>Soil structure</td>
<td>Hard-setting well-structured soils but surface sealing is a problem if excessively cultivated or heavily grazed in early winter. Subsurface structure can be improved but this is unlikely to be economic.</td>
</tr>
<tr>
<td>Water repellence</td>
<td>Not a problem</td>
</tr>
<tr>
<td>Waterlogging</td>
<td>Low risk</td>
</tr>
<tr>
<td>Water erosion</td>
<td>Low risk as usually in valleys</td>
</tr>
<tr>
<td>Wind erosion</td>
<td>Moderately low risk</td>
</tr>
<tr>
<td>Water availability</td>
<td>Moderately high</td>
</tr>
<tr>
<td>Plant rooting depth</td>
<td>Moderately shallow</td>
</tr>
<tr>
<td>Other</td>
<td>These are fertile and very productive soils although yields are reduced in very dry seasons in the ADZ. These soils are at risk of watertable salinity.</td>
</tr>
<tr>
<td>Cereals</td>
<td>Moderate to high yields.</td>
</tr>
<tr>
<td>Canola</td>
<td>Moderate yields</td>
</tr>
<tr>
<td>Grain legumes</td>
<td>Very suitable for pulses</td>
</tr>
<tr>
<td>Pastures</td>
<td>See page 73.</td>
</tr>
</tbody>
</table>

Merredin series

A1 Hard-setting dark brown sandy loam to sandy clay loam
pH 7.0

B21 Reddish brown sandy clay loam to medium clay
Strongly structured. pH 7.5

B22 Reddish brown medium clay.
Strongly structured. Lime segregations. pH 8.5
Red clay valley soils

WA soil group: red brown non-cracking clay

Red-brown clay soils found on broad valley floors of the central and eastern wheatbelt.

**Soil series:** Trayning series.

**Vegetation:** Salmon gum and gimlet.

**Acidity**  Not a problem (alkaline soils)

**Soil structure**  Susceptible to surface sealing if excessively cultivated or heavily grazed in early winter. Subsurface structure can be improved but this is unlikely to be economic.

**Water repellence**  Not a problem

**Waterlogging**  Low risk

**Water erosion**  Low risk as usually in valleys

**Wind erosion**  Low risk

**Water availability**  Moderately high but are too heavy in dry seasons

**Plant rooting depth**  Shallow

**Other**  These are fertile and productive soils but lower yielding than the red-brown sandy loam over clay valley soil in dry seasons. These soils are at risk of watertable salinity.

**Cereals**  High yields in wet seasons. Overall lower yielding than red-brown sandy loam over clay valley soil

**Canola**  Risky soils except in seasons with heavy summer rain

**Grain legumes**  Peas yield well

**Pastures**  See page 73.
Grey clay valley soils

Grey clay soils found on the broad valley floors of the central and eastern wheatbelt.

**Soil series:** Corrigin series.

**Vegetation:** Salmon gum and gimlet, often mainly gimlet.

**Acidity** Not a problem (alkaline subsoil)

**Soil structure** Very hard-setting soil, with a high clay subsoil that can impede root growth. These soils are very susceptible to structural degradation but can be improved by no-till cropping, stubble retention and little or no grazing in winter. Test for gypsum response.

**Water repellence** Not a problem

**Waterlogging** Can be very boggy in wet seasons

**Water erosion** Generally low risk but very erodible on slopes

**Wind erosion** Low risk

**Water availability** Moderate, too heavy in dry seasons, and germination problems are possible with high rainfall after seeding on degraded soils

**Plant rooting depth** Shallow

**Other** Higher risk soils than red clay valley soils. Less alkaline variants may occur in the south and east of the district.

**Cereals** High yields in good seasons. Overall lower yielding than other clay soils

**Canola** Unsuitable

**Grain legumes** Peas can yield well.

**Pastures** See page 73.

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**A1** Grey sandy clay loam to medium clay. Hard-setting, often degraded
Surface cracks may be present
pH 7.5

**B** Greyish brown medium clay
Strongly structured
Calcareous (lime) segregations at depth.
pH 8.5
Landscapes and soils of the Northam district: field trip

The main objectives of the field trip are:
- To give you practical experience in using the decision aids that are in your manual
- To introduce you to local landscapes and soils.

Materials required for this trip:
- Vehicle
- Spade or soil auger, water and towel for soil texturing
- Insect repellent and protective clothing relevant to the season
- Four photocopies of the Northam district soil/landscape investigation sheet

Figure 44 Field trip map shows stops and soil landscape systems and subsystems
Table 29  **Soil landscape system and subsystem descriptions**

<table>
<thead>
<tr>
<th>Soil Landscape System</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Jelcobine system</strong></td>
<td>Undulating to hilly country in the West Northam–Toodyay area, with mainly loam and duplex soils formed from fresh gneissic rocks, gravels and grey shallow to deep sandy duplexes</td>
</tr>
<tr>
<td>Jc Yo (York)</td>
<td>Areas of soils derived from freshly exposed rock. Unit typified by the red soils of the Avon Valley</td>
</tr>
<tr>
<td>Jc Rh (Rocky hills)</td>
<td>Areas of steep, rocky hills</td>
</tr>
<tr>
<td>JcHa (Hamersley)</td>
<td>Narrow, minor drainage lines that lead down to major drainage systems such as the Avon and Dale rivers</td>
</tr>
<tr>
<td><strong>Morbinning system</strong></td>
<td>Undulating grey sandy gravel sandplain remnants, breakaways and slopes, with grey deep sandy duplex (often alkaline), pale deep sand and some yellow sandy earth</td>
</tr>
<tr>
<td>MbQu (Quailing)</td>
<td>Yellow and pale sandplain and gravelly soils of the central wheatbelt that are often found above a breakaway</td>
</tr>
<tr>
<td>MbEW (Ewarts)</td>
<td>Hillslopes containing sand and loamy sand over yellowish clay soils, with some gravel ridges, and some heavier soils that often occur immediately below a breakaway</td>
</tr>
<tr>
<td>MbYo (York)</td>
<td>Areas of soils derived from freshly exposed rock</td>
</tr>
<tr>
<td>Mb 4</td>
<td>Narrow tributary valleys with duplex soils and wandoo vegetation</td>
</tr>
<tr>
<td><strong>Greenhills system</strong></td>
<td>Undulating granitic terrain where erosion has dissected the Morbinning system, with deep sandy duplex (grey and red), brown deep loamy duplex, bare rock and shallow loamy duplex</td>
</tr>
<tr>
<td>GH RH (Rocky hills)</td>
<td>Areas of steep, rocky hills</td>
</tr>
<tr>
<td>GhYo (York)</td>
<td>Areas of soils derived from freshly exposed rock. Often greyer and lighter textured soils than Jelcobine</td>
</tr>
<tr>
<td>GhEw (Ewarts)</td>
<td>Hill slopes containing sand and loamy sand over yellowish clay soils, with some gravel ridges, and some heavier soils that often occur immediately below a breakaway</td>
</tr>
<tr>
<td>Gh 4</td>
<td>Flat narrow tributary valleys of the Mortlock river valleys with saline soils, semi-wet soils and grey sandy duplexes</td>
</tr>
<tr>
<td><strong>Avon Flats system</strong></td>
<td>Alluvial flats associated with the actively draining Avon river and associated with the Jelcobine system. Brown loamy earth, grey non-cracking clay and brown deep sand</td>
</tr>
<tr>
<td><strong>Philips system</strong></td>
<td>Gently undulating windblown lateritic sandplain with poorly drained seepage areas and lakes. Gravelly pale deep and pale deep sands, yellow sandy earths and yellow deep sands</td>
</tr>
<tr>
<td>Ps Cunderdin</td>
<td>Yellow sands and grey sandy gravels</td>
</tr>
<tr>
<td>Ps Eaton</td>
<td>Pale sands and gravelly sands</td>
</tr>
</tbody>
</table>
0.0 km Start at the car park at the Northam Department of Agriculture and Food. Zero your car odometer and drive east on the bypass road to Merredin.

3.4 km—Stop 1 GPS zone 50 0472489E/6499739N. Stop at the road cutting for a good example of Jimperding metamorphic belt gneisses, the Jelcobine system, rocky hills subsystem and rocky red brown loam. Note the topsoil variation as related to the underlying rock.

Drive east towards Meckering. You will be driving through the Jelcobine system York subsystem (York land unit). Note that the subsystem and land unit names are identical in this area. Also note the dissected landscape, frequent rock outcrops and brown soils with York gum and jam vegetation that is characteristic of this unit.

8.2 km—Stop 2 You are crossing the confluence of a Hamersley subsystem, narrow (often V-shaped) waterways and the larger Avon Valley subsystem valley that widens out downstream to contain the alluvial valley soils.

18.2 km—Stop 3 As you go upslope where the road curves to the right, you will notice a change in landscape and vegetation to the Morbinning land system (mainly lateritic soils) and Ewarts subsystem (dissected laterites). Note the pale soils, frequent pallid zone outcrops and mallee/wandoo vegetation. Note also that the York gums on the road reserve have been planted. The main soils here would be shallow hard-setting grey sandy loam over clay, shallow sandy duplex and—on the slopes—deep sandy surfaced duplex.

At 18.8 km turn left on to Watson Road.

—Stop 4 (near an old tractor). GPS 0486969E/6500176N. Note the exposed sandy gravel profile on the road cutting. A change in soil type from duplex sandy gravel on the rise zone to grey sandy duplex towards the tractor is displayed in the exposed profile. Changes in soil type over short distances are not unusual in this unit, with the main soils here being shallow and deep sandy duplexes with sandy gravel topsoil on rises.
Turn left at the T-junction. As you approach Moore Road you will see a ‘machinery graveyard’ in a disused sand quarry. This is an aeolian (Eaton) sand deposit. Note the banksia/rock sheoak vegetation.

Turn right on to Moore Road. Note the change in vegetation from banksia-rock sheoak to York gum (occasionally found on winter moist duplex soils) then mixed salmon gum-wandoo vegetation in the Throssell nature reserve. This reserve (21.9 km—Stop 5 GPS 486507E/6501351N) has a mixture of shallow and deep lateritic sandy duplex soils, with salmon gum indicating shallow duplex and wandoo and rock sheoak on deeper duplexes. Salmon gum and wandoo can have similar trunks but can be easily differentiated by looking at the leaves and branches.

As you leave this stop, note the change in soil and vegetation as you pass from Ewarts unit to the smooth sandy lateritic Quailing unit. Note the pale sandy soils with parrot bush (Dryandra sessilis) on sand over gravel soil, acorn banksia (Banksia prionotes), slender banksia (Banksia attenuata) and planted tagasaste on deep sand patches.
Sites A, B, C, and D have been chosen to illustrate the relationship between landscape and land surfaces.

Figure 48 Land units and location of sites 5 A, B, C and D and site 6

At each of these sites practice using your decision aids, work your way through the categories at each site using a blank site investigation sheet to describe the landscape and soils. After you have reached your conclusion, compare it with the completed site investigation sheets for this site at the end of this document.

**Site A—23.3 km** 488475E/6503142N. Just west of the breakaway. Note the Christmas tree

**Site B—24.1 km** 88637E/6503296N. Below the breakaway

**Site C—24.6 km** 488988E/6503620N. York gums at the T-junction with Meenaar North Road

**Site D—25.3 km** 488674E/6503907N. Meenaar North Road on the right-hand side just past a gravel pit on the left.

As you are leaving site D, note that you are passing over the breakaway onto the stony gravel laterite with characteristic tamma and dryandra vegetation, and then into a very slight dip (a hidden breakaway) to wandoo sandy duplex soils.

**26.6 km—Stop 6** 0488041E/6504959N. Note the change of landscape to dissected with large rock outcrops. This is the Greenhills system-rocky hills subsystem. Note the smooth granitic rocks that are common in this system (in contrast to the more mafic metamorphic rocks of the Jelcobine system) and sandy mixed York gum-jam-rock sheoak vegetation. The quartz-rich granite has weathered to pale gritty sand soils.

You then go back into the Morbinning system, Ewarts subsystem with gravelly and grey duplex lateritic soils. Note the soil and vegetation changes from tamma scrub on gravelly soils to wandoo on sandy duplex soils formed from pallid material.
Figure 49 View of Site 6 showing coarse sandy granitic soils and exposed granite

**28 km—Stop 7** 487053E/6506897N. Note that you are moving onto a mafic gravel ridge with a gravel pit on the left-hand side. You are crossing breakaways as you pass over the ridge with characteristic grey duplex soils and mallee-wando vegetation and pallid zone fragments on the surface. You will also notice a salmon gum with the wando. Although there is no apparent change in soil type, there would be shallow, probably calcareous clay from weathered rock near that spot. Notice the frequent tamma gravelly rise interspersed with wando sandy duplexes.

**29.8 km—Stop 8** 486748E/6507721N. Here is tamma (and sphere banksia) sand over gravel over reticulite. If you look at the edge of the road, you can see where the road grader has revealed the surface of the reticulite layer of this soil. This can be a handy way of verifying a gravelly soil where roads have not had road-making material brought in. Note how the vegetation changes downslope to rock sheoak, indicating a change to deeper sand topsoil.

**32.8 km** Turn left at Southern Brook Road and then right into McManus Road. When the road turns right there is an excellent view of the dissected valley of the Greenhills system, and the escarpment to the north which is a Morbinning system breakaway, with lateritic and aeolian soils further to the north. As you proceed west and come to a right-hand bend there is another good view of the granitic Greenhills system (the valley is most likely following a large fault that passes ES/NW through Meckering). On the horizon is a line of hills that is part of an uplift (the boundary of the Jelcobine system) and is on the east of a fault that is now the Mortlock River north branch.
36.1 km Turn right at the golf club and drive up O’Neill Road.

38.7 km—Stop 9 482192E/6512545N. Turn right up Minney Road. This road provides an excellent opportunity for you to use the indicator vegetation guide and to see the close association between remnant vegetation and soil type. Note how the vegetation varies between tamma scrub gravels, wandoo gravelly duplex, York gum and jam loams, and banksia/woody pear yellow sands.

Just past the ‘Seldom Seen’ homestead is a gravel pit that shows yellow loamy sand over gravel profile. The laterite here has not developed to great depth as evidenced by the salmon gums to the west below the breakaway. On the breakaway face you will notice red flowering mallees (*E. erythronema* white flowering form) and *E. arachnea* growing. This is a good example of mallees being well adapted to loam/clay soils with poorer water-holding capacity due to shallow rock, or poorer clays associated with mottled or pallid zone materials.

Further on where Minney Road turns to the left, you can see the undulating sandplain of the Philips system that stretches all the way to north Cunderdin. To the right is a breakaway with *E. macrocarpa* mallee growing on the edge of the east-facing breakaway. This is a sandplain mallee that often grows in sandplain (yellow sand and yellow sand over gravel, and sometimes white sandy gravels near breakaways).

Return down Minney Road and then turn right back onto O’Neill Road. Follow O’Neill Road until the T-junction where it meets Jennapullen Road (50.3 km). This is the boundary between the Greenhills and Jelcobine systems. Turn left and proceed south.

52.7 km—Stop 10 0477904E/6508955N. Note the mafic gravel pit. This is at the base of a large north–south trending banded ironstone ridge.

53.6 km Turn right onto Southern Brook Road and proceed west. Note the more rugged Jelcobine system with very variable soils formed from Jimperding metamorphic belt rocks.

62.6 km Turn right onto the Northam Goomalling Road and proceed south.
March 2010

70 km Arrive back at the Northam Department of Agriculture of Food.

Appendix 1 Site A

<table>
<thead>
<tr>
<th>Drainage zone</th>
<th>RDZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator vegetation</td>
<td>Christmas tree (<em>Nuytsia floribunda</em>), parrot bush (<em>Banksia sessilis</em>)—this seems to prefer gravelly sands in the RDZ), roadside tea tree (<em>Leptospermum erubescens</em>), and tamma (<em>Allocasuarina campestris</em>). There is also sandplain pine (<em>Actinostrobus arenarius</em>) that is more common on deep yellow sands. See page 38.</td>
</tr>
<tr>
<td>Where are you in the landscape?</td>
<td>On a smooth ridge with grey sandy topsoil just before a breakaway. Lateritic upland, sandy surface</td>
</tr>
<tr>
<td></td>
<td>Quailing unit, Morbining system, Quailing subsystem</td>
</tr>
<tr>
<td>Fragments on the surface</td>
<td>A few scattered gravel stones, loose sandy surface</td>
</tr>
<tr>
<td>Other clues</td>
<td>There is some revegetation on the north side of the road, and rabbit burrows indicating a deep sandy soil</td>
</tr>
<tr>
<td>Your conclusion on the landscape and soil(s)</td>
<td>A hole on the north side of the road had more than 80 cm pale sand, but it is shallower to gravel to the south and closer to the breakaway</td>
</tr>
<tr>
<td></td>
<td>Pale deep sand and pale sand over gravel soils (see pages 74, 77)</td>
</tr>
</tbody>
</table>

Figure 50 Site A
## Appendix 2 Site B

<table>
<thead>
<tr>
<th>Drainage zone</th>
<th>RDZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator vegetation</td>
<td>Mainly wandoo. However, note that the vegetation gradually includes more salmon gum and jam downslope, which indicates shallower and more fertile soils</td>
</tr>
<tr>
<td>Where are you in the landscape?</td>
<td>Upper slope below a breakaway. Dissected landscape sandy surface but the salmon gums indicate a change in basement rock downslope</td>
</tr>
<tr>
<td>Fragments on the surface</td>
<td>Loamy sand surface soil</td>
</tr>
<tr>
<td>Other clues</td>
<td>The road cutting and spur drains indicate at least 40 cm sandy soil</td>
</tr>
<tr>
<td>Your conclusion on the landscape and soil(s)</td>
<td>At the stop the soil is a fairly typical slopes, grey deep sandy duplex soil but the paddock also contains slopes, grey shallow sandy duplex (see pages 81, 82)</td>
</tr>
</tbody>
</table>

Figure 51 Site B
### Appendix 3 Site C

<table>
<thead>
<tr>
<th>Drainage zone</th>
<th>RDZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator vegetation</td>
<td>Mainly York gum and jam</td>
</tr>
<tr>
<td>Where are you in the landscape?</td>
<td>Adjoining a minor valley. Dissected landscape mafic here</td>
</tr>
<tr>
<td>York unit, Morbinning system, York subsystem</td>
<td></td>
</tr>
<tr>
<td>Fragments on the surface</td>
<td>Dolerite outcrops and boulders. Brown loamy surface</td>
</tr>
<tr>
<td>Other clues (e.g. dams, sand or gravel pits, road cuttings, rock outcrops, erosion, salinity or waterlogging)</td>
<td></td>
</tr>
<tr>
<td>Your conclusion on the landscape and soil(s)</td>
<td>Loam soil. Rocky red brown loamy sand/sandy loam (see page 88)</td>
</tr>
</tbody>
</table>

Figure 53 Site C
### Appendix 4 Site D

<table>
<thead>
<tr>
<th>Drainage zone</th>
<th>RDZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator vegetation</td>
<td>Dryandras upslope, tussock grass, some rock sheoak, some tamma, some wandoo</td>
</tr>
<tr>
<td></td>
<td>Note the jam growing opposite the site in the gravel pit which is a volunteer that colonised after the pit was dug</td>
</tr>
<tr>
<td>Where are you in the landscape?</td>
<td>This is a bit tricky as dryandras on the ridge mark the edge of a breakaway that has been hidden by sandy colluvium that comes down to the investigation site. So, using the simple landscape model, it could be described as dissected. On the other hand, the area is a smooth lateritic colluvial surface, and there is a marked change of slope downslope with the change to wandoo on Ewarts sandy duplex soils as in site C (and it probably fits better in the smooth lateritic category)</td>
</tr>
<tr>
<td></td>
<td>Quailing unit, Morbinning system, quailing subsystem</td>
</tr>
<tr>
<td></td>
<td>Sand colour, fragments and the gravel pit all indicate sand derived from mafic lateritic material</td>
</tr>
<tr>
<td>Fragments on the surface</td>
<td>Iron-rich gravel on the surface upslope. Loamy sand surface</td>
</tr>
<tr>
<td>Other clues</td>
<td>Gravel pit downslope on the opposite side of the road with iron-rich gravel</td>
</tr>
<tr>
<td>Your conclusion on the landscape and soil(s)</td>
<td>Yellow gradational loamy sand (see page 76)</td>
</tr>
</tbody>
</table>

Figure 54 Site D
Southern Brook East case study.

Figure 55 shows very gently undulating Eaton unit sandplain (Philips soil landscape system) with a sluggish drainage system between the sandy uplands. In the bottom corner, erosion has cut through the sandplain with soils formed from dissected laterites and weathered igneous rocks (Greenhills soil landscape system). Numbers on the map indicate stops that you can locate with your car odometer or GPS. The arrows indicate the direction in which the photo has been taken.

For example, the arrow below indicates that the photographer was facing the right.

Figure 55 Map showing stops and land mapping units

Travel on the Goomalling road from Northam and turn right on to southern Brook road.

0.0 km Stop 1 GPS zone 50 487189E/651055W. Corner of Southern Brook and Draper roads.

Figure 56 Stop 1 views
View 1A to the NW shows a breakaway, above which is sandplain of the Eaton unit. Below the breakaway are mainly dissected laterites and gravel residuals of the Ewerts unit. You can see the layered foliage of salmon gums in the distance that indicate patches where erosion has revealed mafic rocks with clay loam soils. Note that soils on dissected landscapes are very variable often having intermixed lateritic and igneous rock soils, or a colluvial mixture of both.

View 1B shows a typical granitic outcrop with mainly brownish grey granitic soils and coarse grey granitic sand.

1 km Stop 2  48999E/6511127N. Figure 57 shows a view to the north of gravel soil of the Ewerts unit leading up to a mallee wandoow breakaway on the top right, with a gravelly area exposed in the foreground. On the top left you can see a granite outcrop with York gum-jam vegetation of the Rocky Hills unit that is exposed about half way down the slope.

Figure 57  Stop 2

1.4 km Stop 3  488531E/6510912N. View 3A is at the stream channel showing the active V shaped Hamersley valley unit.
These waterways are mostly saline (note the dead York gums) and often waterlogged (note the sedges). Distinctively shaped jam shrubs can be seen in the right background. View 3B is from the lower York unit slope just past the waterway (note the York gum trees).

4.5 km Stop 4 491216E/6511513N. This is mapped as the York unit, but the wandoo duplex soil formed from pallid zone (shallow hard setting grey sandy loam over clay; page) clearly indicates that it is Ewerts. Most soil mapping was done by a mixture of aerial photo interpretation and field checking, and can miss small areas of variation. Note the pallid rock residuals indicating that this soil is shallow with poor water holding capacity.

Figure 59  Stop4

4.7 km. Stop 5 GPS491847E/6511752N. Figure 60 shows a view to the west of a slope that marks the limit of dissection of the Eaton sandplain (behind the viewer) by the active waterways of the Greenhills and Morbinning soil landscape systems in the valley below. Note the York gum-wandoo remnant vegetation in the valley and the sandy surfaced Ewarts unit (Morbinning soil landscape system) soil in the foreground. A gravel subsoil bank indicates that the soil here is probably shallow pale sand over gravel.

Figure 60  View from stop5 to the dissected valley of the Morbinning and Greenhills systems

6.1 km Stop 6 492506E/6512215N. You have now moved on to the Eaton unit sandplain (Philips system).

Figure 61 shows a granite outcrop with a tiny patch of granitic soil (York unit,) surrounded by sandplain. In this view the granite is the residual of a larger outcrop that has been partially buried by aeolian deposits.
Landscapes and soils of the Northam district

7.9 km Stop 7  493171E/6512505N. This is a good example of subdued pale aeolian Eaton sandplain. Soils have moderately poor water holding ability, and rainfall leaches past the crop root system to emerge in valleys and footslopes as seepages.

Note a soak excavated from seepage is on the right and a tagasaste plantation on pale deep sand on the left. The wheat crop in the foreground is probably better than usual as the season has had adequate rainfall, but no heavy winter rain to leach nitrogen from the root zone.

9.1 km Stop 8  495381E/651296N. Figure 63 shows a typical flat bottomed wet and saline sandy duplex valley draining the Philips sandplain. This is the Mortlock unit (Gomalling system)

Soaks are common on the sides of these valleys. Fringing vegetation has been planted by the farmer with volunteer sedges and samphire in the winter wet flats.
Turn around and turn right on the Meckering Goomalling Road.

9.1 km Stop 9  489780E/6516590N. View 9A shows a view to the south of aeolian yellow (pine and pear) sandplain with a wet sandy duplex valley. The main soil is yellow deep sand (page 75). This soil has a better water holding capacity than the pale sands with good yield potential for crops and deeper rooted legume pastures. These soils are still liable to leaching and there are good underground water supplies in these landscapes. Note the grevillea shrubs on the mid and lower slopes of the road.

In view 9B you can see a pale sand ridge in the distance. Soils are mainly pale sand over gravel, loamy sand and pale deep sand. A large tagasaste plantation is on pale sand in the broad saddle.

End. Return to Northam.
Mawson case study

This example is located in the RDZ, SW of Mawson on the York–Quairading Road.

The area is hilly, partly because it is in the Mawson uplift area where land is slowly rising due to tectonic activity associated with the south west seismic zone. (Dentith and Featherstone 2003). Soils have formed from both mafic and granitic laterites and the underlying igneous rock in the Morbinning soil landscape system.

- **Ewerts unit** (Green), soils formed mainly from dissected laterites
- **Quailing unit** (brown), mafic and sandy gravels and some sandplain
- **York unit**, Soils formed from igneous rocks.
- **Hamersley and Mortlock units. blue** waterlogging and salinity prone waterways

![Map Image](image)

Figure 65  **Mawson case study stops: land unit image (top); aerial photo image (above)**

Numbers on Figure 65 indicate stops that you can locate with your car odometer or GPS. The arrows indicate the direction in which the photo has been taken.
Photos at the stops were taken either in summer, or after heavy autumn rain.

**0 km Stop 1A** Start at the junction of start at corner of York–Quairading and Draper Roads. GPS zone 50 509827E/6460628N.

Figure 66 shows a view from the corner of a Ewerts unit mixed grey sandy duplex soils with a quartz ridge in the background. Drive south on the York–Quairading Road.

**0.4 km Stop 1B** 510245E/6460676N. This is on the crest from the quartz ridge. Quartz ridges usually have wandoo vegetation, but this one has both wandoo (bunchy branches) and salmon gums (layered shiny vegetation). The ridge adjoins a mafic area, so there is probably soil from mafic rocks beside the quartz vein. On the slope on the east side of the road a trench revealed a profile of the poorly structured shallow hard setting grey sandy loam over clay (see page 89).
1.04 km **Stop 2** 510914E/646065N. At this stop in Figure 65 you can see red streaks that indicate soils derived from mafic rock. This stop illustrates a mafic phase of the Ewerts unit with a mafic ridge that was originally lateritised and then eroded.

Salmon gums are growing on sandy loam over clay (see page 88), a colluvial soil formed from mainly mafic rocks. The red morrel trees on the ridge are on the eroded and modified laterite. The soil is a hard setting clay loam over orange brown alkaline clay with numerous lime nodules. The inset image in Figure 68 shows mixed mafic gravel, lime nodule and dolerite fragments on the soil surface.

Upland morrel soils often have dense neutral to slightly acidic gravelly soils as in stop 11b. All morrel soils have a high phosphate retention index.

Veer west on to Murray Road.

1.74 km **Stop 3** 511441E/6460541N. Figure 69 shows the westward view of a Mortlock unit valley, loamy sand surfaced duplex soils and mixed York gum wandoo vegetation. The valleys in this landscape are susceptible to waterlogging and salinity.

---

Figure 68  **Stop2: Salmon gum (left) and red morrel with morrel soil surface inset (right)**

Veer west on to Murray Road.

Figure 69  **View down the main Mortlock unit valley from stop 3**
3.3km . **Stop 4** 512642E/6458992N. This stop shows a range of soils in the Ewerts unit.

View 4A shows a wandoo sandy duplex slope, with mainly deep sandy duplex and loamy sand surfaced duplex soils. In the valley beyond the wandoo patch the landscape changes to mixed soils from igneous rocks of the York unit.

View 4B looks south down the wandoo sandy duplex slope to granitic soils of the York unit that has mixed wandoo-salmon gum-York gum forest. Main soils are brownish grey granitic soil and rocky red brown loamy sand / sandy loam (pages 85, 86). Note that there has been a better germination on the granitic soils than deep sandy duplex soils in the foreground.

View 4C looks east from the sandy duplex in the foreground up to the large breakaway in the background. The breakaway ranges from mafic on the left (note the salmon gums) to granitic on the right. Soils closer to the breakaway are mainly shallow sandy and loamy duplexes.

At the road junction turn left up the Beverley-Mawson Road.
5.1 km Stop 5  513842E/6458613N. The view south on the right hand side of the road shows a typical deep sandy duplex soil with wandoo vegetation.

![Image of Stop 5 view]

5.6 km Stop 6  514101E/6458645N. Figure 72 shows a view south of the crest of the saddle with sandy duplex soils formed on gneissic pallid zone that is exposed in the road cutting (6B). Brown mallet (*E. astringens*) is growing slightly downslope to the right (6C). This is commonly found on breakaway faces usually on mottled zone soils. It can be confused with salmon gum but note the Y shaped branching form that is typical of mallets, the shiny “bunchy” leaves and brownish scaly bark.

From stop 6, drive further down the road to driveway on the left for safe turning at 6.8kms. Turn around and drive west.

![Image of Stop 6: 6A view across the saddle; 6B road cutting; 6C brown mallet]

10.5 km Stop 7  511924/6457488. View south from the Beverley Mawson Road of mixed lower slope soils to a saline waterway of the Mortlock with the lateritic Ewerts unit soils on the ridge.
July 2009

Note the large parallel ridges that mark a fault.

Figure 73  Stop 7

11.4 km  Stop 8  509629E/6456638N. This is a view of a granite outcrop with York and rocky hill units.

Turn left up McDonalds Road.

14.3 km  Stop 9  509869E/645565N. This stop shows a mafic ridge in the background with a buckshot gravel slope leading to a breakaway on the right. Note the varied vegetation described in Figure 74.

Rock sheoak and Proteaceae heath indicates change to sandy laterite.

Wandoo

Mottlecah, often on lateritic yellow loamy sand

Grass tree “Balga” sandy gravels and gravels in RDZ

Mallee. Often on shallow or hard setting soils near breakaways

Figure 74  Stop 9

15.4 km  Stop 10  510339E/6454766N. This stop is below a mafic breakaway with a mixed Ewerts and York units view. In the foreground is a patch of red brown doleritic clay (page 89) where the land surface has been eroded down to the underlying dolerite.

Downslope are mixed colluvial soils from lateritic and fresh rock erosion products.
Figure 75  **Stop 10 view east to the valley**

On the left note the line of pale sand, that has spilt down the slope to mix with other material and form sandy duplex soils. Note also that summer rain germination is better on the loams than the sands or clays.

Turn around from stop 12, turn left at the Beverley Mawson Road and then right down Balkuling Road.

**18.8 km Stop 11**  509105E/6457428N. Views from this stop shown in Figure 76 illustrate how quickly the soils can change in this area.

Figure 76  **Stop 11 views**

View 11A: Hard setting loamy duplex soils below a mafic breakaway with wandoo, salmon gum morrel forest.
View 11B: Morrel rise with loamy gravel vegetation grading to wandoo sandy duplex
downslope and then salmon gum clay loam on the far rise.

View 11C. Red brown doleritic clay with salmon gum forest.

18.8 km Stop 12  509265E/6457751N. Red brown doleritic clay in foreground grades to red
brown loamy soils and then the dam that is on a change to loamy sand surfaced duplex.
Note the brown clay on the drainage bank to the right of the dam, and the pale lateritic clay
on the left. Also note the poorer germination on clay soil than the duplex.

Figure 77  Stop 12

35.8 km Stop 13  GPS516990E/6455384N is on the other side of the ridge at the southern
end of the catchment. To get there continue down Balkuling road, turn right and then right
again on the York Quairading Road. Turn right on to Jacob’s Well road, then right on to
Clulow Road. Drive until you see the pine plantation on the right shown in Figure 78 that has
been planted on spillway deep pale sand (Quailing unit page59) derived from surrounding
sandy laterite ridges. At the road, the soil is grey deep sandy duplex.

Figure 78  Stop 13

End. Return to Northam.
Case study: Darling Range south west of York

Figure 79 shows the eastern edge of the Darling Range south west of York.

On the left side of the map is the uplifted plateau of the Darling Range with the residual Kokeby unit river sediments (see page 69). On the right side of the map, the plateau has been dissected by south east flowing streams, with soils formed from dissected laterites and underlying granites, gneisses and dolerite. Numbers on the map indicate stops that you can locate with your car odometer or GPS. The arrows indicate the direction in which photos has been taken.

For example, the arrow below indicates that the photographer was facing the right

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0.0 km Start at the junction of Talbot and Talbot Hall roads. Note the dolerite rocks on the left as you leave.

0.2 km Stop1 GPS zone 50 46926E/6459418N.Yalanbee gravel ridge with marri, powderbark wandoo, and wandoo forest (see page 65). Note the buckshot gravel profile in the road cutting.
0.6 km Stop 2 GPS 465981E/6459045N. Leaver unit (see page 66). A Leaver unit slope below a breakaway behind you grades to Michibin downslope. Soils are variable due to mixed lateritic and granitic parent materials. Note the granitic dams on the right. Soils here are pale sand over loamy sand/gravel, and deep sandy duplex. Waterways and depressions are often winter waterlogged.

2.7 km Stop 3 GPS 466338E/6457554N. Michibin unit (see page 67). Shallow quartz rich granite outcrop with coarse granitic sand and brownish grey granitic loamy sand soils with marri-rock sheoak -wandoo vegetation. York gums occur downslope on loamier soils.

Soaks are frequent in these granitic sandy soils

4.1 km Stop 4 GPS 465106E/6457046N. Williams unit (see page 68). This valley has mixed colluvial soils with frequently waterlogged and saline areas. Note the flooded gums in the mildly saline and waterlogged waterway.
Stop 4: Note the soil variation along the earthen bank

Turn right on to West Talbot Rd then left into Luelfs Rd.

6.4 km Stop 5  463424E/6456196N. Figure 84 shows a view from a Kokeby or Sheahan sandy valley (pale deep sand soils and Banksia-marri-wandoon-Christmas tree vegetation) to a Yalanbee gravel ridge (buckshot gravel and yellow gravelly loamy sand with jarrah marri vegetation) in the background.
6.9kms. Stop 6  463069/6455866. Remnant paleochannel sands.

Sandy soil in the ancient river sediments have poor water holding capacity. Water leaches from these soils and collects as shallow fresh watertables in the poorly drained valleys. Note banksias and melaleucas on the road, and the flooded gums around the lake.

11.1 km  Stop 7  GPS 462757E/6455521N. Figure 86 shows a Yalanbee buckshot gravel in foreground, and Michibin dissected valley with sandy duplex soils in the background. Note the dam in Michibin granitic / lateritic clay and contour banks and granite outcrops on the more erodible soils of the far slope.

Return to West Talbot Rd and turn left
11.1 km Stop 8  GPS 462310E/6457908N. Kokeby pale sand over gravel. This is a sandy laterite formed on ancient sandy river sediments with pale grey sand surface over pale sand with yellowish sandy ironstone gravel over a pale sandy clay mottled zone. Vegetation here is open wandoo and marri woodland.

Figure 87  Stop 8 Gravel pit on a sandy laterite formed from sandy sediment

12.7 km Stop 9  GPS 461318E/6458991N. Kokeby pale sands at foot slope with banksia woodland.

Figure 88  Stop 9 West Kokeby deep pale sand

End: Return to Northam.
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Glossary

Adamellite A form of granite with roughly equal calcium and potassium-bearing minerals.

Alluvium Material transported and deposited by flowing water such as rivers.

Bleached layer Subsurface soil that is white, near white or much paler than adjacent soil layers, caused by the leaching of soil minerals.

Breakaway A landform found on the edge of a plateau or plateau remnant, where a relatively flat lateritic upland ends abruptly in a low scarp above a debris slope.

Colluvium Materials transported and deposited by gravity.

Craton A large stable mass of the Earth's crust.

Crystalline rock An igneous or metamorphic rock consisting of interlocking crystals, e.g. granite or gneiss.

Dispersion or clay dispersion The complete breakdown of aggregates into sand, silt and clay-sized particles when wet and usually occurs slowly, often taking hours to complete. The dispersed clay can block pores, reducing rainfall infiltration and gas exchange. A characteristic sign of dispersion is muddy or cloudy water, the cloudiness being dispersed clay in suspension.

Dolerite A medium grained basic igneous rock that has crystallised near the surface, typically occurring as a dyke, sill or plug.

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Dyke A sheet-like body of igneous rock cutting across the bedding or structural planes of the host rock. They typically appear on the surface as relatively narrow, linear features.

Effective rooting depth Refers to the rooting depth of the soil in which plants may have an unimpeded path until an obstruction such as a dense layer of clay or rock is encountered. It is only approximate, as good subsoil structure may allow more root penetration.

Erosion The wearing away of the land surface and removal of soil by running water, rain, wind, frost or other geological agents.

Fault A fracture in rock along which there has been movement.

Felsic (acidic) rock Crystalline rock with a high content of silica and light coloured minerals, e.g. granite. Cf. Mafic.

Ferricrete A layer of material strongly cemented by iron which looks like rock, or a dense ironstone gravel layer.

Gabbro A coarse-grained mafic igneous rock similar to dolerite.
| **Gilgai surface relief (or crabhole country)** | Gilgais are irregular small depressions (20-60 cm deep) and mounds separated by level or gently sloping land. They are caused by soils with shrink-swell properties. |
| **Gneiss** | Distinctly foliated generally coarse-grained igneous rocks formed through high grade regional metamorphism. Gneisses and banded granites are often confused (Lane P 2004). |
| **Granite** | A coarse-grained igneous rock consisting essentially of quartz (20 to 40%), feldspar and very commonly mica. |
| **Gravel** | Any coarse mineral material or fragments from 2 to 60 mm in diameter. These could be ironstone, quartz, other rock fragment or any concretions or nodules. |
| **Horizons** | A term used to describe individual layers in a soil profile. Each horizon has morphological properties different from those above and below it. |
| **Indurated layer** | A layer of material hardened by cementation or pressure. |
| **Intrusive rock** | Magma that has not reached the rock surface before cooling. |
| **Landscape** | Part of an area of land that is characterised by processes of erosion, weathering, sedimentation, and movements in the earth's crust. It includes all identifiable and measurable features such as climate, geology, soils and land use. |
| **Laterite** | The lateritic profile typically consists of sand or gravel on top of a ferruginous duricrust where the iron oxides have accumulated. This often overlies a mottled clay and then a pallid zone (white clay on acidic laterites) from which the leaching has occurred. |
| **Lineament** | A major, linear, topographic feature of regional extent of structural or volcanic origin; e.g. a fault system. |
| **Lime (or calcium carbonate)** | Usually found in heavier soils that are alkaline. Lime can be present as soft segregations or nodules, or be finely mixed through the soil. The presence of lime can be detected with a simple test using dilute acid (1M hydrochloric). Drops of acid are placed on a clod of soil and if lime is present the soil effervesces immediately (i.e. bubbles of gas are released), due to the release of carbon dioxide. |
| **Loam** | A medium-textured soil of approximate composition 10 to 25% clay, 25 to 50% silt and less than 50% sand. |
| **Igneous rock** | Those that have been crystallised by magma or become “plastic” due to heat and pressure. |
| **Map unit** | A representation of a soil or group of soils, that occurs within an area. A soil-landscape area is a topographic unit (e.g. low hills and rises or a level to gently undulating plain) that contains a series of common soil units. These units can be found on the corresponding soil-landscape map produced for the area. |
| **Mafic (basic) rock** | Rock with a major component of ferromagnesium (dark coloured) minerals. Cf. Felsic. |
| **Mesa** | Isolated table-top hill with steep sides. |
| **Metamorphic rocks** | Rocks which have been altered by heat and/or pressure. |
Migmatite

Rock composed of two sources: the metamorphic host rock and an invading granitic material.

Mottles

Patches of different colours, often red, brown, orange or blue-grey spots in a soil horizon.

Orogen

A zone of weakness in the earth’s crust along which movement and deformation has taken place during a period of tectonic plate movement. The rocks of an orogen may include deformed and reworked older cratons as well as new volcanic and sedimentary rocks.

Pallid zone

White to pink kaolinitic clay formed in the lower part of the lateritic profile.

pH

Measures the concentration of hydrogen ions in the soil. The pH is measured on a logarithmic scale (i.e. $\text{pH} = \text{negative logarithm of concentration of hydrogen ions}$). A soil with a pH of 5 contains 10 times as many hydrogen ions as a soil with a pH of 6.

Two systems are commonly used to measure pH, one in calcium chloride solution and the other in a soil:water suspension. As a general rule, to convert from pHw to pHCa, subtract 0.8, although the difference can range between 0.6 and 1.2, and in extreme cases from 0 to 2.

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Plateau

A level to rolling landform pattern of plains, rises or low hills standing above a cliff or escarpment.

Plutonic rock

Large masses of crust rock re-melted at least 10 km deep.

Profile

A soil profile is a vertical exposure of soil extending from the surface to the decomposing rock or other underlying consolidated material.

Quartz

A mineral composed of silicon dioxide (main component of sand).

Regolith

All material including the soil from bedrock to the surface.

Reticulite

Indurated layer in a laterite profile, usually with residual root channels.

Relief

The difference in elevation between the high and low points of a land surface.

Rooting condition

Refers to the soil volume available for plant roots and the mechanical impedance to root development. Soil volume can be reduced by rock and gravel content, by dense pans and clay layers.

Salinity

The presence of high concentrations of soluble salts in the soil. It is estimated from the electrical conductivity of a mixture of soil and water.

Saprolite, saprock

Soft, more or less decomposed rock remaining in its original place.

Sedimentary deposits

Materials which have been moved from their site of origin by the action of wind, water, gravity or ice and then deposited. When these materials become consolidated and hard they are known as sedimentary rocks.
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<td>Gravels or other accumulations of material which occur in the soil. They are formed by the concentration of some constituent by chemical or biological action. ‘Ferruginous’ describes concentrations of iron.</td>
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<td>Silcrete</td>
<td>Strongly indurated siliceous material.</td>
</tr>
<tr>
<td>Slaking</td>
<td>Slaking is the disintegration of aggregates (clods) into minute pieces when wet rapidly, because they cannot tolerate the stresses imposed by rapid water intake. Slaking causes the soil to slump and then it either sets hard on drying into a compact mass (hardset surface) or forms a surface crust.</td>
</tr>
<tr>
<td>Slope</td>
<td>An incline either upward or downward from the horizontal.</td>
</tr>
<tr>
<td>Sodicity</td>
<td>A measure of exchangeable sodium in the soil. Soils that are sodic have a high percentage of cation exchange sites occupied by sodium ions. Sodicity adversely affects the stability of the soil and increases the likelihood of the soil dispersing.</td>
</tr>
<tr>
<td>Surface condition</td>
<td>Usually assessed when dry and separated into several groups:</td>
</tr>
<tr>
<td></td>
<td>Cracking: Deep cracks at least 5 mm wide in summer due to shrink-swell clay minerals.</td>
</tr>
<tr>
<td></td>
<td>Firm: Hard but can be indented by pressure of the forefinger.</td>
</tr>
<tr>
<td></td>
<td>Hardsetting: Soil is hard when dry. A pencil cannot easily be pushed into the surface. The artificial aggregates formed after tilling, slake when wetted rapidly and the soil mass slumps and sets very hard on drying.</td>
</tr>
<tr>
<td></td>
<td>Loose to soft: Easily disturbed by pressure of the forefinger and does not hold together (e.g. loose sand).</td>
</tr>
<tr>
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<td>Surface crust: Distinct layer ranging from a few millimetres to a few centimetres thick, which is hard when dry and can be easily separated from and lifted off the soil below.</td>
</tr>
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<td>Texture</td>
<td>A measure of the proportion of sand, silt and clay-sized particles in a soil.</td>
</tr>
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<td>Truncated laterite</td>
<td>A lateritic profile where the upper layers have been stripped by erosion. Soils on truncated laterites have often formed from mottled or pallid zone materials.</td>
</tr>
<tr>
<td>Volcanic rock</td>
<td>Either ejected material or lava flow.</td>
</tr>
<tr>
<td>Waterlogging</td>
<td>Excess water in the root zone either present as a perched watertable or water ponded on the soil surface.</td>
</tr>
<tr>
<td>Water repellence</td>
<td>A condition which affects the wetting pattern of soils, especially sandy soils, and results in an uneven wetting pattern in autumn.</td>
</tr>
<tr>
<td>Weathering</td>
<td>Weathering is the physical and chemical disintegration, alteration, and decomposition of rocks and minerals at or near the earth’s surface by atmospheric and biological agents.</td>
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Glossary

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<td>Slaking is the disintegration of aggregates (clods) into minute pieces when wet rapidly, because they cannot tolerate the stresses imposed by rapid water intake. Slaking causes the soil to slump and then it either sets hard on drying into a compact mass (hardset surface) or forms a surface crust.</td>
</tr>
<tr>
<td><strong>Slope</strong></td>
<td>An incline either upward or downward from the horizontal.</td>
</tr>
<tr>
<td><strong>Sodicity</strong></td>
<td>A measure of exchangeable sodium in the soil. Soils that are sodic have a high percentage of cation exchange sites occupied by sodium ions. Sodicity adversely affects the stability of the soil and increases the likelihood of the soil dispersing.</td>
</tr>
<tr>
<td><strong>Surface condition</strong></td>
<td>Usually assessed when dry and separated into several groups:</td>
</tr>
<tr>
<td>Cracking</td>
<td>Deep cracks at least 5 mm wide in summer due to shrink-swell clay minerals.</td>
</tr>
<tr>
<td>Firm</td>
<td>Hard but can be indented by pressure of the forefinger.</td>
</tr>
<tr>
<td>Hardsetting</td>
<td>Soil is hard when dry. A pencil cannot easily be pushed into the surface. The artificial aggregates formed after tilling, slake when wetted rapidly and the soil mass slumps and sets very hard on drying.</td>
</tr>
<tr>
<td>Loose to soft</td>
<td>Easily disturbed by pressure of the forefinger and does not hold together (e.g. loose sand).</td>
</tr>
<tr>
<td>Surface crust</td>
<td>Distinct layer ranging from a few millimetres to a few centimetres thick, which is hard when dry and can be easily separated from and lifted off the soil below.</td>
</tr>
<tr>
<td><strong>Texture</strong></td>
<td>A measure of the proportion of sand, silt and clay-sized particles in a soil.</td>
</tr>
<tr>
<td><strong>Truncated laterite</strong></td>
<td>A lateritic profile where the upper layers have been stripped by erosion. Soils on truncated laterites have often formed from mottled or pallid zone materials.</td>
</tr>
<tr>
<td><strong>Volcanic rock</strong></td>
<td>Either ejected material or lava flow.</td>
</tr>
<tr>
<td><strong>Waterlogging</strong></td>
<td>Excess water in the root zone either present as a perched watertable or water ponded on the soil surface.</td>
</tr>
<tr>
<td><strong>Water repellence</strong></td>
<td>A condition which affects the wetting pattern of soils, especially sandy soils, and results in an uneven wetting pattern in autumn.</td>
</tr>
<tr>
<td><strong>Weathering</strong></td>
<td>Weathering is the physical and chemical disintegration, alteration, and decomposition of rocks and minerals at or near the earth’s surface by atmospheric and biological agents.</td>
</tr>
<tr>
<td><strong>Water availability</strong></td>
<td>Describes the amount of moisture in the soil that is available to be absorbed by plant roots.</td>
</tr>
</tbody>
</table>