Appendix A – Habitat and erosion potential of selected tributaries to the North Para and South Para rivers

GAWLER RIVER FLOODPLAIN MANAGEMENT STRATEGY

Habitat Condition and Erosion Potential of Selected Tributaries to the North and South Para Rivers

Prep. By

Eco Management Services Pty Ltd

For

Tonkin Consulting

April 2017

Our Ref 540/15

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GAWLER RIVER FLOODPLAIN MANAGEMENT STRATEGY

Habitat Condition and Erosion Potential of Tributaries to the North and South Para Rivers

1.0 Introduction

As part of the Gawler River Floodplain Management Strategy, a high level assessment has been made of the terrestrial and aquatic habitats of the tributary watercourses of the North and South Para Rivers, which are within the Gawler 30 urban development zone, identified in the Adelaide Metropolitan 30 Development Plan, shown on Figure 1. The scope of work carried out was as follows:

- Limiting the watercourse assessment to watercourses within the area defined in the 30 Year Plan;
- Providing an assessment of the main (second order and above, excluding main North and South Para) channels only and excluding the tributaries to these channels (first order watercourses), many of which are likely to be filled and piped in development of the land;
- Review of available information on these watercourses from existing databases and reports. .
- Review of aerial photography to determine water course type, vegetation cover and other visible issues;
- Selected field visits for verification of information obtained from the aerial photography;
- Summarising the stream condition (in reaches) for inclusion in the Stormwater Management Plan

Following the review of the draft report, additional locations examined included:

- West of Lundie Crescent
- West of Lundie Crescent
- Two small tributaries in the area of potential industrial development west of Sturt Highway
- Green Gully
- Open sections of watercourse downstream of McLean Road, Congdon Street and East Terrace

Overall, the intent is to generally provide a snapshot of the condition of the watercourse and available terrestrial and aquatic/riparian habitats.

In addition:

- Provide a high level erosion risk assessment of Tributaries 1, 4 to 13, 18 and 19.

2.0 Overview of Habitat Quality

2.1 General Description of Tributaries within Study Area

The study area is located within the Adelaide Plains (northern), described as a relictual landscape, which is extensively modified with a remaining vegetative cover of <10%. The headwaters of the small tributaries are in the Hills Face Foothills are described as being disproportionally cleared and a fragmented landscape with native vegetation cover below the 30% extinction threshold (DEH, 2009).

The small tributaries in the study area are mostly small 1st, 2nd or third order streams and are gullies with rocky headwaters and outcrops and/or drainage lines in grassy woodlands which drain down more gentle slopes (<20^{o}).

LEGEND

Photo locations and number

Upper reaches

Lower reaches

Water course

1 Tributary number

NORTH PARA RIVER

GAWLER RIVER

SOUTH PARA RIVER

Instream farm dam

Lower reach of tributary in gorge, some mature Eucalyptus camaldulensis with some minor regeneration and dominated by exotic species. Replanting undertaken and much scope for habitat enhancement. In upper section of this reach some aquatic pool habitat.

Lower reach of spring fed tributary 6 with linear swampy area dominated by Bolboschoenus sp and Juncus sp.

P31 P29 P1 - P8 P9 P10 P33 P34 P35 P37 P13 P36 P12 P11 P15 P16 P17 P18 P20 P21 P22 P23 P19 P24 P25 P26 P27 P28 P29

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

0 70 140 210 280 350

Meters

N

Eco Management Services Pty Ltd

GAWLER RIVER FLOODPLAIN MANAGEMENT PLAN
FIGURE 1

These tributaries have short term episodic seasonal flows. The occurrence of any habitat for aquatic fauna (macoinvertebrates) or flora (emergent, submergent) depends on whether there are more permanent spring fed flows/soaks, producing waterlogged or swampy conditions, or permanent or ephemeral pools. Generally, however, they are only generally seen as providing marginal aquatic habitat, and very unlikely to be important for native fish species.

With regards to the riparian and terrestrial habitat, the tributaries have been highly modified, with little of the natural habitat remaining, mainly as a result of clearing, urban development and grazing. Most of the watercourses are pasture areas dominated by introduced understorey species, with scattered tall shrubs and trees. There are occasional isolated stands of mallee box (*Eucalyptus porosa)* in gullies, and very occasional large remnant redgums (*E. camaldulensis*) in tributaries close to the North Para River. Much of the remaining vegetation is introduced woody weeds or amenity plantings of native and exotics. Planted and escaped introduced species, including olive, pepper tree, radiata pine and Aleppo pine also occur as tall shrub storey and overstorey species over pasture areas. Their value as native fauna (particularly mammals and reptiles) habitat is also reduced as a result of the level of modification and the increased presence of feral species and domestic cats and dogs, usually found within or adjacent urban areas. However, some of the older trees have hollows that potentially may be used by a variety of native parrots, possums or gliders.

2.2 Assessing Habitat Quality

2.2.1 Fauna and Flora Habitats

Watercourses in the southern Mount Lofty Ranges range from wide deep channels of permanent water, to faster flowing streams in steep gorges, to intermittent watercourses that collect water at the base of a gully without actually cutting a channel.

Watercourse vegetation can be described in terms of three zones. The **aquatic** zone within a watercourse carries normal flow, and includes the in-stream channel, and will be permanently or frequently under water or wet. The **riparian** zone is the strips of watercourse on either side of the aquatic zone, including the banks, where there is extra moisture associated with the watercourse flow. While the ground is often inundated during flood events, it is not constantly under water. This zone may be up to 30m wide and may include flats immediately adjacent to the channel that floods during high flow, The **outer** zone borders the riparian zone and includes areas that are rarely wet but where deep rooted perennials, herbs and grasses may benefit from groundwater and the extra soil moisture associated with the watercourse.

Most watercourses in the Gawler area have been greatly altered by stock grazing, increased nutrient loads, direct vegetation clearance, planting with non-indigenous varieties or water extraction. In many places, reeds, rushes and sedges have been some of the few native species able to survive along grazed waterways. Most waterways are now dominated by weed species including deciduous woody weeds like Willows and Ash. These weeds do not prevent erosion and they add excessive nutrients through their massive autumn leaf drops. Those watercourses that are now within the urbanised area have been largely replanted and are now managed as open recreation areas or private gardens.

Because the plants that are able to grow in these watercourses are those that are adapted to the specific and fluctuating soil water and inundation regimes, the same set of riparian plants are often found in different watercourses when the form and hydrology of the watercourse is similar, even if the overstorey trees differ.

Watercourses providing fauna habitat can be described based on the overstorey trees as well as on the shape of the valley and stream channel. The main forms in the Gawler region are:

a. Anthropogenic pasture in small and large gullies

The majority of the Gawler area has been grazed by domestic sheep, native and non-native herbivores and the pasture areas are dominated by introduced understorey species. Planted and escaped introduced species including olive, pepper tree, radiata pine and Aleppo pine and occur as tall shrubstorey and overstorey species over pasture areas with occasional isolated stands of mallee box. These areas provide little to no habitat for native species.

Small gullies and creeklines, some of which are tributaries of the South Para River, have some occasional remnant mallee box (*Eucalyptus porosa)*. Some of these older trees have hollows that potentially may be used by a variety of native parrots, possums or gliders.

b. Deep Channel with Big Gum Woodland

These are major watercourses that carry water from a large catchment and meander across gentle slopes and deep, usually fertile, soils. These big channels with deep pools, riffles and slow-moving water often have adjoining floodplains which take water during flooding. There is often substantial underground water associated with the larger channels. Consequently the flats stay moist all year and support large trees, like Red Gum, Blue Gum or Manna Gum over beds of sedges and rushes or tea-tree swamps.

Indicators of Good Condition Big Gum Woodland Deep Channel Watercourse

- The trees form open or closed woodlands. Trees are over 10 m tall and their canopies are clearly separated. The most common Eucalypts are Red Gum, Blue Gum, Pink Gum and Manna Gum.
- Smaller trees such as Drooping Sheoak, Native Cherry, Golden Wattle, Blackwood and Swamp or Wirilda Wattle form an under-tree layer.
- The banks of the watercourse contain a variable diversity and density of woody shrubs such as Silky Tea-tree, Swamp Wattle and River Bottlebrush.
- Rushes and sedges are diverse and abundant.
- Within the stream, aquatic plants such as Water Ribbons (*Triglochin procerum*) occur

Indicators of Very Poor Condition Big Gum Woodland Deep Channel Watercourse

- Very little native vegetation remains.
- Woody, grassy and herbaceous weeds proliferate.

c. Drainage Line in Grassy Woodland

These watercourses drain down gentle slopes (<20^{o}) from a relatively small catchment. Where good groundcover (native or pasture) has been maintained on the slope, the creekline will not be eroded and incised. They are often vegetated with Box Woodlands, such as Peppermint Box, Mallee Box and Grey Box Woodlands.

Indicators of Good Condition Grassy Woodland Drainage Line

- The tree layer is a woodland formation, with the canopies of the trees well separated.

- Under the main canopy, trees are sparse, but may include Golden Wattle, Native pine, Sheoak and Native Apricot.
- The shrub and grass layers are dense, complex, and variable, and retain moisture.
- Tussocks include lron Grasses, Sedges are often present, but not extensive.
- Grasses and herbs include the annual and perennial native species

Indicators of Very Poor Condition Grassy Woodland Drainage Line

- Very little native vegetation remains.
- Woody, grassy and herbaceous weeds dominate.
- Grazed by domestic stock or often harbours rabbits.
- Little plant cover on the ground.
- Storm water is shed quickly from hard ground and causes erosion of unprotected drainage lines.

2.2.2 Criteria used for assessing Habitat Quality

With regard to the above, The qualitative assessment of overall habitat condition has been made using criteria adapted from the Bush Condition Monitoring Manual – Southern Mount Lofty Ranges, as follows:

Riparian

- Large trees bearing nesting hollows H, M, L (2,1,0)
- Diversity of Vegetation Structures (grasses, low shrubs, tall shrubs, trees) H, M, L (2,1,0)
- Part of a Habitat Corridor Y, N (1,0)
- Diversity of Native Plant Species present H, M, L (2,1,0)
- Number of Native Bird Species Present H, M, L (2,1,0)
- Native / Exotic dominance N / E (1,0)

This gives a range of 0 – 10, with the overall classification as follows:

0-2 very low

3-4 low

5-6 moderate

7-8 high

9-10 very high

Overall, the tributaries are classified as lo to very low, except for the lower reach of tributary 1, refer Figure 1.

Aquatic

The relative value of the aquatic habitat of these tributaries becomes apparent when compared with the main North and South Para River channels, where there are large

permanent pools, and swathes of aquatic vegetation and riparian habitat. In comparison the aquatic habitat in the tributaries is minimal. Habitat characteristics would include:

- Presence of pools (permanent, ephemeral), spring fed flows. riffles/cascades
- Presence of aquatic vegetation (amphibious emergent, submerged)
- Continuity, extent of habitat, linkage with North and South Para Rivers

These were largely absent, except on the lower section of tributary 6 (Refer Figure 1)which was spring fed providing a linear watelogged area, supporting a dense swathe of species including *Bolboschoenus caldwellii and Juncus sp.,* and a small pool near the confluence near the South Para River.

2.3 Potential Presence of threatened fauna and flora species

Although a high level examination of the tributaries, consideration has been given to threatened species of fauna and flora and migratory bird species listed as potentially occurring in the Gawler area. The species listed in various studies and databases, are given in Appendix 1, which also summarises the reported occurrences and habitat preferences. These data were compiled for a recent study undertaken in East Gawler. Some birds, reptiles, mammals and amphibians of regional, State and National conservation significance that have also been recorded in the Gawler East and Gawler region recently (KBR 2009, KBR 2010) are:

- *Gallinago hardwickii* (Latham's snipe)
- *Merops ornatus* (rainbow bee-eater)
- *Melithreptus gularis gularis* (south-eastern subspecies) (black-chinned honeyeater)
- *Falco peregrinus* (peregrine falcon)
- *Haliastur sphenurus* (whistling kite)
- *Corcorax melanorhamphos* (white-winged chough)
- *Aprasia pseudopulchella* (Flinders Ranges worm-lizard)
- *Pseudophryne bibroni* (brown toadlet)

Reviewing the information in Appendix 1 and based on the condition of the tributaries, it is unlikely these species are present as their habitat is either not available, or marginal at best. Nevertheless, should any works be proposed in any of the tributaries a more detailed survey should be undertaken.

Table 1 Habitat Condition Overview of Main Tributaries within Study Area

(Tributaries and photograph locations are shown on Figure 1)

Tributary 1 –Lower Reach

Plate 1 Looking south along channel, drt channel with no aquatic flora

Stream Order 3

Tributary flows directly into North Para River

Steep bank eroded on outside of bends

Riparian habitat– Generally low value

Occasional mature *Eucalyptus camaldulensis* with minor regeneration, over exotic grasses, herbs. Planting being undertaken. Scope for development and enhancement with plantings and weed control

Aquatic habitat

Virtually no aquatic habitat.

Plate 2 Looking west along channel – unstable banks

Plate 3 Eroded banks held together by exotic grasses

Plate 4 Looking west to steep western bank

Plate 5 Small gully – occasional large redgum

Plate 6 Narrow grassy channel

Plate 7 Small pool with aquatic vegetation, within weed dominated area

Tributary 2

Plate 8 looking east up small, short gully in urbanised area

Stream Order 1

steep rocky banks in urban area

Riparian

Mostly planted, immature *Eucalyptus spp., Melaleuca spp.* and *Acacia spp.* over exotic grasses, herbs. Continuous canopy. Ground level dominated by Soursob and Kikuyu. Scope for development and enhancement with plantings and weed control.

Aquatic

short-term season flow, virtually no natural aquatic habitat. Farm dam may act as refugia pool

Tributary 1 – Upper Reaches

Plate 9 View east, adjacent agricultural land

Stream Order 2

highly modified minor drainage line in rolling low hills of low elevation

Riparian*P*lanted mixed varieties of mature *Eucalyptus spp.* over exotic grasses, herbs. Occasional larger tree may have small hollows. Adjacent to intensive agricultural land use.

Aquatic

No natural aquatic habitat flows only in regional flood events No permanent water, except for a farm dam, refer Figure 1.

Plate 10 Indistinct grassy channel

Tributaries 3, 4 and 5

These are highly modified and are now just shallow channels across agricultural land, with virtually no remaining habitat value.

Tributary 6 – Lower reach

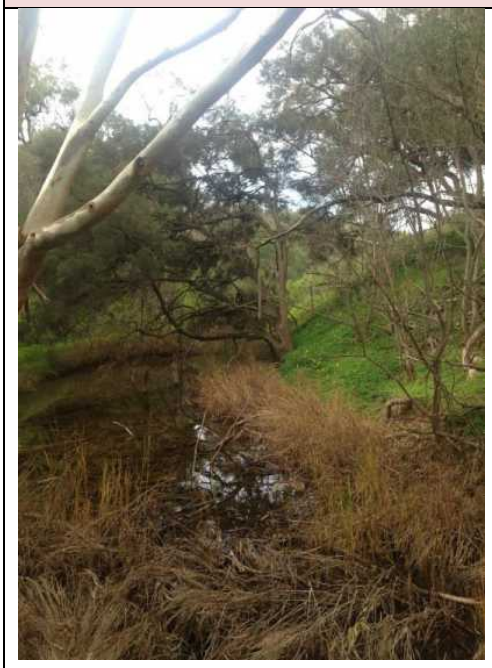


Plate 13 Small pool near confluence with South Para River

Stream Order 3

Direct tributary of South Para River.

In lower reach (approx. 1 km), steep banks with minor erosion near base of spring fed channel. Lower slopes in upper reaches.

Riparian

Occasional mature *Eucalyptus camaldulensis* and *E. porosa* over exotic pasture grasses, herbs. Dense *Juncus usitatus*, *Bolbochoenus caldwellii* and *Cyperus* sp in permanently moist base of channel.

Scope for development and enhancement with plantings and weed control

Aquatic

A small permanent pool and the swathes of aquatic flora along the channel in the lower reach will provide habitat for a range of aquatic fauna. In the upper reaches aquatic habitat is minimal.

Plate 13 Swathe of aquatic flora along channel

Tributary 6 – Upper Reaches

Plate 14 Looking east further upstream – occasional large gums in channel

Drainage line in rolling low hills of low elevation. Banks less steep further upstream

Riparian

Occasional mature planted or self-sown *Eucalyptus spp.* in channel over exotic grasses, herbs.

Aquatic

Minimal aquatic habitat

Tributary 7

Plate 15 Sparse *E. porosa* with olives

Stream Order 2

direct tributary of South Para River. Steep rocky banks with shallow soil. Rock exposed in steep banks near base of channel.

Riparian

Occasional mature *Eucalyptus porosa* with no regeneration, over exotic grasses, herbs. Occasional *Austrostipa* sp. native grass. Some small hollows in big old sprawling *E. porosa.* Very limited, very poor quality habitat for Flinders Ranges worm lizard

Scope for development and enhancement with plantings and weed control

	Aquatic Flows only during major events. Virtually no aquatic habitat.
 Plate 16 High grazing impact	
Tributary 8	
 Plate 17 Looking east – plantation in private garden	**Stream Order 1** Minor drainage line , artificial for much of its length **Riparian** In upper reach, planted mixed *Eucalyptus sp.* and *Acacia spp.*, over exotic grasses, herbs. Some occasional remnant *Eucalyptus porosa* downstream, dominated by exotic invasive species Scope for development and enhancement with plantings and weed control **Aquatic** Flows only during major events. Virtually no aquatic habitat.
	

Plate 18 Olives over exotic grasses and herbs

Tributary 9

Plate 19 Upstream of urban area, just below confluence of to order 1 streams

Stream Order 3

Minor drainage line to confluence with Tributary 10. Below confluence is a highly modified channel. Watercourse formally discharged onto plain, now drained to Gawler River by man-made channel.

Riparian

Highly modified, with planted mixed *Eucalyptus sp. Acacia spp.* and *Melaleuca spp.* over exotic grasses, herbs. No remnant vegetation. Variety of created habitats available for suburban birds, but dominated by exotic invasive species.

Scope for development and enhancement with plantings and weed control

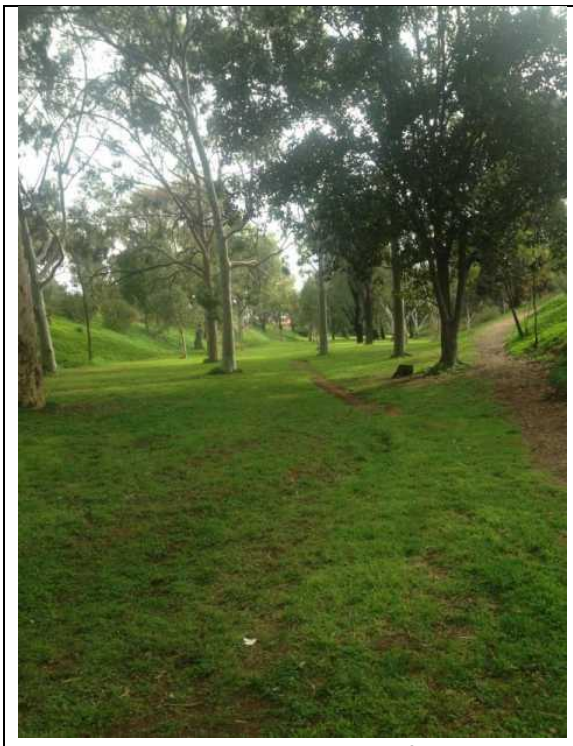
Aquatic

Virtually no aquatic habitat, only a grassy channel, which only has flow during storm events.

Plate 20 Downstream, wide maintained grassy channel

Plate 21 Vies of northern tributary above

	confluence
 Plate 22 Vies of southern tributary above confluence	
Tributary 10	
 Plate 23 Highly modified and maintained grassy channel	Very similar to Tributary 9. Highly modified and maintained landscape. Watercourse is between levees, with the upstream boundary of the tributary in the study area being the embankment flood control bank across the watercourse, with culverts for controlled release.



24 Between levees, maintained flat grassy channel

Plate 25 Bank across watercourse with culverts, minor scour

Plate 26 Watercourse upstream of bank

Tributary 11

Plate 27 Wide channel, dominated by exotic species, such as thistle, thin topsoil

Stream Order 3

Drainage line dissipates onto plains south of Gawler

Riparian

Historically cleared and heavily grazed. No remnant vegetation. Dominated by exotic invasive species

Aquatic

No aquatic habitat

Tributary 12

Plate 28 View along channel, note small shallow channel

Stream Order 4

minor low gradient, drainage line dissipates onto plains south of Gawler

Riparian

Historically cleared. All planted trees (in lower reach only), no remnant vegetation. High levels of human disturbance. Understorey dominated by exotic invasive species.

Aquatic

No aquatic habitat, shallow grassed channel.

Tributaries 13 and 14

Not examined, but from an examination of aerial photographs it is similar to 12 and 13 in that they are highly modified with little remnant vegetation.

Tributary 15 – east of Sturt Highway (runs south)

Plate 29 looking downstream Sparse *E. porosa* with olives

Stream Order 1

Minor low gradient, drainage line flows into main channel of North Para River north of Gawler. Modified through cultivation of minor catchment as part of a cereal cropping paddock.

Riparian

Historically cleared. Remnant vegetation limited to one very small patch with *Eucalyptus porosa* and *E. camaldulensis* over weeds. High levels of human disturbance. Understorey dominated by exotic invasive grass and herb species.

Very low habitat value for native fauna.

Aquatic

No aquatic habitat, shallow channel that holds no standing water.

Plate 30 looking upstream - High human impact

Tributary 16 – east of Sturt Highway (runs east)

Plate 31 Managed exotic vegetation / garden

Stream Order 1

Minor low gradient, drainage line flows into main channel of North Para River north of Gawler

Riparian

Historically cleared. All planted trees and shrubs around dwelling and sheds. Highly managed cottage garden with planted *Eucalyptus* spp. over numerous shrub and undershrub varieties. No remnant vegetation. High levels of human disturbance. Occasional *Schinus molle* (pepper tree) over weeds at lower end. Very occasional *E. porosa.* Understorey dominated by exotic invasive species.

Very low habitat value for native fauna.

Aquatic

No aquatic habitat, shallow channel that holds no standing water.

Plate 32 looking downstream towards North Para River

Tributary 17 – Green Gully

Plate 33 Planted and regenerated non-indigenous trees and shrubs in remnant of quarry at western end

.

Stream Order 1

Minor low gradient, drainage line that dissipates and goes underground in the centre of the commercial section of urban Gawler. All on private land. Western end is a remnant quarry.

Riparian

Historically extensively cleared. All planted trees at western end, with no remnant vegetation. Eastern end planted with numerous garden/non-indigenous trees and shrubs including *Eucalyptus* spp., *Cupressus* sp., *Acacia* spp., *Agonis flexuosa*. Occasional remnant *E. porosa.* High levels of human disturbance throughout. Understorey dominated by exotic invasive grass and herb species.

Very low habitat value for native fauna.

Aquatic

No aquatic habitat, shallow channel that holds no standing water.

Plate 34 eastern upstream end mostly planted *Eucalyptus* spp. over exotic grasses

Tributary 18 – west of Lundie Crs

Plate 35 Planted *Eucalyptus spp. and Acacia spp.* over mown grass at upper end

Stream Order 1

Minor low gradient, drainage line flows into main channel of South Para River on south-eastern fringe of Gawler township. Part of Dead Man's Pass Reserve.

Riparian

Historically cleared. All planted trees and no remnant vegetation at upper end. Some *Eucalyptus camaldulensis* at lower end near river channel. High levels of human disturbance. Understorey dominated by exotic invasive species.

Kikuyu grass provides main stabilisation of channel against soil erosion.

Very low habitat value for native fauna.

Aquatic

Catchment mainly urban stormwater. No aquatic habitat, shallow channel that holds no standing water.

Plate 36 lower part heavily infested with exotic grasses and Olives

Tributary 19 – east of Lundie Crs	
 Plate 37 looking downstream to Olives over exotic grasses and herbs	**Stream Order 1** Minor low gradient, drainage line flows into main channel of South Para River on south-eastern fringe of Gawler township**.** **Riparian** Historically cleared. All planted or self-sown Olives, with no remnant vegetation. High levels of human disturbance. Understorey dominated by exotic invasive grasses and herbs. Very low habitat value for native fauna. **Aquatic** No aquatic habitat, shallow channel that holds no standing water.

3.0 Soil Erosion Risk Assessment

This high level assessment has been undertaken using the method outlined in 'Assessing Agricultural Lands, Agricultural Land Classification Standards used in South Australia's Land Resource Mapping Program' Maschmedt (2002), as outlined below.

Digital data from currently available mapping has been used to provide geographical output to assist with the interpretation of land factors that affect the potential for soil erosion, refer Figure 2. It is based on the methods described and used in the soil landscape analysis and mapping described comprehensively in Hall *et al.* (2009). The "Soil Erosion Risk" modeled for this project has been derived from two of the basic determinants of soil erosion due to water flow, the slope of the land, and the inherent erodibility of the soil, as described below:

- **Inherent Water Erosion Potential**

  Soil landscape mapping at a scale of 1:50,000 was carried out by a team of soil scientists over a period of many years in the agricultural areas of South Australia. This mapping process and the soil descriptions are summarised in Hall *et al.* (2009). A measure of the inherent water erosion potential was assigned to all these described soils, and their spatial distribution mapped as "Soil Landscape Units" within a broader framework of "Land Systems". The soil landscape units are shown on Figure 2.

This water erosion potential is soil specific, derived from physical and chemical properties of a soil type, and independent of other factors such as vegetation cover and climate.

The Inherent Water Erosion Potential used in the modelling for this project was derived from the dominant water erosion potential ratings (E1 to E7) for the Soil Landscape Units as described in Maschmedt (2002), and included as Attachment 2

- **Slope**

Slope analysis was based on the currently available 5 m contour digital terrain model.

Data were processed by interpolating contours to provide 1 m X 1 m cells with a slope in degrees. These cells were amalgamated into seven slope classes. Slope classes were chosen with reference to Table 45 of Maschmedt (2002), refer Attachment 2.

The slope map was then intersected with the soil landscape map, and the appropriate risk value assigned as set out in the matrix below.

Figure 3 Soil Erosion Risk Matrix

Slope class Inherent Water Erosion Potential	< 2°	2° – 4°	4° – 7°	7° – 10°	10° – 15°	15° – 45°	> 45°
1 (E1andE2)	Very Low	Very Low	Low	Low	Moderate	Moderate	Moderate
2 (E3)	Very Low	Low	Low	Moderate	Moderate	Moderate	High
3 (E4)	Low	Low	Moderate	Moderate	Moderate	High	High
4 (E5)	Low	Moderate	Moderate	Moderate	High	High	Very High
5 (E6 and E7)	Moderate	Moderate	Moderate	High	High	Very High	Very High

Using the matrix classification, the erosion risk potential is shown on Figure 3, which actually covers all watercourses within the study area, not those specifically defined. These are shown separately on Figure 5. This digital coverage able to be overlain by other mapped variable relevant to the planning objectives.

- **Interpretive Notes for Mapping**

Spatial resolution is 1 m, and slope classes were derived by amalgamating “single degrees of slope over an area of 1 square metre” into discrete groups and it appears to produce some odd-shaped polygons. These do not represent sharp changes in slope, but a change from one slope class to another.

Soil landscape mapping at a scale of 1 to 50,000 requires some extrapolation of point data to broader areas based on some assumptions, and what is described in Hall et al (2009) and Maschmedt (2002) are the most dominant characteristics within the mapped soil landscape unit area.

In many cases where the Soil Erosion Risk is mapped as Very High, these areas are steep rocky cliffs on the outside of major bends in the drainage lines. As slope is an important landscape factor that affects other aspects of development or town planning, high soil erosion potential in these areas may be less of a limiting factor than other aspects.

Mapping at this level of detail is intended only to highlight potential hotspots where further consideration or information may be required.

Figure 2: Sample Mapping from GIS

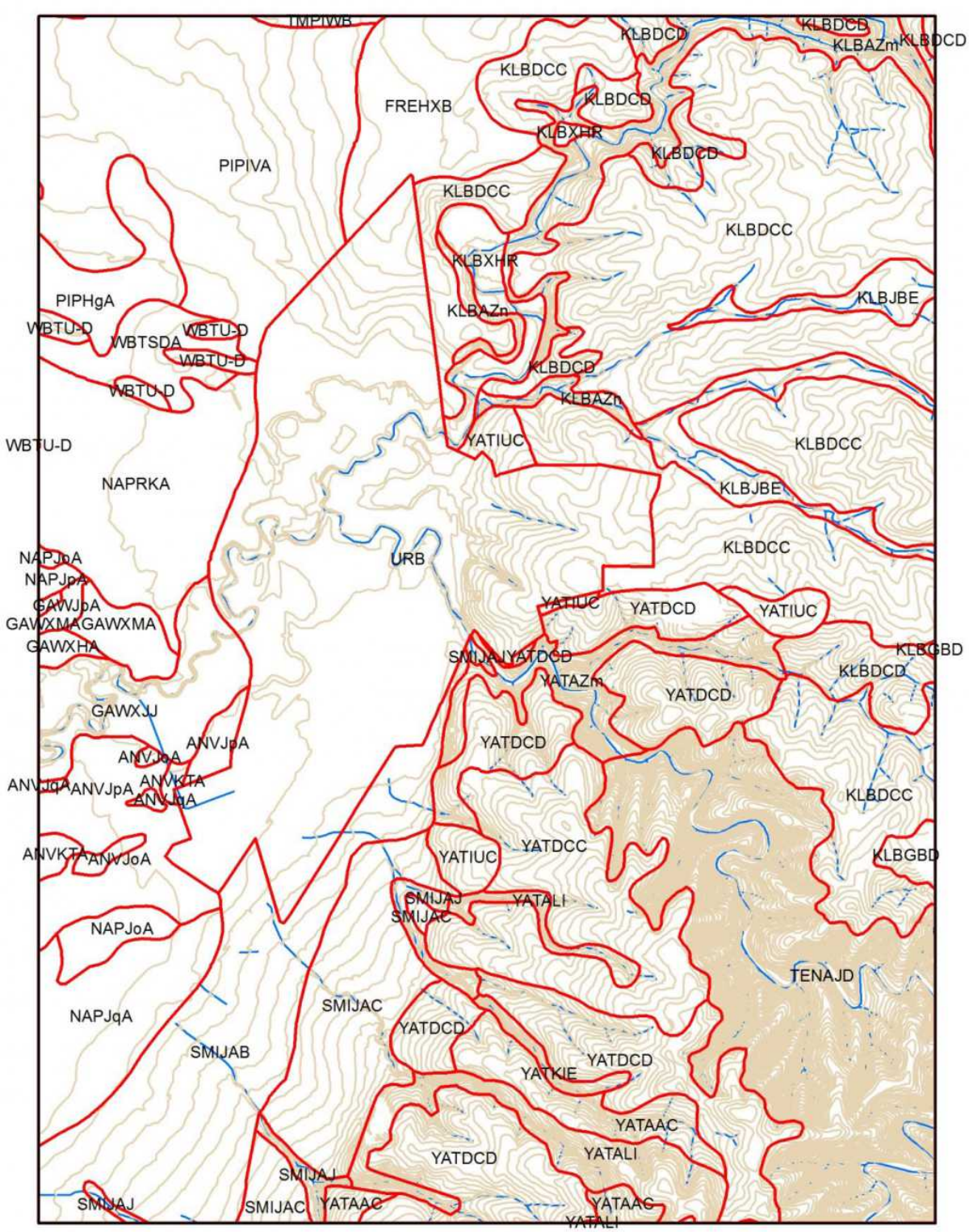
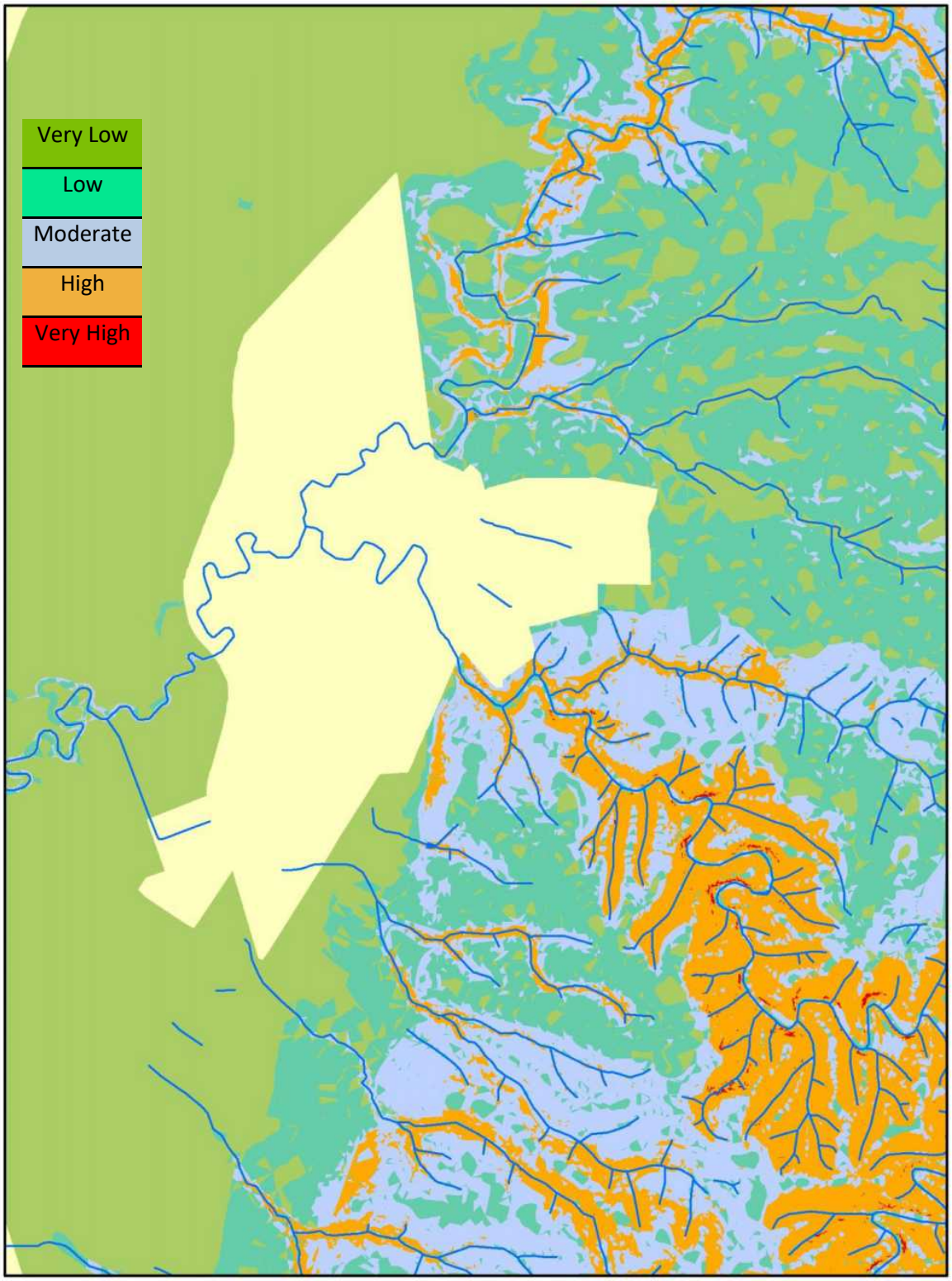


Figure 4: Soil Erosion Risk Classes within Soil Landscape Units



LEGEND
Soil Erosion Risk

- Very Low
- Low
- Moderate
- High
- Unclassified (urban)
- 1 Reach number

NORTH PARA RIVER

GAWLER RIVER

SOUTH PARA RIVER

16 15 3 4 1 2 5 1 17 18 19 6 6 7 8 9 10 11 12 14 13

0 70 140 210 280 350

Meters

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GAWLER RIVER FLOODPLAIN
MANAGEMENT PLAN
FIGURE 5

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Land System Reports available on-line

https://data.environment.sa.gov.au/content/land-system-reports/forms/allitems.aspx

DEWNR Soil and Land Program on-line

http://www.environment.sa.gov.au/Science/Information_data/soil-and-land

Key References and data sources for Threatened Species

Atlas of Living Australia – online database http://www.ala.org.au/

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Numerous Recovery Plans for a range of threatened species from various sources

Appendix 1 Threatened Species and migratory birds listed as potentially occurring in the Gawler area

Table 1 Threatened Species listed as potentially occurring in or near the Gawler area

Fauna Type	Name	Conservation status*		Habitat type	Noted	Comments
		SA	EPBC			
Bird	*Botaurus poiciloptilus* Australasian Bittern	**V**	**E**	wetlands	N	In Australia, the species occurs from south–east Queensland to south–east South Australia, Tasmania and in the south–west of Western Australia. The Australasian Bittern's preferred habitat is wetlands with tall dense vegetation. No habitat occurs in or near the surveyed area. Species very unlikely to be present.
Bird	*Leipoa ocellata* Malleefowl	**V**	**V**	unburnt mallee with deep litter	N	Malleefowl are found in semi-arid to arid shrublands, and low woodlands dominated by mallee and/or acacia. Generally they are only able to nest in long unburnt areas where leaf litter has built up. Very unlikely to occur
Bird	*Rostratula australis* Australian Painted Snipe		**V**	shallow inland wetlands	N	The Australian Painted Snipe is infrequently and irregularly recorded from throughout much of Australia, excluding Tasmania. The Australian Painted Snipe generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains. Typical sites include those with rank emergent tussocks of grass, sedges, rushes or reeds, or samphire; often with scattered clumps of lignum or canegrass or sometimes tea-tree, particularly shallow wetlands with areas of bare wet mud and both upper and canopy cover nearby. No suitable habitat occurs in or near the surveyed area.
Mammal	*Isoodon obesulus obesulus* Southern Brown Bandicoot	**V**	**E**	woodland with dense ground layer understorey	N	Since European settlement, the Southern Brown Bandicoot (eastern) has been recorded from four separate regions of South Australia, one being the Mount Lofty Ranges. This species is quite timid and susceptible to predation from foxes, dogs and cats. Very unlikely to occur
Reptile	*Aprasia pseudopulchella* Flinders Ranges Worm-lizard	**-**	**V**	fissured or loose rocks, cracking clay, deep litter	N	Found mainly north of the surveyed area. Closest records are from Para Wirra Conservation Park, 15 km southeast of the surveyed area in 1993, 1994. Habitat requirements are very variable, and it can be found in quite degraded areas, though preference is for moist places where protection is available, for example, under fallen timber, loose rocks or deep leaf litter. Very few areas of fissured rocks, cracking clay or deep litter are available in the surveyed area to provide protection. Proximity to a major urban area (<2km) where predatory domestic animals roam would make survival difficult.

SA = South Australian National Parks & Wildlife Act 1972; EPBC = Commonwealth Environmental Protection & Biodiversity Conservation Act, 1999 **U** = Uncommon; **R** = Rare; **V** = Vulnerable; **E** = Endangered; **CE** = Critically Endangered

Table 2 Migratory Species Listed as potentially occurring in the Gawler area

Species	EPBC Status	NPWSA Status	Comments
BIRDS			
Haliaeetus leucogaster White-bellied Sea-Eagle	**Mi, Ma**	**E**	The species occurs along coastlines throughout Australia and it can occur inland and found near the major wetlands, including along the River Murray. It requires large areas of habitat and including open water characteristic of the larger rivers, lakes, swamps. Very unlikely to occur in the Gawler area.
Apus pacificus Fork-tailed Swift	**Mi, Ma**	**-**	In South Australia the Fork-tailed Swift is widespread from the Victorian border west to the Spencer Gulf. Almost exclusively an aerial species and summer visitor (October-April). Species has very large foraging range
Ardea ibis Cattle Egret	**Mi, Ma**	**R**	In Australia the principal breeding sites are the central east coast from about Newcastle to Bundaberg. In South Australia breeding has been recorded around Lakes Albert-Alexandrina. No breeding sites known to occur in vicinity of study area. May forage in coastal areas, tidal flats and salt fields. Very unlikely to occur in the Gawler area.
Ardea alba White Egret	**Mi, Ma**	**-**	In Australia, the largest breeding colonies, and greatest concentrations of breeding colonies, are located in near-coastal regions of the Northern Territory. Minor breeding sites are widely scattered across the species' distribution and include sites in western Cape York Peninsula, the central coast of Queensland, north and north-eastern NSW, south-eastern South Australia. No breeding sites known to occur in vicinity of study area. The White Egret has been reported feeding in a wide range of wetland habitats (for example inland and coastal, freshwater and saline, permanent and ephemeral, open and vegetated, large and small, natural and artificial) including swamps and marshes; margins of rivers and lakes; damp or flooded grasslands, pastures or agricultural lands. Very unlikely to occur in the Gawler area.
Gallinago hardwickii Japanese Snipe	**Mi, Ma**	**R**	Breeding in Japan and adjacent parts of Siberia this species forages in freshwater wetlands on inland, upland and coastal plains, preferring soft moist ground or shallow flooded areas. No Australian sites have been identified as internationally important. Very unlikely to occur in the Gawler area.
Hirundapus caudacutus White-throated Needletail	**Mi**	**-**	A visitor to South Australia from South-east Asia, mostly from October to April. It is almost exclusively aerial when present in Australia. The White-throated Needletail is widespread in eastern and south-eastern Australia. In eastern Australia, it is recorded in all coastal regions of Queensland and NSW, extending inland to the western slopes of the Great Divide and occasionally onto the adjacent inland plains. Further south on the mainland, it is widespread in Victoria, though more so on and south of the Great Divide, and there are few records in western Victoria outside the Grampians and the South West. The species occurs in adjacent areas of south-eastern South Australia, where it extends west to the Mount Lofty Ranges and Yorke Peninsula. Species has very large foraging range.

Species	EPBC Status	NPWSA Status	Comments
BIRDS			
Merops ornatus Rainbow Bee-eater	**Mi**	**-**	The Rainbow Bee-eater occurs mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation. It also occurs in inland and coastal sand dune systems, and in mangroves in northern Australia, and has been recorded in various other habitat types including heathland, sedgeland, vine forest and vine thicket, and on beaches. Southern populations spend non-breeding, winter season in the North of Australia. The Rainbow Bee-eater is currently considered to be a low priority for management. The population size and population trends have not been quantified, but the population size is assumed to be reasonably large, and there is little documented evidence of population declines.

Table 3 Threatened Plant Species Listed as potentially occurring in the Gawler area

Species	Conservation status*		Comments
	SA	EPBC	
Caladenia (Arachnorchis) argocalla White-beauty Spider Orchid	**E**	**E**	The White-beauty Spider-orchid is endemic to the Mount Lofty Ranges Region of South Australia (Robertson & Bickerton 2000). Historically it has been recorded in and around the Barossa Valley, on the Fleurieu Peninsula, in the hills just south of Adelaide, east of Beevor Estate Hill and north near Clare. The species' former range, based on herbarium collections, was approximately 200 km from north to south. It no longer occurs south of Adelaide, where it has not been recorded since 1918, and is assumed to be extinct over the southern half of its former range. The present north-south range of the White-beauty Spider-orchid is approximately 130 km. There is a high probability that the species' range will continue to decline due to the very small size of two populations which are now at the southern limit of the species. All known populations of more than 10 plants occur within an area of 10 km² and the area of occupancy, as of the year 2000, was less than 5 ha. Closest records are from Sandy Creek and Cockatoo Valley, 10-15 km east of the surveyed area. Species very unlikely to occur.
Cdenia (Arachnorchis) behrii Pink-lipped Spider Orchid	**E**	**E**	In 1999, the Pink-lipped spider-orchid distribution was known to be limited to two small disjunct areas at least 25 km apart; approximately 60 km² in the Kersbrook/Williamstown region, and approximately 35 km² in the Belair/Clarendon region, giving a total estimated extent of occurrence of 95 km². It is generally found in quartzite-derived soils on steep south facing slopes, but also on ridge tops and occasionally near creek beds, often growing alongside bushwalking paths, vehicle tracks or roads due to the openness of these locations. Closest known population is in Para Wirra Conservation Park, 10 km southeast of the surveyed area. The species is currently known to be confined to the higher parts of the Mount Lofty Ranges. This species is very sensitive to grazing by native and introduced vertebrates, and does not persist in weed infested areas. Given the level of human and weed influences , this species is very unlikely to occur.

Species	Conservation status*		Comments
	SA	EPBC	
Caladenia (Arachnorchis) gladiolata Bayonet Spider-orchid	**E**	**E**	*Caladenia gladiolata* is endemic to South Australia. In 2006 the species was known from four sub populations in two disjunct localities in the Flinders Ranges and Southern Lofty herbarium regions. Known habitat is under *Eucalyptus leucoxylon* woodland on moderate to steep slopes in sandy loam soils with scattered shale and quartzite. Closest known populations are more than 60 km away. Species very unlikely to occur.
Caladenia (Arachnorchis) macroclavia *Large-club Spider-orchid*	**E**	**E**	This is part of the *Arachnorchis dilatata* complex and previously included under that name. Distribution is unsure in South Australia. It occurs in the South East, Murraylands, Northern Lofty region and Flinders Ranges, perhaps on Kangaroo Island. Habitat is dry woodland, low scrub and about rock outcrops in a variety of soil types. The remaining populations are threatened by weed invasions, browsing by introduced and native herbivores and human interference. Given the level of human and weed influences in the surveyed area, this species is unlikely to occur. Closest known population is near Snowtown 70 km from the surveyed area. Species very unlikely to occur .
Caladenia (Arachnorchis) rigida Stiff White Spider Orchid	**E**	**E**	The White Spider-orchid is endemic to the southern Mt. Lofty Ranges in South Australia. Closest known population is in Para Wirra Conservation Park, 10 km southeast of the surveyed area. Its distribution was known to extend from Macclesfield, north to Williamstown in the early 1990s. Historically *Caladenia rigida* was known to occur over 1,153 km². At least 18 sub-populations of *C. rigida* have become extinct in the last 50-100 years, and the extent of occurrence has reduced by at least 60%. The main cause of this decline is thought to be habitat loss and fragmentation. Current main threats are from herbivory, weed invasion and lack of recruitment. Given the level of human and weed influences, this species is very unlikely to occur.
Caladenia (Arachnorchis) tensa Greencomb Spider Orchid	**-**	**E**	This is part of the *Arachnorchis dilatata* complex and previously included under that name. Distribution is unsure in South Australia. It is probably not on Eyre Peninsula but certainly in the South East, Murraylands, Northern Lofty region and Flinders Ranges, perhaps on Kangaroo Island. Habitat is dry woodland, low scrub and about rock outcrops in a variety of soil types. The remaining populations are threatened by weed invasions, browsing by introduced and native herbivores and human interference. Given the level of human and weed influences in the surveyed area, occurrence is unlikely.
Caladenia (Arachnorchis) woolcockiorum Woolcock's Spider-orchid	**E**	**V**	*Caladenia woolcockiorum* is endemic to South Australia. In 2006 the species was known only from nine sub-populations within Mount Remarkable National Park, 200 km north of the surveyed area. Species very unlikely to occur.
Olearia pannosa subsp. pannosa Silver Daisy-bush	**V**	**V**	Distributed in South Australia, Victoria and New South Wales. In South Australia populations are scattered in various regions and within the South Australian Murray Darling Basin populations are known to occur between Mannum, Goolwa, Murray Bridge and Strathalbyn, and near Keith in the Upper South-east. Recent survey work indicates that there are approximately 1100 individual plants remaining in the South Australian Murray Darling Basin. Occurs in a variety of mallee and woodland communities with common native understorey plants including *Acacia*, *Melaleuca*, chenopod shrubs, sedges and grasses. Found in areas with flat, sandy terrain, and woodland or mallee areas with rocky soils. Closest record is from Para Wirra Conservation Park, 10 km south east of the surveyed area. Species very unlikely to occur.
Prasophyllum pallidum Pale Leek-orchid	**R**	**V**	Pale Leek-orchid is known singly or in groups in well-grassed open forests with average annual rainfall exceeding 750 mm from the Flinders Ranges to the Northern and Southern Lofty regions of South Australia. Closest records are 7-10 km from the surveyed area. Unlikely to occur in surveyed area, due to dense exotic grass understorey and suboptimal rainfall.

Species	Conservation status*		Comments
	SA	EPBC	
Prasophyllum pruinosum Plum Leek Orchid	**V**	**E**	Endemic to the Adelaide Hills and Barossa region as far north as Rowland Flat, once common on the Adelaide Plains but extinct there now; it has suffered a rapid decline throughout its limited range in the last 50 years. Occurs in open woodland and grassy forest, in the open or in the shelter of broom-like shrubbery growing in fertile loams. Closest records are 5-10 km east of Gawler.
Pterostylis arenicola Sandhill Greenhood	**V**	**V**	The Sandhill Greenhood is endemic to South Australia and is known from Tailem Bend, Grange (suburban Adelaide), Potters Scrub in Coorong National Park, and Poltalloch and other locations on the Narrung Peninsula. In 1990, the species was considered to be restricted to less than 1% of its original distribution, however more populations have since been found. The population is severely fragmented, and known to exist at no more than 10 locations. Closest records are near Strathalbyn, 60 km south of the surveyed area. Species very unlikely to occur in the surveyed area.
Thelymitra cyanapicata Blue Top Sun-orchid	**E**	**CE**	The Dark-tipped Sun-orchid occurs at one location on the Fleurieu Peninsula near Kuitpo in low-lying seepages, creeks and swamps with wet sandy soils. Very unlikely to occur.

*SA = South Australia; **U** = Uncommon; **R** = Rare; **V** = Vulnerable; **E** = Endangered; **CE** = Critically Endangered

Note - if species is listed on the Commonwealth EPBC Act, 1999, then that Act will apply

Appendix 2

- **Land System reports Maschmedt, D J (2002) – Kalbeeba, Yattalunga, Smithfield, Tenafeate.**
- **Pages 79-81 from Maschmedt (2002).**

YAT Yattalunga Land System

West facing slopes of the Mount Lofty Ranges between Gawler and Little Para Reservoir

Area: 57.6 km^2

Annual rainfall: 475 - 600 mm average

Geology: The landscape is underlain predominantly by siltstones, slates and fine sandstones, variably capped by fine carbonates. In places, the carbonates are indurated to moderately cemented rubbly or sheet calcrete. On gentle upper slopes, the rocks have deeply weathered in situ, forming heavy clays from which distinctive soils are formed. Scattered throughout the basement rocks are strata of coarser sandstones and quartzites, usually marked by rockier land surfaces. Locally derived silty, sandy and light clayey sediments have accumulated in minor drainage depressions. There are isolated remnants of Tertiary sediments in the north. These are capped by calcareous rubble. Small exposures of relic Tertiary sands on the eastern margin are free of carbonate.

Topography: The landscape is essentially a west facing slope, extensively dissected by watercourses flowing to the plains. With the exception of the South Para River which cuts through the northern part of the land system, drainage originates from within the land system. Short watercourses have cut narrow valleys up to 80 m deep through the rocky substrate. Slopes are highly variable, but generally are less than 30%. In the south east are two more or less flat topped crests, which are the relatively intact remnants of an old land surface.

Elevation: 70 m in the west to 298 m in the east

Relief: Local relief is typically 50 - 100 m

Soils: Most of the soils are moderately deep to shallow over basement rock. Typically they have hard loamy surfaces overlying either weathering rock, or more commonly a red friable clay loamy to clayey subsoil. Some are calcareous throughout. On rising ground there are limited areas of deep clay loamy to clayey gradational soils or black cracking clays on highly weathered rocks. On minor lower slopes and creek flats, deep red loam over clay loam to clay soils predominate, with small areas of deep sandy loams. There are minor rubbly calcareous loams over Tertiary sandstones.

Main soils:

Soils formed on calcified basement rock

D1a Shallow loam over red clay
L1 Shallow stony loam
C2 Shallow gradational red loam

Minor soils:

Soils formed on calcified / calcreted basement rock

B6 Shallow loam over red clay on calcrete
A2 Shallow calcareous loam
B2 Shallow calcareous loam on calcrete
D1b Shallow sandy loam over red sandy clay
C5 Shallow dark clay loam

Deep soils formed on highly weathered rocks

A6 Gradational calcareous clay loam
C3 Gradational friable red clay loam
E1 Black cracking clay

Soils formed on calcreted Tertiary sandstones
A4 Deep (rubbly) calcareous loam
Soils formed in alluvium
C1 Gradational red sandy loam
D2 Loam over red clay
M1 Deep sandy loam

Main features: The Yattalunga Land System is a west facing slope, extensively dissected by watercourses flowing to the plains. There is a regular pattern of moderate to moderately steep slopes and narrow drainage depressions. The soils are characteristically shallow to moderately deep, with loamy surfaces either grading directly to weathering rock, or underlain by red more clayey subsoils. Often there is a soft to hard carbonate layer between the soil and the rock. The soils are naturally fertile and well drained, but variable depth limits productivity of dryland crops and pastures. Only 15% of the area is fully arable, but about 95% is suitable for perennial crops. Viticulture in particular has potential where water is available, although westerly exposure may be a limitation.

Soil Landscape Unit summary: 15 Soil Landscape Units (SLUs) mapped in the Yattalunga Land System

SLU	% of area	Main features #
AAC AAD AAI	12.5 0.3 15.2	Moderately steep to steep slopes underlain by siltstones, slates and fine sandstones. Slopes are 18-50% and relief is up to 80 m. There is up to 10% surface stone and rock outcrop. Watercourses are well defined in narrow drainage depressions. Soils are generally loamy and shallow over rock, but many have more clayey subsoils. **AAC** Moderate slopes of 18-30% up to 50 m high. **AAD** Steep slopes of 30-50% up to 50 m high. **AAI** Moderate slopes of 18-30% up to 80 m high, with some eroded watercourses. Most soils are loamy and shallow over calcified siltstone, or siltstone mantled by soft to semi-hard carbonate. Many are calcareous. Main soils: Shallow stony loam - **L1** (E) } all formed on Shallow loam over red clay - **D1a** (C) } weathering rock Shallow calcareous loam - **A2** (L) } Shallow gradational red loam - **C2** (L) } Shallow loam over red clay on calcrete - **B6** (M) } Shallow dark clay loam - **C5** (M) } These slopes are too steep and rocky, and the soils too shallow for cropping, although they are inherently fertile. They are used for rough grazing, but have potential for viticulture where water is available and sites are protected from westerly exposure.
ALD ALI	2.9 7.2	Moderately inclined to steep rocky hillslopes formed on calcified sandstones and siltstones. Slopes range from 15% to 50%, and are up to 60 metres high. This land includes those areas where the basement rocks are mainly sandstones. These occur as rocky reefs in a landscape of generally finer grained rocks. **ALD** Steep rocky hillslopes with relief to 50 m, slopes of 30-50% and up to 20% stone and rock outcrop. **ALI** Moderately inclined hillslopes with relief to 60 m, slopes of 15-30%, some eroded watercourses, and up to 10% stone and rock outcrop. All soils are shallow to moderately shallow over sandstone or siltstone mantled by carbonates. These occur as fine deposits in rock fissures through to semi-hard calcrete. Sandy to loamy surface soils over red brown clays are common, together with shallow loamy sands to loams which may be either calcareous or non calcareous. Main soils: Shallow stony loam - **L1** (E) } all formed on Shallow sandy loam over red sandy clay - **D1b** (C) } weathering rock Shallow loam over red clay - **D1a** (L) } Shallow calcareous loam - **A2** (M) } Shallow calcareous loam on calcrete - **B2** (L)

		This land is rough grazing country, with extensive rock and shallow soils, all on moderately steep to steep slopes. Much of the land retains scattered tree cover. There is some potential for viticulture where water is available, exposure is not excessive and land is accessible (**ALI** only).
AZm	1.9	Steep slopes created by the down cutting of the South Para River. Slopes are variable up to 100% and relief is up to 70 m. There is up to 50% surface stone and rocky outcrop. Minor discontinuous flats adjoin the river. Main soils: Shallow stony loam - **L1** (V) } over basement rock on slopes Shallow loam over red clay - **D1a** (L) } Deep sandy loam - **M1** (L) on flats This land is either steep and rocky, or subject to flooding, so has very limited agricultural potential, but high conservation and water resource protection value.
DCC DCD DCI	5.8 27.3 7.7	Undulating rises and rolling low hills formed on calcified siltstones, slates and fine sandstones. Slopes range from 4% to 18%. Rock outcrop is sporadic, but there is up to 10% surface stone. **DCC** Undulating rises with relief to 40 m and slopes of 4-10%. **DCD** Moderate slopes of 10-18%, up to 50 m high. **DCI** Moderate slopes of 10-18%, up to 50 m high with some eroded watercourses. Most soils are moderately deep to shallow over calcified siltstone, or siltstone mantled by soft to semi hard carbonate. Main soils: Shallow loam over red clay - **D1a** (E) } on weathering rock on slopes Shallow gradational red loam - **C2** (C) } Shallow stony loam - **L1** (L) } Shallow loam over red clay on calcrete - **B6** (L) Loam over red clay - **D2** (M) on alluvium on lower slopes and creek flats The soils are fertile and well drained, although often shallow, thereby restricting waterholding capacity. Surface soils set hard, creating workability and emergence problems, and increasing erosion susceptibility. However, the land is potentially productive - **DCC** is suitable for cropping provided that adequate erosion control measures are used, but **DCD** and **DCI** are marginal due to the potential for erosion. The land is suited to horticultural development where water is available and exposure is not excessive.
DFC DFI	5.1 3.8	Undulating to gently rolling rises and low hills to 60 m high formed on calcified siltstones and slates, commonly deeply weathered. Slopes are 3-20%. **DFC** Undulating rises and low hills to 50 m high with slopes of 3-12%. **DFI** Gently rolling low hills to 60 m high with slopes of 12-20% and some eroded watercourses. A wide variety of soils occurs, differences being mainly attributable to parent materials. Common profiles include loams over red brown clays, cracking clays, and calcareous and non-calcareous loams. Main soils: Shallow loam over red clay - **D1a** (C) } on basement rocks Shallow gradational red loam - **C2** (C) } Shallow stony loam - **L1** (L) } Gradational calcareous clay loam - **A6** (L) } on deeply weathered rocks Gradational friable red clay loam - **C3** (L) } Black cracking clay - **E1** (L) } Loam over red clay - **D2** (M) on alluvium on lower slopes The shallower soils on basement rock are similar to those of **DCC/DCD**, but the deeper soils on highly weathered rocks or alluvium are fertile and have high waterholding capacities. Although some have poor surface structure, they are potentially highly productive. Boron toxicity may be a problem on the deeper soils.
GBD	0.5	Undulating upper slopes of 2-10% formed on Tertiary sandstones, with reworked sandy sediments in hollows and depositional areas. There is negligible surface stone and there are no defined watercourses. Soils are invariably sandy surfaced, usually with more clayey subsoils, but some deep gritty sands occur on reworked sediments. Main soils: Bleached sand over sandy clay loam - **G2** (E) Sandy loam over poorly structured brown clay - **F2** (C) Thick sand over clay - **G3** (L) Deep loamy sand - **M1** (L) These soils are moderately deep, but highly infertile and prone to acidification and water repellence. Drainage is variable, usually moderately well to well, but some hollows are imperfectly

		drained with seepage areas. The sands are highly erodible, to both wind and water, so cropping is not generally sustainable. Most of the land is suitable for perennial horticulture and viticulture, although drainage management is required in some parts.
IUC	3.3	Undulating crests and upper slopes of 4% to 10% and relief up to 50 metres formed on calcreted Tertiary clayey sands, sandy clays, sandstones and limestones. Minor watercourses drain the slopes. Main soil: Deep (rubbly) calcareous loam - **A4** (D) These are moderately deep and well drained, but alkaline due to the high carbonate content. This condition affects the availability of some nutrients. With appropriate attention to nutrition, they are productive soils for field crops and viticulture.
KIE	1.9	Drainage depressions, including concave lower slopes and creek flats, formed on alluvium associated with hillslopes of calcified siltstones and slates. Slopes range from 2% on flats to 10% on lower slopes adjacent to surrounding rising ground. Deep sandy or loamy soils with clayey subsoils, together with a range of miscellaneous alluvial soils occur on the floors of the depressions. On lower slopes, shallower soils are more common, formed on siltstone, or siltstone capped by soft to semi-hard carbonate. Main soils: Gradational red sandy loam - **C1** (C) } on flats Deep sandy loam - **M1** (C) } Shallow calcareous loam - **A2** (L) } on rock on lower slopes Shallow gradational red loam - **C2** (L) } Shallow loam over red clay - **D1a** (L) } The soils of the flats are deep, well drained and moderately fertile, but small in area, so development potential is limited. The soils of the lower slopes are moderately shallow (restricted waterholding capacity), but well drained and fertile.
TBZ	4.6	Undulating summit surfaces formed on clays derived from the deep weathering of siltstone and claystone bedrock. Slopes vary from 0% on crests to 10% on margins. Watercourses are very weakly defined. Soils are clayey to clay loamy. Main soils: Black cracking clay - **E1** (E) Gradational friable red clay loam - **C3** (E) These soils are deep and highly fertile, although sometimes alkaline to the surface. Drainage is impeded by the clayey textures, and soils are prone to wetness at times. Boron toxicity may be a problem in places. Productive potential for field crops is high, although exposure may reduce yields. The soils are less favourable for horticulture and viticulture.

PROPORTION codes assigned to soils within Soil Landscape Units (SLU):

(D)	Dominant in extent (>90% of SLU)	(C)	Common in extent (20–30% of SLU)
(V)	Very extensive in extent (60–90% of SLU)	(L)	Limited in extent (10–20% of SLU)
(E)	Extensive in extent (30–60% of SLU)	(M)	Minor in extent (<10% of SLU)

Detailed soil profile descriptions:

Soils formed on calcified basement rock

A2 Shallow calcareous loam on rock (Paralithic, Calcic Calcarosol)
Medium thickness calcareous reddish brown stony loam, overlying a brown highly calcareous stony clay loam, increasingly calcareous and paler coloured with depth. Highly calcareous weathering siltstone or slate occurs at about 50 cm.

C2 Shallow gradational red loam on rock (Hypercalcic, Red Dermosol)
Medium thickness red brown loam to clay loam, grading a red well structured clay loam, grading to massive semi hard carbonate, over weathering siltstone below 50 cm.

D1a Shallow loam over red clay on rock (Hypercalcic, Red Chromosol)
Medium thickness hard setting loam with a paler and stony A2 horizon, overlying a dark reddish brown, well structured clay which is highly calcareous from about 50 cm. Weathering, calcified siltstone or slate occurs within 100 cm.

D1b Shallow sandy loam over red sandy clay on rock (Hypercalcic, Red Chromosol)
Medium thickness hard sandy loam, with a very stony and paler coloured A2 horizon, overlying a red sandy clay to clay which is highly calcareous from about 50 cm. Weathering calcified sandstone occurs within 100 cm.

L1 Shallow stony loam (Calcareous, Paralithic, Leptic Tenosol)
Thick, stony, reddish brown loam, grading to highly calcified weathering siltstone or fine sandstone within 50 cm.

Soils formed on calcreted basement rock

B2 Shallow calcareous loam (Petrocalcic, Calcic Calcarosol)
Medium thickness calcareous reddish brown stony loam, grading to a brown highly calcareous stony clay loam, increasingly calcareous and paler coloured with depth, over a moderately cemented massive to nodular calcrete pan at about 30 cm, with weathering rock at about 60 cm.

B6 Shallow loam over red clay on calcrete (Petrocalcic, Red Chromosol)
Medium thickness hard setting loam with a paler and stony A2 horizon, overlying a dark reddish brown well structured clay with a massive calcrete pan at 55 cm, overlying a highly calcareous clay loam which grades to weathering calcified rock at variable depths averaging 100 cm.

C5 Shallow dark clay loam (Supracalcic, Black Dermosol)
Medium thickness dark crumbly clay loam, overlying a well structured dark reddish brown to black clay loam to light clay. A carbonate pan or semi hard carbonate layer occurs before 50 cm, grading to weathering calcareous siltstone, marble or limestone by 100 cm.

Deep soils formed on highly weathered rocks

A6 Gradational calcareous clay loam (Pedal, Calcic Calcarosol)
Medium thickness reddish brown calcareous loam to clay loam, grading to a well structured reddish brown clay subsoil, becoming more clayey and calcareous with depth. Coarsely structured brown heavy clay continues below 200 cm.

C3 Gradational friable red clay loam (Calcic, Red Dermosol)
Medium thickness dark reddish brown clay loam, overlying a dark reddish brown well structured clay subsoil which is calcareous with depth. Highly calcareous clay continues below 100 cm.

E1 Black cracking clay (Self-Mulching, Black Vertosol)
Medium thickness brown to black well structured light clay, grading to dark brown to black strongly structured heavy clay, calcareous with depth. Coarsely structured brown heavy clay with soft calcareous segregations continues below 200 cm.

Soils formed on calcreted Tertiary sandstones

A4 Deep (rubbly) calcareous loam (Lithocalcic / Hypercalcic Calcarosol)
Medium thickness dark brown calcareous sandy loam to sandy clay loam, overlying a dark brown highly calcareous clay loam with up to 50% carbonate nodules, grading to a pale brown very highly calcareous clay with more than 50% calcrete nodules (Class III C carbonate) from 50 cm. Weak calcrete pans occur sporadically. Highly calcareous sandstone or limestone from 120 cm.

Soils formed on alluvium

C1 Gradational red sandy loam (Calcic, Red Kandosol)
Thick reddish brown sandy loam to fine sandy loam with a pink A2 horizon, overlying a yellowish red weakly structured clay loam to clay, calcareous with depth.

D2 Loam over red clay (Sodic, Calcic, Red Chromosol)
Thick loam with a paler coloured A2 horizon, overlying a dark reddish brown well structured clay, highly calcareous (Class I carbonate) from about 60 cm. The soil grades to medium to fine grained alluvium below 100 cm.

M1 Deep sandy loam (Basic, Regolithic, Brown-Orthic Tenosol)
Thick brown sandy loam to loamy sand, overlying a reddish brown clayey coarse sand to silty sand, grading to variable sandy and gritty alluvial sediments.

Further information: DEWNR Soil and Land Program

TEN Tenafeate Land System

Strongly dissected slopes of the South Para catchment immediately south east of Gawler

Area: 30.1 km^2

Annual rainfall: 475 – 625 mm average

Geology: The land is underlain by siltstones, slates and fine sandstones, and minor quartzites and dolomites. The rocks are variably capped by fine carbonates of aeolian origin, which occur as a veneer of soft segregations in rock fissures and in the lower soil profile. Locally derived alluvium, usually fine grained, occurs in minor drainage depressions. There are minor remnant laterites and Tertiary gravel deposits. These materials, which presumably covered most of the area at some time, have been all but completely eroded away by the down cutting of the streams.

Topography: The landscape is dominated by steep to moderately steep slopes created by the downcutting of the South Para River just prior to its exit from the ranges on to the plains. The main river channel runs more or less through the centre of the System. It is deeply incised between its point of entry on the eastern side of the System, to its exit in the north west corner. Short closely spaced tributaries draining from the edges of the System to the river in the centre have also cut valleys up to 100 m deep. Drainage depressions are narrow, and where mappable (ie more than 100 m wide) are very well defined. There is typically an abrupt boundary between the creek flat and the adjacent slope.

Elevation: 50 m in the north west where the South Para River flows out, to 290 m in the south west.

Relief: Up to 100 m

Soils: Most soils are shallow to moderately deep over basement rock. Loamy surfaces are usual, but subsoils vary. Well structured red clays are common, particularly on lower slopes. These may or may not be calcareous with depth. However soils with weakly developed or no subsoil are more extensive. They are usually very stony. There is a range of deep soils over alluvium on creek flats. Black clay loams are most characteristic.

Main soils:

Acidic soils formed in weathering basement rock

K2a Acidic loam over red clay
K2b Acidic loam over brown and red clay
L1a Shallow stony loam

Soils formed on calcified basement rock

C2 Shallow gradational red loam
D1 Shallow loam over red clay
L1b Shallow stony loam

Minor soils:

Soils formed in alluvium

F1 Sandy loam over brown sandy clay to clay
M1 Deep sandy loam
M2 Deep black clay loam

Main features: The Tenafeate Land System is dominated by steep slopes. Almost 70% of the area is steeper than 30% and as such is inaccessible to conventional agricultural machinery. The majority of the rest of the land is moderately steep and non arable, although accessible. The soils throughout are loamy with subsoils ranging from thick well structured red clays to nothing (ie soils are shallow over parent rock). They are inherently fertile and well drained, although

of highly variable depth. This affects waterholding capacity and therefore pasture productivity. Perennial horticulture and viticulture are options on the accessible slopes where water is available.

Soil Landscape Unit summary: 6 Soil Landscape Units (SLUs) mapped in the Tenafeate Land System

SLU	% of area	Main features #
AJC AJD	25.8 68.4	Moderately steep to steep strongly dissected low hills and hills, formed on weakly calcified siltstones, slates and fine sandstones, and minor quartzites and dolomites. Gully slopes are up to 50% (100% in extreme cases), grading to more gently inclined upper slopes and crests (10% to 30% slopes, down to 4% on narrow crests). Maximum relief is 100 metres. Water courses are well defined in narrow drainage depressions. Rock outcrop is sporadic, but extensive in places. There is variable surface stone. **AJC** Moderate slopes and rolling low hills with relief to 80 m and slopes of 20-30%. **AJD** Steep hillslopes with relief to 100 m and slopes of 30-100%. Most soils are shallow to moderately deep over siltstone which may be non-calcified or contain soft carbonate in rock fissures. Common profiles include loams over red brown clays, shallow non-calcareous stony loams, and shallow loams over calcified rock. Main soils: Acidic loam over red or brown clay - **K2a** / **K2b** (E) Shallow stony loam - **L1a** / **L1b** (C) Shallow loam over red clay - **D1** (L) Shallow gradational red loam - **C2** (L) Variation in soil depth is considerable, but otherwise the soils are inherently fertile and well drained. The slopes preclude any cultivated agriculture, but gentler slopes where water is available are suitable for perennial horticulture or viticulture.
DGD	1.8	Moderate slopes of 10-20% and up to 80 m high formed on weakly calcified siltstones, slates and fine sandstones, and minor quartzites and dolomites. There is no rock outcrop and up to 10% surface stone. Most soils are shallow to moderately deep over siltstone which may be non-calcified or contain soft carbonate in rock fissures. Surfaces are mostly loamy. Main soils: Acidic loam over red or brown clay - **K2a** / **K2b** (E) Shallow stony loam - **L1a** / **L1b** (L) Shallow loam over red clay - **D1** (L) Shallow gradational red loam - **C2** (L) These soils are moderately deep to shallow, fertile and well drained. The slopes are semi arable, and cropping is not a viable option in the long term. However the land is suitable for perennial horticulture or viticulture where water is available.
FiZ	0.8	Upper slopes and summit surfaces (flat topped crests) underlain by deeply weathered and lateritized schists. Slopes are variable, up to 15%, with some surface ironstone. Soils are characterized by ironstone gravel. Main soils: Ironstone soil - **J2b** (E) Acidic sandy loam over brown clay on kaolinized rock - **K4b** (E) These soils are deep, but imperfectly drained, infertile and acidic. Productive potential is low.
GBD	0.9	Undulating upper slopes of 2-10% formed on Tertiary sandstones, with reworked sandy sediments in hollows and depositional areas. There is negligible surface stone and there are no defined water courses. Soils are invariably sandy surfaced, usually with more clayey subsoils, but some deep gritty sands occur on reworked sediments. Main soils: Bleached sand over sandy clay loam - **G2** (E) Sandy loam over poorly structured brown clay - **F2** (C) Thick sand over clay - **G3** (L) Deep loamy sand - **M1** (L) These soils are moderately deep, but highly infertile and prone to acidification and water repellence. Drainage is variable, usually moderately well to well, but some hollows are imperfectly drained with seepage areas. The sands are highly erodible, to both wind and water, so cropping is not generally sustainable. Most of the land is suitable for perennial horticulture and viticulture, although drainage management is required in some parts.

LdE	2.3	Creek flats formed on clayey alluvium. Main soils: Deep black clay loam - **M2** (E) Sandy loam over brown sandy clay to clay - **F1** (E) Deep sandy loam - **M1** (L) These soils are deep and fertile, but imperfectly drained. Productive potential is high although useable areas are very limited. Irrigation must be carefully managed to avoid waterlogging. Sporadic salinity should be monitored and measures to control water course erosion are required.

PROPORTION codes assigned to soils within Soil Landscape Units (SLU):

(D) Dominant in extent (>90% of SLU)
(V) Very extensive in extent (60–90% of SLU)
(E) Extensive in extent (30–60% of SLU)
(C) Common in extent (20–30% of SLU)
(L) Limited in extent (10–20% of SLU)
(M) Minor in extent (<10% of SLU)

Detailed soil profile descriptions:

Acidic soils formed on weathering basement rock

K2a Acidic loam over red clay (Eutrophic, Red Kurosol)
Medium thickness reddish loam to clay loam with a gravelly and paler coloured A2 horizon, overlying a red very well structured clay grading to weathering siltstone from about 100 cm, but deeper on lower slopes.

K2b Acidic loam over brown and red clay (Eutrophic, Brown Kurosol)
Thick sandy loam to loam surface soil with a paler coloured and gravelly A2 horizon, overlying a yellowish brown, brown and red well structured clay subsoil grading to weathering siltstone or fine sandstone by 100 cm.

L1a Shallow stony loam (Basic, Paralithic, Leptic Tenosol)
Thick stony loam, forming in weathering siltstone at 50 cm or less.

Soils formed on calcified basement rock

C2 Shallow gradational red loam on rock (Hypercalcic, Red Dermosol)
Medium thickness red brown loam to clay loam, grading a red well structured clay loam, grading to massive semi hard carbonate, over weathering siltstone below 50 cm.

D1 Shallow loam over red clay on rock (Hypercalcic, Red Chromosol)
Medium thickness hard setting loam with a paler and stony A2 horizon, overlying a dark reddish brown well structured clay which is highly calcareous from about 50 cm. Weathering calcified siltstone or slate occurs within 100 cm.

L1b Shallow stony loam (Calcareous, Paralithic, Leptic Tenosol)
Thick stony reddish brown loam, grading to highly calcified weathering siltstone or fine sandstone within 50 cm.

Soils formed in alluvium

F1 Sandy loam over brown sandy clay to clay (Hypocalcic, Brown Chromosol)
Thick loamy sand to sandy clay loam with a strongly bleached A2 horizon, sharply overlying a yellowish brown, grey and red mottled sandy clay to clay grading to medium or fine grained alluvium.

M1 Deep sandy loam (Regolithic, Red-Orthic Tenosol)
Thick brown sandy loam to loamy sand, overlying a reddish brown clayey coarse sand to silty sand, grading to variable sandy and gritty alluvial sediments.

M2 Deep black clay loam (Melanic, Eutrophic, Black Dermosol)
Thick black silt loam to clay loam with strong granular structure, overlying a black to dark brown clay with strong blocky structure, becoming yellow and grey mottled with depth.

Further information: DEWNR Soil and Land Program

SMI Smithfield Land System

Gentle slopes between Elizabeth and Gawler

Area: 21.0 km^2

Annual rainfall: 450 – 525 mm average

Geology: Alluvial clays of the Pooraka Formation, derived from the ranges to the east. The clays are mantled by a veneer of fine grained carbonates of aeolian origin.

Topography: The land comprises a simple outwash fan with very gentle to gentle slopes abutting the Gawler Escarpment. Slopes are 2% to 10%. Well defined watercourses enter the land system from the escarpment, but dissipate as the slope wanes.

Elevation: 150 m on the eastern side to 50 m on the western side

Relief: The land surface has a uniform westward gradient with no internal relief other than a few metres in occasional eroded water courses.

Soils: The soils are red, medium to fine grained, and calcareous with depth. The principal variations between the different soils are the degree of contrast between the surface soils and the clayey subsoil. Some soils are clay loamy to clayey throughout, others have a distinct contrast between a loamy surface and the subsoil, and others have a gradual increase in clay content with depth.

Main soils

D2	Loam over red clay
C3	Gradational red loam
C4/M2	Gradational red clay loam

Main features: The Smithfield Land System comprises gentle slopes with deep, inherently fertile and moderately well drained soils. Apart from minor limitations caused by hard setting surfaces and some poorly structured subsoils, they have high productive potential, especially for dryland crops. Drainage problems are likely in some soils under irrigation.

Soil Landscape Unit summary: 3 Soil Landscape Units (SLUs) mapped in the Smithfield Land System

SLU	% of area	Main features #
JAB JAC JAJ	37.5 58.8 3.7	Very gently to gently inclined outwash fans. **JAB** Very gently inclined fans with slopes of 2-4%. **JAC** Gently inclined fans with slopes of 4-10%. **JAJ** Eroded watercourses. The soils are deep and loamy. Main soils: Loam over red clay - **D2** (E) Gradational red loam - **C3** (E) Gradational red clay loam - **C4/M2** (E) These soils are deep and inherently fertile. They are neutral to slightly alkaline at the surface, and alkaline to strongly alkaline with depth. They are moderately well to well drained. Hard setting surfaces and coarsely structured subsoils (C4/M2 soils) are somewhat limiting in terms of infiltration rates, workability, seedling emergence and optimum root growth, but overall productive potential is high. The more clayey types (especially C4) have potential drainage problems under irrigation.

PROPORTION codes assigned to soils within Soil Landscape Units (SLU):

(D) Dominant in extent (>90% of SLU)
(V) Very extensive in extent (60–90% of SLU)
(E) Extensive in extent (30–60% of SLU)
(C) Common in extent (20–30% of SLU)
(L) Limited in extent (10–20% of SLU)
(M) Minor in extent (<10% of SLU)

Detailed soil profile descriptions:

D2 Loam over red clay (Sodic, Calcic, Red Chromosol)
Thick hard loamy surface soil with a paler coloured A2 horizon, overlying a dark reddish brown well structured clay subsoil, highly calcareous (Class I carbonate) from about 60 cm. The soil grades to medium to fine grained alluvium below 100 cm.

C3 Gradational red loam (Sodic, Calcic, Red Dermosol)
Medium thickness reddish brown loam, overlying a dark reddish brown clay loam with granular structure, grading to a red light clay. There is abundant soft Class I carbonate from 70 cm.

C4/M2 Gradational red clay loam (Vertic, Calcic / Eutrophic, Red Dermosol)
Thick reddish brown clay loam to light clay with granular structure, overlying a red clay with strong blocky structure and variable soft carbonate segregations (Class I carbonate) from 65 cm.

Further information: DEWNR Soil and Land Program

KLB Kalbeeba Land System

Undulating rises in the Sandy Creek - Concordia - Sheoak Log area

Area: 74.8 km^2

Annual rainfall: 435 – 570 mm average

Geology: The land is underlain by basement siltstones, slates and fine sandstones, so deeply weathered in places that there is no rock-like material within the upper 200 cm. The rocks and deep weathering materials are commonly capped by a veneer of carbonate of aeolian origin, which has been leached into the upper layers of the rock. In places it has become indurated to calcrete. There are localized deposits of outwash clays, silts and sands on lower slopes and drainage depressions. Remnant Tertiary sediments occur in the south.

Topography: The landscape is typically undulating with slopes of 2 - 12%. However, the North Para River flowing across the System from east to west, together with its short tributaries, has gouged a gully up to 50 m deep, with moderately steep to steep rocky slopes. There are minor moderately steep rocky slopes elsewhere, due to localized dissection. Outwash fans and creek flats make up about 15% of the land area, undulating to gently rolling rises about 75%, and moderately steep to steep rocky slopes about 10%.

Elevation: 50 m in the west where the North Para River flows out on to the plains, to 200 m in the south east.

Relief: Up to 50 m

Soils: Most of the soils are moderately deep to shallow over basement rock. Typically they have hard loamy surfaces overlying either weathering rock, or more commonly a red friable clay loamy to clayey subsoil. Some are calcareous throughout. On rising ground there are limited areas of deep clay loamy to clayey gradational soils on highly weathered rocks. On minor lower slopes and creek flats, deep red loam over clay soils predominate, with small areas of deep sandy loams and heavy dark soils. Sandier soils occur on Tertiary remnants.

Main soils

Soils formed on calcified basement rock

D1 Shallow loam over red clay
C2 Shallow gradational red loam
L1 Shallow stony loam

Minor soils

Soils formed on strongly calcified basement rock

A2 Shallow calcareous loam
B6 Shallow loam over red clay on calcreted rock

Deep soils formed on highly weathered rock

A6 Gradational calcareous clay loam
C3 Gradational friable red clay loam
E1 Black cracking clay

Soils formed on alluvium

C1 Gradational red sandy loam
D2 Loam over red clay
D3a Sandy loam over poorly structured red clay
M1 Deep sandy loam
Soils formed on Tertiary sediments
D3b Gravelly sandy loam over poorly structured red clay
G2 Bleached sand over sandy clay loam
H3 Moderately deep sand

Main features: The Kalbeeba Land System is characterized by undulating to gently rolling rises and low hills. The soils are moderately deep to shallow over basement rock, and usually have loamy surfaces and red more clayey subsoils. They are inherently fertile and well drained, with high production potential. They are especially suited to viticulture where water is available. Mixed with these soils are deeper clay loamy soils over highly weathered materials. These soils are fertile with very high water holding capacities, but may suffer from waterlogging and high boron levels in places. Deep loamy texture contrast soils on creek flats and outwash fans are potentially productive but often poorly structured with hard setting surfaces and dispersive clayey subsoils. The steep rocky slopes, mainly associated with the North Para River, are non arable with mainly shallow stony loams.

Soil Landscape Unit summary: 13 Soil Landscape Units (SLUs) mapped in the Kalbeeba Land System:

SLU	% of area	Main features #
AAC	2.1	Moderately steep rocky slopes underlain by siltstones, slates and fine sandstones. Slopes are 18-30% with relief of 20-50 m. There is up to 20% surface stone and rock outcrop. Soils are generally loamy and shallow over rock, but some have more clayey subsoils. Main soils: Shallow stony loam - **L1** (E) Shallow calcareous loam - **A2** (C) Shallow loam over red clay on calcrete - **B6** (L) Shallow gradational red loam - **C2** (L) Shallow loam over red clay - **D1** (M) all on weathering rock These slopes are too steep and rocky, and the soils too shallow for cropping. They are used for rough grazing.
AZm AZn	7.7 0.5	Moderately steep to steep slopes created by the down cutting of the North Para River. Slopes are variable up to 100% and relief is 20-50 m. There is up to 50% surface stone and rocky outcrop. Minor discontinuous flats adjoin the river. **AZm** Slopes are generally not eroded. **AZn** Slopes are commonly eroded. Main soils: Shallow stony loam - **L1** (V) on rocky slopes Shallow loam over red clay - **D1** (L) on slopes Deep sandy loam - **M1** (L) on flats This land is either steep and rocky, or subject to flooding, so has very limited agricultural potential, but high conservation and water resource protection value.
DCC DCD	32.0 13.3	Undulating rises and rolling low hills formed on calcified siltstones, slates and fine sandstones. Slopes range from 4% to 18%. Rock outcrop is sporadic, but there is up to 10% surface stone. **DCC** Undulating rises with relief to 40 m and slopes of 4-10%. **DCD** Moderate slopes of 10-18%, up to 40 m high. Most soils are moderately deep to shallow over calcified siltstone, or siltstone mantled by soft to semi hard carbonate. Main soils: Shallow loam over red clay - **D1** (E) } on slopes Shallow gradational red loam - **C2** (C) } Shallow loam over red clay on calcrete - **B6** (L) }

		Shallow stony loam - **L1** (L) } Deeper loam over red clay - **D2** (L-M) on lower slopes and creek flats Gradational friable red clay loam - **C3** (M) on gently inclined upper slopes The soils are fertile and well drained, although often shallow, thereby restricting water holding capacity. Surface soils set hard, creating workability and emergence problems, and increasing erosion susceptibility. However, the land is potentially productive - DCC is suitable for cropping provided that adequate erosion control measures are used, but DCD is marginal due to the potential for erosion. The land is suited to horticultural development where water is available.
DFC	27.4	Undulating rises and low hills to 50 m high formed on calcified siltstones and slates, commonly deeply weathered. Slopes are 3-10%. A wide variety of soils occurs, differences being mainly attributable to parent materials. Common profiles include loams over red brown clays, cracking clays, and calcareous and non-calcareous loams. Main soils: Shallow loam over red clay - **D1** (C) } on basement rock Shallow gradational red loam - **C2** (C) } Shallow stony loam - **L1** (L) } Gradational calcareous clay loam - **A6** (L) } on deeply weathered rocks Gradational friable red clay loam - **C3** (L) } Black cracking clay - **E1** (M) } Loam over red clay - **D2** (M) on alluvium on lower slopes The shallower soils on basement rock are similar to those of DCC. The deeper soils on highly weathered rocks or alluvium are fertile and have high water holding capacities. Although some have poor surface structure, they are potentially highly productive. Boron toxicity may be a problem on the deeper soils.
DHC	2.0	Undulating rises to 40 m high with slopes of 4-10%. There is negligible rock outcrop, but minor surface slate, sandstone, quartz and calcrete. Water courses are moderately well defined in shallow broad drainage depressions. These are occasionally salinized. Main soils: Shallow loam over red clay - **D1** (V) on slopes Loam over red clay - **D2** (C) on lower slopes and drainage depressions These soils are moderately deep to deep, inherently fertile and mostly adequately drained. Poor surface structure and associated erosion potential, together with sporadic lower slope salinity, require appropriate management, but productive potential for both field and horticultural crops is nevertheless high.
GBD	1.6	Undulating to gently rolling slopes of 6-16%, to 30 m high, formed on Tertiary clayey sands, sandy clays and sandstones. Sandy loam to sand over clay soils, with uniform to gradational sands, are characteristic. Main soils: Bleached sand over sandy clay loam - **G2** (E) Gravelly sandy loam over red clay - **D3b** (E) Moderately deep sand - **H3** (L) The soils are variable, with low natural fertility characterizing the sandy soils (G2 and H3), and poor structure / drainage typical of the loamier soils (D3b). The soils are highly erodible to both wind and water, so care is needed during crop establishment. The land is generally suited to perennial horticulture and viticulture, where water is available.
JBB JBE JBJ	4.5 3.6 0.5	Very gently sloping outwash fans and drainage depressions formed on alluvial clays derived from the erosion and deposition of basement rock materials, mantled by fine grained carbonates of aeolian origin. **JBB** Very gently inclined fans with slopes of 2-4%. **JBE** Drainage depressions with well defined and sometimes eroded water courses. **JBJ** Drainage depressions with well defined, eroded water courses. Most soils have red texture contrast profiles with a range of surface textures from sandy loam to clay loam, and clayey subsoils. Main soils: Loam over red clay - **D2** (E) Sandy loam over poorly structured red clay - **D3a** (E) Gradational red sandy loam - **C1** (L) These soils are deep and inherently fertile. Poor structure (especially in D3a soils) and associated drainage, infiltration, workability and emergence problems are the main limitations. Improved surface management and gypsum applications will help to alleviate the problem. Sheet/rill erosion

		in paddocks, and gully erosion in water courses are potential problems. Provided erosion is controlled, productive potential is high.
TBB	3.8	Gentle slopes formed on clayey sediments or deeply weathered basement rock. **TBB** Slopes of 2-4%. Main soils: gradational clay loam - **C3a** (E), brown cracking clay - **E3** (E) and hard sandy loam over friable red clay - **D2a** (L), with calcareous loam to clay loam - **A6** (M), red cracking clay - **E2** (M), black cracking clay - **E1** (M) and loam over red clay on calcrete or rubble - **B6/D1** (M). Hard sandy loam over dispersive red clay - **D3a**, brown gradational loam - **M4** and calcareous sandy loam **- A4** occur sporadically. These soils are predominantly deep, fertile and well structured. Exceptions are the D3, D2 and M4 soils which set down hard, shed water and are prone to patchy emergence. The clayey soils are difficult to manage when wet, but are inherently highly productive. High subsoil boron levels are likely in these soils, so tolerant varieties will be needed where symptoms occur.
XHR	1.0	Alluvial flats of the lower North Para River including watercourses, terraces and banks. Underlying sediments are variable silts, clays and sands of relatively recent alluvial deposition, usually mantled by fine grained soft carbonates. Because of the variability of parent sediments, there is a range of soils with sandy to loamy surfaces and reddish or dark coloured sandy clay loam to sandy clay subsoils, calcareous at depth. Near watercourses there are deep medium to coarse grained alluvial soils. Main soils: Deep sandy loam - **M1** (E) Gradational red sandy loam - **C1** (E) These flats are subject to flooding, but are potentially productive, with deep, albeit often sandy and silty soils. Watercourse protection is a significant issue.

PROPORTION codes assigned to soils within Soil Landscape Units (SLU):

(D) Dominant in extent (>90% of SLU)
(V) Very extensive in extent (60–90% of SLU)
(E) Extensive in extent (30–60% of SLU)
(C) Common in extent (20–30% of SLU)
(L) Limited in extent (10–20% of SLU)
(M) Minor in extent (<10% of SLU)

Detailed soil profile descriptions:

A2 Shallow calcareous loam on rock (Paralithic, Calcic Calcarosol)
Medium thickness calcareous reddish brown stony loam, overlying a brown highly calcareous stony clay loam, increasingly calcareous and paler coloured with depth. Highly calcareous weathering siltstone or slate occurs at about 50 cm.

A6 Gradational calcareous clay loam (Pedal, Calcic Calcarosol)
Medium thickness reddish brown calcareous loam to clay loam, grading to a well structured reddish brown clay subsoil, becoming more clayey and calcareous with depth. Coarsely structured, brown heavy clay continues below 200 cm.

B6 Shallow loam over red clay on calcrete (Petrocalcic, Red Chromosol)
Medium thickness hard setting loam with a paler and stony A2 horizon, overlying a dark reddish brown, well structured clay with a massive calcrete pan at 55 cm, overlying a highly calcareous clay loam which grades to weathering, calcified rock at variable depths averaging 100 cm.

C1 Gradational red sandy loam (Calcic, Red Kandosol)
Thick reddish brown sandy loam to fine sandy loam with a pink A2 horizon, overlying a yellowish red weakly structured clay loam to clay, calcareous with depth.

C2 Shallow gradational red loam on rock (Hypercalcic, Red Dermosol)
Medium thickness red brown loam to clay loam, grading a red, well structured clay loam, grading to massive semi hard carbonate, over weathering siltstone below 50 cm.

C3 Gradational friable red clay loam (Calcic, Red Dermosol)
Medium thickness dark reddish brown clay loam, overlying a dark reddish brown, well structured clay subsoil which is calcareous with depth. Highly calcareous clay continues below 100 cm.

D1 Shallow loam over red clay on rock (Hypercalcic, Red Chromosol)
Medium thickness hard setting loam with a paler and stony A2 horizon, overlying a dark reddish brown well structured clay which is highly calcareous from about 50 cm. Weathering, calcified siltstone or slate occurs within 100 cm.

D2 Loam over red clay (Sodic, Calcic, Red Chromosol)
Thick loam with a paler coloured A2 horizon, overlying a dark reddish brown, well structured clay , which is highly calcareous (Class I carbonate) from about 60 cm. The soil grades to medium to fine grained alluvium below 100 cm.

D3a Sandy loam over poorly structured red clay (Calcic, Red Sodosol)
Thick reddish brown massive sandy loam to loam with a pink very hard A2 horizon, overlying a reddish brown clay with prismatic structure and many soft carbonate segregations (Class I carbonate) from 65 cm.

D3b Gravelly sandy loam over poorly structured red clay (Calcic, Red Sodosol)
Medium thickness hard massive sandy loam with variable quartz and ironstone gravel, sharply overlying a coarsely structured red, brown and grey mottled heavy clay, calcareous with depth, grading to Tertiary sandy clay or sandstone between 100 and 150 cm.

E1 Black cracking clay (Self-Mulching, Black Vertosol)
Medium thickness brown to black well structured light clay, grading to dark brown to black strongly structured heavy clay, calcareous with depth. Coarsely structured, brown heavy clay with soft calcareous segregations continues below 200 cm.

G2 Bleached sand over sandy clay loam (Bleached, Mesotrophic, Brown Chromosol)
Thick grey sand with a bleached A2 horizon containing ironstone and sandstone gravel, overlying a brown, yellow and red sandy clay loam to clay, grading to weakly cemented Tertiary sandstone within 100 cm.

H3 Moderately deep sand (Basic, Arenic, Bleached-Orthic Tenosol)
Thick bleached sand grading to yellowish sand, clayey sand or soft sandstone within 100 cm.

L1 Shallow stony loam (Calcareous, Paralithic, Leptic Tenosol)
Thick, stony, reddish brown loam, grading to highly calcified weathering siltstone or fine sandstone before 50 cm.

M1 Deep sandy loam (Regolithic, Brown-Orthic Tenosol)
Thick brown sandy loam to loamy sand, overlying a reddish brown clayey coarse sand to silty sand, grading to variable sandy and gritty alluvial sediments.

Further information: DEWNR Soil and Land Program

13 WATER EROSION POTENTIAL

This section deals with the susceptibility of land to erosion by overland flow of water. Removal of a more or less uniform thickness of soil is called sheet erosion. The formation of shallow gutters which can be obliterated by cultivation is rill erosion. Gully erosion caused by concentrated flow in unprotected watercourses, subsurface (or tunnel) erosion, landslip, mass movement and stream bank erosion are dealt with separately.

This discussion is also confined to the inherent potential of land in a clean cultivated condition to erode, as determined by soil properties, topography and rainfall. It does not deal with the susceptibility of land to erosion as a result of a particular land use or management practice. Thus a steep well grassed hill slope has a high erosion potential due to its slope, but a low erosion hazard because it is well protected by vegetation.

Factors affecting water erosion potential

Topography

Three elements of topography influence erosion potential. Potential increases with:

- Slope steepness
- Slope length
- Proximity to rising ground (source of run-on water)

Soil

The inherent potential of a particular soil type to erode on a specified slope in a clean cultivated condition is called its erodibility. Erodibility is influenced by the capacity of soil to absorb the rain that falls on it and the resistance of the surface soil to raindrop impact and to being dragged along (entrained) by overland flow. The rate at which water enters the soil surface (infiltration), the rate at which it moves through the soil (permeability) and the stability of the soil surface are therefore the key soil properties. As discussed in Section 7, the stability of the surface is largely determined by its texture and organic matter content.

Rainfall

Rainfall affects erosion potential in three ways:

- If the infiltration of rainfall into the soil is impeded the surface soil becomes saturated, loses strength and is more likely to erode.
- Rainfall which is unable to infiltrate will run off, thereby providing a medium in which soil particles can move downhill.
- The impact of raindrops dislodges surface soil particles and thereby makes it easier for them to become entrained in overland flow. The kinetic energy of rainfall as it strikes the earth is defined as its erosivity.

The intensity and duration of rainfall events are key factors, modified by the moisture status of the soil before the rain.

Consequences of water erosion

On-site effects

Sheet and rill erosion removes the most valuable layer of the soil profile, the surface. This is the zone of concentration of nutrients and organic matter. Loss of topsoil usually exposes soil of lower fertility and less organic matter with poorer structure and stability. Erosion therefore makes the soil even more erodible. Erosion also reduces the moisture holding capacity of the soil.

Rills and small gullies, which sometimes occur on inadequately protected land during heavy rain, can affect

access across the land until they are removed by cultivation.

Soil formation rates are usually so slow that for practical purposes erosion represents a permanent loss of the resource.

Rill erosion

Erosion rill exposing calcrete substrate

Silt deposit at bottom of slope

Off-site effects

Eroded soil is often deposited on lower ground where it can damage or bury fences, block culverts, silt up dams and water courses and cover roads. These all involve public or private expense to rectify. Finer grained material, particularly clay, remains suspended in runoff water and can eventually pollute creeks and reservoirs. Nutrients, particularly nitrogen and phosphorus, attached to clay particles cause eutrophication of water supplies, pesticides adsorbed on clay colloids poison water and the clay particles themselves make the water turbid.

Assessing water erosion potential

Rainfall erosivity

All districts in South Australia are subject to annual rainfall events of sufficient erosivity to warrant precautionary management practices for susceptible soils on all but the gentlest of slopes. Although there are differences in rainfall intensity across the state, they are not sufficently large to warrant the designation of rainfall erosivity zones for the purpose of land classification.

Slope

Slope length and run-on potential are not included in the classification of land with respect to water erosion potential, even though they must be taken into account when assessing land. In general, recommended practices for erosion control include agronomic or engineering techniques which effectively break slopes into smaller segments and divert water flow away from susceptible land.

Gradient is the major determinant of erosion potential. Erosion potential classes are based on slope categories, but the actual criteria used to define the categories vary depending on soil erodibility.

Soil erodibility

Six categories of erodibility are defined based on field observations. The categories are incomplete and represent a preliminary attempt to rank soil erodibility easily in the field. They should be treated only as a guide.

Draft erodibility categories for a range of soil profiles are defined in Table 45.

Table 45 Draft soil erodibility categories (water)

Soil profile characteristics	Erodibility
Soils with sandy to loamy surfaces, shallower than 30 cm, overlying clayey subsoils.	
- Loose or soft surface	Very high
- Dispersive surface	Very high
- Hard setting loamy sand to loam surface	High
- Structured sandy loam to clay loam surface	Moderate
- Weakly structured, friable sandy loam to loam surface	Moderate
Note: - Increase erodibility by one category if subsoil is dispersive	
- Decrease erodibility by one category if depth to clay is more than 30 cm	
Calcareous soils	
- Loamy sand to sand over Class IV carbonate:	
Deeper than 50 cm	Negligible
Shallower than 50 cm	Very low
- Sandy loam to clay loam grading to :	
Class III B or III C carbonate	Very low
Class III A carbonate	Low
Class I carbonate shallower than 50 cm	Moderate
Class I carbonate deeper than 50 cm	Low
- Loamy sand to loam over Class II carbonate	Moderate
- Loam over calcareous weathering rock:	
Deeper than 50 cm	Low
Shallower than 50 cm	Moderate
Deep sands (more than 80 cm)	
Non water repellent	Negligible
Water repellent	Low
Strongly water repellent	Moderate
Deep (more than 80 cm) uniform sandy loams to clay loams	
Well structured	Very low
Massive	Low
Clay soils	
Well structured	Low
Massive	Moderate
Skeletal soils (shallow over bedrock)	
Gritty, stony sands on sandstone, quartzite	High
Stony loams on shale, siltstone	Moderate