Government of **Western Australia**
Department of **Water**

Waterway assessment of the upper Lockhart River: Camm River confluence to Newdegate

Water resource management series
Looking after all our water needs

Report no. WRM 58
December 2009

Waterway assessment of the upper Lockhart River: Camm River confluence to Newdegate

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Department of Water

Water resource management series

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Disclaimer

Cover photo: Salt lake reflections, Commonwealth Road, Shire of Kulin. Photograph by Claire Hamersley.

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Summary

Management of water resources in the Avon River basin is a high priority under the Avon Catchment Council's natural resource management strategy and investment plans. Through the Avon Rivercare Project, the Department of Water has initiated a project to investigate the riparian condition and management needs of waterways in the Avon River basin within the zone of ancient drainage. This upper Lockhart River project is the sixth of these waterway assessments, following those of the Salt River, lower and upper Yilgarn River, lower Lockhart River and Camm River.

The Lockhart River extends from near Lake Biddy in the south, flowing in a general north-westerly direction until it converges with the Salt River at the Caroline Gap, south of Kellerberrin. This study has focused on the section of the Lockhart River from the Camm River confluence to the catchment divide at Watson Road near Newdegate.

The purpose of this waterway assessment is to investigate the Lockhart River's current condition by recording a snapshot survey of nine remnants in its upper catchment, identifying threatening processes and proposing management recommendations for improving its condition.

The key management issues identified in the study area are:

- increased salinity, higher watertables and longer periods of inundation on the valley floor
- loss of fringing riparian vegetation, especially around the edges of the larger lakes
- further clearing
- impedance of floodwaters by road crossings
- pest species degrading riparian vegetation
- stock access causing soil erosion
- weed invasion
- lack of corridors linking areas of remnant vegetation
- fire risk
- rubbish dumping in floodplain areas.

Of these, the most damaging is hydrological change (increased salinity, higher watertable and longer periods of inundation) experienced on the valley floors. Management of these processes needs to be at a catchment scale, through partnerships between landholders, all levels of government and non-government agencies.

1 Introduction

1.1 Avon River basin

The Avon River is one of Western Australia's major river systems, draining approximately 120 000 km^2 from Dalwallinu in the north, Southern Cross in the north-east and Lake King in the south-east. The Avon River becomes the Swan River at confluence of Wooroloo Brook in Walyunga National Park and enters the ocean at Fremantle.

There are four main subcatchments within the Avon River basin including:

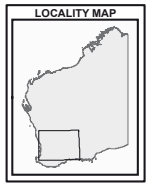
- the Yilgarn River catchment, which drains an area of approximately 55 900 km^2. It originates north-east of Southern Cross from Lake Seabrook and Lake Deborah and flows to the south-west past Merredin to its confluence with the Lockhart River at the Caroline Gap, south of Kellerberrin.
- the Lockhart River catchment, which drains an area of approximately 28 700 km^2. It originates around the locality of Lake Biddy, near Newdegate, and flows north-west through Kondinin, Corrigin and Bruce Rock to the Caroline Gap. The catchment also includes the Pingrup River, which originates at Chinocup Lake south of Lake Grace, and the Camm River, which originates at Lake King.
- the Mortlock River system, which drains an area of approximately 16 770 km^2. The Mortlock River system consists of the Mortlock River, Mortlock River North, Mortlock River East and Mortlock River South, and joins the Avon River at Northam.
- the Avon River, which drains an area of approximately 15 500 km^2, and includes the Salt River, Avon River South Branch, Dale River, Mackie River, Toodyay Brook, Brockman River and Wooroloo Brook catchments.

Map 1 shows the major subcatchments of the Avon River basin and the location of the upper Lockhart River study area.

1.2 Managing natural resources in the Avon River basin

The Avon Catchment Council (ACC) is the peak natural resource management (NRM) body in the diverse Avon River basin. The ACC completed the *Avon River Basin Natural Resource Management Strategy* in 2005 and updated the *Avon Investment Plan* in 2006, both of which identify priorities for actions to bring about change in the condition of water, land, vegetation and other landscape assets.

Map 1
Location of the Lockhart River study area within the Avon River basin



N

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Kilometres

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SOURCES

The Department of Water acknowledges the following datasets and their custodians in the production of this map:

Towns – Landgate – 2007
Roads, 1M, GA – Landgate – 2008
Hydrography, linear (hierarchy) – DoW – 2007
Hydrographic catchments – DoW – 2007

This map is a product of the Department of Water, Spatial Services Section and was completed in May 2009.

This map was produced with the intent that it be used for the Lower Lockhart River mapping project at the scale of 1:2 500 000.

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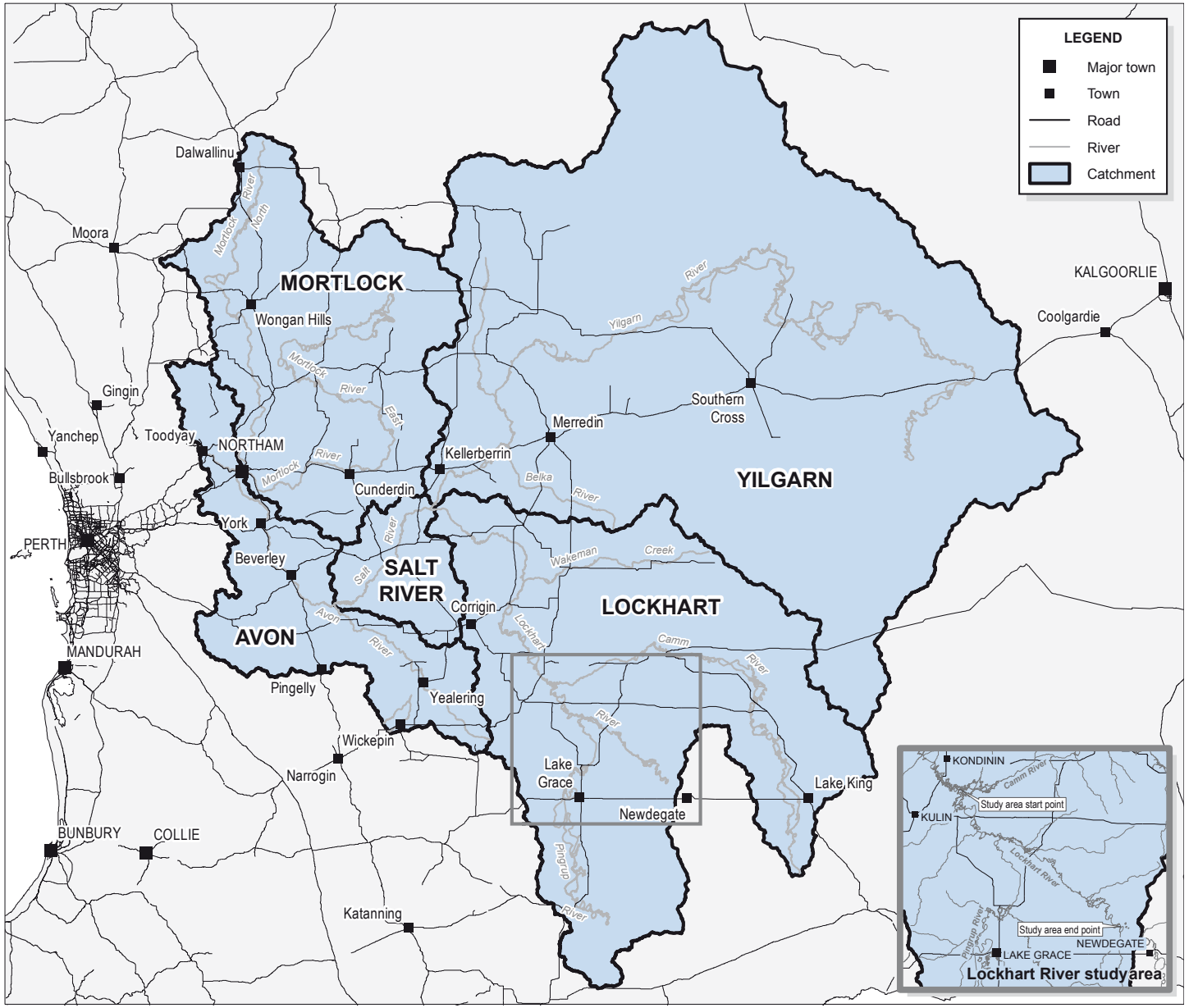

Supporting the Avon NRM strategy, the Ballardong NRM Working Group has completed *Ballardong Noongar Budjar: 'Healthy Country – Healthy People'* (2006) which presents the Noongar perspective on Caring for Country and how to involve the Ballardong people in the Avon NRM region.

The Avon Natural Diversity Alliance (ANDA) was formed to facilitate the delivery of projects from the *Avon Investment Plan*. The Department of Water, Department of Environment and Conservation (DEC), Greening Australia Western Australia (GAWA) and WWF-Australia (WWF) are working in partnership with the ACC to deliver a range of natural diversity projects.

Management of water resources, including waterways and lakes, is a high priority in the *Avon River basin NRM strategy*. Through the Avon Rivercare Project, the Department of Water has initiated a project to investigate the riparian condition and management needs of waterways in the Avon River basin within the zone of ancient drainage. To date five waterway assessments have been completed on reaches of the Salt, Yilgarn (two), Lockhart and Camm rivers.

1.3 Aims of the upper Lockhart River waterway assessment

The main aim of the upper Lockhart River waterway assessment is to gain an understanding of the current condition and management needs of the waterway and its associated floodplains, from the Camm River confluence to Newdegate by:

- describing the nature of the waterway and floodplain
- identifying and describing areas of riparian vegetation and areas of remnant vegetation closely linked to riparian vegetation
- identifying threatening processes impacting on waterway health.

Waterway managers including the Department of Water, DEC, ACC, local shires and landholders will use the information gained through this waterway assessment to plan and prioritise for the future management of the upper Lockhart River. It will also provide landholders with information on best-practice waterways management.

1.4 Nature of the upper Lockhart River study area

Upper Lockhart River study area

The Lockhart River catchment drains an area of approximately 28 400 km^2. It originates near the locality of Lake Biddy, near Newdegate, and flows in a north-westerly direction past Kondinin, Corrigin and Bruce Rock to the Caroline Gap, south of Kellerberrin. There it converges with the Yilgarn River and becomes the Salt River, although the reach of the Lockhart from the Caroline Gap to Lake Jilakin may also be known as the Salt River (Leoni & Murphy-White 2006). The Lockhart River catchment

also includes the drainages of the Pingrup and Camm rivers.

The study area includes the salt lakes, channels and floodplain of the Lockhart River from the confluence with the Camm River in the vicinity of Gnarming Road East, upstream approximately 85 km to the catchment divide with the Lake Magenta internal catchment, at Watson Road, near Newdegate.

The Department of Water selected nine survey sites to represent the range of riparian landscapes found on this section of the Lockhart River. The site sizes vary from 170 ha and 1660 ha.

Map 2 shows the location of the study area and **maps 3a** and **3b** show the location of the survey sites.

Nature of the Lockhart River landscape

Landscapes and soils

The Avon River basin forms part of the Great Plateau of Western Australia, with ancient crystalline rocks that have weathered to form deep (10–30 m) shallow soils. The rocks are mostly granitic surrounded by gneisses, with dolerite dyke intrusions. The valleys are extensively in-filled with unconsolidated sediments.

Most of the Avon River basin is internally drained, with salt-lake chains low in the landscape that only flow in wetter years (Galloway 2004). This area of sluggish drainage and low relief is known as the zone of ancient drainage. The Lockhart River system lies within this zone (Lantzke 1992).

The Avon River south-east lakes subregion, in which the Lockhart River is situated, is characterised by gently undulating and low-relief landscapes with sluggish drained salt-lake systems of broad valley floors, typically 5–8 km wide. Crests and slopes are typically duplex soils with some gravel, originally vegetated with mallee eucalypts interspersed with scattered heath. Lower slopes and valley floors are typically sandy and loamy duplexes, usually with sodic and calcareous subsoil, and were originally vegetated by woodlands.

Broad vegetation communities

The upper Lockhart River study area occupies part of the Hyden System within the Roe Botanical District (Beard 1980). The landscape is very gently undulating with wide flat valleys and long gentle slopes rising to broad uplands, usually capped with laterite and sand. The soils are variable and the vegetation is highly mosaic in structure and composition. The characteristic catena of the Hyden System is heath and thicket on upland sandplains, mallee on the slopes, mallee with patches of woodland on upper valley soils, woodland on lower valley soils and a mosaic of woodland, shrubland and samphire in saline areas.

Map 2
Lockhart River study area

N

0 1 2 4 6
Kilometres

LEGEND

- Town

Road network
- Highway
- Main road
- Local road
- Track

Waterways
- Major waterway
- Minor waterway
- Lakes

Boundaries
- Nature reserve
- Local government authorities
- Lockhart River catchment

Datum and Projection Information
Vertical Datum: Australian Height Datum (AHD)
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SOURCES

The Department of Water acknowledges the following datasets and their custodians in the production of this map:

Towns – Landgate – 2007
Road Centrelines – Landgate – 2008
Hydrography, Linear (Hierarchy) – DoW – 2007
Local Govt Authorities – Landgate – 2006

Government of Western Australia
Department of Water

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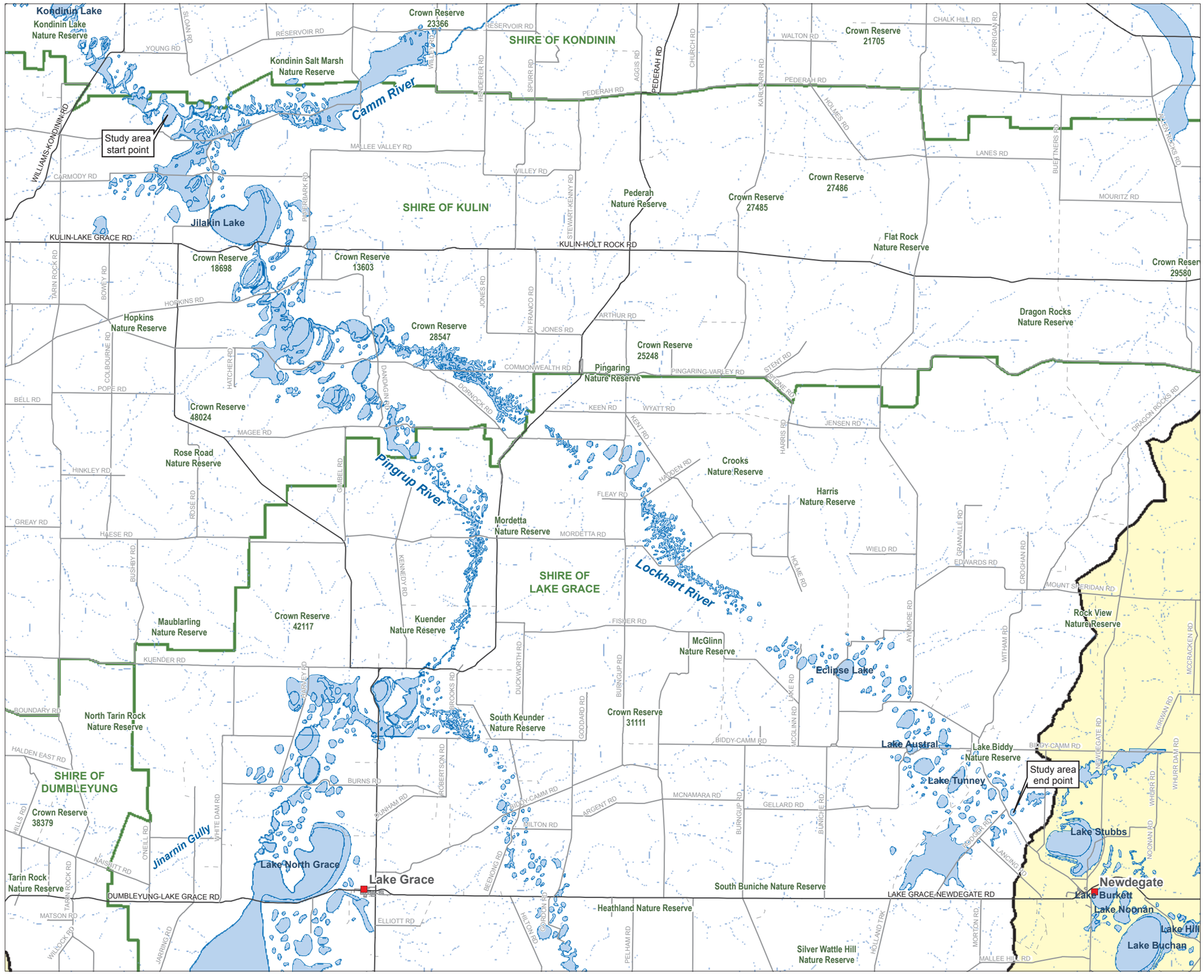
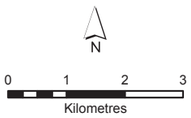


Map 3a
Lockhart River survery site locations (ULR01 to ULR05)



LEGEND

Waterways
- Major waterway
- Minor waterway

Road network
- Main road
- Local road
- Track
- Local government authorities
- Cadastre
- Corrigin South Orthomosiac 2000
- Pederah Orthomosiac 2004

Datum and Projection Information
Vertical Datum: Australian Height Datum (AHD)
Horizontal Datum: Geocentric Datum of Australia 94
Projection: MGA 94 Zone 50
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Map Author: Davina Gan
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SOURCES

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Road Centrelines – Landgate – 2008
Hydrography, Linear (Hierarchy) – DoW – 2007
Cadastre – Landgate – 2008
Local Govt Authorities – Landgate – 2006

Government of Western Australia
Department of Water

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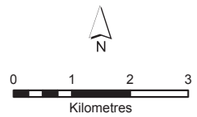
Map 3b
Lockhart River survery site locations (ULR06 to ULR09)



LEGEND

Waterways
- Major waterway
- Minor waterway

Road network
- Main road
- Local road
- Track
- Local government authorities
- Cadastre
- Pederah Orthomosiac 2004
- Burngup Orthomosiac 2003

Datum and Projection Information
Vertical Datum: Australian Height Datum (AHD)
Horizontal Datum: Geocentric Datum of Australia 94
Projection: MGA 94 Zone 50
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SOURCES

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Cadastre – Landgate – 2008
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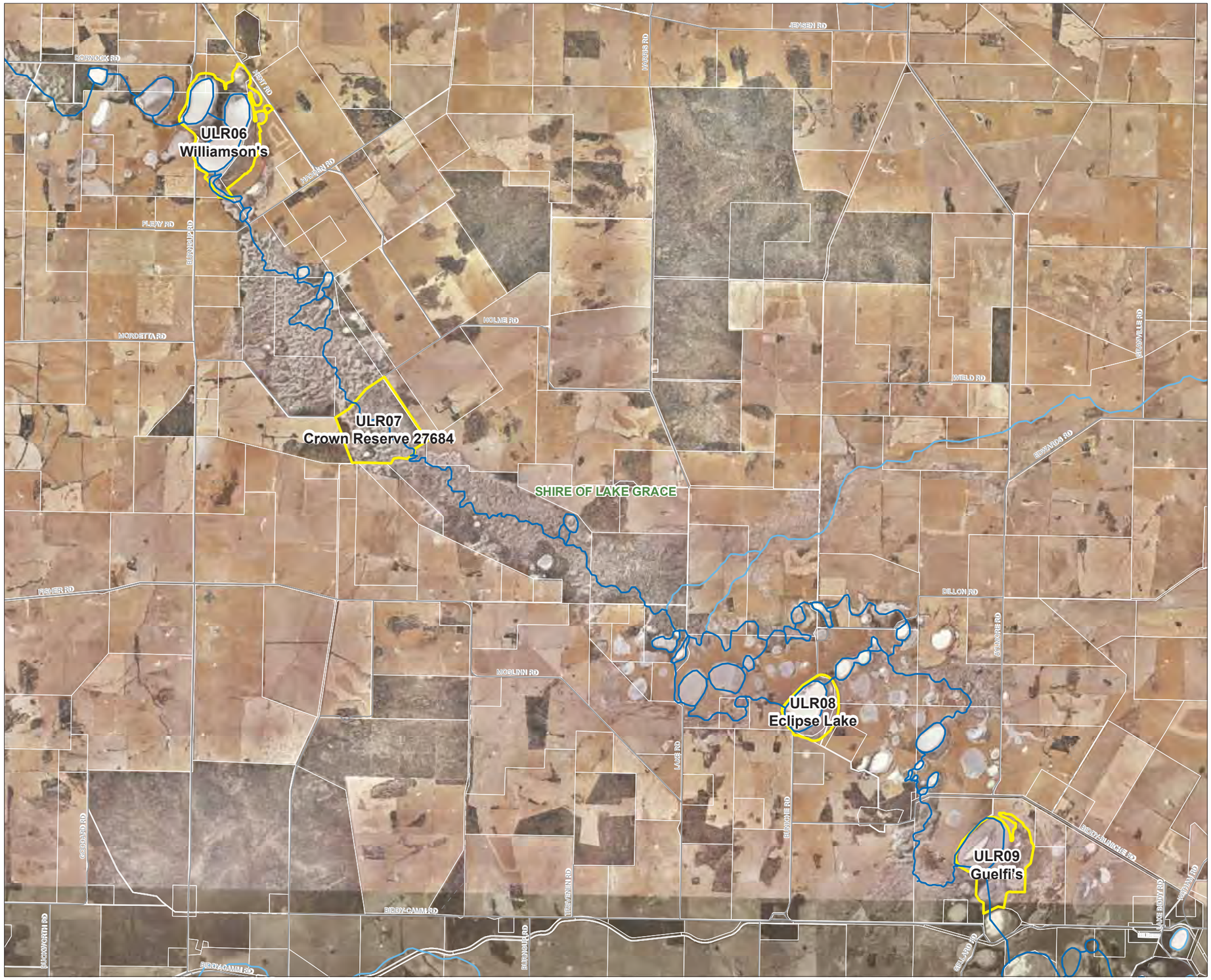

Beard (1980)[1] mapped valley floors as bare areas (salt lakes), mosaic of shrublands of teatree (probably *Melaleuca* species), succulent steppe with woodland thickets dominated by yorrell (*Eucalyptus yilgarnensis*), and Kondinin blackbutt (*E. kondininensis*) over teatree and samphire (*Tecticornia* [formerly *Arthrocnemum* or *Halosarcia*] species).

The lower valley floors are mapped as woodland of salmon gum (*E. salmonophloia*), red morrell (*E. longicornis*) and gimlet (*E. salubris*): these occupy both sides of the valley floors south of Lake Jilakin. To the east and south, redwood (*E. transcontinentalis)* and black marlock (*E. subangusta)* mallee are mapped, with patches of salmon gum and gimlet woodland.

Post-clearing changes to vegetation communities

The study area has sites located in two local government areas. Four sites are in the Shire of Kulin and five in the Shire of Lake Grace.

Clearing has been extensive in the Shire of Kulin, with 12 per cent of the pre-European vegetation remaining. This is similar to the overall estimate of 13.5 per cent for the Avon catchment. Less vegetation has been cleared in the Shire of Lake Grace, with 21.9 per cent of the pre-European vegetation remaining (Shepherd, Beeston & Hopkins 2002). The threshold level below which species loss appears to accelerate exponentially, at an ecosystem level, is regarded to be 30 per cent of the pre-clearing extent; while at levels below 10 per cent, the ecosystem is regarded as endangered (Shepherd, Beeston & Hopkins 2002). Further degradation of the existing vegetation has occurred since clearing, mainly as a result of grazing or hydrological change. While the Lockhart River is naturally saline, clearing has led to a rise in the watertable, increased periods of inundation and an increase in salinity. The naturally salt-tolerant native vegetation has struggled to adapt to these changes, leading to a decline in vegetation condition and plant death in some areas.

Hydrology and water quality

The upper Lockhart River receives streamflow from further upstream, groundwater seepage and numerous tributaries including the Pingrup River. The river system is characterised by low hydraulic gradients, intermittent and highly variable surface flow, and high regolith salt loads. The gradient of the 85km-long reach of the upper Lockhart River from Newdegate to the confluence with the Camm River on Gnarming Road is 24 m: an average of 0.28 m/km or 1:3500 (Chipfunde, DoW, pers. comm).

[1] Several of the botanical names used by Beard have changed since his report was published. Yorrell, at the time of writing, was the common name of *Eucalyptus gracilis*, but now refers to *E. yilgarnensis*. It is possible that *E. myriadena*, which looks similar to yorrell and was first described in 1981, may also be included as yorrell. Samphires were known as *Arthrocnemum* species: they are now mostly *Tecticornia* species. *E. redunca* (in the Wheatbelt) now refers to various species, but is presumed to be *E. subangusta*.

Beard (1999) calculated the total fall of the 170km-long Lockhart system to be 41 m, an average of 0.24 m/km. This grade is interrupted by large, relatively flat salt lakes that disperse water from one to another as they fill and overflow. These systems do not flow as one linked system and the low gradient means significant discharges are unlikely except in extreme rainfall events (Beard 1999).

Annual average rainfall across the study area is approximately 340 mm and is highly seasonal, with approximately 70 per cent of the annual total falling between April and September (BoM 2007) and highly variable between years (**Figure 1**).

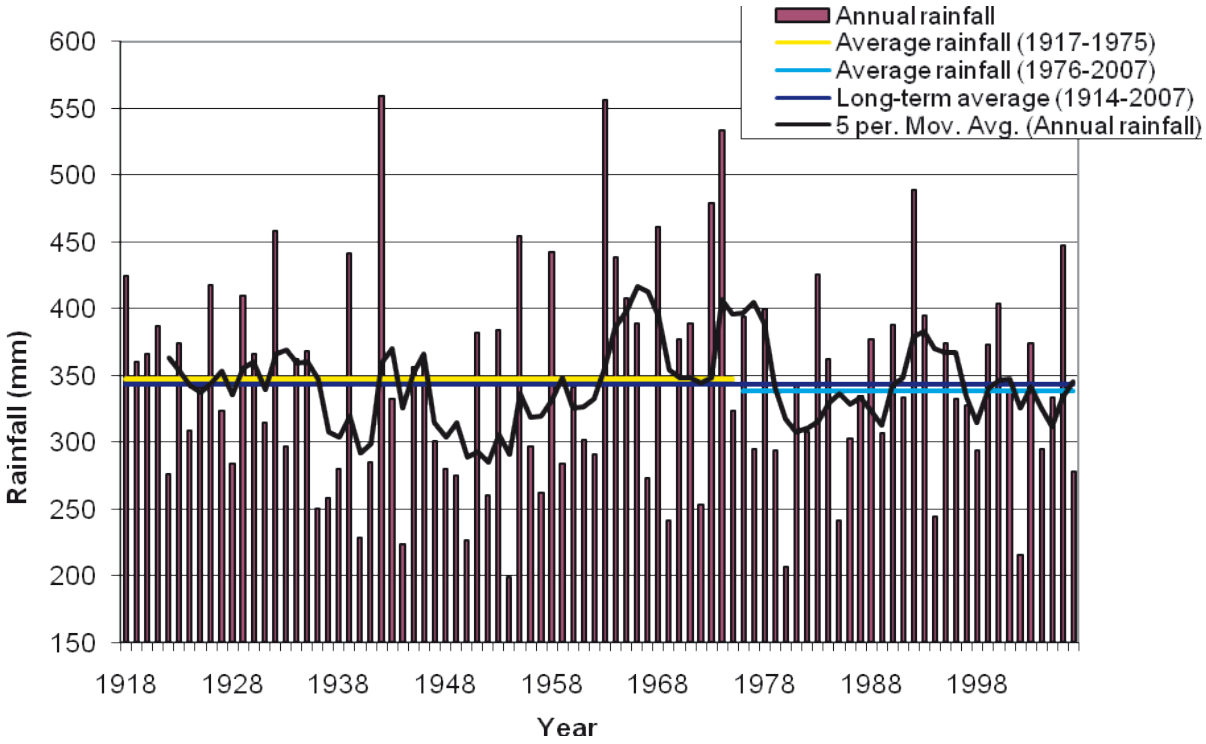

Figure 1 Annual rainfall data for Kondinin 1917–2007 (BoM 2007)

NB: median (decile 5) rainfall (mm)

Monthly or annual median (decile 5 or 50th percentile) total precipitation. The annual decile value must be calculated from the individual yearly totals of rainfall, and cannot be obtained by adding together the monthly deciles. Decile values are used to give an indication of the spread of the observations over the period of record.

The low gradient of the valley floor, and variation in runoff due to rainfall and internal storage or overflow in the lake systems, leads to high variability in streamflow from year to year.

Groundwater in palaeochannels and beneath salt lakes in the Lockhart catchment is commonly greater than 5000 mS/m. Where this groundwater reaches the surface, evaporation concentrates salts, resulting in hypersalinity (Leoni & Murphy-White 2006).

The Department of Water undertakes an annual water-sample snapshot at selected sites in the Wheatbelt. Samples collected from the Lockhart catchment in spring 2006 and 2007 indicated that most of the water samples were saline and alkaline. A summary of the available sample results is presented in **Table 1** below.

Table 1 Water quality results for the 2006 and 2007 Avon River basin water quality snapshot

Year	Site code	Stream name	Site name	Easting	Northing	TDS mg/L	TN mg/L	TP mg/L	pH
2006	LU02	Kulin south-east tributary	Kulin–Lake Grace Rd	620870	6383910	49988	1.30	0.018	8.53
2006	LU03	Lockhart River	Jilakin Rock Rd	625030	6386910	47283	0.99	0.007	8.68
2006	LU04	Lake Jilakin	Actual lake	627690	6384590	20967	1.20	0.007	8.93
2006	LU05	Lockhart River	Kulin–Holt Rock Rd	628400	6384010				No flow
2006	LU06	Hinkley tributary	Commonwealth Rd	624880	6376290				No flow
2006	LU07	Lockhart River	Dandagin Rd	636920	6377560	24663	1.40	0.006	10.13
2006	LU08	Daisy Downs tributary	Commonwealth Rd	648090	6374540				No flow
2006	LU09A	Eastland north tributary	Lake Grace–Karlgarin Rd	650800	6372750				No flow
2006	LU10	Lockhart River	Lake Grace–Karlgarin Rd	649070	6371170				No flow
2007	LU04	Lake Jilakin	Actual lake	627690	6384590	68653			8.23

TDS = total dissolved salts, TN = total nitrogen, TP = total phosphorus.

Source: Department of Water 2009

Land tenure

Most of the land in the upper Lockhart River study area is freehold land used for agriculture. However, there are a number of Crown reserves within or adjacent to the floodplain, most of which contain salt lakes. The vesting of these reserves varies. Reserves that are vested for conservation and located within or close to the floodplain of the study area are listed in **Table 2**.

Table 2 Crown reserves close to the floodplain in the study area

Site name	**Name**	**Approx. distance (km) and direction from study sites**	**Size** (ha)
Lucca Pty Ltd (ULR 01)	Kondinin Salt Marsh Nature Reserve	2.5 km E	2828
	Crown Reserve 15385	3.0 km S	105
	Crown Reserve 18698	4.5 km S	148
	Hopkins Nature Reserve	10.0 km S	584
Jilakin Lake (ULR 02)	Crown Reserve 15385	Adjacent to site (SW boundary)	105
	Crown Reserve 18698	Adjacent to site (SW boundary	148
	Crown Reserve 14730	1.0 km S	435
	Kondinin Salt Marsh Nature Reserve	4.0 km N	2828
	Hopkins Nature Reserve	7.0 km SW	584
Scadding's (ULR 03)	Crown Reserve 28547	2.0 km E	522
	Crown Reserve 13603	3.0 km N	26
Crown Reserve 28547 (ULR 04)	Crown Reserve 28547	Part of reserve	522
	Crown Reserve 13603	7.0 km NW	26
Stone's (ULR 05)	Pingaring Nature Reserve	5.0 km NE	95
	Crown Reserve 28547	6.5 km NW	522
	Mordetta Nature Reserve	7.0 km SW	346
Williamson's (ULR 06)	Crown Reserve 18962	0.5 km N	73
	Crown Reserve 19511	1.0 km N	26
	Crooks Nature Reserve	5.0 km SW	602
	Pingaring Nature Reserve	6.0 km N	95
	Mordetta Nature Reserve	10.0 km SW	316
CR27684 (ULR 07)	Crown Reserve 27684	Site part of reserve	
	Crooks Nature Reserve	4.0 km NE	602
	Harris Nature Reserve	6.0 km E	3500
	Crown Reserve 31111	8.0 km SW	2630
Eclipse Lake (ULR 08)	Crown Reserve 18960	2.2 km SE	49
	Harris Nature Reserve	6.0 km N	3500
Guelfi's (ULR 09)	Crown Reserve 18553	4.0 km SE	413
	Lake Biddy Nature Reserve	5.6 km SE	52

Post-clearing changes to naturally saline waterways

Naturally saline waterways still retain many natural, social, heritage and economic values. However these are under increasing pressure from threats arising from widespread land clearing.

Changes in hydrology

Land clearing has been extensive throughout the Wheatbelt, with only 13.5 per cent of pre-European vegetation extent remaining (Shepherd, Beeston & Hopkins 2002). Many of the threats facing this vegetation, including hydrological change, continue to modify these communities.

Before clearing, most of the intercepted rainfall would have been used by the vegetation, including drawing on reserves of groundwater over the summer (Hatton, Ruprecht & George 2003). There was little surface runoff and it is likely that few well-defined drainage lines existed in areas that are now streams (Hatton, Ruprecht & George 2003).

After clearing, the pattern of rainfall use has changed to winter use only in areas with annual crops and pastures (Hatton, Ruprecht & George 2003). This has allowed runoff to increase fivefold and groundwater to recharge, filling deep sedimentary materials and bringing highly saline water to the surface (Hatton, Ruprecht & George 2003).

Before clearing it is likely that salt lakes generally contained water for several months through winter and spring, although cyclonic rain would have occasionally filled the lakes in summer or autumn (Halse, Ruprecht & Pinder 2003). Salinity levels would have been relatively low when the lakes were filled and increased as the lakes dried (Halse, Ruprecht & Pinder 2003). Increased runoff and groundwater discharge as a result of land clearing now means the lakes are wetter for longer periods and more saline.

Leoni and Murphy-White (2006) consider that salinity development in the Lockhart catchment is expected to reach equilibrium between 2030 and 2075. Groundwater has reached within 2 m of the surface in most of the valley floor areas and is at equilibrium, although seasonal fluctuations are expected to continue. In upper slope areas groundwater is generally greater than 10 m in depth and continues to rise.

Rates of watertable rise beneath hill slopes have been estimated to vary between 0.15 and 0.30 m/yr (George et al. 2008). This is likely to result in salinity expression at change-of-slope locations and the expansion of currently saline areas on valley floors. However, the expansion of saline areas will depend on elevation, slope and soil type. In valleys and lower slopes, falling groundwater levels have been noted in three bores in the catchment which appear to be associated with declining rainfall (Leoni & Murphy-White 2006).

This contrasts with recent Land Monitor mapping of the area, indicates that a salinity hazard still exists on the valley floors (Landgate 2009).

Additional salinisation is expected to occur in the tributary valleys that lie perpendicular to and converge into the main valleys. These flat areas will be more prone to lateral expansion of salinity because of poor surface drainage and waterlogging (Leoni & Murphy-White 2006).

Acidification

Although surface water tends to be neutral to alkaline (pH 7–8), groundwaters in the eastern Wheatbelt and other areas with abundant salt lakes can be acidic, with pH readings of less than 4.5 recorded as far back as 1974 (Shand & Degens 2008). Acid groundwaters are a natural regolith phenomenon and existed in the Wheatbelt before any drains were installed (Shand & Degens 2008). However, rising watertables increase the threat of acidic groundwater interacting with surface environments. Deep drainage and groundwater pumping can accelerate discharge rates and the mixing of acidic groundwater and more neutral surface waters.

The causes of groundwater acidification are poorly understood, although scientists believe a common cause may be that high concentrations of dissolved iron in the groundwater react with oxygen in the atmosphere to form iron precipitates and acidic hydrogen ions (Fitzpatrick et al. 2005). Another source of acidity is the oxidation of pyritic material in soils, in which sulfide-containing materials are exposed to air, thus releasing significant amounts of sulfuric acid – although this is not known to be a significant source of acidic waters in the eastern Wheatbelt (Shand & Degens 2008.

Low pH waters can leach high concentrations of naturally-occurring heavy metals including iron, aluminium, cobalt, copper, zinc, uranium and lead from soils (Shand & Degens 2008). In many cases, metal and trace element levels are 10–100 times greater in acid groundwaters than in regional surface waters (Shand & Degens 2008). Heavy metals can be transported to, and accumulate in, aquatic environments where they are likely to be harmful to flora and fauna (Shand & Degens 2008).

Based on limited information, McConnell et al. (2005) noted a low threat risk for increasing groundwater acidification in the south-east lakes subregion of the Avon River basin. There is evidence of secondary acidification of smaller lakes occurring in the Lockhart River between the Camm and Yilgarn confluence (Degens, Fitzpatrick & Hicks 2008), but it is not certain whether this extends above the Camm confluence.

As few plants and animal communities are adapted to acidic conditions, secondary acidification poses a significant threat to biodiversity, both in aquatic and riparian ecosystems.

Impacts on fringing vegetation

Saline lakes and waterways are a natural feature of the Western Australian landscape, reflected in a high diversity of salt-adapted flora and fauna. Yet increased salinity and waterlogging, changed periods of inundation, increased nutrient loads and acidification have affected fringing and aquatic vegetation and their associated fauna.

Secondary salinisation has altered the environmental conditions of the fringing vegetation, which, before these changes, was adapted to fluctuating salinity and water levels. Now, permanent saline groundwater close to the surface has caused a decline in vegetation health and has changed the composition of vegetation communities.

Before clearing, wetlands would have been covered by sheoak (*Allocasuarina* and *Casuarina* spp.), paperbark (*Melaleuca* spp.) and teatree (*Leptospermum* spp.) forming a dense canopy over low shrubs. Many wetlands would have had beds of sedges and rushes, with some having aquatic vegetation such as nardoo (*Marsilea* spp.) (Sanders 1991).

Increased salinity and waterlogging have led to the death of much of the fringing vegetation, with salt and waterlogging-tolerant species colonising large areas. These would have previously been restricted to small patches. Samphire (*Tecticornia* spp.) has commonly replaced much of the fringing vegetation in the Wheatbelt. The introduced spiny rush (*Juncus acutus*) has replaced native rush and sedge species, invading saline and waterlogged areas on the edges of the floodplain, tributaries and groundwater seeps.

Impacts on aquatic communities

Before clearing, it is likely the primary determinants of aquatic macroinvertebrate diversity were geographic position, geology and rainfall. After clearing, land use became the major determinant by affecting the quantity of runoff into rivers and wetlands, the duration of inundation and water salinity levels. Simplification of habitats through sedimentation and loss of woody debris and leaf litter also affected species occurrence, a situation exacerbated by salinisation (Halse, Ruprecht & Pinder 2003). Altered communities tend to be relatively homogenous, having similar composition throughout, when compared with freshwater or naturally saline wetlands (Pinder et al. 2004). Species diversity generally shows an inverse relationship with salinity (Hammer 1986). However, this relationship is not always linear as faunal groups differ in their extent of salt tolerance. For example, *Cladocera* (water fleas) are relatively intolerant, *Ostracoda* (seed shrimps) have intermediate tolerance and waterbirds are quite tolerant (Halse, Ruprecht & Pinder 2003). Changes in hydrology and water condition can also significantly affect species abundance and diversity in these communities.

The types of aquatic vegetation present also change with increasing salinity. Freshwater plants are first replaced by salt-tolerant submerged macrophytes, such as *Ruppia* and water-mat (*Lepilaena*) species. As salinity increases, these are replaced with phytoplankton-dominated communities, then with benthic microbial mat-dominated communities characterised by cyanobacteria (blue-green algae) and halophilic (salt tolerant) bacteria. This simplification tends to have a flow-on effect to other fauna in the food chain (Davis 2004; Strehlow et al. 2005).

2 Waterway assessment methodology

This waterway assessment uses a method that the Department of Water developed to evaluate the existing riparian condition and management needs of waterways in the zone of ancient drainage (DoW 2007).

The methodology of Keighery (1994) was used to assess the vegetation condition: this compares the current vegetation condition with the equivalent vegetation in pristine condition (with all structural layers intact, showing no impacts from threatening processes and all natural processes operating). All individual site assessments, found in Appendix 1, include a table of the Keighery bushland condition scores.

2.1 Site selection

Given the size of the floodplains in the zone of ancient drainage, which can be kilometres wide, the waterway assessment methodology relies on information collected at a number of representative sites rather than surveying the whole reach.

The Department of Water selected nine survey sites from this section of the Lockhart River. The sites were chosen to represent one or more of the following criteria:

- the full range of geomorphic features within the study area; for example, salt lakes, areas of braided channels and areas with more defined channels
- high environmental, social and/or cultural value, including nature reserves and lakes used for water-skiing
- vegetation communities in good or degraded condition.

Sites were selected using a number of tools, including aerial photography, cadastral information, anecdotal information and a reconnaissance survey.

The locations of the study sites are included in maps 3a and 3b. Descriptions of individual sites can be found in the relevant site report in **Appendix 1**.

2.2 Recording of survey information

To ensure consistency, information for each site was recorded on a standard survey form, which is included in **Appendix 2**.

Floodplain features

Floodplain features define the physical nature of the waterway and give indications of habitat and potential management issues.

Natural and constructed features within the floodplain are identified, including playa

lakes, channel forms, lunettes, tributaries, drains and dams. A list of definitions is included in the Glossary in Section 5, with illustrations of floodplain and channel forms available in Water and Rivers Commission report no. RR17 (2002), which is available online at <www.water.wa.gov.au>.

Description of the riparian vegetation

Healthy undisturbed vegetation plays an important role in maintaining waterway health. The wide array of plant species that comprise the fringing vegetation and their accompanying animal species, including birds, mammals, reptiles, frogs and invertebrates, have significant biodiversity value. The fringing vegetation also provides habitat, including shade and shelter provided by exposed root systems, as well as food resources for aquatic ecosystems.

A comparison of the current condition and structure of riparian vegetation in its pristine state indicates how the waterway condition has changed over time. Identification of threatening processes affecting vegetation condition helps show why these changes have occurred, and how the vegetation may change in the future.

The Keighery bushland condition assessment method (Keighery 1994), which was originally designed to assess vegetation on the Swan coastal plain and determine management priorities, was adapted for use in the study area. The method does not require a high level of technical knowledge. However, the assessor's experience with a range of conditions for each vegetation type will ensure a more accurate allocation of condition type and facilitate repeat assessments in the future.

Pre-European vegetation types

Beard vegetation association data (Beard 1980; Shepherd, Beeston & Hopkins 2002) collected during the survey and anecdotes from landholders were used to gain an understanding of the original pre-European vegetation at each site. Together, this information indicates what the vegetation would have been like before clearing, and helps with assigning a vegetation-condition score. As an example, a site that was once salmon gum woodland but is now saltbush and bluebush shrubland would indicate that the condition of this vegetation has declined significantly.

The Beard vegetation-association descriptions listed on the site-survey report sheets reflect the pre-European vegetation (as mapped by Beard) but do not indicate that this vegetation still exists on the site.

Vegetation structure and cover

Vegetation structure is the plant form in each stratum, or layer, present in each vegetation community. Vegetation structures are combined with names of plant species to form a description of the vegetation community (vegetation association).

Crown cover is the amount of shade, expressed as a percentage that each plant stratum would cast if the sun was directly overhead. To simplify the estimation of cover, cover classes are used rather than an actual percentage, which are then allocated a description: *closed* for 70–100 per cent vegetation cover, *open* for 30–70 per cent vegetation cover, *sparse* for 10–30 per cent vegetation cover and *very open* for 2–10 per cent vegetation cover. Vegetation with less than 2 per cent overall cover is not assessed.

A simplified version of the vegetation descriptions of Muir (1977), omitting shrub-height descriptions but retaining details of each stratum, is used throughout this report. Up to three dominant species are included in each stratum; however, if more than three species are dominant, the stratum is described as 'mixed'.

For each site assessed, an overall cover of each stratum (trees, mallees, shrubs etc.) is included. This is a composite value estimated from all vegetated areas of the site, and does include a vegetation structure with an overall cover of less than 2 per cent if that structure occurs as a vegetation community. Bare areas, including lake beds, are not included in the overall cover estimate for the site.

Individual cover values for each vegetation association are included in the description for that vegetation.

Vegetation condition

Vegetation condition was assessed against an adapted version of the Keighery (1994) bushland condition rating scale, shown in **Table 3** below. An additional category has been added to account for areas of revegetation.

For each survey site, an estimated overall percentage of the vegetated areas that fall into each vegetation condition category has been calculated (see the assessments in **Appendix 1**). Note that only vegetated areas can be assessed for vegetation condition. Bare areas, such as those that occur in salt lakes and stream channels, cannot be assessed for vegetation condition, unless there is evidence that vegetation once occurred there. It is therefore likely, in these salinised and silted landscapes, that the percentage of the site which is *completely degraded* is always underestimated – as we have no way to assess aquatic vegetation that formerly existed when conditions were less saline.

Table 3 Vegetation condition rating scale, as adapted from Keighery (1994)

Condition	Description
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted.
Pristine	No obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affects individual species only and weeds are non-aggressive species.
Very Good	Vegetation structure altered; obvious signs of disturbance.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate.
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management.
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species.

Examples of each vegetation condition are shown in **Appendix 3**.

Vegetation condition is linked to disturbance factors, which are listed for each site along with the degree of threat they pose. Common disturbance factors that lead to a decline in vegetation condition include salinity and waterlogging (which, when combined, can be described as hydrological change), clearing, weed invasion, fires, feral animals and stock access.

Species presence

Plant species, both native and introduced, were identified. This process indicated the diversity of plant species at each site, and sought to identify species suitable for riparian revegetation or potential management issues.

Where a plant could not be identified to species level, it was identified to the greatest level of certainty possible – such as its genus or family and then using the term ‘species’ instead of a full dichotomous name. ‘Species’ is abbreviated to ‘sp.’ for a single species and ‘spp.’ for more than one species. The dominant plants used in the vegetation description were identified.

A comprehensive flora survey was not undertaken and only common plants were listed. This gives a snapshot of the species present, but not a full flora inventory of the study site.

Plant names quoted in this report are correct at the time of writing, and are sourced from the following:

- FloraBase (Western Australian Herbarium & DEC 2008) for scientific names and occasional common names

- Bennett (1991) and Lefroy, Hobbs and Atkins (1991) for common names of native plants
- Hussey et al. (2007) for common names of weeds.

Links to protected remnant vegetation

The approximate distance and direction to protected remnant vegetation within 10 km of each site is recorded. Protected vegetation includes nature reserves and Crown reserves vested for conservation purposes.

Links between remaining remnant vegetation are particularly important in a highly fragmented landscape like the Western Australian Wheatbelt. These links allow for the movement of fauna around the landscape and gene flow among plant communities.

Aquatic vegetation

Aquatic vegetation in the Wheatbelt usually comprises salt-tolerant submerged macrophyte communities, phytoplankton communities or benthic microbial mat-dominated communities. The diversity of the macroinvertebrate population is often linked to the type of aquatic vegetation present, with higher diversity often associated with submerged macrophyte communities (Davis 2004; Strehlow et al. 2005).

Where aquatic vegetation was identified as present, the type was identified if possible.

Water quality data

Where lake or flowing water was accessible, water quality data (pH, salinity and temperature) was collected. Data collected during the survey is a snapshot of water quality at the time of sampling and cannot be used to make comments on long-term trends.

Management

Information on current management activities such as fencing, revegetation and groundwater and surface-water management was collected. Any issues identified as requiring management were noted.

Fauna species

Fauna surveys were not undertaken as part of this study; however, opportunistic observations were noted. Fauna was observed either directly (by sight or sound) or indirectly (by the presence of scats, track or diggings).

Fauna observations provide a snapshot of the species present, but are unlikely to

provide a comprehensive list of species. This was especially true for this study, as wet and windy conditions were experienced when the survey was undertaken. Birds were often not moving around, making observation and identification difficult.

The identification of bird species present was the focus because they are easier to find and identify than other types of fauna, they are a major component of most ecosystems and they are sensitive to many kinds of disturbance (Birds Australia 2005).

Where possible, birds were classified as remnant-dependent or priority species, based on a classification that Greening Australia Western Australia (2004) uses to indicate the importance of a remnant for birds.

Fauna names used in this report are accurate at the time of writing and are taken from FaunaBase (Western Australian Museum 2008).

2.3 How is the information that is collected used?

In Section 3, the information collected during the survey is used to:

- draw conclusions about current riparian conditions
- identify issues impacting on current conditions
- make recommendations for management
- draw links with existing projects and programs in the Avon River basin that can help waterway managers to improve the condition of the upper Lockhart River.

3 Main findings and management recommendations

The results for each study site are presented in **Appendix 1**.

While it cannot be confirmed, it is generally considered that the number of samphire species present on each site may indicate the time since the area became suitable for colonisation by *Tecticornia* spp. Thus, while samphires were generally not identified to species level, the number of species on each site was estimated.

3.1 Vegetation condition

Only one of the surveyed sites supported an area of *pristine* condition vegetation. This was salmon gum (*Eucalyptus salmonophloia)* woodland in Crown Reserve 28547 (ULR04), which is managed by the DEC.

Five of the surveyed sites supported vegetation in *excellent* condition. These were ULR01 (Lucca Pty Ltd), ULR03 (Scadding's), ULR04 (Crown Reserve 28547), ULR06 (Williamson's) and ULR07 (Crown Reserve 27684). The vegetation communities were generally on lower slopes rather than valley floors and included York gum woodlands (ULR01), red morrell and gimlet woodlands (ULR03, ULR06), mallee and swamp mallet woodland (ULR04, ULR07). There was also some *excellent* condition vegetation on the valley floor, including rock sheoak low woodland (ULR04) and melaleuca woodland (ULR07).

All of the sites surveyed contained vegetation in *very good* or *good* condition. Most of this vegetation was eucalypt woodland or mallee on valley slopes and melaleuca shrubland on raised areas on the valley floor. Three sites contained samphire on the valley floor that was in *very good* condition – ULR03, ULR04 and ULR08 (Eclipse Lake) and two sites contained samphire in *good* condition – ULR02 (Jilakin Lake) and ULR09 (Guelfi's).

All sites had vegetation in *degraded* condition. Three of these were Kondinin blackbutt woodland on lower slopes (ULR02) with a depleted understorey dominated by introduced grasses, and low-lying floodplain vegetation dominated by samphire (*Tecticornia* spp.) (ULR01, ULR06). They were assessed as degraded because of loss of native species, which have either not been replaced (largely bare areas that formerly supported vegetation) or have been replaced by salt-tolerant species or weeds. Dense areas of samphire were assessed as degraded when they had few or no dead sticks, or had other species among the samphire. Few dead sticks (compared with many) indicate that the vegetation was not previously a shrubland, and may have contained samphire before clearing, although at lower densities.

All sites had vegetation in *completely degraded* condition. These were areas with sparse samphire with large bare areas (ULR02) and samphire with many dead sticks, which indicates a former shrubland, probably dominated by *Melaleuca* species (ULR05, ULR07). These areas were unlikely to have included samphire in their pre-European state.

Sites illustrating the various conditions are displayed in **photos A3.1–A3.6** in Appendix 3.

Areas without any vegetation were not assessed for condition. These included playa lakes and bare stream channels, which have undoubtedly become more degraded since clearing, but not in terms of terrestrial vegetation.

An estimate of the area of vegetation in each vegetation condition category is shown in **Figure 2** below. Although this figure is an estimate (based on the approximate percentage of each condition in each remnant and an estimate of the proportion of vegetated area in each remnant), it shows that most of the vegetation surveyed is in *completely degraded* condition.

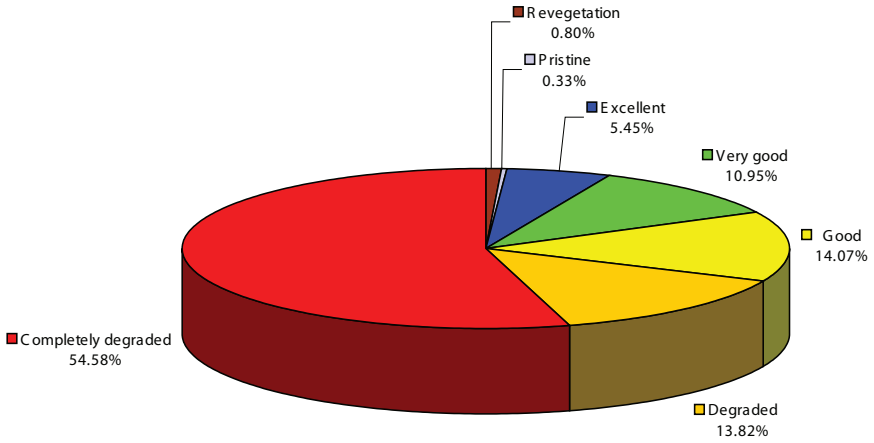

Figure 2 Estimated area of vegetation surveyed within each vegetation condition rating

The *degraded* and *completely degraded* vegetation present in the lower part of the landscape indicates that significant changes affecting vegetation condition have occurred in the upper Lockhart River system. Increased salinity, rising watertables and increased periods of inundation – all a result of widespread clearing for agriculture – are the most obvious causes of these changes.

Before clearing, the pre-European vegetation in these low-lying areas was mostly samphire (*Tecticornia* spp.) fringing the playa lakes and channels and occurring on the floodplain's flatter areas (Beard 1980a; Shepherd, Beeston & Hopkins 2002). Slightly further upslope were woodlands, often yorrell (*Eucalyptus yilgarnensis*, but probably also including *E. myriadena*), Kondinin blackbutt (*E. kondininensis*) over teatree (which may refer to *Melaleuca* spp. or *Leptospermum* spp.) and samphire. Slightly further upslope again were a variety of woodlands, including salmon gum (*E. salmonophloia*), gimlet (*E. salubris*), red morrell (*E. longicornis*), York gum (*E. loxophleba* subsp. *loxophleba*) or mallee scrub (*E. subangusta*).

Most of these vegetation types are still present.

3.2 Management issues

Management issues impacting on the upper Lockhart River, as identified from the site surveys, include:

- increased salinity, raised watertables and increased periods of inundation in the valley floor
- acidification
- loss of fringing riparian vegetation
- clearing
- impediment of floodwaters by road crossings
- pest species degrading riparian vegetation
- dumping of rubbish
- erosion by stock and vehicle tracks
- weed invasion
- fire risk
- lack of corridors linking remnant native vegetation.

The most challenging management issue is hydrological change (rising watertables, increased salinity, acidification and increased periods of inundation).

Implementation of many management strategies will have multiple benefits. For example, fencing to exclude livestock from the upper Lockhart River and its tributaries – combined with revegetation – will improve bank stability, reduce sedimentation, improve water quality and contribute to biodiversity conservation by facilitating the distribution of flora and fauna throughout the landscape.

These and other management issues are discussed below.

Implementation of the management recommendations will be through partnerships between waterway managers including the Department of Water, DEC, ACC, landholders, local shires and community groups using a wide variety of funding sources.

3.3 Salinity and waterlogging

Increased salinity and waterlogging are the most significant threats on the upper Lockhart River floodplain. These changed conditions have already affected vegetation condition, water quality, infrastructure and farm productivity on the floodplain. Options for reducing inundation and waterlogging include surface-water management, water harvesting, engineering works to lower groundwater tables and revegetation to reduce recharge. Research has shown that different approaches

are required for different types of salinity impacts, depending on catchment characteristics and the types of infrastructure affected. The following sections provide some options for salinity management including biological and engineering management options.

Engineering options

Engineering options are being considered by an increasing number of landholders concerned about salinity and waterlogging. Options include the construction of deep drains (2–3 m), groundwater pumps and shallow drainage to control surface-water movement. While engineering options can reduce local groundwater levels effectively, a major challenge is the disposal of excess water and salt.

The upper Lockhart River catchment has low-gradient slopes (less than three degrees gradient) with poor surface drainage. Low gradients increase the risks associated with slow or impeded water movement (Leoni & Murphy-White 2006) and impose restrictions on engineering options intended to reduce the impacts of salinity and waterlogging.

Notices of Intent (NOI) to construct deep drains or pump groundwater are a legal requirement under the *Soil and Land Conservation Act 1945* (WA) and must be submitted to the Commissioner for Soil and Land Conservation. Recent changes to the *Environmental Protection Act 1986* (WA), which prevent environmental harm due to inappropriate disposal of drainage waters, must also be considered before pumping groundwater.

The Department of Agriculture and Food (DAFWA) has published various best-management practice standards for conservation earthworks. These publications outline design criteria, suitable conditions for construction and placement, planning considerations, legal aspects, environmental aspects, operation and maintenance, construction and references.

Engineering evaluation and implementation in the Wheatbelt

The Engineering Evaluation Initiative (EEI) was a state government project to deliver a better understanding of engineering approaches to managing salinity in the Wheatbelt. The EEI's main object was to review current knowledge on engineering options to mitigate dryland salinity and clarify best practice by establishing demonstration sites for a range of engineering options (Dogramaci & Degens 2003).

The EEI had three main programs:

- evaluation of specific engineering options, including groundwater pumping, siphon and relief bores, deep drains and surface-water management
- safe disposal, including natural disposal sites and engineered disposal/re-use
- regional drainage planning.

Information on the EEI is available on the Department of Water website at <www.water.wa.gov au>.

The Wheatbelt Drainage Evaluation (WDE) was established in 2005 as part of the National Action Plan for Salinity and Water Quality, and is due for completion in December 2009. Although the WDE's focus is on the Yenyening and Yarra Yarra catchments, it will also include a review of Wheatbelt drainage governance and management, a study of options for treating acidic groundwater discharge and a project to classify Wheatbelt wetlands.

The WDE project may have implications for water management in the Lockhart catchment, especially because it is upstream from the Yenyening lakes.

Deep drainage

Deep drains (2–3 m) are used to collect and transport groundwater, and sometimes surface water, to detention basins or into natural basins or waterways. They are being used to protect low-lying land from salinisation and rehabilitate marginally saline lands in the Wheatbelt (Ali et al. 2004). Deep drains are most effective when they intersect permeable soils, including clay overlying permeable saprolite; sandy sediments and clays with preferred pathways such as sand seams (Leoni & Murphy-White 2006); and when they penetrate the ferricrete or siliceous layer (Ali *et al*. 2004).

The use of deep drains at break-of-slope or on valley floors may be useful in preventing groundwater rise when the natural drainage system is unable to remove excess water and salt, resulting in lost agricultural production. However, drains in the eastern Wheatbelt can carry acidic water that may also contain large amounts of iron, aluminium and other metals, salt, and the rare earth elements of lanthanum and cerium (Degens & Shand 2008). Disposal of discharge waters from drains is therefore likely to be problematic.

The amount of excess water and salt delivered into the stream network by artificial drains depends on the method of disposal. Disposal options include the existing stream and lake networks, bypassing existing lakes, or disposal to evaporation basins (Dogramaci & Degens 2003). Disposal into the existing stream and lake network will result in salt concentration in the lake system through evaporation. When the lake overflows, the discharge will be extremely saline. The frequency and volume of lake discharge could be reduced by engineering lake discharge levels (Viney et al. 2008). Alternatively, discharge could bypass the lake system or be collected in evaporation basins within each subcatchment so that drainage water and salt are retained locally. Based on simulation modelling, the subcatchment retention option has the greatest impact on reducing mean annual discharges and salt loads. However, this option is likely to be costly (Viney et al. 2008).

Soils, groundwater geochemistry and pilot excavation should be assessed before drain construction to determine the risk of acid groundwater and trace element

issues. Proper design, potential land degradation and safe disposal of discharge water need to be considered before deep drains are constructed. If deep drains are also to conduct surface water, they must be designed to do so. The amount of land lost to drains and spoil piles – when compared with the potential gain in productive area – needs to be assessed, along with the costs of supporting infrastructure (such as bridges and fences) and ongoing drain maintenance costs.

The environmental impacts of deep drains should also be considered. In the Wakeman subcatchment near Narembeen, a comparison of sites treated with deep drainage and untreated sites has shown significant increases in salinity and acidity and a reduction in turbidity in surface water from treated sites (Stewart, Strehlow & Davis 2009). Discharge water from the deep drains resulted in a sharp decline in species richness and the composition of macroinvertebrate communities downstream of the drains. For example, crustaceans were virtually absent from macroinvertebrate communities associated with deep drainage. Increased acidity was considered the major factor in this decline, as the Wheatbelt does not have a large pool of organisms that thrive in acid conditions (Stewart, Strehlow & Davis 2009).

Groundwater pumping

Groundwater pumping to reverse broadscale salinisation processes is generally considered to be uneconomic (Clarke et al. 2002; George 2009); however, each case should be considered on its merits. Appropriate design, the potential for land degradation and the safe disposal of pumped water need to be considered before wells are constructed. Groundwater pumping is generally considered to be more effective on lighter-textured soils where water and salts drain more quickly.

Groundwater pumping bores in the Lockhart River catchment have all yielded highly saline water (up to 8000 mS/m) (Leoni & Murphy-White 2006). Disposal of such saline water involves the issues previously noted for deep drainage.

Surface-water management

Surface-water management uses earthworks (such as grade and interceptor banks, shallow drainage channels and dams) to capture surface runoff and subsurface flow higher in the landscape, with the aim to reduce recharge in the valley floors. Surface runoff is usually relatively fresh and can be intercepted to augment farm water supplies.

Regional drainage

Recent modelling of the hydrological impacts of artificial drainage in the Avon catchment predict that open and leveed surface drains result in significant increases in salt load and streamflows throughout the catchment (Viney et al. 2008). Open drains are installed along creeklines and receive and transport drainage water as well as natural flows generated from surface and subsurface runoff. Leveed drains

are installed adjacent to natural creek and drainage lines so that the levee prevents admission of surface water. Subsurface runoff is admitted to the drain but only from one side of the valley.

Modelling shows that both surface-drainage options are effective in reducing groundwater levels, but when they are applied to existing salinised areas and areas predicted to be salinised in 2100, streamflow and salt load increase. At the Avon catchment outlet, salinity concentrations are predicted to more than double by 2100 and for the Lockhart system to increase from a flow-weighted average of 8 GL to 74 GL with artificial drainage. Streamflow in the Lockhart is predicted to increase from 6 GL/y to 30 GL/y by 2100. Artificial drains have little impact on peak flow rates which are governed largely by surface runoff processes (Viney et al. 2008).

Revegetation

Revegetation can be used to intercept surface flows in recharge areas or to use soil water reserves, thus reducing discharge. Groundwater levels are best managed by addressing the area of water input (recharge zones). Planting local native species can also have benefits for conservation and biodiversity. Riparian trees provide shade, protect banks against erosion and drop wood and leaf debris which provides important habitat for fish and invertebrates in streams. Planting species that can be harvested for timber or used as fodder crops can also provide economic benefits.

Strategic revegetation can be used to:

- reclaim hillside seeps and sandplain seeps by planting up-slope, thus reducing groundwater recharge and discharge down-slope
- provide linkages in the landscape between areas of remnant vegetation, which may then be used as wildlife corridors
- reduce soil erosion on stream banks, especially when combined with fencing and stock exclusion
- filter sediments and nutrients from surface flow
- provide buffers between existing vegetation and farmland, including intercepting agricultural sprays
- enhance biodiversity and agricultural productivity.

At the local scale, the re-introduction of perennials, which remain physiologically active through the dry season, is essential for reducing runoff and groundwater recharge to pre-clearing levels. While remediation of saline seeps using appropriate trees can show results in a few years, the control of salt loads to south-west Australia's river systems may take hundreds of years to achieve after revegetation. This is due to the low gradients, low groundwater turnover, high salt loads and long lengths of these regional systems (Hatton, Ruprecht & George 2003). Past studies demonstrate that increased tree cover proportionally reduces groundwater levels but

there is considerable debate about the area required to achieve hydrological control. Estimates ranges from 25–30 per cent tree cover (Salama et al. 1993) to 70–80 per cent tree cover (George et al. 1999).

Tree plantations can be used to lower groundwater levels in localised areas; however, the downstream impacts on watertables may not extend more than a few tens of metres from the plantation (George et al. 1999). Groundwater uptake by vegetation is also limited by the groundwater quality. It has been suggested that in flat landscapes the groundwater sink that can develop under a plantation (or remnant woodland) can cause a reversal of flow towards the trees, with the potential to impact on their health through localised salinisation (Salama & Bartle 1995). There is evidence of rising watertables under remnant vegetation by this phenomenon.

Biodiversity plantings

Planting local native species for biodiversity and conservation can provide linkages between remnant vegetation in the landscape, which act as wildlife corridors. Plantings can also provide a buffer between farmland and remnant vegetation. Local species from the Lockhart River catchment that are suitable for revegetation are listed in **Appendix 4**.

Commercial plantings

A wide range of species are suitable for commercial planting on recharge areas in the Wheatbelt. These include oil mallees and other eucalypts for wood, oil production or bioenergy; *Acacia* species for seed, fodder and bioenergy; *Melaleuca* species for broombush fencing; and sandalwood (*Santalum spicatum*) for oil. Trials have also been established (2006) to determine the economic viability of growing salt-tolerant species for biofuel and rubber production. These include the non-native species *Moringa oleifera* and *Pongamia pinnata* which are mainly used for biodiesel production; and *Parthenium argentatum* for latex and rubber production (Brockman 2007).

Commercial plantings in slightly to moderately saline areas include saltland pasture, usually saltbush (*Atriplex* spp.) and bluebush (*Maireana* spp.). Native legumes from the genus *Cullen* have shown promise for controlling dryland salinity in trials in the northern Wheatbelt. *Cullen australasicum* was the best-performing species and showed superior persistence and productivity compared with commercial lucerne cultivars (Bennett et al. 2008).

Introduced species can also be used to improve the nutritional value of pastures, such as puccinellia (*Puccinellia ciliata*), which is tolerant of waterlogging but less tolerant of salinity, and tall wheatgrass (*Thinopyrum elongatum*) (Barrett Lennard & Malcolm 1995). However, these grasses can become weeds so native grasses or legumes should be used when possible. **Appendix 5** contains a list of plants suitable for saltland grazing.

Limitations associated with commercial plantings include the availability of suitable soil types and site conditions. Salinity levels, soil fertility and the availability of water are also factors. Oil mallees rely on processing plants and a market for oil. A processing plant for broombush, to be located in the central Wheatbelt, is currently being negotiated. There is a large market for sandalwood in South East Asia but growth rates of *Santalum spicatum* are low, with plantations expected to reach commercial size 20 years after planting in the 400–600 mm rainfall zone of the Wheatbelt (Brand, Jones & Donovan 2004).

Lake Bryde Natural Diversity Recovery Catchment

The Lake Bryde Natural Diversity Recovery Catchment (LBNDRC) provides an example of an integrated approach to managing salinity and waterlogging to protect biodiversity assets. The Lake Bryde wetland complex was identified as a natural diversity recovery catchment in 1999 due to its high biodiversity values. Prolonged inundation has been identified as the dominant hydrological process driving degradation of the flat valley landscape. Increased runoff in the catchment since vegetation clearing has increased the frequency of inundation. The management aim for the LBNDRC is to slow the rate of decline of biodiversity across valley-floor assemblages and to conserve high-value biodiversity assets. Natural diversity recovery catchments are also important for investigating and trialling salinity control treatments, with works often undertaken in partnership with local landholders.

The Lake Bryde catchment covers an area of approximately 140 000 ha in the upper reaches of the Lockhart subcatchment. It consists of a series of freshwater and naturally saline lakes that drain northwards. Lake Bryde is significant because its waters remain relatively fresh in an increasingly saline landscape. Management of the recovery catchment is being coordinated by DEC and involves a combination of revegetation, fencing to protect remnant native vegetation and construction of a valley-floor waterway. The waterway is designed to reduce inundation of vegetation and move water to selected disposal sites. It will also reduce the impacts of waterlogging on farmland and help protect local roads and infrastructure. Strategic revegetation is being used to reduce recharge and includes planting native species for their commercial potential (oil mallees) and for carbon sequestration. Monitoring of water movement and changes in the condition of biodiversity assets is ongoing (DEC 2008).

Recommendations for the management of salinity and waterlogging

Salinity and waterlogging are processes that require management at a catchment scale. The following general management recommendations are proposed:

- retention of surface water, water quality permitting, higher in the catchment to slow recharge in the valley
- use of surface-water management strategies to collect and redirect water to controlled management areas, particularly where water accumulation can

result in waterlogging, salt scald development or exacerbate recharge

- use of landscaping such as raised beds and broad-based mounding in waterlogged and inundation-prone areas
- revegetation along tributaries to slow movement of surface water onto the valley floor without increasing flood risk and to reduce sedimentation of streams
- evaluation of commercial revegetation options, including agroforestry, bioenergy production, carbon sequestration and saltland pastures
- identification of recharge areas that are suitable for revegetation to control local watertables
- continue groundwater and surface-water quality and quantity monitoring so the impacts of management practices can be assessed.

3.4 Flows being impeded by road crossings

Low gradients contribute to slow flows throughout the upper Lockhart River study area. Road crossings can add significantly to this problem, exacerbating waterlogging issues across the floodplain. As well as physically impeding surface flows, subsurface compaction to create a stable road base interferes with subsurface flows, further contributing to water ponding problems.

Approximately 0.12 per cent of main roads and 2 per cent of local roads in the Lockhart catchment are in low-lying areas and may be susceptible to flooding, waterlogging and salinity. The poor quality of surface waters can contribute to degradation of road assets and the annual cost for repairs and maintenance due to salinity was estimated at $20 000/km for main roads and $6600/km for local roads in 2003 (Leoni & Murphy-White 2006). One example in the study area is the Kulin–Holt Rock Road – a causeway on the edge of Lake Jilakin and a major freight haulage route for the eastern part of Kulin shire. Significant rainfall events in January 2006 resulted in substantial inflows to Lake Jilakin, which overflowed and submerged the road during and after the flood event. The road alignment has previously been shifted twice, but each time its elevation remained below the natural full supply level of the lake. This has necessitated base and pavement remedial works (Yandle, Giraudo & Seaby 2008).

There are many road crossings within the upper Lockhart River study area. These include Carmody Road, Jilakin Rock Road, Kulin–Holt Rock Road, Hopkins Road, Commonwealth Road, Dandagin Road, North Lake Grace–Karlgarin Road, Dornock Road, Kent Road, Hadden Road, Holme Road, Fisher Road, Lake Road, Buniche Road, Biddy–Buniche Road, Gellard Road, Biddy–Camm Road and Lake Biddy Road. Not all road crossings were examined for evidence that water flows were being impeded; however, ponding was observed at several sites, including Crown Reserve 28547 (ULR04), Stone's (ULR05) and Eclipse Lake (ULR08).

It is unlikely that the road crossings restrict flow during normal rainfall years, but during flood events they appear to impede water flow, resulting in ponding and structural damage to the roads. In some cases there is evidence that vegetation has been affected by ponding. At Stone's (ULR05), for example, ponding above Buniche Road has contributed to recent flooding, resulting in plant deaths due to waterlogging.

Recommendations for the management of flood flows

It is the nature of waterways in the zone of ancient drainage to retain water in braided channels and lakes on the valley floors. However, road crossings may contribute to localised flooding. The recommendations proposed for flood management are:

- evaluate road crossings for flood risk
- analyse the costs and benefits of upgrading pipes and culverts to increase flow through road crossings where significant ponding is evident
- where decline of vegetation has been noted due to ponding, re-alignment of roads may be warranted, followed by revegetation of salt-affected areas
- to prevent structural damage to the road, raising the road-base level may be necessary where road re-alignment is not feasible.

3.5 Tributaries

Inflows to the Lockhart River study area arise from the Pingrup River in the south and numerous small, unnamed tributaries. It is recognised that additional salinisation is expected to occur in tributary valleys that lie perpendicular to and converge into the main valleys of the Lockhart catchment, due to poor surface drainage and waterlogging (Leoni & Murphy-White 2006).

Most minor tributaries in the study area are not well defined, and tend to be broad flat expanses covered with samphire (*Tecticornia* spp.). Active degradation within tributary channels could be managed by constructing shallow waterways to redirect flows to more degraded valley areas, thereby minimising ad hoc flows and water ponding. This would provide opportunities for vegetation re-establishment, particularly samphire. Erosion could be reduced by fencing to exclude livestock from floodplains, followed by revegetation. Plant roots would stabilise the soil and plant stems would slow water flow into the tributary, thereby reducing bank erosion. Rocks or logs placed in the channel would also slow the velocity of water flow by providing a riffle effect.

Recommendations for tributary management

To reduce soil erosion and sedimentation problems and increase the value of tributaries as landscape links between areas of remnant vegetation, the following

recommendations are proposed:

- establish an effective riparian buffer along tributaries using native species to:
  - reduce soil erosion and sedimentation
  - provide corridors linking areas of remnant vegetation higher in the landscape with riparian areas
- fence tributary floodplains to exclude livestock and prevent soil compaction and erosion
- install riffles, where appropriate, to reduce flow velocity and trap sediments before they reach the floodplain
- use shallow drainage channels to redirect small flows away from areas where vegetation decline is evident, to more degraded valley areas (Farmer 2007).

3.6 Management of remnant vegetation

Remnant vegetation in the upper Lockhart River study area, like much of the Wheatbelt, is highly fragmented. The size, shape and condition of patches also vary widely.

The composition of remnant vegetation has changed significantly since clearing, particularly in the floodplain due to increased waterlogging and salinity. Melaleuca shrublands have been replaced by more salt-tolerant species, including samphire (*Tecticornia* spp.).

Connections between remnants are very important to allow species to disperse across the landscape. All of the survey sites have protected remnants within a radius of 10 km – increasing their value as wildlife corridors.

Remnant vegetation on public land vested for conservation is protected from clearing but is not immune from degradation due to environmental conditions such as salinity and waterlogging. One of the study sites was vested for conservation: Crown Reserve 28547 (ULR04). Two sites included unvested Crown land: Jilakin Lake (ULR02) (ULR07) and Eclipse Lake (ULR08) and one site was Crown land for which no vesting information was available: Crown Reserve 27684 (ULR07).

Crown Reserve 28547 (ULR04) contained *pristine* condition vegetation. This site is managed by DEC. It also contained significant areas of *excellent* condition vegetation. Four other sites contained *excellent* condition vegetation: three were privately owned (ULR01, ULR03 and ULR06) and one site was Crown land (ULR07).

Recommendations for remnant vegetation management

To manage remnant vegetation and improve landscape linkages in the Lockhart River catchment, the following recommendations are proposed:

- fence all remnant vegetation to exclude livestock
- strategically enhance degraded remnant vegetation by planting tree and shrub seedlings within the remnant – if the causes of degradation have been reduced sufficiently to give the seedlings a good chance of survival, but natural regeneration has not occurred
- encourage landholders to value their remnant vegetation and suggest a suitable conservation covenant scheme for better condition vegetation
- control rabbits to allow natural regeneration of plant species, particularly if a fire is experienced in remnant vegetation
- plant buffers of vegetation along the edges of remnant vegetation – either mixed native species or species suitable for saltland grazing – to provide a buffer between the remnant and agricultural activities
- identify areas of private land that can be revegetated to create or enhance links between the remnant vegetation
- investigate reconstruction of landscape links along public lands, such as road reserves.

3.7 Riparian vegetation

Riparian vegetation in the upper Lockhart River catchment is mainly samphire (*Tecticornia* spp.); however, areas of eucalypt woodlands can be found on lunettes and some areas of the previously common *Melaleuca* spp. shrubland still survive.

Revegetating floodplain areas with local native species can have a number of benefits including:

- localised salinity control
- conservation and biodiversity benefits
- filtering of nutrients and sediments from surface runoff
- improved visual amenity.

Species that are suitable for revegetation in the Lockhart River catchment are listed in **Appendix 4**. It is important to tailor selection of revegetation species for riparian areas to the current site conditions. This should take into account that salinity and waterlogging, periods of inundation, water quality and weed cover have changed and will continue to change site conditions. Time and budget constraints, including the cost of fencing and seedlings, also need to be considered when developing revegetation projects. A useful tool for selecting species for specific site conditions is ‘Species Navigator’ available on the Greening Australia Florabank website at <www.florabank.org.au>.

Recommendations for riparian vegetation

Recommendations to enhance the condition of riparian vegetation, and to create and strengthen environmental linkages between good quality riparian areas and other remnant vegetation, are as follows:

- encourage natural regeneration and reduce soil degradation and erosion of riparian areas by fencing to exclude livestock
- investigate using native local species for revegetation
- use samphire to stabilise denuded channel edges, trap sediment and dissipate energy during larger flow events
- consider strategic revegetation within riparian remnants, including replanting lunettes to replace plants killed in recent floods
- fence revegetated areas to exclude livestock
- consider planting saltland grazing species adjacent to fenced riparian areas.

3.8 Fencing and stock access

Significant areas in the greater Lockhart River catchment have been affected by soil degradation (Leoni & Murphy-White 2006), including:

- 62 per cent by subsurface compaction
- 53 per cent by soil-structure decline
- 50 per cent by subsurface acidification
- 46 per cent by wind erosion
- 44 per cent by water repellency.

Although not all of these soil-degradation hazards affect the floodplain, it is clear that some of these hazards are relevant to the upper Lockhart River floodplain.

Soil-structure decline, water erosion, and wind erosion of fine soil particles observed in the floodplain were all exacerbated by livestock trampling. Livestock grazed many of the surveyed areas for part of the year, particularly during summer and autumn, to fill the feed gap at that time. Damage to the soil surface, which leads to erosion, was observed. This compounds the soil-structure decline that has resulted from increased salinity. Livestock grazing affects natural regeneration, while faeces and urine are likely to be adding to the nutrient loads in the waterways.

Recommendations for fencing

It recommended that the following areas be considered for fencing:

- *good* or better condition vegetation to exclude livestock grazing and allow natural regeneration
- areas with observed soil degradation to exclude livestock grazing to prevent further degradation and erosion
- areas that have been revegetated
- tributaries and lunettes associated with lakes to exclude livestock and improve bank and dune stability.

3.9 Pest species

Introduced animal pest species are very common in the Wheatbelt. Rabbits (*Oryctolagus cuniculus*) were present on most sites. Signs of foxes (*Vulpes vulpes*) were observed at six sites. Foxes are likely to be present in all remnants, as are feral cats (*Felis catus*), which were recorded at three sites (ULR04, ULR06 and ULR09).

Introduced plant pests (weeds) were present on all sites: 36 species were identified during the field survey. While there were no 'serious' weeds as declared by DAFWA (2007), there were two weeds listed as 'high risk' by the *Environmental weed strategy of Western Australia* (CALM 1999): wild turnip *(Brassica tournefortii)* and Guildford grass (*Romulea rosea)*. Weeds are rated as 'high risk' based on their ability to invade bushland and waterways (*invasiveness*), on having a wide current or potential *distribution* and on their ability to change the structure, composition and function of ecosystems (*environmental impacts*). Fifteen of the recorded weeds were rated as 'moderate risk', scoring yes for two of the above criteria.

Field observations found the most serious and common weeds to be wild turnip (*Brassica tournefortii),* capeweed (*Arctotheca calendula*), slender iceplant (*Mesembryanthemum nodiflorum*)*,* red brome (*Bromus rubens*)*,* ferny cotula (*Cotula bipinnata*), annual ryegrass (*Lolium rigidum*), thread iris (*Moraea setifolia*), coast barbgrass (*Parapholis incurva*), false hair grass (*Pentaschistis airoides*) and silver grass (*Vulpia myuros*). Weed species are often a result of soil disturbance, and their presence can limit natural regeneration of native species. Slender iceplant and coast barbgrass are indicators of a salinising landscape, and will persist in salty environments.

Recommendations for the management of pest species

The following recommendations for the management of pest species are proposed:

- monitor and manage rabbit and fox populations by using a coordinated baiting program on both private and public lands
- target local rabbit populations after a fire in remnant vegetation to allow natural regeneration

- undertake appropriate weed control and deep ripping (if required) the year before planting and weed control again in the year of planting.

3.10 Flora and fauna

A total of 205 native plant species were identified during the field survey. This includes all commonly occurring plant species but should not be considered a comprehensive flora list for the area. Not all taxa were identified to species level (including samphires, of which there were approximately five species). Some native grasses could not be identified to species level because they did not have seeds. The most common species included samphires (*Tecticornia* spp.), Kondinin blackbutt (*Eucalyptus kondininensis*), red morrel (*Eucalyptus longicornis*), gorada (*Melaleuca lateriflora*), boree (*M. pauperiflora*), silver saltbush (*Atriplex bunburyana*), small leaved bluebush (*Maireana brevifolia*), twining purslane (*Calandrinia eremaea*), yellow top (*Calocephalus multiflorus*), *Didymanthus roei*, round-leaved pigface (*Disphyma crassifolium*), ruby saltbush (*Enchylaena tomentosa*), *Hyalochlamys globifera*, Australian boxthorn (*Lycium australe*), scented matrush (*Lomandra effusa),* golden longheads (*Podotheca gnaphalioides*), rhagodia (*Rhagodia preissii*), grey copper-burr (*Sclerolaena diacantha*) and foxtail mulga grass (*Neurachne alopecuroidea*).

Many orchids were noted on Crown Reserve 28547 (ULR04) and the Priority 3 flora species, *Frankenia drummondii*, was observed at three sites (ULR01, ULR07 and ULR09).

Forty-three bird species were recorded during the field survey. The most commonly observed birds were the white-fronted chat (*Epthianura albifrons*), Australian ringneck parrot (*Platycercus zonarius*), white-browed babbler (*Pomatostomus superciliosus*), Australian raven (*Corvus coronoides*) and galah (*Cacatua roseicapilla*). All of these birds are common farmland species except the white-browed babbler which is remnant dependent.

Priority birds are those that will be lost from the landscape if nothing is done to protect and enhance their habitat (GAWA 2004). Five Priority bird species were recorded in the survey area. These were the spiny-cheeked honeyeater (*Acanthagenys rufogularis*), grey shrike thrush (*Colluricincla harmonica*), crested bellbird (*Oreoica gutturalis*), rufous whistler (*Pachycephala rufiventris*) and red-capped robin (*Petroica goodenovii*).

The yellow-rumped thornbill (*Acanthiza chrysorrhoa*), red wattlebird (*Anthochaera carunculata*), Horsefield's bronze cuckoo (*Chrysococcyx basalis*), grey butcherbird (*Cracticus torquatus*), pallid cuckoo (*Cuculus pallidus*), singing honeyeater (*Lichenostomus virescens*), brown honeyeater (*Lichmera indistinca*), striated pardalote (*Pardalotus striatus*), common bronzewing (*Phaps chalcoptera*), white-browed babbler (*Pomatostomus superciliosus*), willy wagtail (*Rhipidura leucophrys*) and weebill (*Smicrornis brevirostris*) are described as remnant dependent, which

indicates they are likely to decline in number if remnant vegetation is lost or degrades (GAWA 2004).

The presence of these species indicates that the remaining remnant vegetation, including riparian vegetation, is important for bird habitat.

The only native mammals observed were the western grey kangaroo (*Macropus fuliginosus*), short-beaked echidna (*Tachyglossus aculeatus*) and fat-tailed dunnart (*Sminthopsis crassicaudata*). These three species are described as abundant by Van Dyck & Strahan (2008). The western grey kangaroo was observed, or signs of its presence were seen, on six sites, although it is likely to occur on all sites. The fat-tailed dunnart was found dead but not predated at Lucca's (ULR01) and echidna diggings were observed at two sites (ULR01 and ULR04).

No reptiles were observed, which is not surprising given the sites were surveyed in September when the weather was cool and wet.

A full list of native flora and fauna species is found in **Appendix 6**.

Recommendations for flora and fauna conservation

The following recommendations for the conservation of native flora and fauna are proposed:

- fencing to exclude grazing and preserve areas of *good* or better condition vegetation, as these are likely to have the most native plant and animal species
- identify areas suitable for revegetation to provide links between areas of good or better condition remnant vegetation
- use local native species including trees, understorey and groundcover plants, where possible and appropriate for revegetation
- retain fallen logs and branches within remnants to provide habitat for birds and reptiles
- avoid moving loose sheets of granite from exposed rocks as these provide habitat for reptiles
- plant buffer areas of revegetation beside remnant vegetation to protect the remnant from agricultural chemical sprays
- control weeds adjacent to and within the remnants, if possible
- eradicate feral animal species.

3.11 Fire risk

Fires originating from stubble fires, machinery or lightning strikes can threaten remnant vegetation. It is unlikely that samphire vegetation would burn but woodlands and shrublands are vulnerable.

Landholders are responsible for maintaining fire breaks on their property under the *Bush Fires Act 1954* (WA) and local government fire plans. The DEC is responsible for fire breaks and fire access on DEC-managed land.

3.12 Rubbish

Several areas of dumped rubbish were observed during the field surveys. In most cases the dumps were of old fencing material and bottles that did not pose an environmental hazard.

Dumping of chemicals, chemical containers, household refuse, fuels and oils or vehicles may pose a risk to the environment, especially in waterways where pollutants can be washed downstream during flood events. Dumped rubbish may also be hazardous if it blocks water flow. Dumping of rubbish close to waterways should therefore be prevented.

Advice for rubbish management

Dumping of rubbish on Crown lands, including road reserves, council lands and nature reserves is illegal under the *Litter Act 1979* (WA) and can be reported to the local shire or DEC office.

Clean, rinsed empty farm chemical containers can be disposed of through the *drumMUSTER* program. The Kulin and Lake Grace shire councils participate in *drumMUSTE*R and can be contacted for details.

4 Glossary

Acid(ic)	See pH.
Alkaline	See pH.
Alluvial	Transported by water flow processes; for example, ‘alluvial plain’.
Alluvium	Sediment deposited by flowing water.
Anabranching	Anabranching rivers are characterised by a network of diverging and converging channels separated by large, long-lived islands that are inundated only by floodwaters.
Aquifer	A layer of rock or soil capable of receiving, storing and transmitting quantities of water.
Braided river / channel	A braided river is characterised by numerous, interlaced channels that divide and rejoin around unstable bars and small islands.
Break-of-slope	The junction of steep upper slopes and flatter lower slopes where revegetation has most impact in reducing waterlogging down-slope.
Catchment	An area of land that intercepts rainfall and contributes the collected water to a common point through surface water and groundwater.
Completely degraded	Vegetation structure no longer intact and the area is without or almost without native vegetation (Keighery bushland condition scale).
Confluence	Flowing together or intermingling; for example, where a tributary joins the main river channel.
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management (Keighery bushland condition scale).
Discharge	Volumetric outflow rate of water, typically measured in cubic metres per second (m3/s). Applies to both groundwater and surface water.
Discharge area or zone	Area where groundwater discharges to the surface.

Ecosystem	A biological community of interacting organisms and their physical environment.
Excellent	Vegetation structure intact; disturbance affecting individual species only and weeds non-aggressive (Keighery bushland condition scale).
Floodplain	A broad, flat, low-lying area of land within the valley floor that is inundated during a 100-year flood. Includes the flood fringe and floodway.
Flood – 100 year	The 100-year flood has a statistical probability of occurring, on average, once every 100 years. The 100-year flood level is the contour to which this flood will rise.
Floodfringe	The area of the floodplain, outside of the floodway, that is affected by flooding.
Floodway	The river channel and portion of the floodplain which forms the main flow path for flood waters once the main channel has overflowed.
Geomorphology	The study of the origin, characteristics and development of landforms.
Gigalitre (GL)	1 000 000 000 litres or 1 million cubic metres or 1 million kilolitres (kL).
Gilgai	An area where the land surface is irregular with alternating mounds (puffs) and depressions (hollows) and is commonly referred to as ‘crab hole’ country. Gilgai micro relief is formed due to clay horizons shrinking and swelling with alternate drying and wetting cycles.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate (Keighery bushland condition scale).
Groundwater	Water that occupies the pores and crevices of rock or soil.
Hydrology	The study of water, its properties, distribution and use, on and below the earth’s surface.
Kilolitres (kL)	1000 litres or one cubic metre.
Kilotonne (kt)	1 000 000 kilograms or 1000 tonnes.

Macroinvertebrates	Aquatic invertebrates (animals without backbones) that are retained on a 0.25 mm mesh net and therefore big enough to be seen with the naked eye.
Natural resource management	The ecologically sustainable management of the land, water, air and biodiversity resources for the benefit of existing and future generations.
Nutrient load	The amount of nutrient (usually nitrogen and/or phosphorus) reaching a waterway over a given time period from its catchment area.
pH	The concentration of hydrogen ions in solution that indicates the acidity or alkalinity in water. A pH value of 7 is neutral, above 7 is alkaline and below 7 is acidic.
Pristine	No obvious signs of disturbance (Keighery bushland condition scale).
Recharge	Volumetric inflow rate of water to an aquifer, typically measured in cubic metres per second (m3/s).
Recharge area or zone	An area through which water percolates to replenish (recharge) an aquifer. Unconfined aquifers are recharged through rainfall. Confined aquifers are recharged in specific areas where water leaks from overlying aquifers, or where the aquifer rises to meet the surface.
Remnant vegetation	An area of vegetation remaining after a major disturbance, such as land clearing.
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted (Keighery bushland condition scale).
Riparian zone	The riparian zone includes the floodplain and adjacent verge. The width of the riparian zone varies greatly, from tens of metres to kilometres, depending on the type of waterway and its catchment.
Riparian vegetation	Vegetation growing within the riparian zone.
River basin	The area drained by a waterway and its tributaries (see Catchment).
Runoff	Water that flows over the soil surface when rainfall is greater than the infiltration capacity of the soil. Flow in waterways results from rainfall runoff.

Salinity	A measure of the total soluble (dissolved) salts in water. Commonly measured in terms of total dissolved solids (TDS) in milligrams per litre (mg/L), or electrical conductivity, in millisiemens per metre (mS/m) or millisiemens per centimetre (mS/cm). Water resources are classified as fresh, marginal, brackish or saline on the basis of salinity.
Salinisation	An increase in the concentration of soluble salts in soil or water.
Sediment load	The amount of sediment reaching a waterway over a given time period from its catchment area. Also refers to the amount of sediment being transported by a waterway.
Sp.	Species (singular), usually used when the plant or animal is identified to genus level but not identified to species level.
Spp.	Species (plural): a group of plants or animals of the same genus.
Surface water	Water flowing or held in waterways.
Tributary	A waterway that flows into a larger waterway.
Verge	Upland area adjacent to the floodplain.
Very good	Vegetation structure altered; obvious signs of disturbance (Keighery bushland condition scale).
Water quality	The physical, chemical and biological measures of water.
Waterlogging	Excess water close to the soil surface.
Watertable	Saturated level of unconfined groundwater. Wetlands in low-lying areas may be surface expressions of groundwater.
Waterway	Surface-water bodies, including streams, rivers, lakes, wetlands, estuaries, coastal lagoons and inlets. Can be seasonally or permanently inundated.

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Appendix 1 Site survey reports

Site ULR01 — Lucca

General details	
Site name	Lucca
Landholder	Lucca Pty Ltd, Sergio and Mary Lucchesi
Surveyed by	Lyn Atkins and Catherine Krens (Ecoscape)
Date	09.09.2008

Site description	
Landform	The site is largely in the valley floor and consists of a series of braided channels and low-lying, often clay soil areas, and playa lakes with emergent 'islands'.
Site size	170 ha

Beard vegetation description
Beard vegetation association 8: Medium woodland; salmon gum and gimlet
Beard vegetation association 37: Shrublands; teatree thicket
Beard vegetation association 551: Shrublands; *Allocasuarina campestris* thicket
Beard vegetation association 959: Succulent steppe with sparse woodland & thicket; yorrell & Kondinin blackbutt over teatree and samphire

Overall vegetation structure and cover (for vegetated areas only)

Vegetation layer	**Canopy cover class**	**Dominant species**
Trees	2–10%	*Eucalyptus spathulata, E. kondininensis, E. loxophleba* subsp. *loxophleba*
Mallees	0	
Shrubs	10–30%	*Melaleuca lateriflora, M. atroviridis, M. pauperiflora, Acacia acuminata, Exocarpos aphyllus, Hakea kippistiana, Rhagodia preissii, Enchylaena tomentosa, Maireana brevifolia, Atriplex hymenotheca*
Grasses	< 2%	*Austrostipa* sp.
Herbs	10–30%	*Lomandra effusa, Gunniopsis septifraga, Senecio* sp.
Rushes and sedges	< 2%	*Lepidosperma* sp.
Litter	< 2%	
Bare ground	30–70%	
Rock outcrop	< 2%	

Summary

The islands are either shrublands dominated by *Melaleuca* spp., or at times with emergent trees (Kondinin blackbutt or swamp mallet). Low lying areas are either bare or with scattered samphire shrubs or herbs in low-lying 'claypan' areas. The western and northern sides of the site (on the very edge only) are York gum woodlands with granite outcrops on lower valley slopes.

Individual vegetation association descriptions

Vegetation 1	*Melaleuca lateriflora* and *M. teuthidoides* Scrub to 4 m with scattered *Eucalyptus spathulata* over *Rhagodia preissii* and *Enchylaena tomentosa* Open Dwarf Scrub over mixed annual Herbs
Vegetation 2	*Tecticornia* spp. (3) Dwarf Scrub over *Mesembryanthemum nodiflorum, Gunniopsis septifraga* and *Senecio* sp. Very Open Herbs
Vegetation 3	*Eucalyptus loxophleba* subsp. *loxophleba* Open Low Woodland over *Acacia acuminata* Low Woodland over *Maireana brevifolia* and *Enchylaena tomentosa* Open Low Scrub over mixed annual Dense Herbs
Vegetation 4	*Melaleuca carrii, Exocarpos aphyllus* and *Hakea kippistiana* Low Scrub over *Atriplex hymenotheca* and *Enchylaena tomentosa* Open Dwarf Scrub over mixed annual Very Open Herbs
Vegetation 5	*Eucalyptus kondininensis* and *E. spathulata* Open Low Woodland over *Melaleuca atroviridis* and *Acacia acuminata* Open Scrub over *Rhagodia preissii* and *Enchylaena tomentosa* Dwarf Scrub over *Lomandra effusa* and mixed annual Open Herbs

Native species

Scientific name	Common name
Acacia acuminata	jam
Aristida sp.	three-awned spear grass
Atriplex hymenotheca	saltbush
Atriplex sp.	saltbush
Austrostipa elegantissima	feather speargrass
Austrostipa sp.	speargrass
Borya laciniata	pin-grass
Borya sphaerocephala	pincushions
Brachyscome sp.	daisy
Caladenia hirta subsp. *rosea*	pink candy orchid
Calocephalus multiflorus	yellow-top
Cheilanthes austrotenuifolia	rock fern
Crassula sp.	stonecrop
Darwinia halophila	darwinia
Dianella revoluta	blueberry lily
Didymanthus roei	
Disphyma crassifolium	round-leaved pigface
Enchylaena tomentosa	ruby saltbush
Eragrostis dielsii	mallee lovegrass
Eremophila decipiens	slender fuchsia
Erodium cygnorum	blue heron's-bill
Eucalyptus kondininensis	Kondinin blackbutt
Eucalyptus loxophleba subsp. *loxophleba*	York gum
Eucalyptus spathulata	swamp mallet
Exocarpos aphyllus	leafless ballart
Frankenia drummondii	frankenia
Frankenia sp.	frankenia
Gunniopsis septifraga	

Native species (continued)	
Scientific name	**Common name**
Hakea kippistiana	hakea
Hyalochlamys globifera	
Lawrencella rosea	pink everlasting
Lepidosperma sp.	sword sedge
Levenhookia sp.	stylewort
Lomandra effusa	scented matrush
Lycium australe	Australian boxthorn
Maireana brevifolia	small-leaf bluebush
Maireana sp.	bluebush
Melaleuca atroviridis	broombush
Melaleuca carrii	
+Melaleuca lateriflora	gorada
Melaleuca pauperiflora	boree
Melaleuca teuthidoides	
Podolepis capillaris	wiry podolepis
Podolepis lessonii	podolepis
Podotheca gnaphalioides	golden longheads
Ptilotus sp.	mulla mulla
Ptilotus spathulatus	mulla mulla
Quinetia urvillei	
Rhagodia drummondii	rhagodia
Rhagodia preissii	rhagodia
Rhodanthe manglesii	pink sunray
Roycea spinescens	
Rutidosis multiflora	small wrinklewort
Sclerolaena diacantha	grey copper-burr
Senecio spp.	groundsel
Siloxerus multiflorus	
Tecticornia lylei	samphire
Tecticornia spp.	samphire (3 species)
Triglochin calcitrapa	spurred arrowgrass
Triglochin mucronata	prickly arrowgrass
Waitzia acuminata	orange immortelle

+ Regeneration noted

Weed species	
Scientific name	**Common name**
Aira cupaniana	hair-grass
Arctotheca calendula	capeweed
Avena barbata	bearded oat
Brassica tournefortii	wild turnip
Bromus rubens	red brome
Cotula bipinnata	ferny cotula
Mesembryanthemum nodiflorum	slender ice-plant
Monoculus monstrosus	stinking Roger
Parapholis incurva	coast barbgrass
Parentucellia latifolia	common bartsia
Pentaschistis airoides	false hair-grass
Spergularia sp.	spurry
Ursinia anthemoides	ursinia
Vulpia myuros	silver grass

Other plant lists for the general area
Beard (1980)
Grein (1994)
Lefroy *et al*. (1991)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	0
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	4
Very good	Vegetation structure altered, obvious signs of disturbance	8
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	26
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	6
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	44

Disturbance factors contributing to vegetation condition score							
Disturbance factor	**Level of threat**			**Disturbance factor**	**Level of threat**		
	H	**M**	**L**		**H**	**M**	**L**
Salinity	x			Rubbish			x
Waterlogging	x			Plant disease			
Ponding from road crossing				Erosion			
Drainage				Service corridors			
Clearing				Feral animals			x
Fire risk				Recreation			
Weed invasion			x	Point source discharge			
Stock access			x	Other			
Vehicle access							

Comments
There is evidence of rabbits.

Links to protected areas of remnant vegetation		
Name	**Area** (ha)	**Approximate distance and direction from site**
Kondinin Salt Marsh Nature Reserve	2828	2.5 km E
Crown Reserve 15385	105	3.0 km S
Crown Reserve 18698	148	4.5 km S
Hopkins Nature Reserve	584	10.0 km S

Management
There is an old fence along the wetland and fencing along the top boundary of the site. There are vehicle tracks inside the wetland.
Salinity and waterlogging are likely to have the most impact on vegetation at this site, however, management should be implemented on a catchment basis. It is recommended that rubbish (drums and wire) be removed from the site. Rabbits should be controlled.

Fauna	
Scientific name	**Common name**
Birds	
Acanthagenys rufogularis	spiny-cheeked honeyeater
Acanthiza spp.	thornbills
Anthus australis	Australian pipit
Cacatua roseicapilla	galah
Circus assimilis	spotted harrier
Chrysococcyx basalis	Horsfield's bronze cuckoo
Colluricincla harmonica	grey shrike thrush
Coracina novaehollandiae	black-faced cuckoo-shrike
Cracticus nigrogularis	pied butcher bird
Cracticus tibicen	magpie
Cuculus pallidus	pallid cuckoo
Epthianura albifrons	white-fronted chat
Grallina cyanoleuca	magpie-lark
Ocyphaps lophotes	crested pigeon
Petroica goodenovii	red-capped robin
Phaps chalcoptera	common bronzewing
Platycercus zonarius	Australian ringneck parrot
Pomatostomus superciliosus	white browed babbler
Mammals	
Macropus fuliginosus	western grey kangaroo
Oryctolagus cuniculus	European wild rabbit*
Sminthopsis crassicaudata	fat-tailed dunnart
Tachyglossus aculeatus	short-beaked echidna
Vulpes vulpes	European red fox*
** Introduced species*	

Other fauna lists for the general area
Greening Australia of Western Australia (2004)
Grein (1994)
Lefroy *et al*. (1991)

Notes:

- The site may be grazed (uncertain), but if so there is no evidence of damage
- There is a borrow pit on the eastern side of the site that has largely fresh water in it and smaller borrow pits scattered throughout the site, possibly for stock water
- Plant deaths (Melaleucas) have occurred along stream edges and on the edge of the island, probably due to an earlier flood event (possibly 2006).
- There are very few weeds, mainly slender ice plant
- A fat-tailed dunnart was found dead but not predated
- Water sampled from a borrow pit was pH 8.0, temperature 24^{o}C, conductivity 1.59 mS/cm.

Photo A1.1: ULR01
Very good condition vegetation association 1: *Melaleuca lateriflora* and *M. teuthidoides* Scrub with scattered *Eucalyptus spathulata* over *Rhagodia preissii* and *Enchylaena tomentosa* Open Dwarf Scrub over mixed annual Herbs

Photo A1.2: ULR01
Degraded condition vegetation association 2: *Tecticornia* spp. Dwarf Scrub over *Mesembryanthemum nodiflorum*, *Gunniopsis septifraga* and *Senecio* sp. Very Open Herbs

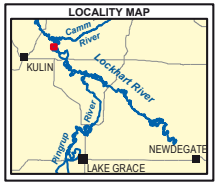
Photo A1.3: ULR01
Excellent condition vegetation association 3: *Eucalyptus loxophleba* subsp. *loxophleba* Open Low Woodland over *Acacia acuminata* Low Woodland over *Maireana brevifolia* and *Enchylaena tomentosa* Open Low Scrub over mixed annual Dense Herbs

Photo A1.4: ULR01
Good condition vegetation association 4: *Melaleuca carrii*, *Exocarpos aphyllus* and *Hakea kippistiana* Low Scrub over *Atriplex hymenotheca* and *Enchylaena tomentosa* Open Dwarf Scrub over mixed annual Very Open Herbs

Photo A1.5: ULR01
Very good condition vegetation association 5: *Eucalyptus kondininensis* and *E. spathulata* Open Low Woodland over *Melaleuca atroviridis* and *Acacia acuminata* Open Scrub over *Rhagodia preissii* and *Enchylaena tomentosa* Dwarf Scrub over *Lomandra effusa* and mixed annual Open Herbs

Map A1
Vegetation condition for survery site ULR01

Lucca Pty Ltd



N

LEGEND

Vegetation condition

- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

Datum and Projection Information
Vertical Datum: Australian Height Datum (AHD)
Horizontal Datum: Geocentric Datum of Australia 94
Projection: MGA 94 Zone 50
Spheroid: Australian National Spheroid

Project Information
Client: Shepherd Chipfunde
Map Author: Davina Gan
Task ID: 7113
Filepath: J:\gisprojects\Project\B_Series\B410C\0001\mxd\
Filename: MapA1_Veg_cond_survey_site_ULR01.mxd
Compilation date: May 2009
Edition: 1

SOURCES

The Department of Water acknowledges the following datasets and their custodians in the production of this map:

Corrigin South Orthomosiac – Landgate – 2000

This map is a product of the Department of Water, Spatial Services Section and was completed in May 2009.

This map was produced with the intent that it be used for the Lower Lockhart River mapping project at the scale of 1:10 000.

While the Department of Water has made all reasonable efforts to ensure the accuracy of this data, the department accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.

Site ULR02 — Jilakin Lake

General details	
Site name	Jilakin Lake
Landholder	Vacant Crown Land (Lake) and Lucca Pty Ltd (land east of Lake)
Surveyed by	Lyn Atkins and Catherine Krens (Ecoscape)
Date	09.09.2008

Site description	
Landform	The site is mostly a large playa lake, with an extensive area of water. The north-eastern, some of the southern and eastern sides of the lake are slightly elevated with gradual sloping banks. The northern side of the lake has steep, sloping high banks.
Site size	1660 ha

Beard vegetation description
Beard vegetation association 8: Medium woodland; salmon gum and gimlet
Beard vegetation association 125: Bare areas; salt lakes
Beard vegetation association 676: Succulent steppe; samphire

Overall vegetation structure and cover (for vegetated areas only)

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	*Eucalyptus kondininensis, E. loxophleba* subsp. *loxophleba*
Mallees	0	
Shrubs	10–30%	*Melaleuca pauperiflora, Maireana brevifolia, Enchylaena tomentosa, Tecticornia* spp., *Atriplex* spp.
Grasses	2–10%	*Lolium rigidum, Austrostipa* spp.
Herbs	10–30%	*Sisymbrium* sp., *Atriplex semibaccata, Mesembryanthemum nodiflorum, Sclerolaena diacantha*
Rushes and sedges	0	
Litter	2–10%	
Bare ground	> 70%	
Rock outcrop	0	

Summary

The gently sloping banks are either bare, with some wet areas, samphire, or samphire and saltbush. The northern side of the lake has steeply sloping high banks with woodland and Melaleuca sp on the slopes and tops with the lower slopes and outer edge of the lake degraded and mostly dead Melaleuca sp and samphire.

Individual vegetation association descriptions	
Vegetation 1	*Eucalyptus kondininensis* Open Low Woodland over *Melaleuca pauperiflora* Open Scrub to 4 m over *Sisymbrium* sp. Open Herbs and *Lolium rigidum* Open Low Grass
Vegetation 2	*E. loxophleba* subsp*. loxophleba* Low Woodland over *Enchylaena tomentosa* Open Dwarf Scrub over *Austrostipa* spp. Open Tall Grass over mixed Open Herbs
Vegetation 3	*Tecticornia* spp. (2) Dwarf Scrub
Vegetation 4	*Tecticornia* spp. (2) and *Atriplex* sp. Low Heath over mixed Very Open Herbs
Vegetation 5	*E. loxophleba* subsp*. loxophleba* and *E. kondininensis* Open Low Woodland over *Maireana brevifolia* Open Dwarf Scrub over *Mesembryanthemum nodiflorum, Sclerolaena diacantha* and *Atriplex semibaccata* Open Herbs

Native species	
Scientific name	**Common name**
Acacia acuminata	jam
Atriplex amnicola	swamp saltbush
Atriplex semibaccata	berry saltbush
Atriplex sp.	saltbush
Austrostipa sp*.*	speargrass
Caesia micrantha	pale grass-lily
Calandrinia eremaea	twining purslane
Calandrinia granulifera	pygmy purslane
+Casuarina obesa	swamp sheoak
Enchylaena tomentosa	ruby saltbush
+Eucalyptus kondininensis	Kondinin blackbutt
Eucalyptus longicornis	red morrell
+Eucalyptus loxophleba subsp. *loxophleba*	York gum
Eucalyptus salicola	salt gum
Eucalyptus salubris	gimlet
Maireana brevifolia	small-leaf bluebush
Maireana carnosa	cottony bluebush
+Melaleuca atroviridis	
+Melaleuca lateriflora	gorada
Melaleuca pauperiflora	boree
Melaleuca teuthidoides	
Pittosporum angustifolium	native apricot
Ptilotus polystachyus	bottle washers
Rhagodia preissii	rhagodia
Ruppia sp. or *Lepilaena* sp.	waterweed
Sclerolaena diacantha	grey copper-burr
Spergularia marina	salt sand spurry
Tecticornia spp.	samphire (3 species)
Teucrium sessiliflorum	camel bush

+ Regeneration noted

Weed species	
Scientific name	**Common name**
Arctotheca calendula	capeweed
Brassica tournefortii	wild turnip
Bromus rubens	red brome
Cotula bipinnata	ferny cotula
Ehrharta longiflora	annual veldt grass
Erodium sp.	storksbill
Hordeum leporinum	barley grass
Hypochaeris glabra	flatweed
Lolium rigidum	annual ryegrass
Malva parviflora	marshmallow
Medicago sp.	medic
Mesembryanthemum nodiflorum	slender ice-plant
Moraea setifolia	thread iris
Pentaschistis airoides	false hair-grass
Raphanus raphanistrum	wild radish
Sisymbrium sp.	mustard
Sonchus oleraceus	sowthistle
Trifolium cherleri	cupped clover
Vulpia myuros	silver grass

Other plant lists for the general area
Beard (1980)
Grein (1994)
Lefroy *et al*. (1991)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	2
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	0
Very good	Vegetation structure altered, obvious signs of disturbance	0
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	7
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	6
Completely degraded	Vegetation structure no longer intact and the area is without/ almost without native species	60

Disturbance factors contributing to vegetation condition score							
Disturbance factor	**Level of threat**			**Disturbance factor**	**Level of threat**		
	H	**M**	**L**		**H**	**M**	**L**
Salinity	x			Rubbish			x
Waterlogging	x			Plant disease			
Ponding from road crossing				Erosion			
Drainage				Service corridors			
Clearing				Feral animals			x
Fire risk		x		Recreation			x
Weed invasion	x			Point source discharge			
Stock access		x		Other			
Vehicle access			x				

Comments

There is an electric fence at the boundary between crop and pasture and a fence running down to the lake. A gazetted double-fenced northern road is under water on the northern part of the lake bed. The lake is used for recreation and there are vehicle tracks to a catamaran. The eastern (privately owned) part of the site is grazed and sheep are present. There is a large bund through the site on the southern side of the lake which appears to have been recently constructed (purpose unknown but suspected to be related to flood events). There is evidence of minor clearing on the eastern side of the lake. Rubbish, including broken bottles and old drums, are present on the site.

Links to protected areas of remnant vegetation		
Name	**Area** (ha)	**Approximate distance and direction from site**
Crown Reserve 15385	105	Adjacent to site
Crown Reserve 18698	148	4.5 km S
Kondinin Salt Marsh Nature Reserve	2828	4.0 km N
Hopkins Nature Reserve	584	7.0 km SW

Management

Fencing has been undertaken around the site. However, the eastern side of the lake is grazed and this would contribute to the high density of weeds. Vegetation condition could be improved by excluding grazing, controlling weed and feral animals, and revegetating cleared areas. It is also recommended that rubbish be removed from the site.

Fauna	
Scientific name	**Common name**
Birds	
Acanthagenys rufogularis	spiny-cheeked honeyeater
Aquila audax	wedge-tailed eagle
Cacatua roseicapilla	galah
Coracina novaehollandiae	black-faced cuckoo-shrike
Corvus coronoides	Australian raven
Cracticus nigrogularis	pied butcher bird
Cracticus tibicen	magpie
Epthianura albifrons	white-fronted chat
Falco cenchroides	Australian kestrel
Grallina cyanoleuca	magpie-lark
Lichenostomus virescens	singing honey-eater
Manorina flavigula	yellow throated miner

Fauna (continued)	
Scientific name	**Common name**
Birds	
Pardalotus striatus	striated pardalote
Platycercus zonarius	Australian ringneck parrot
Pomatostomus superciliosus	white-browed babbler
Rhipidura leucophrys	willy wagtail

Other fauna lists for the general area
Greening Australia Western Australia (2004)
Grein (1994)
Lefroy *et al*. (1991)

Notes:

From discussions with landholders:

- The lake slowly increased in salinity in living memory
- The farm on the eastern side of the lake is noticeably saltier
- Floods in 2006 resulted in water 1.5 m over the road to the south, but did not appear to increase salinity
- Flood waters took over one month to subside and left a residue of black mud
- Vegetation in the area that was covered by flood waters at the lake edge has died
- Crustaceans up to 1.5 cm were noted after the floods
- The lake filled in 2000 but did not flood
- The eastern side of the lake has always been saltbush/samphire.

From field observations:

- Revegetation is present; saltbush has been planted and there has been regeneration along the roadside
- Water sampled from Lake Jilakin was pH 7.5, temperature 25.7^{o}C and conductivity was 216 mS/cm.

Photo A1.6: ULR02

Degraded condition vegetation association 1: *Eucalyptus kondininensis* Open Low Woodland over *Melaleuca pauperiflora* Open Scrub over *Sisymbrium* sp. Open Herbs and *Lolium rigidum* Open Low Grass

Photo A1.7:ULR02

Very good condition vegetation association 2: *Eucalyptus loxophleba* subsp. *loxophleba* Low Woodland over *Enchylaena tomentosa* Open Dwarf Scrub over *Austrostipa* spp. Open Tall Grass over mixed Open Herbs

Photo A1.8: ULR02

Completely degraded condition vegetation association 3: *Tecticornia* spp. Dwarf Scrub

Photo A1.9: ULR02

Good condition vegetation association 4: *Tecticornia* spp. and *Atriplex* sp. Low Heath over mixed Very Open Herbs

Photo A1.10: ULR02

Good condition vegetation association 5: *Eucalyptus loxophleba* subsp. *loxophleba* and *E. kondininensis* Open Low Woodland over *Maireana brevifolia* Open Dwarf Scrub over *Mesembryanthemum nodiflorum*, *Sclerolaena diacantha* and *Atriplex semibaccata* Open Herbs

Map A2
Vegetation condition for survery site ULR02
Jilakin Lake

N

LEGEND

Vegetation condition

- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

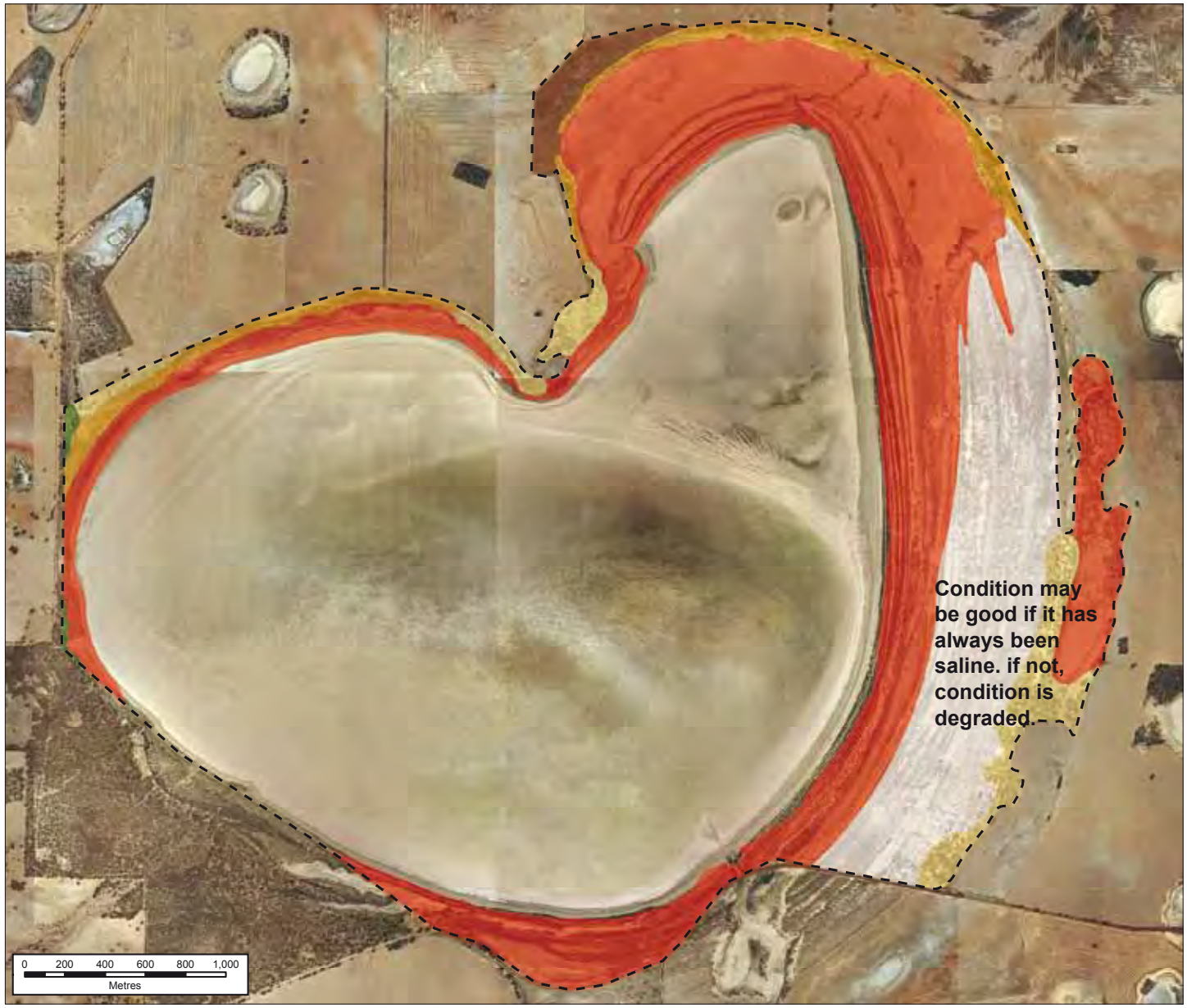
Datum and Projection Information
Vertical Datum: Australian Height Datum (AHD)
Horizontal Datum: Geocentric Datum of Australia 94
Projection: MGA 94 Zone 50
Spheroid: Australian National Spheroid

Project Information
Client: Shepherd Chipfunde
Map Author: Davina Gan
Task ID: 7113
Filepath: J:\gisprojects\Project\B_Series\B410C\0001\mxd\
Filename: MapA2_Veg_cond_survey_site_ULR02.mxd
Compilation date: May 2009
Edition: 1

SOURCES

The Department of Water acknowledges the following datasets and their custodians in the production of this map:

Corrigin South Orthomosiac – Landgate – 2000



Site ULR03 — Scadding's

General details	
Site name	Scadding's
Landholder	Norman Scadding
Surveyed by	Lyn Atkins and Catherine Krens (Ecoscape)
Date	08.09.2008

Site description	
Landform	The site is within the valley floor, with a small section in the north-west corner on the lower valley slopes. The three large playa lakes on the western side have water in them and in channels between them. The eastern lake has water but is not flowing and is not connected to other lakes. The lakes have (mostly) steeply-sided banks.
Site size	190 ha

Beard vegetation description

Beard vegetation association 8: Medium woodland; salmon gum and gimlet
Beard vegetation association 131: Mosaic: Medium woodland; salmon gum and gimlet / Shrublands; mallee scrub, redwood & black marlock
Beard vegetation association 953: Succulent steppe with thicket; teatree over samphire

Overall vegetation structure and cover (for vegetated areas only)

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	Eucalyptus kondininensis, E. longicornis, E. salubris
Mallees	10–30%	*E. loxophleba* subsp. *gratia*e, *E. horistes*
Shrubs	10–30%	*Melaleuca pauperiflora, M. atroviridis, M. teuthidoides, Santalum acuminatum, Acacia acuminata, A. colletioides, Atriplex bunburyana, Hakea kippistiana, Rhagodia drummondii, R. preissii, Enchylaena tomentosa, Sclerolaena diacantha, Olearia dampieri, Rinzia crassifolia, Scaevola spinescens*, *Lycium australe, Frankenia* sp., *Tecticornia* sp.
Grasses	2–10%	*Austrostipa* spp.
Herbs	2–10%	Disphyma crassifolium, Lomandra effusa
Rushes and sedges	2–10%	*Lepidosperma* spp., *Desmocladus* sp.
Litter	2–10%	
Bare ground	30–70%	
Rock outcrop	0	

Summary

The lakes are fringed by melaleucas and some samphire. Raised areas are either Kondinin blackbutt or sand mallee (*Eucalyptus horistes*) on lunettes, or on lower valley slopes, red morrell/gimlet or Lake Grace gum mallee. Understorey and lower-lying areas are various *Melaleuca* spp. These areas are degraded or completely degraded in lower-lying areas. Flat areas, probably former lake bed areas, are saltbush/*Frankenia* spp. (with some samphire) on clay soil.

Individual vegetation association descriptions	
Vegetation 1	*Eucalyptus kondininensis* Low Woodland over *Melaleuca pauperiflora* Open Scrub to 3 m over *Atriplex bunburyana* and *Rhagodia drummondii* Open Dwarf Scrub over *Disphyma crassifolium* Very Open Herbs
Vegetation 2	*Melaleuca lateriflora* and *Melaleuca teuthidoides* Scrub over *Rhagodia preissii* Open Dwarf Scrub over mixed introduced annual Dense Herbs
Vegetation 3	*Eucalyptus longicornis* and *E. salubris* Open Woodland over *Melaleuca pauperiflora* Open Scrub to 4 m over *Atriplex bunburyana* Dwarf Scrub over *Austrostipa* spp. Very Open Tall Grass
Vegetation 4	*Eucalyptus loxophleba* subsp. *gratia*e Open Tree Mallee over *Acacia acuminata* Open Scrub to 3 m over *Rhagodia drummondii*, *Enchylaena tomentosa* and *Sclerolaena diacantha* Open Dwarf Scrub over mixed introduced annual Open Herbs
Vegetation 5	*Eucalyptus horistes* Open Tree Mallee over *Melaleuca atroviridis* and *Santalum acuminatum* Open Scrub to 5 m over *Olearia dampieri, Rhagodia drummondii* and *Rinzia crassifolia* Open Dwarf Scrub over *Lomandra effusa* Very Open Herbs and *Lepidosperma* spp. and *Desmocladus* sp. Very Open Low Sedges
Vegetation 6	*Melaleuca atroviridis* and *M. lateriflora* Scrub to 5 m with scattered *Eucalyptus spathulata* over mixed Open Herbs
Vegetation 7	*Eucalyptus kondininensis* Open Woodland over *Melaleuca pauperiflora* Open Low Woodland to 5 m over *Hakea kippistiana, Acacia colletioides* and *Rhagodia preissii* Open Scrub over *Scaevola spinescens* and *Lycium australe* Open Dwarf Scrub over *Disphyma crassifolium* Very Open Herbs
Vegetation 8	*Atriplex* sp., *Frankenia* sp. and *Tecticornia* spp. Dwarf Scrub over *Disphyma crassifolium* Very Open Herbs

Native species	
Scientific name	**Common name**
Acacia acuminata	jam
Acacia ancistrophylla	wattle
Acacia colletioides	wait-a-while
Acacia erinacea	spiny wattle
Acacia merrallii	Merrall's wattle
Actinobole uliginosum	flannel cudweed
Alyxia buxifolia	dysentery bush
Atriplex bunburyana	silver saltbush
Atriplex sp.	saltbush
Austrostipa elegantissima	feather speargrass
Austrostipa sp.	speargrass
Brachyscome iberidifolia	Swan River daisy
*Bulbine semibarba*ta	leek lily
Calandrinia eremaea	twining purslane
Calocephalus multiflorus	yellow-top
Calytrix leschenaultii	purple star flower
Crassula colorata	dense stonecrop
Desmocladus sp.	
Dianella revoluta	blueberry lily
Didymanthus roei	
Disphyma crassifolium	round-leaved pigface
Enchylaena tomentosa	ruby saltbush
Eragrostis dielsii	mallee lovegrass
Eremophila decipiens	slender fuchsia
Erymophyllum sp.	everlasting

Native species (continued)	
Scientific name	**Common name**
Eucalyptus horistes	white-flowered mallee
Eucalyptus kondininensis	Kondinin blackbutt
Eucalyptus longicornis	red morrell
Eucalyptus loxophleba subsp. *gratiae*	Lake Grace gum
Eucalyptus salubris	gimlet
Eucalyptus spathulata	swamp mallet
Frankenia sp.	frankenia
Gahnia ancistrophylla	hooked-leaf saw sedge
Gahnia sp.	saw sedge
Gunniopsis septifraga	
Hakea kippistiana	hakea
Hakea preissii	needle tree
Hyalochlamys globifera	
Lepidobolus sp.	
Lepidosperma spp.	sword sedge (2 species)
Lomandra effusa	scented matrush
Lycium australe	Australian boxthorn
Maireana brevifolia	small-leaf bluebush
Maireana sp.	bluebush
Melaleuca atroviridis	broombush
Melaleuca brevifolia	
Melaleuca cuticularis	saltwater paperbark
Melaleuca lateriflora	gorada
Melaleuca pauperiflora	boree
Melaleuca teuthidoides	
Melaleuca thyoides	
Neurachne alopecuroidea	foxtail mulga grass
Olearia dampieri	daisy bush
Pittosporum angustifolium	native apricot
Podotheca angustifolia	sticky longheads
Podotheca gnaphalioides	golden longheads
Rhagodia drummondii	rhagodia
Rhagodia preissii	rhagodia
Rhodanthe chlorocephala	
Rhodanthe spicata	
Rinzia crassifolia	
Rutidosis multiflora	small wrinklewort
Santalum acuminatum	quandong
Sarcocornia blackiana	samphire
Scaevola spinescens	currant bush
Sclerolaena diacantha	grey copper-burr
Senecio sp.	groundsel
Siloxerus multiflorus	
Spergularia marina	salt sand spurry
Tecticornia spp.	samphire (2 species)
Trachymene cyanopetala	
Triglochin mucronata	prickly arrowgrass
Waitzia acuminata	orange immortelle

No regeneration noted

Weed species	
Scientific name	**Common name**
Arctotheca calendula	capeweed
Brassica tournefortii	wild turnip
Bromus rubens	red brome
Cotula bipinnata	ferny cotula
Hypochaeris glabra	flatweed
Lolium rigidum	annual ryegrass
Mesembryanthemum nodiflorum	slender ice-plant
Monoculus monstrosus	stinking Roger
Moraea setifolia	thread iris
Oxalis pes-caprae	soursob
Parapholis incurva	coast barbgrass
Pentaschistis airoides	false hair-grass
Romulea rosea	Guildford grass
Sonchus oleraceus	common sowthistle
Ursinia anthemoides	ursinia
Vulpia myuros	silver grass

Other plant lists for the general area
Beard (1980)
Grein (1994)
Lefroy *et al*. (1991)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	0
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	1
Very good	Vegetation structure altered, obvious signs of disturbance	20
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	12
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	2
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	5

Disturbance factors contributing to vegetation condition score							
Disturbance factor	**Level of threat**			**Disturbance factor**	**Level of threat**		
	H	**M**	**L**		**H**	**M**	**L**
Salinity		x		Rubbish			x
Waterlogging		x		Plant disease			
Ponding from road crossing				Erosion			
Drainage				Service corridors			
Clearing				Feral animals		x	
Fire risk		x		Recreation			x
Weed invasion			x	Point source discharge			
Stock access		x		Other			
Vehicle access							

Comments

The site has been grazed and sheep tracks are present. A new fence has been erected along the road and old fencing material, including rolls of wire, remain on the site.

Part of the site is completely degraded. There is evidence of rabbits and foxes. Non-native plants have been established and part of the site is very weedy. There have been recent deaths of samphire in low-lying areas and trees are dying close to lake.

Bank erosion has occurred and there is minor eutrophication, with dead weed at the edges of the waterbody. Embankments have been constructed to stop channel inflow to the lake.

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
Crown Reserve 28547	522	2.0 km E
Crown Reserve 13603	26	3.0 km N

Management

Salinity and waterlogging are impacting vegetation on the site. Vegetation condition has also been impacted by grazing and it is recommended that the floodplain be fenced to exclude grazing. Rabbits and weeds should also be controlled and rubbish removed from the site. Revegetation could assist in stabilising the banks. This should also reduce sedimentation and eutrophication.

Fauna

Scientific name	Common name
Birds	
Acanthagenys rufogularis	spiny-cheeked honeyeater
Acanthiza chrysorrhoa	yellow-rumped thornbill
Anthochaera carunculata	red wattlebird
Ardea alba	great egret
Artamus cinereus	black-faced woodswallow
Cacatua roseicapilla	galah
Chrysococcyx basalis	Horsfield's bronze cuckoo
Circus australis	spotted harrier
Corvus coronoides	Australian raven
Cracticus nigrogularis	pied butcher bird
Cracticus tibicen	magpie
Cracticus torquatus	grey butcherbird
Cuculus pallidus	pallid cuckoo
Cygnus atratus	black swan
Epthianura albifrons	white-fronted chat
Grallina cyanoleuca	magpie-lark
Lichenostomus virescens	singing honey-eater
Ocyphaps lophotes	crested pigeon
Oreoica gutturalis	crested bellbird
Pardalotus striatus	striated pardalote
Phaps chalcoptera	common bronzewing
Platycercus varius	mulga parrot
Pomatostomus superciliosus	white browed babbler
Rhipidura leucophrys	willy wagtail
Tadorna tadornoides	Australian shelduck (mountain duck)
Vanellus tricolor	banded lapwing
Unidentified species	honeyeater

Mammals	
Oryctolagus cuniculus	European wild rabbit*
Vulpes vulpes	European red fox*

* *Introduced species*

Other fauna lists for the general area
Greening Australia Western Australia (2004)
Grein (1994)
Lefroy *et al*. (1991)

Notes:

- Water sampled from one of the lakes was pH 7.9, temperature 23.4^{o}C and conductivity was 90.7 mS/cm.

Photo A1.11: ULR03

Very good condition vegetation association 1: *Eucalyptus kondininensis* Low Woodland over *Melaleuca pauperiflora* Open Scrub over *Atriplex bunburyana* and *Rhagodia drummondii* Open Dwarf Scrub over *Disphyma crassifolium* Very Open Herbs

Photo A1.12: ULR03

Good condition vegetation association 2: *Melaleuca lateriflora* and *Melaleuca teuthidoides* Scrub over *Rhagodia preissii*, Open Dwarf Scrub over mixed introduced annual Dense Herbs

Photo A1.13: ULR03

Excellent condition vegetation association 3: *Eucalyptus longicornis* and *E. salubris* Open Woodland over *Melaleuca pauperiflora* Open Scrub over *Atriplex bunburyana* Dwarf Scrub over *Austrostipa* spp. Very Open Tall Grass

Photo A1.14: ULR03

Good condition vegetation association 4: *Eucalyptus loxophleba* subsp. *gratiae* Open Tree Mallee over *Acacia acuminata* Open Scrub over *Rhagodia drummondii*, *Enchylaena tomentosa* and *Sclerolaena diacantha* Open Dwarf Scrub over mixed introduced annual Open Herbs

Photo A1.15: ULR03

Very good condition vegetation association 5: *Eucalyptus horistes* Open Tree Mallee over *Melaleuca atroviridis* and *Santalum acuminatum* Open Scrub over *Olearia dampieri*, *Rhagodia drummondii* and *Rinzia crassifolia* Open Dwarf Scrub over *Lomandra effusa* Very Open Herbs and *Lepidosperma* spp. and *Desmocladus* sp. Very Open Low Sedges

Photo A1.16: ULR03

Good condition vegetation association 6: *Melaleuca atroviridis* and *M. lateriflora* Scrub with scattered *Eucalyptus spathulata* over mixed Open Herbs

Photo A1.17: ULR03

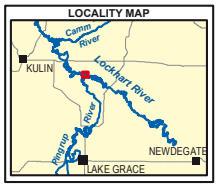
Very good condition vegetation association 7: *Eucalyptus kondininensis* Open Woodland over *Melaleuca pauperiflora* Open Low Woodland over *Hakea kippistiana*, *Acacia colletioides* and *Rhagodia preissii* Open Scrub over *Scaevola spinescens* and *Lycium australe* Open Dwarf Scrub over *Disphyma crassifolia* Very Open Herbs

Photo A1.18: ULR03

Very good condition vegetation association 8: *Atriplex* sp., *Frankenia* sp. and *Tecticornia* spp., Dwarf Scrub over *Disphyma crassifolia* Very Open Herbs

Map A3
Vegetation condition for survery site ULR03

Scadding's



N

LEGEND

Vegetation condition

- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

Datum and Projection Information
Vertical Datum: Australian Height Datum (AHD)
Horizontal Datum: Geocentric Datum of Australia 94
Projection: MGA 94 Zone 50
Spheroid: Australian National Spheroid

Project Information
Client: Shepherd Chipfunde
Map Author: Davina Gan
Task ID: 7113
Filepath: J:\gisprojects\Project\B_Series\B410C\0001\mxd\
Filename: MapA3_Veg_cond_survey_site_ULR03.mxd
Compilation date: May 2009
Edition: 1

SOURCES

The Department of Water acknowledges the following datasets and their custodians in the production of this map:

Corrigin South Orthomosiac – Landgate – 2000

Site ULR04 — Crown Reserve 28547

General details	
Site name	Crown Reserve 28547
Landholder	DEC
Surveyed by	Lyn Atkins and Catherine Krens (Ecoscape)
Date	10.09.2008

Site description	
Landform	Most of the site is valley floor with a braided, discontinuous flow line over low-lying areas. The south west corner and north side, especially the north east corner are valley slopes with granite outcropping. There are a few small playa lakes near the north east corner.
Site size	395 ha

Beard vegetation description

Beard vegetation association 945: Mosaic: Medium woodland; salmon gum / Shrublands; mallee scrub, redwood and black marlock

Beard vegetation association 953: Succulent steppe with thicket; teatree over samphire

Overall vegetation structure and cover (for vegetated areas only)

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	*Eucalyptus salmonophloia, E. salubris, E. longicornis, E. spathulata*
Mallees	2–10%	*Eucalyptus subangusta, E. horistes*
Shrubs	10–30%	*Acacia assimilis, Alyxia buxifolia, Allocasuarina campestris, Melaleuca lateriflora, M. laxiflora, M. pauperiflora, Lycium australe, Dodonaea viscosa* subsp. *angustissima Verticordia chrysanthella, Platysace effusa, Leptospermum erubescens, Jacksonia* sp., *Rinzia crassifolia, Microcybe multiflora, Olearia muelleri, Olearia dampieri, Phebalium tuberculosum, Scaevola spinescens, Atriplex bunburyana, Santalum acuminatum, Beyeria leschenaultia, Tecticornia* spp., *Frankenia* sp., *Roycea spinescens*
Grasses	2–10%	*Amphipogon* sp., *Spartochloa scirpoidea*
Herbs	30–70%	*Borya sphaerocephala, B. laciniata, Brachyscome* sp., *Podolepis capillaris, Stylidium repens, Angianthus tomentosus, Mesembryanthemum nodiflorum, Disphyma crassifolia, Carpobrotus modestus, Crassula* sp., *Senecio* sp.
Rushes and sedges	2–10%	*Lepidosperma drummondii, Lepidobolus chaetocephalus, Desmocladus asper*
Litter	2–10%	
Bare ground	30–70%	
Rock outcrop	2%	

Summary

The valley slopes support mallee and woodlands. Raised areas on the valley floor support melaleuca shrublands or woodlands, often virtually undisturbed or in *excellent* condition. The woodlands on the higher lands on the northern side are in *excellent* to *pristine* condition.

Individual vegetation association descriptions

Vegetation 1	*Eucalyptus subangusta* Very Open Tree Mallee over *Acacia assimilis*, *Alyxia buxifolia* and *Allocasuarina campestris* Open Scrub over *Platysace effusa* Open Dwarf Scrub over *Lepidosperma drummondii* Open Low Sedges over *Amphipogon* sp. and *Spartochloa scirpoidea* Very Open Tall Grass over mixed annual Open Herbs
Vegetation 2	*Leptospermum erubescens* and *Acacia assimilis* Open Scrub over *Spartochloa scirpoidea* Very Open Tall Grass over *Verticordia chrysanthella* and *Platysace effusa* Dwarf Scrub over *Borya sphaerocephala*, *Stylidium repens* and mixed annual Herbs
Vegetation 3	*Melaleuca lateriflora* and *Lycium australe* Scrub over *Atriplex bunburyana* Open Dwarf Scrub over *Angianthus tomentosus* and *Mesembryanthemum nodiflorum* Herbs
Vegetation 4	*Melaleuca pauperiflora*, *Lycium australe*, *Rhagodia preissii* and *Dodonaea viscosa* subsp. *angustissima* Low Scrub over *Jacksonia* sp. and *Rinzia crassifolia* Open Dwarf Scrub over *Borya laciniata*, *Brachyscome* sp. and *Podolepis capillaris* Open Herbs
Vegetation 5	*Allocasuarina huegeliana* Low Woodland over *Leptospermum erubescens* and *Acacia assimilis* Open Dwarf Scrub over *Spartochloa scirpoidea* Very Open Tall Grass over mixed annual Dense Herbs
Vegetation 6	*Eucalyptus salmonophloia*, *E. salubris* and *E. longicornis* Open Woodland over *Santalum acuminatum* Open Low Woodland over *Melaleuca laxiflora* Open Scrub over *Microcybe multiflora*, *Olearia muelleri*, *Scaevola spinescens* and *Atriplex bunburyana* Dwarf Scrub
Vegetation 7	*Eucalyptus horistes* Open Shrub Mallee over *Beyeria leschenaultii* and *Melaleuca laxiflora* Low Scrub over *Olearia dampieri* and *Phebalium tuberculosum* Open Dwarf Scrub over *Lepidosperma drummondii*, *Lepidobolus chaetocephalus* and *Desmocladus asper* Very Open Low Sedges
Vegetation 8	*Eucalyptus spathulata* Open Low Woodland over *Dodonaea viscosa* subsp. *angustissima* and *Hakea kippistiana* Low Scrub over *Rhagodia drummondii*, *Rinzia crassifolia* and *Enchylaena tomentosa* Open Dwarf Scrub over *Disphyma crassifolia* and *Carpobrotus modestus* Very Open Herbs
Vegetation 9	*Tecticornia* spp. (3), *Frankenia* sp., *Atriplex* sp. and *Roycea spinescens* Low Heath over *Crassula* sp. and Senecio sp. Very Open Herbs

Native species

Scientific name	Common name
Acacia acuminata	jam
Acacia assimilis	wodjil
Acacia erinacea	spiny wattle
Acacia hemiteles	tan wattle
Acacia merrallii	Merrall's wattle
Actinobole uliginosum	flannel cudweed

Native species (continued)	
Scientific name	**Common name**
Allocasuarina acutivalvis	sheoak
Allocasuarina campestris	tamma
Allocasuarina huegeliana	rock sheoak
Alyxia buxifolia	dysentery bush
Amphipogon sp.	greybeard grass
Angianthus tomentosus	camel-grass
Atriplex bunburyana	silver saltbush
Atriplex hymenotheca	saltbush
Atriplex sp.	saltbush
Austrostipa sp.	speargrass
Baeckea sp.	myrtle
Beyeria leschenaultii	pale turpentine bush
Borya laciniata	pin-grass
Borya sphaerocephala	pincushions
Brachyscome iberidifolia	Swan River daisy
Brachyscome sp.	daisy
Caladenia flava	cowslip orchid
Calandrinia eremaea	twining purslane
Calandrinia granulifera	pygmy purslane
Calandrinia spp.	parakeelya
Callistemon phoeniceus	lesser bottlebrush
Calocephalus multiflorus	yellow-top
Calotis hispidula	bindy eye
Calytrix leschenaultii	purple starflower
Carpobrotus modestus	inland pigface
Cheilanthes austrotenuifolia	rock fern
Chorizema aciculare	needle-leaved chorizema
Chthonocephalus pseudevax	woolly groundheads
Clematis delicata	clematis
Comesperma integerrimum	milkwort
Dampiera lavandulacea	
Darwinia halophila	darwinia
Desmocladus asper	
Dianella revoluta	blueberry lily
Didymanthus roei	
Disphyma crassifolium	round-leaved pigface
Diuris porrifolia	donkey orchid
Dodonaea sp.	hopbush
Dodonaea viscosa subsp. *angustissima*	sticky hopbush
Drosera macrantha	bridal rainbow
Drosera sp.	sundew
Enchylaena tomentosa	ruby saltbush
Erodium cygnorum	blue heron’s-bill
Erymophyllum tenellum	everlasting
Eucalyptus horistes	white-flowered mallee
Eucalyptus kondininensis	Kondinin blackbutt
Eucalyptus longicornis	red morrell
Eucalyptus loxophleba subsp. *gratiae*	Lake Grace gum
Eucalyptus salmonophloia	salmon gum

Native species (continued)	
Scientific name	**Common name**
Eucalyptus salubris	gimlet
Eucalyptus sheathiana	ribbon-barked gum
Eucalyptus spathulata	swamp mallet
Eucalyptus subangusta	black marlock
Frankenia sp.	frankenia
Gahnia sp.	saw sedge
Gnephosis uniflora	
Gonocarpus nodulosus	
Grevillea anethifolia	grevillea
Gunniopsis septifraga	
Hakea kippistiana	hakea
Hyalochlamys globifera	
Hyalosperma glutinosum	
Jacksonia sp.	
Lawrencella rosea	pink everlasting
Lepidobolus chaetocephalus	bristle-headed chaff rush
Lepidosperma drummondii	sword sedge
Leptospermum erubescens	roadside tea-tree
Leucopogon sp.	beard heath
Levenhookia sp.	stylewort
Lomandra effusa	scented matrush
Lycium australe	Australian boxthorn
Maireana spp.	bluebush (2 spp.)
Melaleuca acuminata	
Melaleuca adnata	
Melaleuca carrii	
Melaleuca hamata	broombush
Melaleuca lateriflora	gorada
Melaleuca laxiflora	
Melaleuca pauperiflora	boree
Melaleuca scalena	broombush
Melaleuca thyoides	
Microcybe multiflora	
Neurachne alopecuroidea	foxtail mulga grass
Olearia dampieri	daisy bush
Olearia muelleri	goldfields daisy
Phebalium filifolium	slender phebalium
Phebalium tuberculosum	
Platysace effusa	
Podolepis canescens	bright podolepis
Podolepis capillaris	wiry podolepis
Podotheca angustifolia	sticky longheads
Podotheca gnaphalioides	golden longheads
Prasophyllum regium	king leek orchid
Ptilotus sp.	mulla mulla
Rhagodia drummondii	rhagodia
Rhagodia preissii	rhagodia
Rinzia crassifolia	
Roycea spinescens	

Native species (continued)	
Scientific name	**Common name**
Rutidosis multiflora	small wrinklewort
Santalum acuminatum	quandong
Scaevola spinescens	currant bush
Sclerolaena diacantha	grey copper-burr
Senecio sp.	groundsel
Siloxerus multiflorus	
Spartochloa scirpoidea	
Stackhousia monogyna	
Stylidium insensitivum	insensitive triggerplant
Stylidium repens	matted triggerplant
Tecticornia spp.	samphire (3 species)
Templetonia sulcata	centipede bush
Toxanthes perpusillus	tiny bow-flower
Velleia cycnopotamica	
Verticordia chrysanthella	featherflower
Waitzia acuminata	orange immortelle
No regeneration noted	

Weed species	
Scientific name	**Common name**
Arctotheca calendula	capeweed
Brassica tournefortii	wild turnip
Bromus rubens	red brome
Cotula bipinnata	ferny cotula
Lolium rigidum	annual ryegrass
Mesembryanthemum nodiflorum	slender ice-plant
Monoculus monstrosus	stinking Roger
Parentucellia latifolia	common bartsia
Pentaschistis airoides	false hair-grass
Vulpia myuros	silver grass

Other plant lists for the general area
Beard (1980)
Grein (1994)
Lefroy *et al*. (1991)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	0
Pristine	No obvious signs of disturbance	2
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	16
Very good	Vegetation structure altered, obvious signs of disturbance	18
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	10
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	5
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	43

Disturbance factors contributing to vegetation condition score							
Disturbance factor	**Level of threat**			**Disturbance factor**	**Level of threat**		
	H	**M**	**L**		**H**	**M**	**L**
Salinity		x		Rubbish			x
Waterlogging		x		Plant disease			
Ponding from road crossing		x		Erosion			
Drainage				Service corridors			
Clearing				Feral animals		x	
Fire risk		x		Recreation			
Weed invasion			x	Point source discharge			
Stock access				Other			
Vehicle access							

Comments

There is some ponding associated with the road. Rubbish has been dumped on the site, and includes broken bottles and industrial infrastructure on the side of the road. A track has been ripped from the road into the site. An old fence remains on the site boundary.

Links to protected areas of remnant vegetation

Name	**Area** (ha)	**Approximate distance and direction from site**
Crown Reserve 28547	522	Part of reserve
Crown Reserve 13603	26	7 km NW

Management

It is recommended that rubbish be removed from the site and feral animals should be controlled. Areas damaged by track should be ripped and revegetated. Installation of culverts may be necessary to improve drainage and prevent ponding associated with the road.

Fauna

Scientific name	**Common name**
Birds	
Aquila audax	wedge-tailed eagle
Cacatua roseicapilla	galah
Coracina novaehollandiae	black-faced cuckoo-shrike
Corvus coronoides	Australian raven
Cracticus tibicen	magpie
Cuculus pallidus	pallid cuckoo
Epthianura albifrons	white-fronted chat
Grallina cyanoleuca	magpie-lark
Lichenostomus virescens	singing honey-eater
Lichmera indistincta	brown honeyeater
Neophema elegans	elegant parrot
Ocyphaps lophotes	crested pigeon

Fauna	
Scientific name	**Common name**
Birds	
Oreoica gutturalis	crested bellbird
Pachycephala rufiventris	rufus whistler
Pardalotus striatus	striated pardalote
Phaps chalcoptera	common bronzewing
Platycercus varius	mulga parrot
Platycercus zonarius	Australian ringneck parrot
Pomatostomus superciliosus	white browed babbler
Mammals	
Felis catus	cat*
Macropus fuliginosus	western grey kangaroo
Oryctolagus cuniculus	European wild rabbit*
Tachyglossus aculeatus	short-beaked echidna
Vulpes vulpes	European red fox*

* *Introduced species*

Other fauna lists for the general area
Greening Australia Western Australia (2004)
Grein (1994)
Lefroy *et al*. (1991)

Notes:

- Vegetation decreases close to the water, with mortality of *Melaleuca* spp. and samphire close to wet areas
- There is evidence of water runoff, erosion and scalding of the soil surface layer
- Many orchids were present, including donkey orchids
- DRF have been previously recorded within the site
- Water sampled from the lake was pH 7.2, temperature 20.0^{o}C and conductivity was 232 mS/cm.

Photo A1.19: ULR04
Excellent condition vegetation association 1: *Eucalyptus subangusta* Very Open Tree Mallee over *Acacia assimilis*, *Alyxia buxifolia* and *Allocasuarina campestris* Open Scrub over *Platysace effusa* Open Dwarf Scrub over *Lepidosperma drummondii* Open Low Sedges over *Amphipogon* sp. and *Spartochloa scirpoidea* Very Open Tall Grass over mixed annual Open Herbs

Photo A1.20: ULR04
Excellent condition vegetation association 2: *Leptospermum erubescens* and *Acacia assimilis* Open Scrub over *Spartochloa scirpoidea* Very Open Tall Grass over *Verticordia chrysanthella* and *Platysace effusa* Dwarf Scrub over *Borya sphaerocephala, Stylidium repens* and mixed annual Herbs

Photo A1.21: ULR04
Very good condition vegetation association 3: *Melaleuca lateriflora* and *Lycium australe* Scrub over *Atriplex bunburyana* Open Dwarf Scrub over *Angianthus tomentosus* and *Mesembryanthemum nodiflorum* Herbs

Photo A1.22: ULR04
Very good condition vegetation association 4: *Melaleuca pauperiflora*, *Lycium australe*, *Rhagodia preissii* and *Dodonaea viscosa* subsp. *angustissima* Low Scrub over *Jacksonia* sp. and *Rinzia crassifolia* Open Dwarf Scrub over *Borya laciniata*, *Brachyscome* sp. and *Podolepis capillaris* Open Herbs

Photo A1.23: ULR04
Excellent condition vegetation association 5: *Allocasuarina huegeliana* Low Woodland over *Leptospermum erubescens* and *Acacia assimilis* Open Dwarf Scrub over *Spartochloa scirpoidea* Very Open Tall Grass over mixed annual Dense Herbs

Photo A1.24: ULR04
Pristine condition vegetation association 6: *Eucalyptus salmonophloia*, *E. salubris* and *E. longicornis* Open Woodland over *Santalum acuminatum* Open Low Woodland over *Melaleuca laxiflora* Open Scrub over *Microcybe multiflora, Olearia muelleri, Scaevola spinescens* and *Atriplex bunburyana* Dwarf Scrub

Photo A1.25: ULR04

Excellent condition vegetation association 7: *Eucalyptus horistes* Open Shrub Mallee over *Beyeria leschenaultia* and *Melaleuca laxiflora* Low Scrub over *Olearia dampieri* and *Phebalium tuberculosum* Open Dwarf Scrub over *Lepidosperma drummondii*, *Lepidobolus chaetocephalus* and *Desmocladus asper* Very Open Low Sedges

Photo A1.26: ULR04

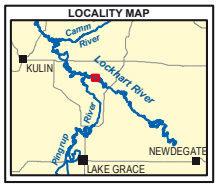
Excellent condition vegetation association 8: *Eucalyptus spathulata* Open Low Woodland over *Dodonaea viscosa* subsp. *angustissima* and *Hakea kippistiana* Low Scrub over *Rhagodia drummondii*, *Rinzia crassifolia* and *Enchylaena tomentosa* Open Dwarf Scrub over *Disphyma crassifolia* and *Carpobrotus modestus* Very Open Herbs

Photo A1.27: ULR04

Very good condition vegetation association 9: *Tecticornia* spp., *Frankenia* sp., *Atriplex* sp. and *Roycea spinescens* Low Heath over *Crassula* sp. and *Senecio* sp. Very Open Herbs

Map A4
Vegetation condition for survery site ULR04

Crown Reserve 28547



N

LEGEND

Vegetation condition

- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

Datum and Projection Information
Vertical Datum: Australian Height Datum (AHD)
Horizontal Datum: Geocentric Datum of Australia 94
Projection: MGA 94 Zone 50
Spheroid: Australian National Spheroid

Project Information
Client: Shepherd Chipfunde
Map Author: Davina Gan
Task ID: 7113
Filepath: J:\gisprojects\Project\B_Series\B410C\0001\mxd\
Filename: MapA4_Veg_cond_survey_site_ULR04.mxd
Compilation date: May 2009
Edition: 1

SOURCES

The Department of Water acknowledges the following datasets and their custodians in the production of this map:

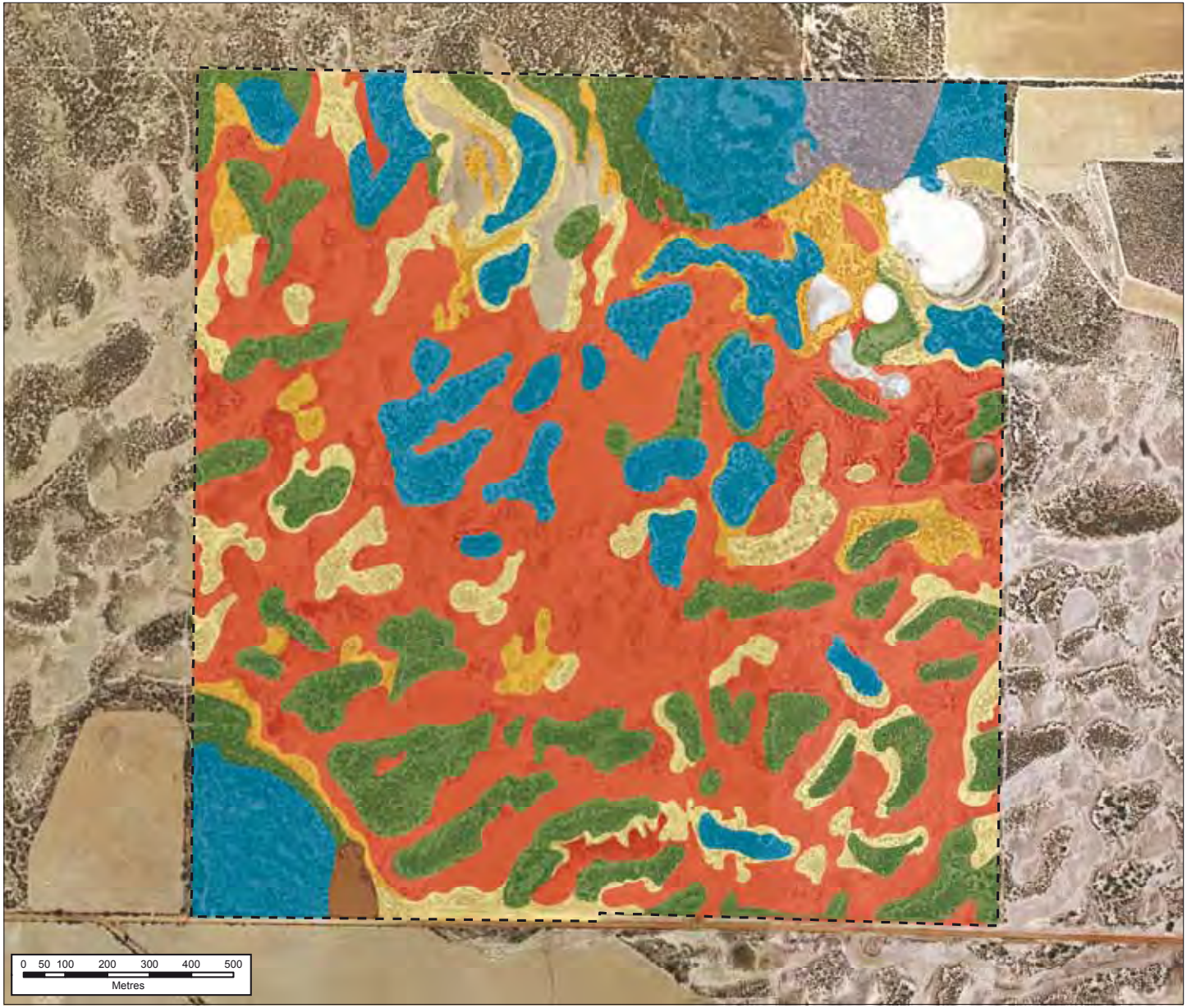
Corrigin South Orthomosiac – Landgate – 2000
Pederah Orthomosiac – Landgate – 2004

Government of Western Australia
Department of Water

This map is a product of the Department of Water, Spatial Services Section and was completed in May 2009.

This map was produced with the intent that it be used for the Lower Lockhart River mapping project at the scale of 1:12 000.

While the Department of Water has made all reasonable efforts to ensure the accuracy of this data, the department accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.



Site ULR05 — Stone's

General details	
Site name	Stone's
Landholder	MN & DC Stone
Surveyed by	Lyn Atkins and Catherine Krens (Ecoscape)
Date	10.09.2008

Site description	
Landform	The site is mostly valley floor, and has a channel, largely continuous, on the western side of the site, and some discontinuous low-lying areas on the south side.
Site size	157 ha

Beard vegetation description

Beard vegetation association 945: Mosaic: Medium woodland; salmon gum / Shrublands; mallee scrub, redwood and black marlock

Beard vegetation association 953: Succulent steppe with thicket; teatree over samphire

Overall vegetation structure and cover (for vegetated areas only)

Vegetation layer	Canopy cover class	Dominant species
Trees	0	
Mallees	10–30%	*Eucalyptus horistes*
Shrubs	10–30%	*Melaleuca lateriflora, M. pauperiflora, M. acuminata, M. scalena, M laxiflora, Tecticornia* spp., *Leptospermum erubescens, Leptomeria* sp., *Grevillea hookeriana, Calytrix leschenaultia*, *Baeckea* sp., *Rhagodia preissii*, *Maireana* sp., *Enchylaena tomentosa*
Grasses	2–10%	*Neurachne alopecuroidea, Triodia rigidissima, Parapholis incurva*
Herbs	10–30%	*Mesembryanthemum nodiflorum, Cotula bipinnata*
Rushes and sedges	< 2%	
Litter	< 2%	
Bare ground	> 70%	
Rock outcrop	0	

Summary

Most of the site is degraded with recent melaleuca deaths, and only the raised island areas near the south side and some slightly higher areas on the edges of the channel are in *good* or better condition. The north west corner is on the valley slope and has mallee. The dense melaleuca thicket along the North Lake Grace Road (north side) is weedy and in *good* condition.

Individual vegetation association descriptions	
Vegetation 1	*Tecticornia* spp.(3) Dwarf Scrub over *Mesembryanthemum nodiflorum* and *Cotula bipinnata* Very Open Herbs and *Parapholis incurva* Very Open Low Grass
Vegetation 2	*Melaleuca lateriflora, M. pauperiflora, M. acuminata* and *M. scalena* Scrub to 4 m over mixed annual introduced Herbs
Vegetation 3	*Eucalyptus horistes* Open Shrub Mallee over *Melaleuca scalena, M. pauperiflora, Leptospermum erubescens, Leptomeria* sp. and *Grevillea hookeriana* Open Scrub to 3 m over *Calytrix leschenaultia* and *Baeckea* sp. Open Dwarf Scrub over *Neurachne alopecuroidea* and *Triodia rigidissima* Very Open Low Grass
Vegetation 4	*Melaleuca lateriflora, M. pauperiflora* Scrub to 3 m over *Rhagodia preissii*, *Maireana* sp. and *Enchylaena tomentosa* Open Dwarf Scrub over mixed annual Open Herbs

Native species	
Scientific name	**Common name**
Alyxia buxifolia	dysentery bush
Austrostipa elegantissima	feather speargrass
Baeckea sp.	myrtle
Brachycome iberidifolia	Swan River daisy
Calocephalus multiflorus	yellow-top
Calytrix leschenaultii	purple starflower
Comesperma integerrimum	milkwort
Crassula colorata	dense stonecrop
Desmocladus asper	
Didymanthus roei	
Drosera glanduligera	pimpernel sundew
Enchylaena tomentosa	ruby saltbush
Eragrostis dielsii	mallee lovegrass
Eremophila ionantha	violet-flowered eremophila
Eucalyptus celastroides	mirret
Eucalyptus horistes	white-flowered mallee
Eucalyptus spathulata	swamp mallet
Gnephosis uniflora	
Grevillea hookeriana	black tooth brushes
Hyalochlamys globifera	
Lepidosperma drummondii	sword sedge
Leptomeria sp.	currant bush
Leptospermum erubescens	roadside tea-tree
Lycium australe	Australian boxthorn
Maireana brevifolia	small-leaf bluebush
Melaleuca acuminata	
Melaleuca adnata	
Melaleuca carrii	
Melaleuca lateriflora	gorada
Melaleuca pauperiflora	boree
Melaleuca scalena	broombush
Melaleuca viminea	mohan
Neurachne alopecuroidea	foxtail mulga grass
Podolepis capillaris	wiry podolepis

Native species (continued)	
Scientific name	**Common name**
Rhagodia drummondii	rhagodia
Rhagodia preissii	rhagodia
Roycea spinescens	
Rutidosis sp.	wrinklewort
Santalum acuminatum	quandong
Santalum murrayanum	bitter quandong
Sclerolaena diacantha	grey copper-burr
Siloxerus multiflorus	
Spergularia marina	salt sand spurry
Tecticornia spp.	samphire (3 species)
Triglochin sp.	spurred arrowgrass
Triodia rigidissima	spinifex
Waitzia acuminata	orange immortelle
No regeneration noted	

Weed species	
Scientific name	**Common name**
Arctotheca calendula	capeweed
Bromus rubens	red brome
Cotula bipinnata	ferny cotula
Hordeum marinum	sea barley grass
Hypochaeris glabra	flatweed
Mesembryanthemum nodiflorum	slender ice-plant
Moraea setifolia	thread iris
Parapholis incurva	coast barbgrass
Pentaschistis airoides	false hair-grass
Ursinia anthemoides	ursinia
Zaluzianskya divaricata	zedweed

Other plant lists for the general area
Beard (1980)
Grein (1994)
Lefroy *et al*. (1991)

Vegetation condition

Condition	Description	% of site
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	0
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	0
Very good	Vegetation structure altered, obvious signs of disturbance	9
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	24
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	13
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	28

Disturbance factors contributing to vegetation condition score							
Disturbance factor	**Level of threat**			**Disturbance factor**	**Level of threat**		
	H	**M**	**L**		**H**	**M**	**L**
Salinity		x		Rubbish			x
Waterlogging		x		Plant disease			
Ponding from road crossing		x		Erosion			
Drainage				Service corridors			
Clearing				Feral animals			x
Fire risk				Recreation			
Weed invasion		x		Point source discharge			
Stock access			x	Other			
Vehicle access							

Comments

Water is banked up against the road on the north-eastern point. The island is fenced to exclude grazing. Rubbish and gravel have been dumped at the corner of the site near the rail line. Sandbagging has been used to prevent flooding.

Links to protected areas of remnant vegetation

Name	**Area** (ha)	**Approximate distance and direction from site**
Pingaring Nature Reserve	95	5.0 km NE
Crown Reserve 28547	522	6.5 km NW
Mordetta Nature Reserve	346	7.8 km SW

Management

Revegetation of upslope areas could used to reduce the flow of water onto the site. Some of the site may be suitable for saltbush grazing.

It is recommended that rubbish and dumped gravel be removed from the site and that feral animals be controlled. Culverts may be necessary to prevent ponding associated with the road.

Fauna

Scientific name	**Common name**
Birds	
Cacatua roseicapilla	galah
Corvus coronoides	Australian raven
Epthianura albifrons	white-fronted chat
Lichenostomus virescens	singing honey-eater
Lichmera indistincta	brown honeyeater
Pomatostomus superciliosus	white browed babbler
Mammals	
Macropus fuliginosus	western grey kangaroo
Vulpes vulpes	European red fox*

* *Introduced species*

Other fauna lists for the general area
Greening Australia Western Australia (2004)
Grein (1994)
Lefroy *et al*. (1991)

Notes:

- Many dead *Melaleuca* sp. were noted which appear to have resulted from recent flooding
- The site is in very poor condition with high plant mortality and few birds
- Upslope is in better condition but the site is weedy throughout
- Orchids were present
- Crops were in poor condition
- Water sampled from the drain was pH 8.4, temperature 24.0^{o}C and conductivity 4.5 mS/cm.

Photo A1.28: ULR05

Completely degraded condition vegetation association 1: *Tecticornia* spp. Dwarf Scrub over *Mesembryanthemum nodiflorum* and *Cotula bipinnata* Very Open Herbs and *Parapholis incurva* Very Open Low Grass

Photo A1.29: ULR05

Good condition vegetation association 2: *Melaleuca lateriflora*, *M. pauperiflora*, *M. acuminata* and *M. scalena* Scrub to 4 m over mixed annual introduced Herbs

Photo A1.30: ULR05

Very good condition vegetation association 3: *Eucalyptus horistes* Open Shrub Mallee over *Melaleuca scalena*, *M. carrii*, *Leptospermum erubescens*, *Leptomeria* sp. and *Grevillea hookeriana* Open Scrub over *Calytrix leschenaultia* and *Baeckea* sp. Open Dwarf Scrub over *Neurachne alopecuroidea* and *Triodia rigidissima* Very Open Low Grass

Photo A1.31: ULR05

Very good condition vegetation association 4: *Melaleuca lateriflora* and *M. pauperiflora* Scrub over *Rhagodia preissii*, *Maireana* sp. and *Enchylaena tomentosa* Open Dwarf Scrub over mixed annual Open Herbs

Map A5
Vegetation condition for survery site ULR05
Stone's

N

LEGEND

Vegetation condition

- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

Datum and Projection Information
Vertical Datum: Australian Height Datum (AHD)
Horizontal Datum: Geocentric Datum of Australia 94
Projection: MGA 94 Zone 50
Spheroid: Australian National Spheroid

Project Information
Client: Shepherd Chipfunde
Map Author: Davina Gan
Task ID: 7113
Filepath: J:\gisprojects\Project\B_Series\B410C\0001\mxd\
Filename: MapA5_Veg_cond_survey_site_ULR05.mxd
Compilation date: May 2009
Edition: 1

SOURCES

The Department of Water acknowledges the following datasets and their custodians in the production of this map:

Pederah Orthomosiac – Landgate – 2004

Government of Western Australia
Department of Water

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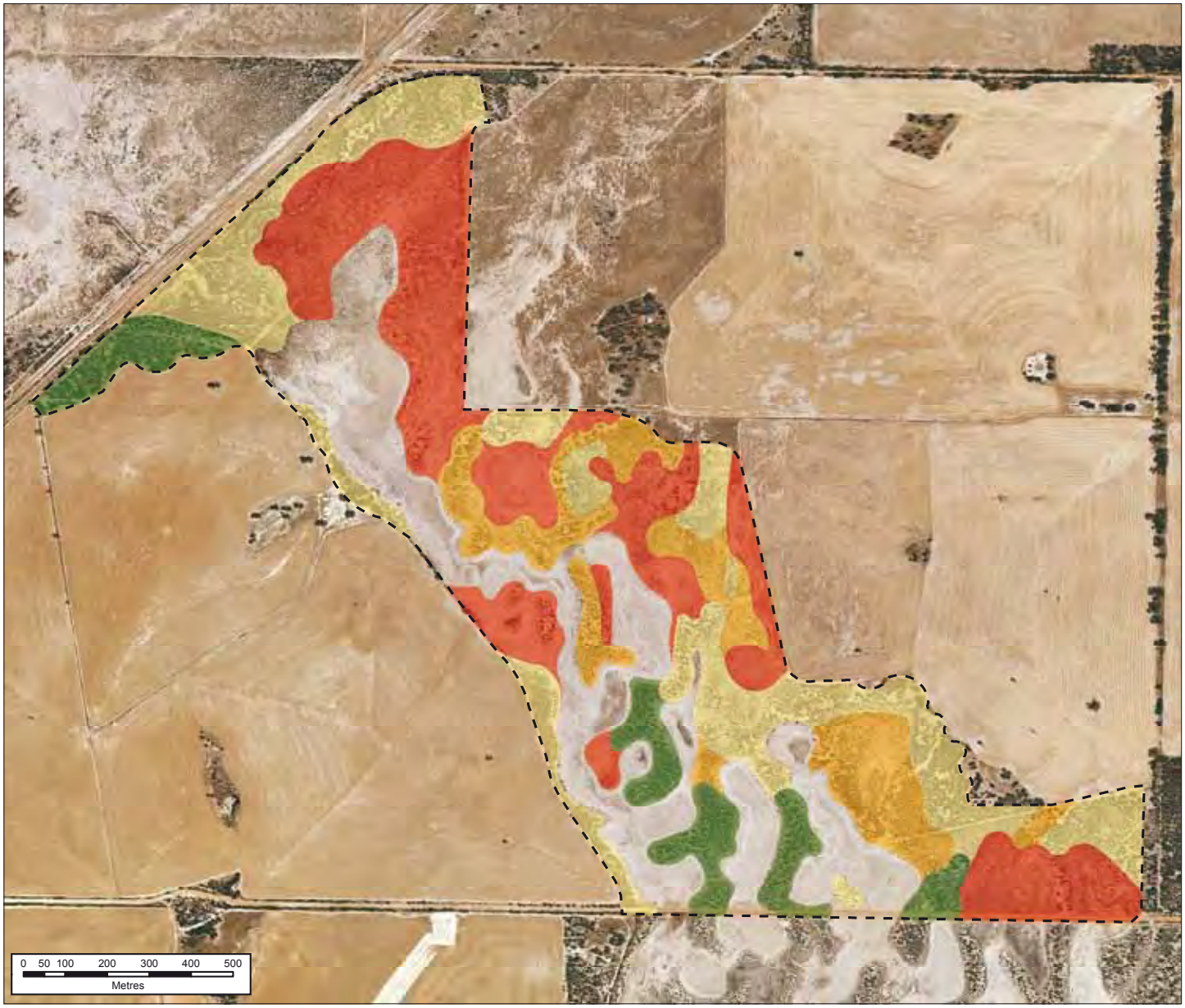


Site ULR06 — Williamson's

General details	
Site name	Williamson's
Landholder	David Williamson
Surveyed by	Lyn Atkins and Catherine Krens (Ecoscape)
Date	11.09.2008

Site description	
Landform	There are two large playa lakes, with a tall lunette between the two, 5-10 m high and wooded. The banks of the lakes on the west, north and (for the northern lake) eastern side are steep. The lakes are connected by a raised but distinctive channel, ~2 m above the current lake floor level.
Site size	503 ha

Beard vegetation description

Beard vegetation association 41: Shrublands; teatree scrub

Beard vegetation association 125: Bare areas; salt lakes

Beard vegetation association 511: Medium woodland; salmon gum and morrell

Beard vegetation association 516: Shrublands; mallee scrub, black marlock

Overall vegetation structure and cover (for vegetated areas only)

Vegetation layer	Canopy cover class	Dominant species
Trees	10–30	*Eucalyptus kondininensis*, *E. salicola*, *E. longicornis*, *E. salmonophloia*, *E. salubris*
Mallees	< 2%	*Eucalyptus horistes*
Shrubs	30–70	*Tecticornia* spp., *Melaleuca carrii, Atriplex bunburyana*
Grasses	2–10	*Avena fatua*, *Lolium rigidum*, *Bromus rubens*, *Parapholis incurva*
Herbs	2–10	*Lomandra effusa, Disphyma crassifolium*, *Mesembryanthemum nodiflorum, Sclerolaena diacantha*
Rushes and sedges	< 2%	*Lepidosperma drummondii*
Litter	2–10%	
Bare ground	30–70%	
Rock outcrop	0	

Summary

Both lakes have a samphire fringe, then a narrow band of *Melaleuca* sp., rising to woodland. On the southern side of both lakes is a broad flat area of samphire, in places with dead sticks indicating a former melaleuca community. Seedling *Melaleuca* sp. on the raised channel connecting the two lakes indicate recent flooding. The southern lake has a broad expanse of samphire and saltbush on the southern and south-eastern sides, some of which may have been cleared. The lake inlet is degraded.

Individual vegetation association descriptions	
Vegetation 1	*Eucalyptus kondininensis, E. salicola, E. longicornis* and *E. salmonophloia* Woodland over *Lomandra effusa* Very Open Herbs
Vegetation 2	*Melaleuca carrii* Thicket to 4 m over *Tecticornia* spp. Open Dwarf Scrub
Vegetation 3	*Tecticornia* spp. Low Heath over *Disphyma crassifolium* and *Mesembryanthemum nodiflorum* Very Open Herbs and *Parapholis incurva* Very Open Low Grass
Vegetation 4	*Eucalyptus salubris* and *E. kondininensis* Open Woodland over *Atriplex bunburyana* Dwarf Scrub over *Sclerolaena diacantha* and mixed annual (native) Very Open Herbs
Vegetation 5	*Atriplex bunburyana* Low Scrub over *Tecticornia spp.* and *Maireana brevifolia* Dwarf Scrub over *Avena fatua, Lolium rigidum* and *Bromus rubens* introduced Low Grass

Native species

Scientific name	**Common name**
Acacia acuminata	jam
+Acacia chrysella	wattle
Acacia erinacea	spiny wattle
Acacia hemiteles	tan wattle
Acacia merrallii	Merrall's wattle
Actinobole uliginosum	flannel cudweed
Allocasuarina huegeliana	rock sheoak
Atriplex amnicola	swamp saltbush
Atriplex bunburyana	silver saltbush
Austrostipa sp.	speargrass
Brachyscome sp.	daisy
Calandrinia eremaea	twining purslane
Calandrinia granulifera	pygmy purslane
Calotis hispidula	bindy eye
Casuarina obesa	swamp sheoak
Clematis delicata	clematis
Comesperma volubile	love creeper
Crassula colorata	dense stonecrop
Dampiera lavandulacea	
Disphyma crassifolium	round leaved pigface
Enchylaena tomentosa	ruby saltbush
Eremophila decipiens	slender fuchsia
Eucalyptus horistes	white-flowered mallee
Eucalyptus kondininensis	Kondinin blackbutt
Eucalyptus longicornis	red morrell
Eucalyptus salicola	salt gum
Eucalyptus salmonophloia	salmon gum
+Eucalyptus salubris	gimlet
Eucalyptus yilgarnensis	yorrell
Gahnia sp.	saw sedge
Hakea kippistiana	hakea
Helichrysum leucopsideum	everlasting
Hyalochlamys globifera	

Native species (continued)	
Scientific name	**Common name**
Hydrocotyle callicarpa	small pennywort
Lepidium rotundum	veined peppercress
Lepidosperma drummondii	sword sedge
Lomandra effusa	scented matrush
Lycium australe	Australian boxthorn
Maireana spp.	bluebush (3 species)
Melaleuca brevifolia	
+Melaleuca carrii	
Melaleuca lateriflora	gorada
Neurachne alopecuroidea	foxtail mulga grass
Olearia muelleri	goldfields daisy
+Pittosporum angustifolium	native apricot
Podotheca gnaphalioides	golden longheads
Rhagodia drummondii	rhagodia
Santalum acuminatum	quandong
Scaevola spinescens	currant bush
Sclerolaena diacantha	grey copper-burr
Sclerolaena sp.	
Senecio sp.	groundsel
Spartochloa scirpoidea	
Tecticornia spp.	samphire (approx 4 species)
Templetonia sulcata	centipede bush
Triglochin mucronata	prickly arrowgrass
Triodia rigidissima	spinifex
Vittadinia sp.	fuzz weed
Waitzia acuminata	orange immortelle

+ Regeneration noted

Weed species	
Scientific name	**Common name**
Arctotheca calendula	capeweed
Avena barbata	bearded oat
Brassica tournefortii	wild turnip
Bromus rubens	red brome
Cotula bipinnata	ferny cotula
Hordeum leporinum	barley grass
Lolium rigidum	annual ryegrass
Moraea setifolia	thread iris
Parapholis incurva	coast barbgrass
Pentaschistis airoides	false hair-grass
Trifolium tomentosum	woolly clover
Zaluzianskya divaricata	zedweed

Other plant lists for the general area
Beard (1980)
Grein (1994)
Lefroy *et al*. (1991)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	0
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	4
Very good	Vegetation structure altered, obvious signs of disturbance	2
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	8
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	21
Completely degraded	Vegetation structure no longer intact and the area is without/ almost without native species	8

Disturbance factors contributing to vegetation condition score							
Disturbance factor	**Level of threat**			**Disturbance factor**	**Level of threat**		
	H	**M**	**L**		**H**	**M**	**L**
Salinity	x			Rubbish			x
Waterlogging	x			Plant disease			
Ponding from road crossing				Erosion			
Drainage				Service corridors			
Clearing			x	Feral animals		x	
Fire risk			x	Recreation		x	
Weed invasion			x	Point source discharge			
Stock access		x		Other			
Vehicle access		x					

Comments

There is no fencing between crops and the site. An area has been excavated near the crop, probably for sand extraction. A fence runs into the lake. There is vehicle access between the site and pasture and a vehicle track into the wetland.

Erosion is evident on sand flats and in the paddock.

Rubbish, including dumped batteries, mounds of dirt, and rolls of mesh have been left on the site. There has been some clearing and logs have been left on the bank. Much of the understorey has been removed by grazing.

There has been high mortality of samphire and some Melaleuca sp behind the samphire have also died.

Links to protected areas of remnant vegetation		
Name	**Area** (ha)	**Approximate distance and direction from site**
Crooks Nature Reserve	602	5.0 km SW
Pingaring Nature Reserve	95	6.0 km N
Mordetta Nature Reserve	346	10.0 km SW

Management

Salinity and waterlogging are the major factors impacting vegetation at this site and this should be managed on a catchment scale. Vegetation condition could also be improved by fencing to exclude stock from the floodplain and revegetating bare areas to control erosion. It is also recommended that rubbish be removed from the site.

Fauna	
Scientific name	**Common name**
Birds	
Anthus australis	Australian pipit
Aquila audax	wedge-tailed eagle
Artamus cinereus	black-faced woodswallow
Cacatua roseicapilla	galah
Corvus coronoides	Australian raven
Cracticus tibicen	magpie
Epthianura albifrons	white-fronted chat
Grallina cyanoleuca	magpie-lark
Manorina flavigula	yellow throated miner
Ocyphaps lophotes	crested pigeon
Pardalotus striatus	striated pardalote
Phaps chalcoptera	common bronzewing
Platycercus zonarius	Australian ringneck parrot
Polytelis anthopeplus	regent parrot
Smicrornis brevirostris	weebill
Tadorna tadornoides	Australian shelduck (mountain duck)
Mammals	
Felis catus	cat*
Macropus fuliginosus	western grey kangaroo

** Introduced species*

Other fauna lists for the general area

Greening Australia of Western Australia (2004)

Grein (1994)

Lefroy *et al*. (1991)

Notes:

From discussions with the landholder:

- Salinity and water levels don't seem to be changing
- In 2006 the lake filled but did not overflow
- In 1974 floods were higher, but there were no floods between 1974 and 2006.

From the site survey:

- Water sampled from the smaller lake was pH 7.4, temperature 22.0^{o}C and conductivity was 236 mS/cm.

Photo A1.32: ULR06

Good condition vegetation association 1: *Eucalyptus kondininensis, E. salicola*, *E. longicornis* and *E. salmonophloia* Woodland over *Lomandra effusa* Very Open Herbs

Photo A1.33: ULR06

Very good condition vegetation association 1: *Eucalyptus kondininensis*, *E. salicola*, *E. longicornis* and *E. salmonophloia* Woodland over *Lomandra effusa* Very Open Herbs

Photo A1.34: ULR06

Good condition vegetation association 2: *Melaleuca carrii* Thicket over *Tecticornia* spp. Open Dwarf Scrub

Photo A1.35: ULR06

Good condition vegetation association 3: *Tecticornia* spp. Low Heath over *Disphyma crassifolium* and *Mesembryanthemum nodiflorum* Very Open Herbs and *Parapholis incurva* Very Open Low Grass

Photo A1.36: ULR06

Excellent condition vegetation association 4: *Eucalyptus salubris* and *E. kondininensis* Open Woodland over *Atriplex bunburyana* Dwarf Scrub over *Sclerolaena diacantha* and mixed annual (native) Very Open Herbs

Photo A1.37: ULR06

Degraded condition vegetation association 5: *Atriplex bunburyana* Low Scrub over *Tecticornia* spp. and *Maireana brevifolia* Dwarf Scrub over *Avena fatua*, *Lolium rigidum* and *Bromus rubens* introduced Low Grass

Map A6
Vegetation condition for survery site ULR06

Williamson's

N

LEGEND

Vegetation condition

- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

Datum and Projection Information
Vertical Datum: Australian Height Datum (AHD)
Horizontal Datum: Geocentric Datum of Australia 94
Projection: MGA 94 Zone 50
Spheroid: Australian National Spheroid

Project Information
Client: Shepherd Chipfunde
Map Author: Davina Gan
Task ID: 7113
Filepath: J:\gisprojects\Project\B_Series\B410C\0001\mxd\
Filename: MapA6_Veg_cond_survey_site_ULR06.mxd
Compilation date: May 2009
Edition: 1

SOURCES

The Department of Water acknowledges the following datasets and their custodians in the production of this map:

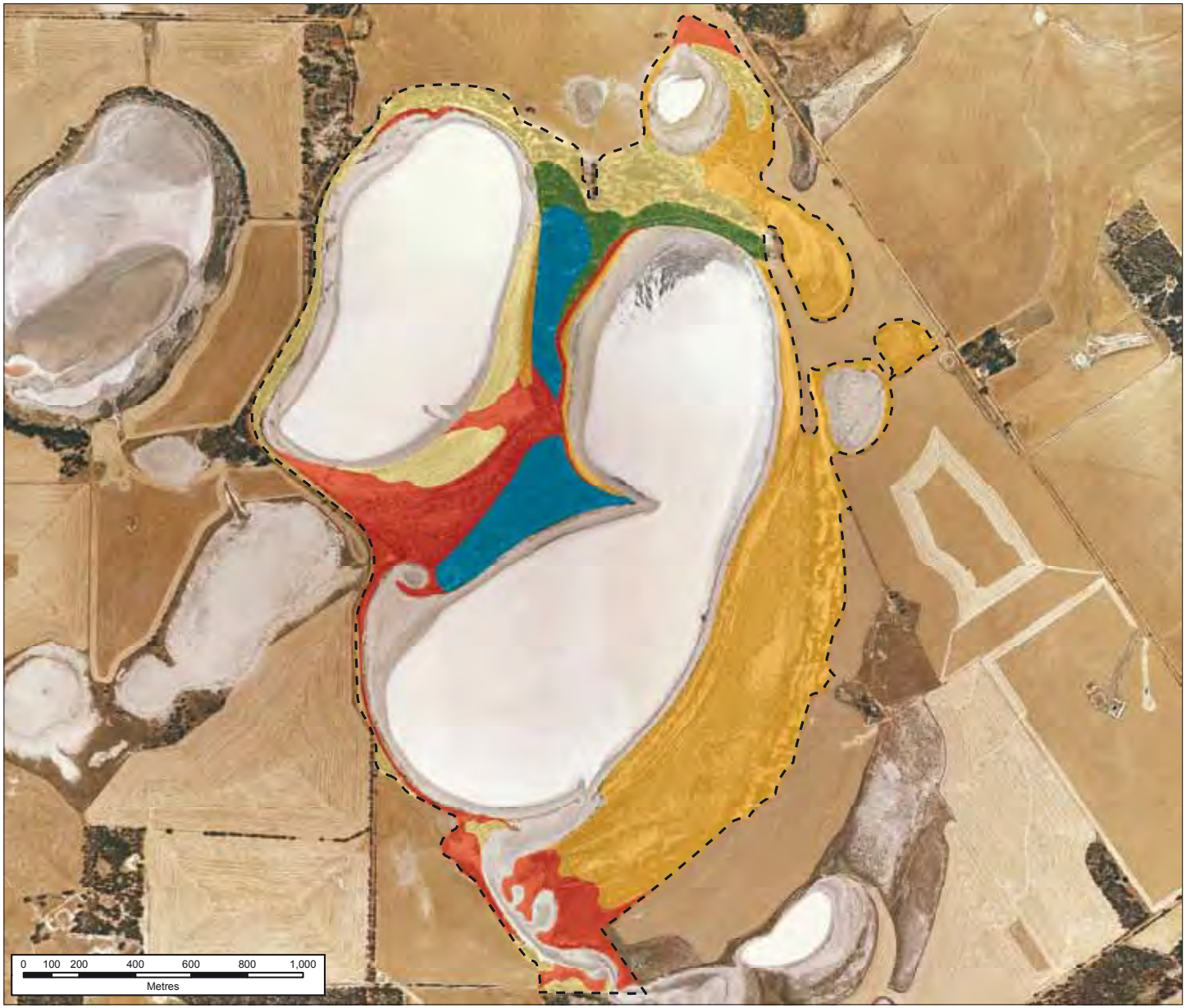
Pederah Orthomosiac – Landgate – 2004

Government of Western Australia
Department of Water

This map is a product of the Department of Water, Spatial Services Section and was completed in May 2009.

This map was produced with the intent that it be used for the Lower Lockhart River mapping project at the scale of 1:18 000.

While the Department of Water has made all reasonable efforts to ensure the accuracy of this data, the department accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.



Site ULR07 — Crown Reserve 2768

General details	
Site name	Crown Reserve 27684
Landholder	DEC
Surveyed by	Lyn Atkins and Catherine Krens (Ecoscape)
Date	11.09.2008

Site description	
Landform	The site is largely in the valley floor and consists of a braided channel with raised islands between, although the main channel is more distinctive and less convoluted than the others. There is a perched hypersaline highly acidic lake in the south west not connected to the stream lines.
Site size	329 ha

Beard vegetation description
Beard vegetation association 41: Shrublands; teatree scrub
Beard vegetation association 516: Shrublands; mallee scrub, black marlock

Overall vegetation structure and cover (for vegetated areas only)

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	*Eucalyptus spathulata*, *E. celastroides*, *E. longicornis*, *E. salubris*, *E. salmonophloia*
Mallees	2–10%	*E. yilgarnensis*, *E. horistes*, *E. subangusta*, *E. celastroides*
Shrubs	10–30%	*Melaleuca lateriflora*, *M. atroviridis*, *M. acuminata*, *M. carrii*, *M. thyoides*, *M. pauperiflora*, *M. cucullata*, *Jacksonia* sp., *Acacia acanthoclada*, *Eremophila decipiens*, *Atriplex bunburyana*, *Tecticornia* spp.
Grasses	2–10%	*Triodia rigidissima, Spartochloa scirpoidea, Amphipogon* sp.
Herbs	10–30%	*Borya constricta, Sclerolaena diacantha*
Rushes and sedges	2–10%	*Lepidosperma drummondii, Lepidobolus chaetocephalus*
Litter	2–10%	
Bare ground	30–70%	
Rock outcrop	< 1%	

Summary

The central portion of the site with secondary channels is degraded, but the samphire area in the vicinity of the main channel is in better condition, with woodlands and mallees in very good to excellent condition, and some areas of *Melaleuca* sp. in very good condition. The eastern side of the site is low-lying but slightly higher and has woodland and *Melaleuca* sp. in variable condition. The western side is on the valley slopes and has healthy woodland and mallee. There is a very wet but apparently not saline area of *Melaleuca* sp. near the south-western corner.

Individual vegetation association descriptions	
Vegetation 1	*Eucalyptus spathulata* group Open Low Woodland over *Melaleuca carrii* and *M. thyoides* Open Scrub over mixed annual Herbs
Vegetation 2	*Melaleuca lateriflora*, *M. atroviridis* and *M. acuminata* Thicket to 3 m over mixed Open Herbs
Vegetation 3	*Eucalyptus subangusta* Very Open Shrub Mallee over *Spartochloa scirpoidea* and *Amphipogon* sp. Very Open Low Grass and *Lepidosperma drummondii* and *Lepidobolus chaetocephalus* Open Low Sedges over *Borya constricta* and mixed annual Herbs
Vegetation 4	*Eucalyptus horistes* Very Open Shrub Mallee over *Jacksonia* sp. and *Melaleuca carrii* Low Scrub over *Triodia rigidissima* Open Low Grass
Vegetation 5	*Tecticornia* spp. (3) Dwarf Scrub over *Mesembryanthemum nodiflorum* and mixed annual Very Open Herbs
Vegetation 6	*Melaleuca pauperiflora* Thicket to 4 m over *Sclerolaena diacantha* and mixed annual Very Open Herbs
Vegetation 7	*Melaleuca pauperiflora* and *M. cucullata* Open Woodland to 6 m over *Melaleuca lateriflora* and *Acacia* sp. Open Scrub to 4 m over mixed annual Open Herbs
Vegetation 8	*Eucalyptus celastroides* Open Tree Mallee over *Melaleuca pauperiflora* Scrub to 4 m over *Acacia acanthoclada* and *Eremophila decipiens* Low Scrub over *Sclerolaena diacantha* and mixed annual Open Herbs
Vegetation 9	*Eucalyptus longicornis*, *E. salubris* and *E. salmonophloia* Open Woodland over *E. yilgarnensis* Very Open Tree Mallee over *Melaleuca pauperiflora* Open Scrub to 5 m over *Atriplex bunburyana* Open Dwarf Scrub

Native species	
Scientific name	**Common name**
Acacia acanthoclada	harrow wattle
Acacia acoma	wattle
Acacia erinacea	spiny wattle
Acacia hemiteles	tan wattle
Acacia merrallii	Merrall's wattle
Acacia sp.	wattle
Alyxia buxifolia	dysentery bush
Amphipogon sp.	greybeard grass
Atriplex bunburyana	silver saltbush
Atriplex hymenotheca	saltbush
Atriplex sp.	saltbush
Austrostipa elegantissima	feather speargrass
Blennospora drummondii	
Borya constricta	pin-grass
Borya laciniata	pin-grass
Brachyscome sp.	daisy
Calocephalus multiflorus	yellow-top
Calytrix leschenaultii	purple starflower
Carpobrotus modestus	inland pigface
Comesperma integerrimum	milkwort
Crassula colorata	dense stonecrop

Native species (continued)	
Scientific name	**Common name**
Crassula sp.	stonecrop
Darwinia halophila	darwinia
Desmocladus sp.	
Didymanthus roei	
Disphyma crassifolium	round-leaved pigface
Drosera glanduligera	pimpernel sundew
Drosera macrantha	bridal rainbow
Drosera sp.	sundew
Enchylaena tomentosa	ruby saltbush
Eragrostis dielsii	mallee lovegrass
Eremophila decipiens	slender fuchsia
Erymophyllum tenellum	everlasting
Eucalyptus celastroides	mirret
Eucalyptus kondininensis	Kondinin blackbutt
Eucalyptus longicornis	red morrell
Eucalyptus salmonophloia	salmon gum
Eucalyptus salubris	gimlet
Eucalyptus spathulata	swamp mallet
Eucalyptus subangusta	black marlock
Eucalyptus yilgarnensis	yorrell
Exocarpos aphyllus	leafless ballart
Frankenia drummondii	frankenia
Frankenia sp.	frankenia
Gahnia sp.	saw sedge
Gnephosis uniflora	
Grevillea anethifolia	grevillea
Gunniopsis septifraga	
Hakea kippistiana	hakea
Hyalochlamys globifera	
Jacksonia sp.	
Juncus sp.	rush
Lawrencella rosea	pink everlasting
Lepidobolus chaetocephalus	bristle-headed chaff rush
Melaleuca acuminata	
Melaleuca atroviridis	broombush
Melaleuca brevifolia	
Melaleuca carrii	
Melaleuca cucullata	
+Melaleuca lateriflora	gorada
+Melaleuca pauperiflora	boree
Melaleuca thyoides	
Neurachne alopecuroidea	foxtail mulga grass
Olearia muelleri	goldfields daisy
Pelargonium havlasae	geranium
Podolepis canescens	bright podolepis
Podolepis capillaris	wiry podolepis

Native species (continued)	
Scientific name	**Common name**
Podolepis lessonii	podolepis
Podotheca gnaphalioides	golden longheads
Ptilotus holosericeus	mulla mulla
Ptilotus sp.	mulla mulla
Rhagodia preissii	rhagodia
Rhodanthe citrina	
Rhodanthe manglesii	pink sunray
Rhodanthe sp.	
Rinzia crassifolia	
Rutidosis sp.	wrinklewort
Santalum acuminatum	quandong
Sclerolaena diacantha	grey copper-burr
Senecio sp.	groundsel
Siloxerus multiflorus	
Spartochloa scirpoidea	
Spergularia marina	salt sand spurry
Stylidium repens	matted triggerplant
Tecticornia lylei	samphire
Tecticornia sp.	samphire
Trachymene pilosa	dwarf parsnip
Triodia rigidissima	spinifex
Waitzia acuminata	orange immortelle
Wilsonia humilis	silky wilsonia
No regeneration noted	

Weed species	
Scientific name	**Common name**
Bromus rubens	red brome
Cotula bipinnata	ferny cotula
Hypochaeris glabra	flatweed
Lolium rigidum	annual ryegrass
Mesembryanthemum nodiflorum	slender ice-plant
Monoculus monstrosus	stinking Roger
Moraea setifolia	thread iris
Parapholis incurva	coast barbgrass
Parentucellia latifolia	common bartsia
Pentaschistis airoides	false hair-grass
Ursinia anthemoides	ursinia
Vulpia myuros	silver grass

Other plant lists for the general area
Beard (1980)
Grein (1994)
Lefroy *et al*. (1991)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	0
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	7
Very good	Vegetation structure altered, obvious signs of disturbance	8
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	9
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	4
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	72

Disturbance factors contributing to vegetation condition score							
Disturbance factor	**Level of threat**			**Disturbance factor**	**Level of threat**		
	H	**M**	**L**		**H**	**M**	**L**
Salinity	x			Rubbish			x
Waterlogging	x			Plant disease			
Ponding from road crossing				Erosion			
Drainage				Service corridors			
Clearing				Feral animals			x
Fire risk			x	Recreation			
Weed invasion		x		Point source discharge			
Stock access				Other			
Vehicle access			x				

Comments

Rubbish including beer bottles, old fencing mesh and infrastructure has been deposited on the site. There are recent vehicle tracks on site. There have been deaths of samphire and *Melaleuca* sp. close to wet areas with some *Melaleuca* sp. stressed on the main channel. More deaths were noted in backwater areas.

Links to protected areas of remnant vegetation		
Name	**Area** (ha)	**Approximate distance and direction from site**
Crooks Nature Reserve	602	5.0 km SW
Harris Nature Reserve	3500	6.0 km E
Crown Reserve 31111	2630	8.0 km SW

Management
The main impact on vegetation condition is salinity and waterlogging which should be managed on a catchment scale. It is recommended that rubbish be removed from the site and that weeds and feral animals be controlled.

Fauna	
Scientific name	**Common name**
Birds	
Acanthagenys rufogularis	spiny-cheeked honeyeater
Acanthiza sp.	thornbills
Aquila audax	wedge-tailed eagle
Coracina novaehollandiae	black-faced cuckoo-shrike
Dromaius novaehollandiae	emu
Epthianura albifrons	white-fronted chat
Neophema elegans	elegant parrot
Oreoica gutturalis	crested bellbird
Phaps chalcoptera	common bronzewing
Platycercus zonarius	Australian ringneck parrot
Vanellus tricolor	banded lapwing
Mammals	
Macropus fuliginosus	western grey kangaroo
Oryctolagus cuniculus	European wild rabbit*
Vulpes vulpes	European red fox*

** Introduced species*

Other fauna lists for the general area
Greening Australia Western Australia (2004)
Grein (1994)
Lefroy *et al*. (1991)

Notes:

- A DRF species has been previously recorded close to the site, within the same broad vegetation type
- A Priority 3 flora species, *Frankenia drummondii* was recorded on the site
- Water sampled from the lake was pH 3.5, temperature 15.2^{o}C and conductivity was 113.1 mS/cm.

Photo A1.38: ULR07
Very good condition vegetation association 1: *Eucalyptus spathulata* Open Low Woodland over *Melaleuca pauperiflora* and *M. thyoides* Open Scrub over mixed annual Herbs

Photo A1.39: ULR07
Very good condition vegetation association 2: *Melaleuca lateriflora*, *M. atroviridis* and *M. acuminata* Thicket over mixed Open Herbs

Photo A1.40: ULR07
Excellent condition vegetation association 3: *Eucalyptus subangusta* Very Open Shrub Mallee over *Spartochloa scirpoidea* and *Amphipogon* sp. Very Open Low Grass and *Lepidosperma drummondii* and *Lepidobolus chaetocephalus* Open Low Sedges over *Borya constricta* and mixed annual Herbs

Photo A1.41: ULR07
Excellent condition vegetation association 4: *Eucalyptus horistes* Very Open Shrub Mallee over *Jacksonia* sp. and *Melaleuca carrii* Low Scrub over *Triodia rigidissima* Open Low Grass

Photo A1.42: ULR07
Completely degraded vegetation association 5: *Tecticornia* spp. Dwarf Scrub over *Mesembryanthemum nodiflorum* and mixed annual Very Open Herbs

Photo A1.43: ULR07
Good condition vegetation association 6: *Melaleuca pauperiflora* Thicket over *Sclerolaena diacantha* and mixed annual Very Open Herbs

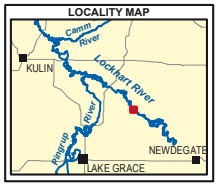
Photo A1.44: ULR07
Excellent condition vegetation association 7: *Melaleuca pauperiflora* and *M. cucullata* Open Woodland over *Melaleuca lateriflora* and *Acacia* sp. Open Scrub over mixed annual Open Herbs. Melaleucas senescent but seedlings present.

Photo A1.46: ULR07
Excellent condition vegetation association 9: *Eucalyptus longicornis*, *E. salubris* and *E. salmonophloia* Open Woodland over *E. yilgarnensis* Very Open Tree Mallee over *Melaleuca pauperiflora* Open Scrub over *Atriplex bunburyana* Open Dwarf Scrub

Photo A1.45: ULR07
Excellent condition vegetation association 8: *Eucalyptus celastroides* Open Tree Mallee over *Melaleuca pauperiflora* Scrub over *Acacia acanthoclada* and *Eremophila decipiens* Low Scrub over *Sclerolaena diacantha* and mixed annual Open Herbs

Map A7
Vegetation condition for survery site ULR07

Crown Reserve 27684



N

LEGEND

Vegetation condition

- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

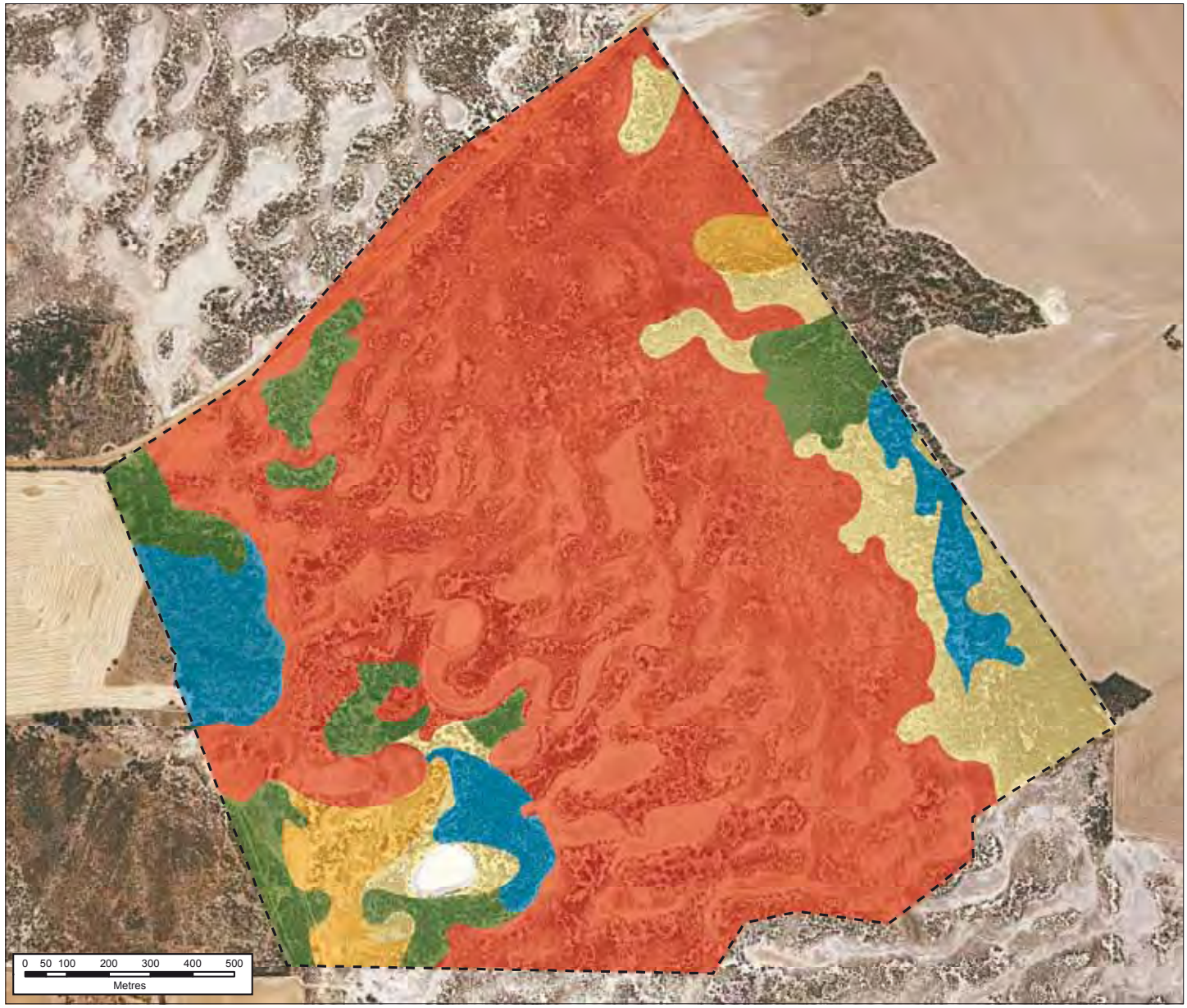
Datum and Projection Information
Vertical Datum: Australian Height Datum (AHD)
Horizontal Datum: Geocentric Datum of Australia 94
Projection: MGA 94 Zone 50
Spheroid: Australian National Spheroid

Project Information
Client: Shepherd Chipfunde
Map Author: Davina Gan
Task ID: 7113
Filepath: J:\gisprojects\Project\B_Series\B410C\0001\mxd\
Filename: MapA7_Veg_cond_survey_site_ULR07.mxd
Compilation date: May 2009
Edition: 1

SOURCES

The Department of Water acknowledges the following datasets and their custodians in the production of this map:

Pederah Orthomosiac – Landgate – 2004



Site ULR08 — Eclipse Lake

General details	
Site name	Eclipse Lake
Landholder	DEC
Surveyed by	Lyn Atkins and Catherine Krens (Ecoscape)
Date	12.09.2008

Site description	
Landform	Eclipse Lake is a playa lake in the valley floor, and consists largely of water or bare soil. The eastern portion of the lake bed is raised slightly and in most areas shows signs of soil structure decline. The banks around the rim of the lake are steep and approximately 5 m high.
Site size	184 ha

Beard vegetation description

Beard vegetation association 125: Bare areas; salt lakes

Beard vegetation association 511: Medium woodland; salmon gum and morrell

Overall vegetation structure and cover (for vegetated areas only)

Vegetation layer	Canopy cover class	Dominant species
Trees	10–30	*Eucalyptus kondininensis*
Mallees	0	
Shrubs	10–30	*Melaleuca pauperiflora, M. lateriflora, Tecticornia* spp. (2), *Atriplex bunburyana*
Grasses	< 2%	*Hordeum leporinum, Lolium rigidum*
Herbs	2–10	*Mesembryanthemum nodiflorum*
Rushes and sedges	0	
Litter	< 2%	
Bare ground	> 70%	
Rock outcrop	0	

Summary

The eastern portion of the lake supports species-poor samphire. The banks around the rim of the lake support samphire on the lower slopes, grading into melaleuca scrub, with *Eucalyptus kondininensis* higher up the banks.

Individual vegetation association descriptions	
Vegetation 1	*Eucalyptus kondininensis* Open Low Woodland over *Melaleuca pauperiflora* and *M. lateriflora* Open Scrub to 4 m over *Atriplex bunburyana* Dwarf Scrub over *Mesembryanthemum nodiflorum* introduced Very Open Herbs
Vegetation 2	*Tecticornia* spp. (2) Open Dwarf Scrub over bare soil

Native species	
Scientific name	**Common name**
Atriplex bunburyana	silver saltbush
Crassula colorata	dense stonecrop
Disphyma crassifolium	round-leaved pigface
Eucalyptus kondininensis	Kondinin blackbutt
Eucalyptus longicornis	red morrell
Frankenia sp.	frankenia
Jacksonia sp.	
Lomandra effusa	scented matrush
Lycium australe	Australian boxthorn
Maireana brevifolia	small-leaf bluebush
Maireana spp.	bluebush (2 spp.)
Melaleuca lateriflora	gorada
Melaleuca pauperiflora	boree
Roycea spinescens	
Sclerolaena diacantha	grey copper-burr
Tecticornia spp.	samphire (2 spp.)
No regeneration noted	

Weed species	
Scientific name	**Common name**
Avena fatua	wild oat
Hordeum leporinum	barley grass
Lolium rigidum	annual ryegrass
Mesembryanthemum nodiflorum	slender ice-plant
Moraea setifolia	thread iris
Parapholis incurva	coast barbgrass

Other plant lists for the general area
Beard (1980)
Grein (1994)
Lefroy *et al*. (1991)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	0
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	0
Very good	Vegetation structure altered, obvious signs of disturbance	6
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	4
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	13
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	19

Disturbance factors contributing to vegetation condition score							
Disturbance factor	**Level of threat**			**Disturbance factor**	**Level of threat**		
	H	**M**	**L**		**H**	**M**	**L**
Salinity	x			Rubbish			x
Waterlogging	x			Plant disease			
Ponding from road crossing			x	Erosion			
Drainage				Service corridors			
Clearing				Feral animals			x
Fire risk			x	Recreation			
Weed invasion			x	Point source discharge			
Stock access				Other			
Vehicle access			x				

Comments

Rubbish, including rolls of old fencing wire, has been deposited on the site. The site is fenced with vehicle access around site. Cropping has occurred on the site perimeter. Soil degradation is evident. There have been some *Melaleuca* sp. deaths.There is minor water ponding in a drain by the side of road on western side of site

Links to protected areas of remnant vegetation

Name	**Area** (ha)	**Approximate distance and direction from site**
Harris Nature Reserve	3500	6.0 km N

Management

It is recommended that degraded areas be revegetated and rubbish be removed from the site. Sediments should be removed from the drain to prevent ponding.

Fauna

Scientific name	**Common name**
Birds	
Anthus australis	Australian pipit
Artamus cinereus	black-faced woodswallow
Epthianura albifrons	white-fronted chat
Rhipidura leucophrys	willy wagtail
Tadorna tadornoides	Australian shelduck (mountain duck)
Mammals	

** Introduced species*

Other fauna lists for the general area

Greening Australia Western Australia (2004)

Grein (1994)

Lefroy *et al*. (1991)

Notes:

From discussions with the adjacent landholder:

- The lake used to fill to the road level, before the 1970s, in summer floods
- Now the creek flow seems to have been diverted and inflow to the lake is only local, probably due to silting up of the waterway
- There was almost no additional flow into the lake in 2006 despite flooding downstream.

From the site survey and past reports

- A Priority 3 flora species has previously been recorded within the site
- Water sampled from the northern extremity of the lake was pH 6.4, temperature 22.0^{o}C and conductivity was 236 mS/cm.

Photo A1.47: ULR08

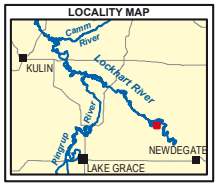
Very good condition vegetation association 1: *Eucalyptus kondininensis* Open Low Woodland over *Melaleuca pauperiflora* and *M. lateriflora* Open Scrub over *Atriplex bunburyana* Dwarf Scrub over *Mesembryanthemum nodiflorum* introduced Very Open Herbs

Photo A1.48: ULR08

Very good condition vegetation association 2: *Tecticornia* spp. Open Dwarf Scrub over bare soil

Map A8
Vegetation condition for survery site ULR08

Eclipse Lake



N

LEGEND

Vegetation condition

- Revegetation
- Pristine
- Excellent
- Very good
- Good
- Degraded
- Completely degraded

Datum and Projection Information
Vertical Datum: Australian Height Datum (AHD)
Horizontal Datum: Geocentric Datum of Australia 94
Projection: MGA 94 Zone 50
Spheroid: Australian National Spheroid

Project Information
Client: Shepherd Chipfunde
Map Author: Davina Gan
Task ID: 7113
Filepath: J:\gisprojects\Project\B_Series\B410C\0001\mxd\
Filename: MapA8_Veg_cond_survey_site_ULR08.mxd
Compilation date: May 2009
Edition: 1

SOURCES

The Department of Water acknowledges the following datasets and their custodians in the production of this map:

Pederah Orthomosiac – Landgate – 2004

Government of Western Australia
Department of Water

This map is a product of the Department of Water, Spatial Services Section and was completed in May 2009.

This map was produced with the intent that it be used for the Lower Lockhart River mapping project at the scale of 1:10 000.

While the Department of Water has made all reasonable efforts to ensure the accuracy of this data, the department accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.

Site ULR09 — Guelfi's

General details	
Site name	Guelfi's
Landholder	Gary Guelfi
Surveyed by	Lyn Atkins and Catherine Krens (Ecoscape)
Date	12.09.2008

Site description	
Landform	The site consists of a series of lakes and other low-lying areas, with lunettes between the lakes.
Site size	334 ha

Beard vegetation description
Beard vegetation association 125: Bare areas; salt lakes
Beard vegetation association 511: Medium woodland; salmon gum and morrell

Overall vegetation structure and cover (for vegetated areas only)

Vegetation layer	Canopy cover class	Dominant species
Trees	10–30%	*Eucalyptus kondininensis*
Mallees	10–30%	*Eucalyptus calycogona*
Shrubs	10–30%	*Melaleuca pauperiflora*, *Melaleuca* sp., *Tecticornia* spp.*, Atriplex bunburyana*
Grasses	< 2%	*Hordeum leporinum*
Herbs	2–10%	*Disphyma crassifolium*, *Helichrysum leucopsideum*, *Mesembryanthemum nodiflorum*
Rushes and sedges	0	
Litter	2–10%	
Bare ground	> 70%	
Rock outcrop	0	

Summary

The eastern portion of the site includes cultivated land and areas that may have been cultivated in the past, then abandoned, which has now converted to saltbush. The largest lake is either bare soil, water (usually in linear areas between rises) or samphire on rises. The southern lake is filled with water, and the other smaller lakes are largely covered in samphire. The lunettes and raised areas between the lakes have, or had woodlands.

Individual vegetation association descriptions	
Vegetation 1	*Tecticornia* spp. (2) Dwarf Scrub over *Mesembryanthemum nodiflorum* Very Open Herbs
Vegetation 2	*Eucalyptus kondininensis* Low Woodland over *Melaleuca pauperiflora* Scrub to 3 m over *Disphyma crassifolium* and *Mesembryanthemum nodiflorum* Very Open Herbs
Vegetation 3	*Eucalyptus calycogona* Open Tree Mallee over *Melaleuca hamulosa* Open Scrub over *Helichrysum leucopsideum* Very Open Herbs

Native species	
Scientific name	**Common name**
Atriplex bunburyana	silver saltbush
Atriplex lindleyi	saltbush
Atriplex sp.	saltbush
Austrostipa sp.	speargrass
Brachyscome sp.	daisy
Calandrinia eremaea	twining purslane
Calocephalus multiflorus	yellow-top
Didymanthus roei	
Disphyma crassifolium	round-leaved pigface
Dodonaea viscosa	sticky hopbush
Enchylaena tomentosa	ruby saltbush
Erymophyllum tenellum	everlasting
Eucalyptus alipes	mallee
Eucalyptus calycogona subsp. calycogona	square-fruited mallee
Eucalyptus kondininensis	Kondinin blackbutt
Eucalyptus yilgarnensis	yorrell
Frankenia drummondii	frankenia
Frankenia sp.	frankenia
Gunniopsis sp.	
Helichrysum leucopsideum	everlasting
Hydrocotyle sp.	pennywort
Jacksonia sp.	
Lycium australe	Australian boxthorn
Maireana brevifolia	small-leaf bluebush
Maireana spp.	bluebush
Melaleuca cucullata	
Melaleuca carrii	
Melaleuca hamulosa	
+Melaleuca lateriflora	gorada
Melaleuca pauperiflora	boree
+Melaleuca hamulosa	
Millotia tenuifolia	soft millotia
Mirbelia spinosa	
Neurachne alopecuroidea	foxtail mulga grass
Pittosporum angustifolium	native apricot
Podotheca gnaphalioides	golden longheads

Native species (continued)	
Scientific name	**Common name**
Spergularia marina	salt sand spurry
Rhagodia preissii	rhagodia
Rhodanthe sp.	
Roycea spinescens	
Tecticornia spp.	samphire (2 species)
+ Regeneration noted	

Weed species	
Scientific name	**Common name**
Arctotheca calendula	capeweed
Avena barbata	bearded oat
Brassica tournefortii	wild turnip
Bromus rubens	red brome
Chenopodium glaucum	oak-leaved goosefoot
Cotula bipinnata	ferny cotula
Hordeum leporinum	barley grass
Lolium rigidum	annual ryegrass
Malva parviflora	marshmallow
Medicago minima	small burr medic
Mesembryanthemum nodiflorum	slender ice-plant
Monoculus monstrosus	stinking Roger
Moraea setifolia	thread iris
Parapholis incurva	coast barbgrass
Ursinia anthemoides	ursinia
Vulpia myuros	silver grass

Other plant lists for the general area
Beard (1980)
Grein (1994)
Lefroy *et al*. (1991)

Vegetation condition		
Condition	**Description**	**% of site**
Revegetation	An area of formerly cleared or otherwise degraded land that has been replanted	0
Pristine	No obvious signs of disturbance	0
Excellent	Vegetation structure intact, disturbance affecting individual species only and weeds non-aggressive species	0
Very good	Vegetation structure altered, obvious signs of disturbance	13
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	10
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	19
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	48

Disturbance factors contributing to vegetation condition score							
Disturbance factor	**Level of threat**			**Disturbance factor**	**Level of threat**		
	H	**M**	**L**		**H**	**M**	**L**
Salinity	x			Rubbish			x
Waterlogging	x			Plant disease			
Ponding from road crossing				Erosion			x
Drainage				Service corridors			
Clearing		x		Feral animals			x
Fire risk			x	Recreation			
Weed invasion			x	Point source discharge			
Stock access			x	Other			
Vehicle access			x				

Comments

Although the site is not fenced, there is no evidence of livestock grazing. There is evidence of wind erosion. Deaths of Melaleuca sp have occurred on small lake banks where they have been replaced by samphire. Samphire on a low lunette has been killed by flooding. There is an old fence running through the large lake. There is rubbish on the site, including old tin sheeting, an old water tank and shotgun cartridges. Weeds are present on vegetated areas throughout the site.

Links to protected areas of remnant vegetation		
Name	**Area** (ha)	**Approximate distance and direction from site**
Crown Reserve 18553	409	4 km SE
Lake Biddy Nature Reserve	48	5.6 km SE

Management

Salinity and waterlogging are the major disturbance factors impacting on vegetation condition. While these factors should be managed on a catchment basis, some improvement of condition could be achieved by revegetating around areas subject to wind erosion, implementing weed and feral animal control and removing rubbish from the site. It is also recommended that stock continue to be excluded from the site.

Fauna	
Scientific name	**Common name**
Birds	
Anthus australis	Australian pipit
Calidris sp.	sandpiper
Corvus coronoides	Australian raven
Cracticus nigrogularis	pied butcher bird
Cuculus pallidus	pallid cuckoo
Epthianura albifrons	white-fronted chat
Grallina cyanoleuca	magpie-lark
Petroica goodenovii	red-capped robin
Platycercus zonarius	Australian ringneck parrot
Pomatostomus superciliosus	white browed babbler
Strepera versicolor	grey currawong
Tadorna tadornoides	Australian shelduck (mountain duck)

Mammals	
Felis catus	cat*
Macropus fuliginosus	western grey kangaroo
Oryctolagus cuniculus	European wild rabbit*
Vulpes vulpes	European red fox*

** Introduced species*

Other fauna lists for the general area
Greening Australia Western Australia (2004)
Grein (1994)
Lefroy *et al*. (1991)

Notes:

- DRF and Priority 4 flora species have previously been recorded close to the site, within the same broad vegetation type
- A Priority 3 flora species, *Frankenia drummondii*, was recorded on the site
- Water sampled from the large lake was pH 8.0, temperature 17.0^{o}C and conductivity was 61.7 mS/cm.

Photo A1.49: ULR09

Good condition vegetation association 1 (varies from completely degraded to good in less saline areas): *Tecticornia* spp. Dwarf Scrub over *Mesembryanthemum nodiflorum* Very Open Herbs

Photo A1.50: ULR09

Very good condition vegetation association 2: *Eucalyptus kondininensis* Low Woodland (previously cleared) over *Melaleuca pauperiflora* Scrub over *Disphyma crassifolium* and *Mesembryanthemum nodiflorum* Very Open Herbs

Photo A1.51: ULR09

Very good condition vegetation association 3: *Eucalyptus calycogona* Open Tree Mallee over *Melaleuca hamulosa* Open Scrub over *Helichrysum leucopsideum* Very Open Herbs

Appendix 2 Standard survey form

General details

Recorder's name: …… Survey date: ……

Site number: ……. Site name……..

Landholder: …….. Contact Number: ……

Property address: ……

Site position in landscape

❒ Valley floor

❒ Valley slope

❒ Uplands

❒ Rocky outcrop

Floodplain features

Natural features:

❒ Salt lakes (playas)

- ❒ Permanent water
- ❒ Seasonally wet

❒ Braided channel

- ❒ Discontinuous
- ❒ Continuous

❒ Lunettes (dunes)

❒ Tributary

Constructed features

❒ Drain

❒ Dam

❒ Other…….

Vegetation description (from Keighery, 1994)

Beard vegetation association

Number	Description
8	Medium woodland; salmon gum and gimlet
125	Bare areas; salt lakes
356	Succulent steppe with open woodland; eucalypts over saltbush
413	Shrublands; Acacia neurophylla and A. species thicket
511	Medium woodland; salmon gum and morel
631	Succulent steppe with woodland and thicket; York gum over Melaleuca thyoides and samphire

955	Mosaic; Shrublands; scrub-heath (SE Avon)/Shrublands; Allocasuarina campestris thicket
1049	Medium woodland; wandoo, York gum, salmon gum, morel and gimlet
1053	Shrublands; Melaleuca uncinata thicket with scattered York gum
1061	Mosaic; Medium sparse woodland; salmon gum and yorrell/succulent steppe; saltbush and samphire

Vegetation structure and cover (both native and weed species)

Vegetation layer	**Canopy cover class***	**Dominant species****
Trees		
Mallees		
Shrubs		
Grasses		
Herbs		
Rushes and sedges		
Litter		
Bare ground		
Rock outcrop		

*Canopy cover class	Very open 2-10%	Sparse 10-30%	Open 30-70%	Closed 70-100%

**More than 3 dominant species described as mixed

Native species list

Record number of species if all species cannot be identified by name

Regeneration ❒ Yes ❒ No Species: ……

Weed species list

Record number of species if all species cannot be identified by name

Vegetation condition (from Keighery, 1994)

Condition	Description	% of site
Revegetation	An area of formerly cleared, or otherwise degraded, land that has been replanted	
Pristine	No obvious signs of disturbance	
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species	
Very good	Vegetation structure altered, obvious signs of disturbance	
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	

Disturbance factors affecting vegetation condition score

Disturbance factor	Threat level		
	High	Mediu	Low
Salinity			
Waterlogging			
Ponding from road crossing			
Drainage			
Clearing			
Fire risk			
Weed invasion			
Stock access			
Vehicle access			
Rubbish			
Plant disease			
Service corridors			
Feral animals			
Recreation			
Point source discharge			
Other			

Linkages to protected remnant vegetation

Site name	Area (ha)	Approximate distance and direction from site

Water quality data (channels, wetlands, drains, tributaries)

Sample number	pH	Conductivity (mS/m)	Temperature (°C)	Location

Evidence of management

Tick the appropriate boxes:

❒ Revegetation
❒ Fencing
❒ Drainage
❒ Fire break control
❒ Weed control
❒ Surface water management
❒ Groundwater management
❒ Other: ……

Ideas for management

Tick the appropriate boxes:

❒ Prescribed burning
❒ Firebreak control
❒ Fencing
❒ Erosion control
❒ Saltland grazing
❒ Agroforestry
❒ Weed control
❒ Drainage
❒ Sediment management
❒ Surface water management
❒ Groundwater management
❒ Road crossing
❒ Other……

Fauna list

Photographs

Number	Description

Appendix 3 Vegetation condition photographs

Photo A3.1

Pristine condition woodland, Crown Reserve 28547 (ULR04 vegetation association 6).

Photo A3.2

Excellent condition tree mallee, Crown Reserve 28547 (ULR04 vegetation association 1).

Photo A3.3

Very good condition woodland, Guelfi's (ULR09 vegetation association 2).

Photo A3.4

Good condition woodland, Williamson's (ULR06 vegetation association 1).

Photo A3.5

Degraded samphire (formerly *Melaleuca* sp.), Lucca's (ULR01 vegetation association 2).

Photo A3.6

Completely degraded samphire (formerly *Melaleuca* sp), Stone's (ULR05 vegetation association 1).

Appendix 4 Examples of local native species suitable for revegetation

Table A4 Examples of local species suitable for revegetation in valley floors in the Lockhart catchment.

Inclusion in this table does not guarantee availability of seed or tubestock for revegetation, nor success of establishment.
Information is sourced from Oversby (2004), Mitchell & Wilcox (1994), Lefroy, Hobbs & Atkins (1991), and observations during the field survey.

Species	Tolerance			Propagation				Seed harvested	Notes
	Salt	Water-logging	Drought	Direct seeding	Tubestock	Cuttings/ transplanting	Self-seeding		
Understorey									
+ *Atriplex amnicola* (river saltbush)	Very	Moderate (when mature)	Moderate	Yes	Yes	Yes		Dec-Feb	
+ *Atriplex semibaccata* (creeping saltbush)	Slightly	Not	Very	Yes	Yes			Jan-Mar	Grows naturally near salt lakes and in woodlands. Short-lived but regenerates well.
Cyperus gymnocaulos (spiny flat-sedge)	Moderate	Short periods		Yes		Yes		Jan-Feb	Grows in a wide variety of soils, including floodways, seeps and lake edges, especially in disturbed areas with high nutrient levels.
+ *Eragrostis dielsii* (mallee lovegrass)	Moderate	Moderate	Moderate	Yes	Yes				Prefers lighter soils.
Gahnia trifida (coast saw-sedge)	Very	Moderate		Low success		Yes		Jan-Mar	Grows in a wide variety of soil types, including floodways, clay pans and lake edges.
+ *Maireana brevifolia* (small-leaf bluebush)	Yes	Slightly	Very	Yes	Yes		Yes	Dec-Mar	Grows naturally on drier parts of floodplain.

Species	Tolerance			Propagation				Seed harvested	Notes
	Salt	Water-logging	Drought	Direct seeding	Tubestock	Cuttings/ transplanting	Self-seeding		
+ *Rhagodia drummondii* (lake fringe rhagodia)	Very	Slightly	Very	Yes	Yes				Grows in a wide variety of soils, especially sand.
Sporobolus virginicus (native marine couch)	Moderate	Very		Yes		Yes		Jan-Mar	Prefers lighter soils.
+ *Tecticomia* species (samphire)	Various	Very	Very		Yes	Yes	Yes		
Midstorey									
+ *Acacia acuminata* (jam)	Slightly	Slightly	Very	Yes	Yes			Nov-Dec	Grows in a wide variety of soil types.
Acacia microbotrya (manna wattle)	Slightly	Slightly		Yes	Yes			Oct-Dec	Grows in a wide variety of soil types.
Callistemon phoeniceus (lesser bottlebrush)	High-Mod	High-Mod	High-Mod	Yes	Yes			All year	Grows in a wide variety of soil types.
Grevillea paniculata	Not	Not			Yes				Suitable for fresh flood fringes.
+ *Hakea kippistiana*									Found naturally regenerating on the edge of salt lakes.
+ *Hakea preissii* (needle tree)	Moderate	Moderate			Yes				Grows in many soil types.

Species	Tolerance			Propagation				Seed harvested	Notes
	Salt	Water-logging	Drought	Direct seeding	Tubestock	Cuttings/ transplanting	Self-seeding		
+ *Melaleuca adnata*	Moderate								Grows in floodplains.
+ *Melaleuca acuminata*									Grows in floodplains.
+ * *Melaleuca brevifolia*	Moderate								Grows in floodplains.
+ * *Melaleuca cuticularis* (saltwater paperbark)	Mod-High								Grows in saline floodplains and on the edge of lakes.
+ *Melaleuca hamata* (broombush)	Moderate								One of the broombush melaleucas (formerly included with *M. uncinata*). Found near the edge of salt lakes.
+ *Melaleuca thyoides*	Mod-High								Grows on the edge of salt lakes.
Melaleuca atroviridis (broombush)	Moderate	Variable							Grows in a wide variety of soil types.
Overstorey									
+ * *Casuarina obesa* (swamp sheoak)	Very	Very		Yes	Yes				Grows in many soil types.
+ *Eucalyptus horistes* (white flowered mallee)									Grows on dunes near salt lakes and waterways. Includes the mallee formerly called *Eucalyptus hypochlamydea.*

Species	Tolerance			Propagation				Seed harvested	Notes
	Salt	Water-logging	Drought	Direct seeding	Tubestock	Cuttings/ transplanting	Self-seeding		
+ * *Eucalyptus kondininensis* (Kondinin blackbutt)									Prefers loamy soils near slat lakes.
+ *Eucalyptus longicornis* (red morrell)									Grows in saline fine-textured loams and clays on valley floors.
+ * *Eucalyptus loxophleba* (York gum)	Some moderate	Not		Yes	Yes			All year	Grows in many soil types. Both mallee (subsp. *gratiae*) and tree (subsp. *loxophleba*) suitable.
Eucalyptus myriadena									Similar in appearance to yorrel. Prefers clay soils near salt lakes.
+ *Eucalyptus salmonophloia* (salmon gum)	Moderate	Not							Grows in loams and duplex soils on lower slopes and valley floors.
+ * *Eucalyptus salubris* (gimlet)	Moderate								Grows in loams and duplex soils on lower slopes and valley floors.
Eucalyptus sargentii (Salt River gum)	Mod-High	Some		Yes	Yes			All year	Grows in a wide variety of soils associated with salt lakes and saline waterways.
+ *Eucalyptus spathulata* (swamp mallet)	Moderate								Grows close to salt lakes
+ *Eucalyptus yilgarnensis* (yorrell)									Grows in saline fine-textured loams and clays on valley floors.

+ species found during field survey

** natural regeneration observed during field survey*

Appendix 5 Examples of species suitable for saltland pasture

Table A5 Examples of species suitable for saltland pasture.

Sourced from Oversby (2004), Phelan (2004), Butler,(2001), Barrett-Lennard & Malcolm (1995), Mitchell & Wilcox (1994) and Runciman & Malcolm (1991).

Species		Tolerance			Propagation				Seed harvested	Notes
	Origin	Salt	Water-logging	Drought	Direct seeding	Tubestock	Cuttings	Self-seeding		
saltbush										
Atriplex amnicola (river saltbush)	Local	Very	Moderate (when mature)	Moderate	Yes	Yes	Yes		Dec-Feb	Good forage with up to 10% protein. Recovers well from grazing.
Atriplex cinerea (grey saltbush)	WA	On saline seeps	Moderate		Yes		Yes			Palatability varies
Atriplex nummularia (old man saltbush)	Australia	Moderate	Sensitive		Yes	Yes			Sept-Oct	Not as palatable as other species, brittle and easily damaged by trampling.
Atriplex semibaccata (creeping saltbush)	Local	Slightly	Not	Very	Yes	Yes			Jan-Mar	Short-lived but regenerates well. Very palatable and prone to being eaten out.
Atriplex undulata (wavy-leaf saltbush)	Intro-duced	Yes	Moderate		Yes			Yes		Palatable. Recovers well from grazing.

Species	Origin	Tolerance			Propagation				Seed harvested	Notes
		Salt	Water-logging	Drought	Direct seeding	Tubestock	Cuttings	Self-seeding		
samphire										
Tecticornia species (samphire)	Various	Very	Very			Yes	Yes	Yes		Can survive moderate grazing. Highly saline, therefore sheep must have access to fresh water and graze in conjunction with stubble or other sources.
bluebush										
Maireana brevifolia (small-leaf bluebush)	Local	Yes	Slightly	Very	Yes	Yes		Yes	Dec-Mar	Good forage with up to 16% protein, very palatable. Recovers well from grazing.
pasture legumes										
Cullen australas-icum	Australia			Moderate				Yes		Higher persistence and productivity than lucerne on Wheatbelt soils
grasses										
Grass species	Various	Various	Various	Various						A number of summer active grasses are available: contact the Department of Agriculture and Food for details. Includes Tall Wheatgrass and *Puccinellia*.

Appendix 6 Flora and fauna lists

Table A6.1 Native plant species found during the survey

Species	Common name
Acacia acanthoclada	harrow wattle
Acacia acoma	wattle
Acacia acuminata	jam
Acacia ancistrophylla	wattle
Acacia assimilis	wodjil
Acacia chrysella	wattle
Acacia colletioides	wait-a-while
Acacia erinacea	spiny wattle
Acacia hemiteles	tan wattle
Acacia merrallii	Merrall's wattle
Acacia sp.	wattle
Actinobole uliginosum	flannel cudweed
Allocasuarina acutivalvis	sheoak
Allocasuarina campestris	tamma
Allocasuarina huegeliana	rock sheoak
Alyxia buxifolia	dysentery bush
Amphipogon sp.	greybeard grass
Angianthus tomentosus	camel-grass
Aristida sp.	three-awned spear grass
Atriplex amnicola	swamp saltbush
Atriplex bunburyana	silver saltbush
Atriplex hymenotheca	saltbush
Atriplex lindleyi	saltbush
Atriplex semibaccata	berry saltbush
Atriplex sp.	saltbush
Austrostipa elegantissima	feather speargrass
Austrostipa sp.	speargrass
Baeckea sp.	myrtle
Beyeria leschenaultii	pale turpentine bush
Blennospora drummondii	
Borya constricta	pin-grass
Borya laciniata	pin-grass
Borya sphaerocephala	pincushions
Brachyscome iberidifolia	Swan River daisy
Brachyscome sp.	daisy
Bulbine semibarbata	leek lily
Caesia micrantha	pale grass-lily
Caladenia flava	cowslip orchid
Caladenia hirta subsp. rosea	pink candy orchid
Calandrinia eremaea	twining purslane
Calandrinia granulifera	pygmy purslane
Calandrinia spp.	parakeelia
Callistemon phoeniceus	lesser bottlebrush
Calocephalus multiflorus	yellow-top
Calotis hispidula	bindy eye
Calytrix leschenaultii	purple starflower

Species	Common name
Carpobrotus modestus	inland pigface
Casuarina obesa	swamp sheoak
Cheilanthes austrotenuifolia	rock fern
Chorizema aciculare	needle-leaved chorizema
Chthonocephalus pseudevax	woolly groundheads
Clematis delicata	clematis
Comesperma integerrimum	milkwort
Comesperma volubile	love creeper
Crassula colorata	dense stonecrop
Crassula sp.	
Dampiera lavandulacea	
Darwinia halophila	darwinia
Desmocladus asper	
Desmocladus sp.	
Dianella revoluta	blueberry lily
Didymanthus roei	
Disphyma crassifolium	round-leaved pigface
Diuris porrifolia	orchid
Dodonaea sp.	hopbush
Dodonaea viscosa	sticky hopbush
Dodonaea viscosa subsp. angustissima	sticky hopbush
Drosera glanduligera	pimpernel sundew
Drosera macrantha	bridal rainbow
Drosera sp.	sundew
Enchylaena tomentosa	ruby saltbush
Eragrostis dielsii	mallee lovegrass
Eremophila decipiens	slender fuchsia
Eremophila ionantha	violet-flowered eremophila
Erodium cygnorum	blue heron's-bill
Erymophyllum sp.	everlasting
Erymophyllum tenellum	everlasting
Eucalyptus alipes	mallee
Eucalyptus calycogona subsp. calycogona	square-fruited mallee
Eucalyptus celastroides	mirret
Eucalyptus horistes	white-flowered mallee
Eucalyptus kondininensis	Kondinin blackbutt
Eucalyptus longicornis	red morrell
Eucalyptus loxophleba subsp. gratiae	Lake Grace gum
Eucalyptus loxophleba subsp. loxophleba	York gum
Eucalyptus salicola	salt gum
Eucalyptus salmonophloia	salmon gum
Eucalyptus salubris	gimlet
Eucalyptus sheathiana	ribbon-barked gum
Eucalyptus spathulata	swamp mallet
Eucalyptus subangusta	black marlock
Eucalyptus yilgarnensis	yorrell
Exocarpos aphyllus	leafless ballart
Frankenia drummondii	frankenia
Frankenia sp.	frankenia
Gahnia ancistrophylla	hooked-leaf saw sedge

Species	Common name
Gahnia sp.	saw sedge
Gnephosis uniflora	
Gonocarpus nodulosus	
Grevillea anethifolia	grevillea
Grevillea hookeriana	red tooth brushes
Gunniopsis septifraga	
Gunniopsis sp.	
Hakea kippistiana	hakea
Hakea preissii	needle tree
Helichrysum leucopsideum	everlasting
Hyalochlamys globifera	
Hyalosperma glutinosum	
Hydrocotyle callicarpa	small pennywort
Hydrocotyle sp.	pennywort
Jacksonia sp.	
Juncus sp.	rush
Lawrencella rosea	pink everlasting
Lepidium rotundum	veined peppercress
Lepidobolus chaetocephalus	bristle-headed chaff rush
Lepidobolus sp.	
Lepidosperma drummondii	sword sedge
Lepidosperma spp.	sword sedge (2 species)
Leptomeria sp.	currant bush
Leptospermum erubescens	roadside tea-tree
Leucopogon sp.	beard heath
Levenhookia sp.	stylewort
Lomandra effusa	scented matrush
Lycium australe	Australian boxthorn
Maireana brevifolia	small-leaf bluebush
Maireana carnosa	cottony bluebush
Maireana sp.	bluebush (3 species)
Melaleuca acuminata	
Melaleuca adnata	
Melaleuca atroviridis	broombush
Melaleuca brevifolia	
Melaleuca carrii	
Melaleuca cucullata	
Melaleuca cuticularis	saltwater paperbark
Melaleuca hamata	broombush
Melaleuca hamulosa	
Melaleuca lateriflora	gorada
Melaleuca laxiflora	
Melaleuca pauperiflora	boree
Melaleuca scalena	broombush
Melaleuca teuthidoides	
Melaleuca thyoides	
Melaleuca viminea	mohan
Microcybe multiflora	
Millotia tenuifolia	soft millotia
Mirbelia spinosa	

Species	Common name
Neurachne alopecuroidea	foxtail mulga grass
Olearia dampieri	daisy bush
Olearia muelleri	goldfields daisy, dusky daisy bush
Pelargonium havlasae	geranium
Phebalium filifolium	slender phebalium
Phebalium tuberculosum	
Pittosporum angustifolium	native apricot
Platysace effusa	
Podolepis canescens	bright podolepis
Podolepis capillaris	wiry podolepis
Podolepis lessonii	
Podotheca angustifolia	sticky longheads
Podotheca gnaphalioides	golden longheads
Prasophyllum regium	king leek orchid
Ptilotus holosericeus	mulla mulla
Ptilotus polystachyus	bottle washers
Ptilotus sp.	mulla mulla
Ptilotus spathulatus	mulla mulla
Quinetia urvillei	
Rhagodia drummondii	rhagodia
Rhagodia preissii	rhagodia
Rhodanthe chlorocephala	
Rhodanthe citrina	
Rhodanthe manglesii	pink sunray
Rhodanthe sp.	
Rhodanthe spicata	
Rinzia crassifolia	
Roycea spinescens	
Ruppia sp. *or Lepilaena* sp.	waterweed
Rutidosis multiflora	small wrinklewort
Rutidosis sp.	wrinklewort
Santalum acuminatum	quandong
Santalum murrayanum	bitter quandong
Sarcocornia blackiana	samphire
Scaevola spinescens	current bush
Sclerolaena diacantha	grey copper-burr
Sclerolaena sp.	
Senecio sp.	groundsel
Siloxerus multiflorus	
Spartochloa scirpoidea	
Spergularia marina	salt sand spurry
Stackhousia monogyna	
Stylidium insensitivum	insensitive triggerplant
Stylidium repens	matted triggerplant
Tecticornia lylei	samphire
Tecticornia spp.	samphire (approx 4 species)
Templetonia sulcata	centipede bush
Toxanthes perpusillus	tiny bow-flower
Trachymene cyanopetala	
Trachymene pilosa	dwarf parsnip

Species	Common name
Triglochin calcitrapa	spurred arrowgrass
Triglochin mucronata	prickly arrowgrass
Triglochin sp.	spurred arrowgrass
Triodia rigidissima	spinifex
Velleia cycnopotamica	
Verticordia chrysanthella	featherflower
Vittadinia sp.	fuzz weed
Waitzia acuminata	orange immortelle
Wilsonia humilis	silky wilsonia

Table A6.2 Introduced plant species found during the survey

Species	Common name
Aira cupaniana	hair-grass
Arctotheca calendula	capeweed
Avena barbata	bearded oat
Avena fatua	wild oat
Brassica tournefortii	wild turnip
Bromus rubens	red brome
Chenopodium glaucum	oak-leaved goosefoot
Cotula bipinnata	ferny cotula
Ehrharta longiflora	annual veldt grass
Erodium sp.	storksbill
Hordeum leporinum	barley grass
Hordeum marinum	sea barley grass
Hypochaeris glabra	flatweed
Lolium rigidum	annual ryegrass
Malva parviflora	marshmallow
Medicago minima	small burr medic
Medicago sp.	medic
Mesembryanthemum nodiflorum	slender ice-plant
Monoculus monstrosus	stinking Roger
Moraea setifolia	thread iris
Oxalis pes-caprae	soursob
Parapholis incurva	coast barbgrass
Parapholis sp.	barbgrass
Parentucellia latifolia	common bartsia
Pentaschistis airoides	false hair-grass
Raphanus raphanistrum	wild radish
Romulea rosea	Guildford grass
Sisymbrium sp.	mustard
Sonchus oleraceus	common sowthistle
Spergularia sp.	sand spurry
Trifolium cherleri	cupped clover
Trifolium tomentosum	woolly clover
Ursinia anthemoides	ursinia
Vulpia myuros	silver grass
Zaluzianskya divaricata	zedweed

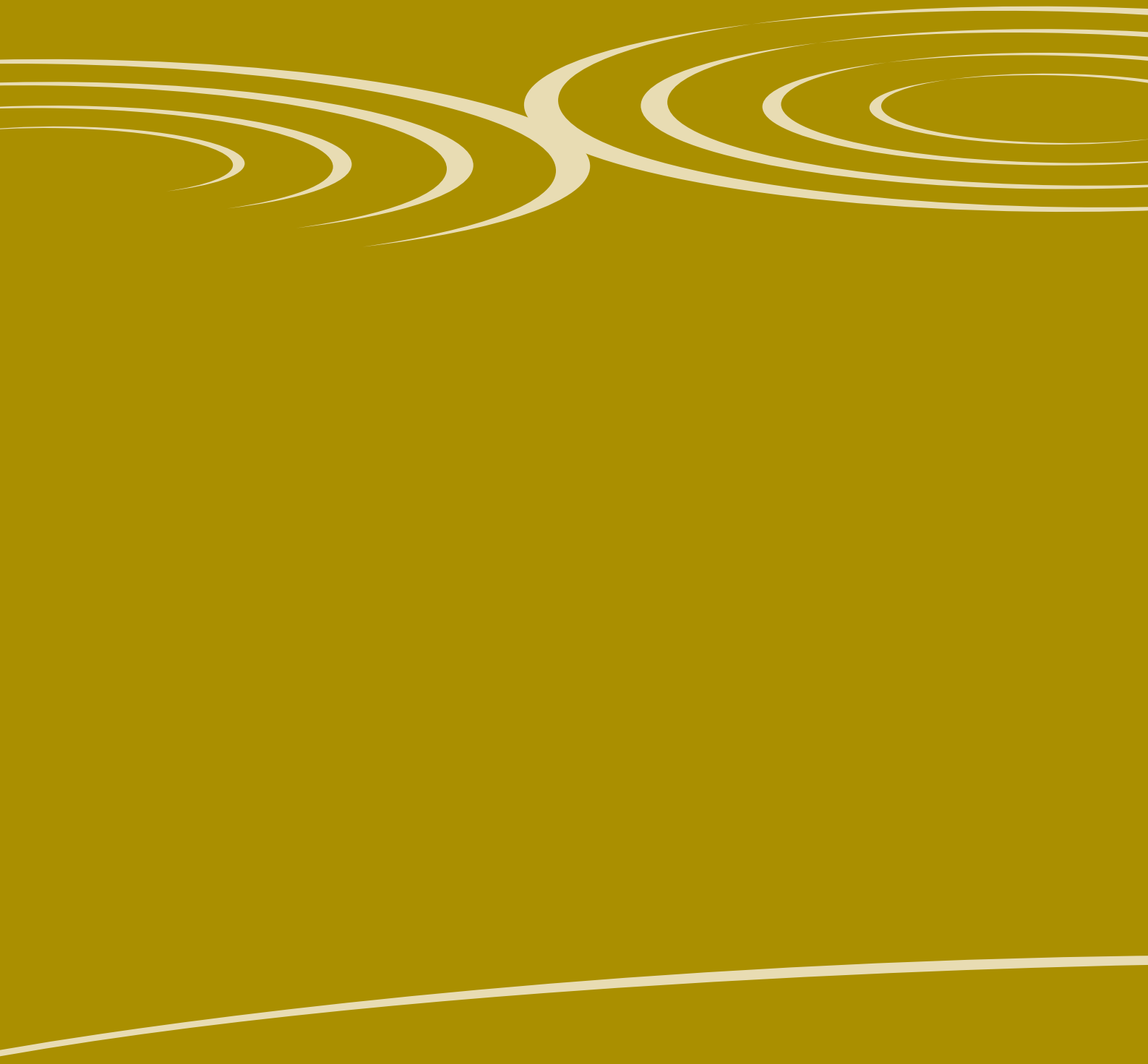
Table A6.3 Birds recorded during the survey

Species	Common name
Acanthagenys rufogularis	spiny-cheeked honeyeater
Acanthiza chrysorrhoa	yellow-rumped thornbill
Acanthiza sp.	thornbills
Anthochaera carunculata	red wattlebird
Anthus australis	Australian pipit
Aquila audax	wedge-tailed eagle
Ardea alba	great egret
Artamus cinereus	black-faced woodswallow
Cacatua roseicapilla	galah
Calidris sp.	sandpiper
Chrysococcyx basalis	Horsfield's bronze cuckoo
Circus assimilis	spotted harrier
Colluricincla harmonica	grey shrike thrush
Coracina novaehollandiae	black-faced cuckoo-shrike
Corvus coronoides	Australian raven
Cracticus nigrogularis	pied butcher bird
Cracticus tibicen	magpie
Cracticus torquatus	grey butcherbird
Cuculus pallidus	pallid cuckoo
Cygnus atratus	black swan
Dromaius novaehollandiae	emu
Epthianura albifrons	white-fronted chat
Falco cenchroides	Australian kestrel
Grallina cyanoleuca	magpie-lark
Lichenostomus virescens	singing honey-eater
Lichmera indistincta	brown honeyeater
Manorina flavigula	yellow throated miner
Neophema elegans	elegant parrot
Ocyphaps lophotes	crested pigeon
Oreoica gutturalis	crested bellbird
Pachycephala rufiventris	rufous whistler
Pardalotus striatus	striated pardalote
Petroica goodenovii	red-capped robin
Phaps chalcoptera	common bronzewing
Platycercus varius	mulga parrot
Platycercus zonarius	Australian ringneck parrot
Polytelis anthopeplus	regent parrot
Pomatostomus superciliosus	white browed babbler
Rhipidura leucophrys	willy wagtail
Smicrornis brevirostris	weebill
Strepera versicolor	grey currawong
Tadorna tadornoides	Australian shelduck (mountain duck)
Vanellus tricolor	banded lapwing

Table A6.4 Mammals recorded during the survey

Species	Common name
Felis catus	cat*
Macropus fuliginosus	western grey kangaroo
Oryctolagus cuniculus	European wild rabbit*
Sminthopsis crassicaudata	fat-tailed dunnart
Tachyglossus aculeatus	short-beaked echidna
Vulpes vulpes	European red fox*

* *Introduced species*



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