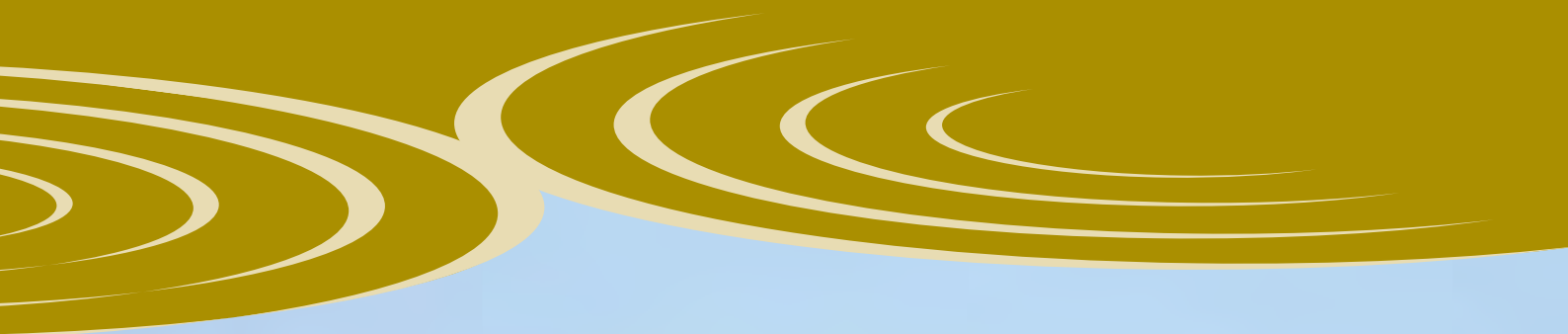




Government of **Western Australia**
Department of **Water**



Waterway assessment of the Camm River: Lockhart River confluence to Hyden

Water resource management series
Looking after all our water needs

Report no. WRM 57
December 2009

Waterway assessment of the Camm River: Lockhart River confluence to Hyden



Australian Government

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Department of Water

Water resource management series

Report no. WRM 57

December 2009

Department of Water

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December 2009

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Cover photo: Lake Gounter near Hyden. 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 Camm River project is the fifth of these waterway assessments, following those of the Salt River, lower Yilgarn River, lower Lockhart River, and the Lockhart–Lake Kurrenkutten to Camm River confluence.

The Camm River originates at Lake King and flows north-west through Lake Carmody and then west past Hyden to the Lockhart River confluence downstream from Jilakin Lake. This study has focused on the section of the Camm River between the confluence with the Lockhart River and Graham Rock, east of Hyden, including the south-east Hyden tributary.

The purpose of this waterway assessment is to investigate the Camm River catchment's current condition by recording a snapshot survey of 12 remnants in the 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 watertable and longer periods of inundation on the valley floor
- acidification
- loss of fringing riparian vegetation, especially around the edges of the larger lakes
- impediment of floodwaters by road crossings
- pest species degrading riparian vegetation
- stock access, particularly 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 the 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.

Waterway managers including the Avon Catchment Council, Department of Water, Department of Environment and Conservation, Avon Waterways Committee, local shires and landholders will use the information gained through this waterway assessment to plan and prioritise for the future management of the Camm River.

1 Introduction

1.1 Avon River basin

The Avon River is one of Western Australia's major river systems, draining approximately 120 000 km² 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 the locality of Upper Swan and enters the ocean at Fremantle.

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

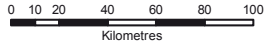
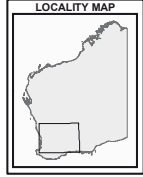
- The Yilgarn River catchment, which drains an area of approximately 55 900 km². It originates north-east of Southern Cross from Lake Seabrook and Lake Deborah and flows to the south-west past Merredin to its confluence with the Lockhart River at the Caroline Gap, south of Kellerberrin.
- The Lockhart River catchment, which drains an area of approximately 28 700 km². It originates around the locality of Lake Bidy, 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 km². 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 km², 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 Camm 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 Camm River study area within the Avon River basin




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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 Edition: 1

SOURCES

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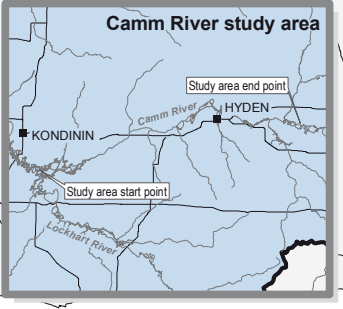
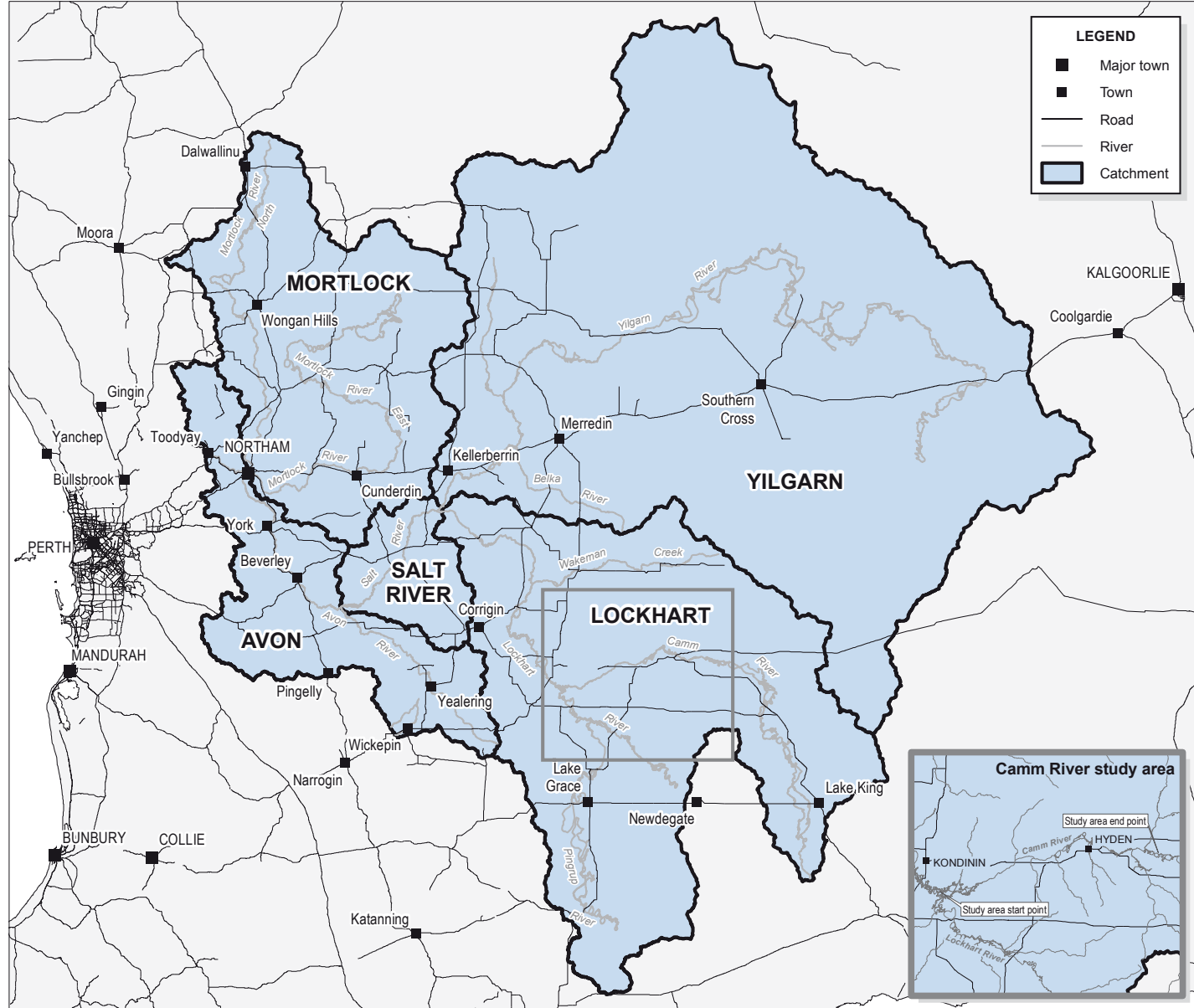
- Towns – Landgate – 2007
- Roads, 1M, GA – Landgate – 2008
- Hydrography, linear (hierarchy) – DoW – 2007
- Hydrographic catchments – DoW – 2007



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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 natural resource management 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 four waterway assessments have been completed on reaches of the Salt, Yilgarn and Lockhart rivers.

1.3 Aims of the Camm River waterway assessment

The primary aim of the Camm River waterway assessment is to gain an understanding of the current condition and management needs of the waterway and its associated floodplains, from the confluence with the Lockhart River to Graham Rock, east of Hyden (including the south-east Hyden tributary) 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, Avon Waterways Committee (AWC), local shires and landholders will use the information gained through this waterway assessment to plan and prioritise for the future management of the Camm River.

1.4 Nature of the Camm River study area

Camm River study area

The Camm River catchment drains an area of approximately 10 300 km². The Camm River is a major tributary of the Lockhart River. It originates from Lake King and Lake Camm, near the township of Lake King, and flows in a north-westerly direction through Lake Carmody and then west past Hyden to the Lockhart River confluence downstream of Jilakin Lake, near Kulin.

The study area includes the salt lakes, channels and floodplain of the Camm River from the confluence with the Lockhart River upstream approximately 85 km to Graham Rock, east of Hyden. The south-east Hyden tributary of the Camm River is also included in the study area.

The Department of Water selected 12 survey sites to represent the range of riparian landscapes found on the Camm River. The site sizes vary from 30 ha to 570 ha.

Map 2 shows the location of the study area, with the survey sites on Map 3.

Nature of the Camm 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) as well as shallow soils. The rocks are mostly granitic surrounded by gneisses, with dolerite dyke intrusions. The valleys are extensively in-filled with unconsolidated sediments.

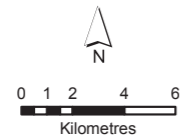
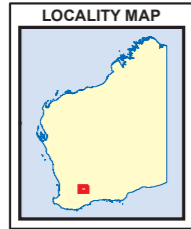
Most of the Avon River basin is internally drained, with salt-lake chains low in the landscape that only link up and overflow in wetter years (Galloway 2004). The Camm River system lies within an area of sluggish drainage and low relief, known as the zone of ancient drainage (Lantzke 1992).

The Avon River south-east lakes subregion, in which the Camm 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 gravels, 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 Camm River study area occupies a part of the Hyden System within the Roe Botanical District (Beard 1980a). 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 Camm River study area



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)
 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: 7114
 Filepath: J:\gis\projects\ProjectB_Series\B410C\0002\mxd
 Filename: Map02_Camm_River_study_area_A3.mxd
 Compilation date: May 2009
 Edition: 1

SOURCES

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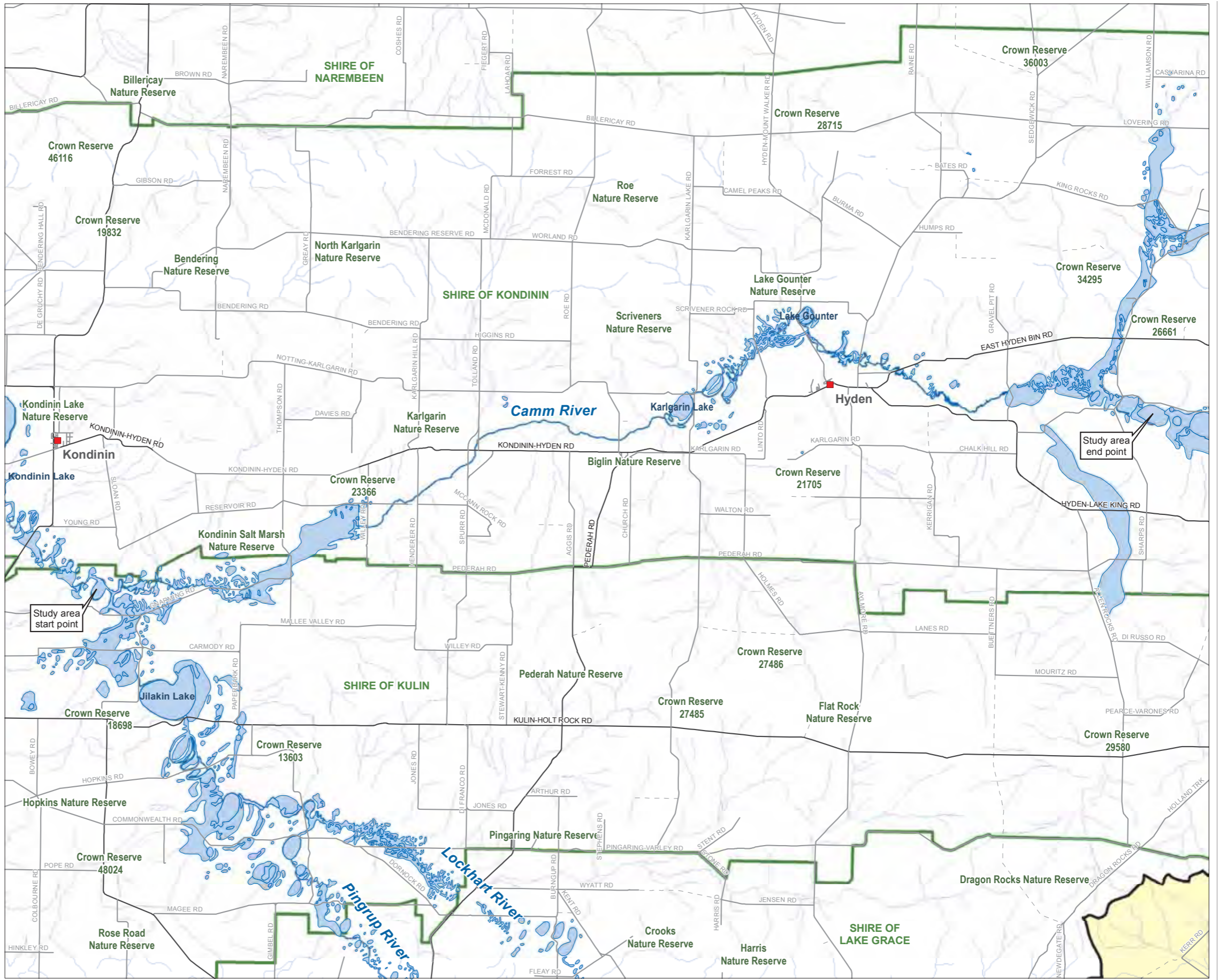
- Towns – Landgate – 2007
- Road Centrelines – Landgate – 2008
- Hydrography, Linear (Hierarchy) – DoW – 2007
- Local Govt Authorities – Landgate – 2006

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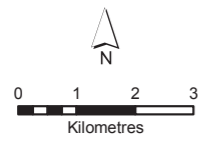
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Map 3a Camm River survery site locations (CR01 to CR05)



LEGEND

Waterways

- Major waterway
- Minor waterway

Road network

- Main road
- Local road
- Track

Local government authorities

- Local government authorities

Cadastre

- Naremben Orthomosaic 2005
- Corrigin South Orthomosaic 2000
- Hyden Orthomosaic 2004
- Pederah Orthomosaic 2004

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:\gis\projects\ProjectB_Series\B410C\0002\mxd
 Filename: Map03a_Camm_River_survery_site_locations.mxd
 Compilation date: May 2009
 Edition: 1

SOURCES

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

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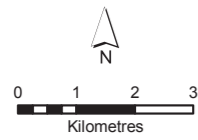
This map is a product of the Department of Water, Spatial Services Section and was completed in May 2009.

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Map 3b Camm River survey site locations (CR06 to CR12)



LEGEND

Waterways

- Major waterway
- Minor waterway

Road network

- Main road
- Local road
- Track

Local government authorities

- Local government authorities

Cadastre

- Hyden Orthomosaic 2004
- Pederah Orthomosaic 2004
- Oconnor Orthomosaic 2004
- Hurlstone Orthomosaic 2004

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:\gis\projects\ProjectB_Series\B410C\0002\mxd
 Filename: Map03b_Camm_River_survey_site_locations.mxd
 Compilation date: May 2009
 Edition: 1

SOURCES

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- Cadastre – Landgate – 2008
- Local Govt Authorities – Landgate – 2006

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Beard (1980a)¹ Several of the botanical names used by Beard mapped the valley floor as shrublands dominated by teatree (*Melaleuca* spp.), salt lakes as bare areas and samphire flats as succulent steppe with sparse woodland thicket of yorrell (*Eucalyptus yilgarnensis*/*E. myriadena*) and Kondinin blackbutt (*E. kondininensis*) over teatree and samphire (*Tecticornia* [formerly *Arthrocnemum* or *Halosarcia*] spp.).

The lower valley slopes are mapped as woodland of salmon gum (*E. salmonophloia*) and red morrell (*E. longicornis*). West of Hyden the lower valley slopes are mapped as mosaic of mallee (redwood and black marlock), shrublands and patches of salmon gum woodland.

Post-clearing changes to vegetation communities

This study has sites located in two local government areas. Ten sites are located in the Shire of Kondinin and two sites in the Shire of Kulin. Clearing has been extensive in both shires, with only 13.1 per cent of pre-European vegetation remaining in Kondinin and 12 per cent in Kulin. This is similar to the average of 13.5 per cent for the Avon catchment (Shepherd, Beeston & Hopkins 2002).

Further degradation has occurred since clearing, mainly as a result of grazing and hydrological change. While the Camm River is naturally saline, clearing has resulted in groundwater discharge in low-lying areas and increased salinity and waterlogging in the root zone of plants. Even naturally salt-tolerant plants are unable to adapt to these changes, leading to a decline in vegetation condition and increased plant death in some areas

Hydrology and water quality

Streamflow in the Camm River originates from upstream, groundwater seepage and the south-east Hyden tributary. The Camm River has a very low gradient. The fall of the 85-km-long reach from the Graham Rock Road and Lake Carmody Road intersection to the confluence with the Lockhart River on Gnarming Road is 34 m: an average 0.4 m/km or 1:2500 (Chipfunde, DoW, pers. comm). This grade is interrupted by large, essentially flat playas that drop water from one to another when they 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). The Lake King catchment (86 km², 95 per cent cleared, mean annual rainfall 320 mm) experiences many years of no flow, interspersed with either extreme summer events or a wet winter (Hatton, Ruprecht & George 2003). Variation in runoff, due to rainfall and internal storage or overflow in the lake systems, leads to high variability in stream salinity from year to year.

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*.

Groundwater in palaeochannels and beneath salt-lake areas is greater than 5000 mS/m. Where this groundwater reaches the surface, evaporation accumulates salts –resulting in hypersaline surface water. Acid groundwater (pH < 4) has been recorded in the south-east Hyden tributary (Leoni & Murphy-White 2006).

Annual average rainfall across the study area is approximately 340 mm/annum but is highly variable from year to year (Figure 1). Rainfall is also highly seasonal with 70 per cent occurring between April and September.

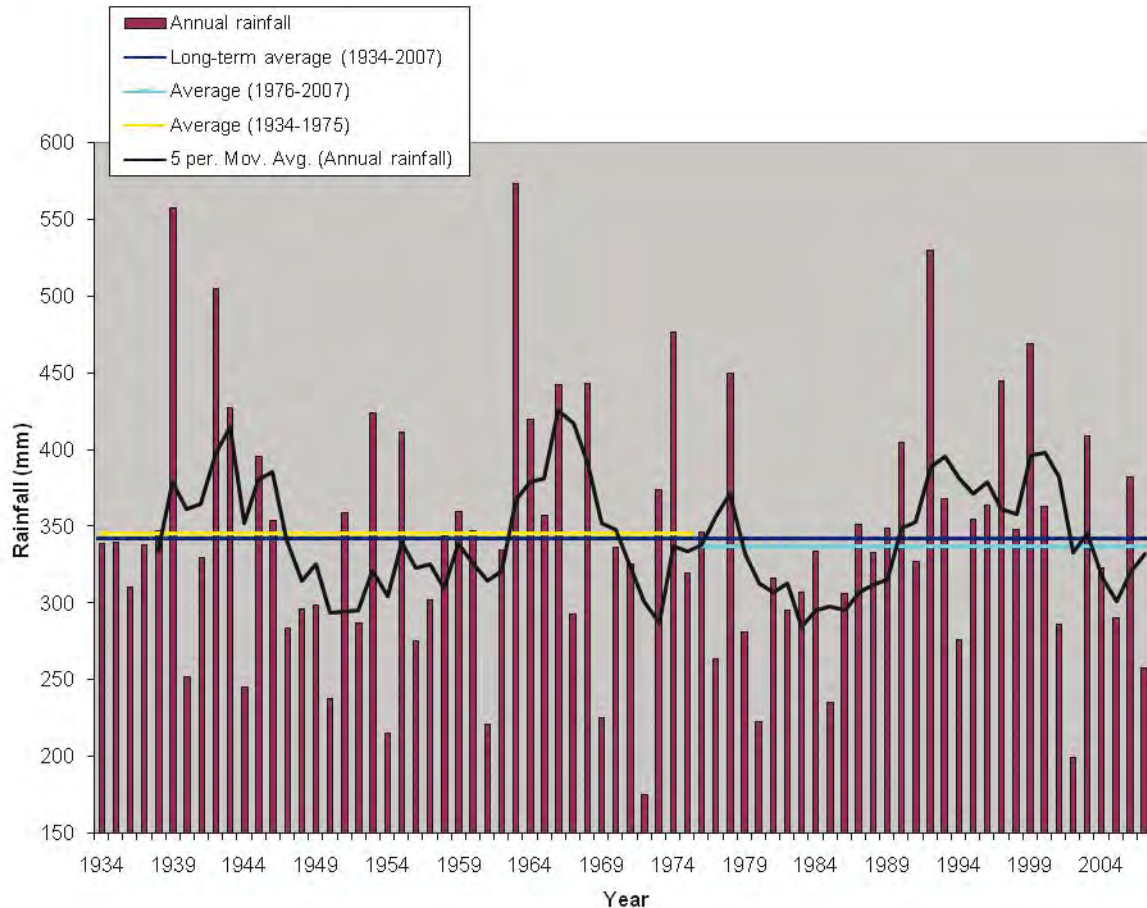


Figure 1 Annual rainfall at Graham Rock from 1934 to 2007 (Bureau of Meteorology rainfall station 10560)

Long-term rainfall trends have varied across the Camm River catchment. The northern and western parts of the catchment have experienced a decrease in rainfall of up to 27 per cent in the 30 years to 2005. In contrast, summer rainfall at Hyden increased by 11 per cent and winter rainfall by 7 per cent over the same 30-year period (Leoni & Murphy-White 2006). Average annual rainfall at Graham Rock has declined slightly in the 30 years to 2005 (Figure 1) but was higher during the 1990s than in the previous five decades (Figure 2).

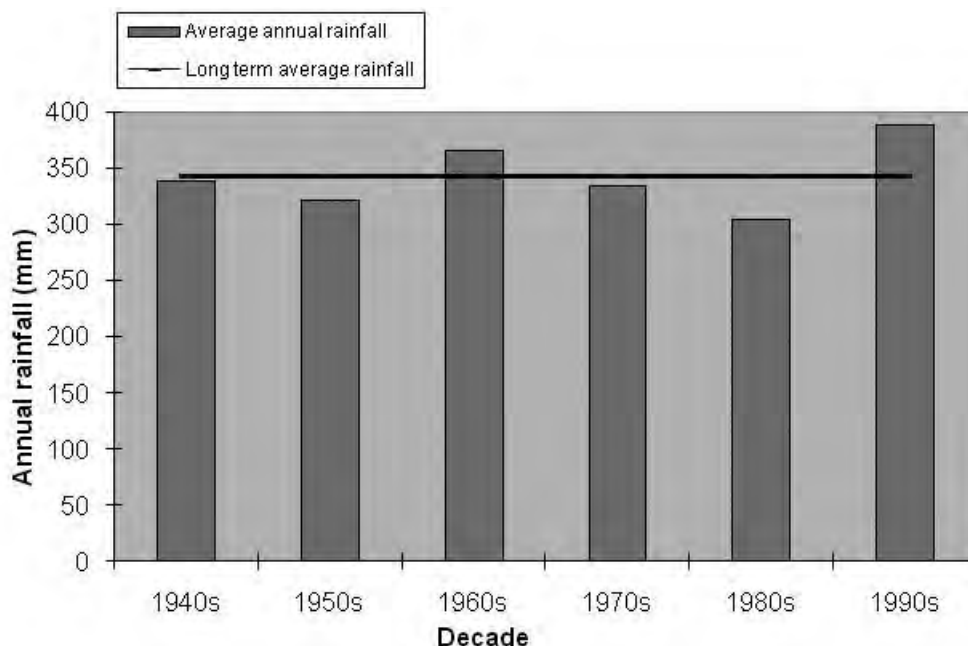


Figure 2 Average annual rainfall at Graham Rock (Bureau of Meteorology rainfall station 10560) for each decade (1940s to 1990s)

The Department of Water undertakes annual water-sample collections at selected sites in the Wheatbelt. Samples collected from the Camm River catchment in spring 2006 and 2007 indicated that most of the water sampled was acidic. 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	LC04	Camm River	Kondinin–Hyden Rd	649500	6403470	No flow			
2006	LC08A	Camm River	Lake Gounter	672950	6413100	173589	3.80	0.031	2.88
2006	LC09	Hyden town tributary	Hyden–Lake King Rd	675975	6408205	40448	1.20	0.006	3.46
2006	LC11	Hyden south-east tributary	Graham Rock Rd	690860	6405070	60308	2.60	0.020	6.05
2006	LC16	Timcobs north tributary	East Hyden Bin Rd	696440	6411580	No flow			
2006	LC17A	Nyonger east tributary	King Rocks Rd	701180	6419192	No flow			
2006	LC18	Timcobs north tributary	King Rocks Rd West	698690	6421580	No flow			
2007	LC08A	Camm River	Lake Gounter	672950	6413100	183674			2.76

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

Source: Department of Water 2009

Land tenure

Most of the land in the Camm River study area is freehold land used for agriculture. However, there are a number of Crown reserves within or in close proximity to the floodplain, most of which contain salt lakes. Table 2 lists those reserves vested for conservation.

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

Site name	Reserve name	Approx distance (km) and direction from study sites	Size (ha)
Kondinin Salt Marsh Reserve (CR01)	Kondinin Salt Marsh Nature Reserve	Part of reserve	2828
	Crown Reserve 23366	5 km NE	939
	Crown Reserve 15385	6 km S	105
	Crown Reserve 18698	6 km S	150
Hardy's (CR02)	Crown Reserve 23366	1.5 km NE	939
	Kondinin Salt Marsh Nature Reserve	2 km E	2828
Henderer's (CR03)	Crown Reserve 23366	Adjacent to reserve (northern boundary)	939
	Karlgarin Nature Reserve	1 km N	469
Weewarra Nominees (CR04)	Scriveners Nature Reserve	6 km NE	906
	Lake Gounter Nature Reserve	9 km E	3283
Richter's (CR05)	Scriveners Nature Reserve	5 km N	906
	Lake Gounter Nature Reserve	6 km E	3283
	Crown Reserve 22579	3.5 km NE	570
Karlgarin Lake (CR06)	Crown Reserve 22579	Part of reserve	570
	Lake Gounter Nature Reserve	Adjacent to reserve (NE corner)	3283
	Scriveners Nature Reserve	3.5 km N	906
	Crown Reserve 21705	9 km SE	156
Lake Gounter Reserve A (CR07)	Lake Gounter Nature Reserve	Part of reserve	3283
	Crown Reserve 21705	7.5 km SE	156
	Roe Nature Reserve	10 km NW	1242
Lake Gounter Reserve B (CR08)	Lake Gounter Nature Reserve	Part of reserve	3283
	Crown Reserve 21705	7 km S	156
	Graham Rock Nature Reserve	6 km E	2163
Lake Magic (CR09)	Lake Gounter Nature Reserve	Adjacent to reserve (S & W boundaries)	3283
	Graham Rock Nature Reserve	3 km E	2163
	Crown Reserve 21705	7 km S	156
CR10	Graham Rock Nature Reserve	Adjacent to reserve (N & W boundaries)	2163
	Crown Reserve 27162	1 km	520
	Crown Reserve 34295	7 km N	934
CR11	Graham Rock Nature Reserve	Adjacent to reserve (N boundary)	2163
	Crown Reserve 34295	8.5 km NW	934
Di Russo's (CR12)	Dragon Rocks Nature Reserve	8 km SW	32084
	Graham Rock Nature Reserve	7.5 km N	2163
	Crown Reserve 20341	10 km SE	546

Post-clearing changes to naturally saline waterways

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

Changes in the water balance

Land clearing has been extensive throughout the Wheatbelt, with only 13.5 per cent of pre-European vegetation extent remaining. The Camm River passes through the Shire of Kondinin, which has only 13.1 per cent of native vegetation remaining; and the Shire of Kulin, with 12 per cent of vegetation remaining (Shepherd, Beeston & Hopkins 2002). The remaining vegetation in these shires is now highly fragmented. Many of the threats facing this vegetation, including hydrological change, continue to modify these communities.

Before clearing, virtually all of the rainfall was intercepted by vegetation, evaporated or transpired. Most of the rainfall reaching the soil infiltrated locally, and surface runoff was usually small, fresh and episodic. Net groundwater recharge has been estimated at less than 1 mm/yr. With little surface runoff, it is likely that few well-defined drainage lines existed in areas that are now streams (Davis 2004; Hatton, Ruprecht & George 2003).

After clearing, the pattern of rainfall use has changed to winter use only in areas with annual crops and pastures. This has allowed runoff to increase fivefold and groundwater to recharge, filling deep sedimentary materials and bringing highly saline water to the surface (Davis 2004; Hatton, Ruprecht & George 2003).

In most of the Camm River catchment's valley-floor areas the groundwater is within 2 m of the surface and has reached equilibrium, although groundwater will continue to fluctuate seasonally. However, in the east of the catchment groundwater levels are increasing and not expected to reach equilibrium until 2030–75 (George et al. 2005).

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. 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 that the lakes are wetter for longer periods and more saline.

Additional salinisation is expected to occur in the tributary valleys of the Lockhart catchment, including the Camm River and south-east Hyden tributary. These flat areas will be more prone to lateral expansion of salinity due to poor surface drainage and waterlogging (Leoni & Murphy-White 2006).

The interrupted flows in the Camm River system may impact on waterway management because the lakes may hold (and concentrate, through evaporation)

poor quality water or toxins, which may cause local problems before being flushed downstream in the next flood event. Inflow to the lakes from tributaries or drains may increase salinity and periods of inundation, and have the potential to increase acidity or contribute toxins to the river and lakes.

Acidification

Although surface water is generally neutral to alkaline (pH 7–8), groundwater 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 (Rogers & George 2005). Acid groundwaters discharge naturally through seeps and into waterways. Acidic streamwater has been recorded in 2006–07 in the Camm River, at Lake Gounter (pH 2.8) and in the Hyden town tributary (pH = 3.5) (Table 1).

Acid groundwaters are a natural regolith phenomena and existed in agricultural areas before any drains were installed (Rogers & George 2005). However, 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 hydrogen ions (acid). 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 (Fitzpatrick et al. 2005). The high concentrations of dissolved iron that now exist in many groundwaters may be the result of pyrite oxidation in deep underlying sediment during previous climatic periods. Shallow pyritic materials are likely to occur in many low-lying areas around salt lakes and waterways. The construction of drains through such areas will cause oxidation and subsequent release of acid from such materials.

Acid groundwater has the potential to leach high concentrations of naturally-occurring heavy metals such as aluminium, cobalt, copper, zinc and lead from soils. In many cases, metal and trace-element levels are 10–100 times higher in acid groundwaters than in regional surface waters. Heavy metals can be transported to, and accumulate in, aquatic environments where they are likely to be harmful to flora and fauna (Fitzpatrick et al. 2005) While McConnell et al. (2005) noted there was a low threat risk for increasing groundwater acidification in the south-east lakes subregion, 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, altered 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, were 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 had 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 (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*) species have commonly replaced much of the fringing vegetation in the Wheatbelt.

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 through its effect on the quantity of runoff into rivers and wetlands, duration of inundation and impacts on water salinity. 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, 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, water fleas (*Cladocera*) are relatively intolerant, seed shrimps (*Ostracoda*) intermediate and waterbirds 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 unpublished).

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 12 survey sites for this section of the Camm River. These sites were selected 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, as shown 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 on page 39, 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 helps provide habitat, including shade and shelter from exposed root systems, as well as food resources for aquatic ecosystems.

A comparison of the current condition and structure of riparian vegetation with 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 Camm River survey 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 more accurate allocation of condition type and greater repeatability of the assessment.

Pre-European vegetation types

Beard vegetation-association data (Beard 1980a; 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 vegetation description by 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 is 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.

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.

An estimated overall percentage of the vegetated areas that fall into each vegetation condition category has been calculated for each survey site (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.

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 potential species 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 as ‘sp.’ for a single species and ‘spp.’ for more than one species. Particular attention was given to identifying the dominant plants used in the vegetation description.

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 survey area.

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 important in a highly fragmented landscape like the Western Australian Wheatbelt. These links allow for the movement of fauna and gene flow among plant populations.

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, physio-chemical 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 sightings were recorded. 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, thus making it difficult to observe and identify species.

The identification of bird species present was the focus because they are easier to find and identify than other types of fauna. Birds are a major component of most ecosystems and 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 remnants 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 4, 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 Camm River.

3 Main findings and management recommendations

The results for each survey 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

None of the sites surveyed had any areas of *pristine* condition vegetation.

Eight of the sites surveyed supported some *excellent* condition vegetation. These included CR01 (Kondinin Salt Marsh Nature Reserve), CR04 (Weewarra Nominees), CR05 (Richter's), CR06 (Karlgarin Lake), CR07 and CR08 (Lake Gounter Nature Reserve), CR10 and CR11. The vegetation communities were generally on lower slopes rather than valley floors and included gimlet and salmon gum woodlands (CR05), eucalypt, acacia and sheoak mosaic woodlands on lower slopes (CR06) and mallee on sand (CR10, CR11). There were also some areas of *excellent* condition vegetation on raised areas on the valley floors including eucalypt woodlands on dunes (CR01) and melaleuca shrublands and salt gum woodland on lunettes (CR04, CR07).

All of the sites surveyed except CR12 contained vegetation in *very good* and *good* condition. Most of this vegetation was melaleuca shrubland, mallee or eucalypt woodland on raised areas on the valley floors.

The existing vegetation in *degraded* or *completely degraded* condition was low-lying floodplain vegetation dominated by samphire (*Tecticornia* spp.). It was assessed as *degraded* or *completely degraded* because of the loss of native species, which have either not been replaced by anything (largely bare areas formerly supporting vegetation) or have been replaced by salt-tolerant species or weeds. Areas with sparse samphire and dead sticks, which indicate a former shrubland, probably dominated by *Melaleuca* spp., were assessed as *completely degraded*. Samphire areas were also assessed as *completely degraded* when the area had clearly not included samphire in its pre-European state. Dense areas of samphire, with only a few or no dead sticks, or with other species among the samphire, were assessed as *degraded*. Before clearing, these areas may have already had samphire present although likely at lower densities.

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

Areas without any vegetation were not assessed for vegetation condition. This 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 3 below. Although this figure is an estimate (based on an estimate of the percentage of each condition category in each remnant and an estimate of the proportion of vegetated area in each remnant), it shows that most of the vegetation surveyed in the study area is in *completely degraded* condition.

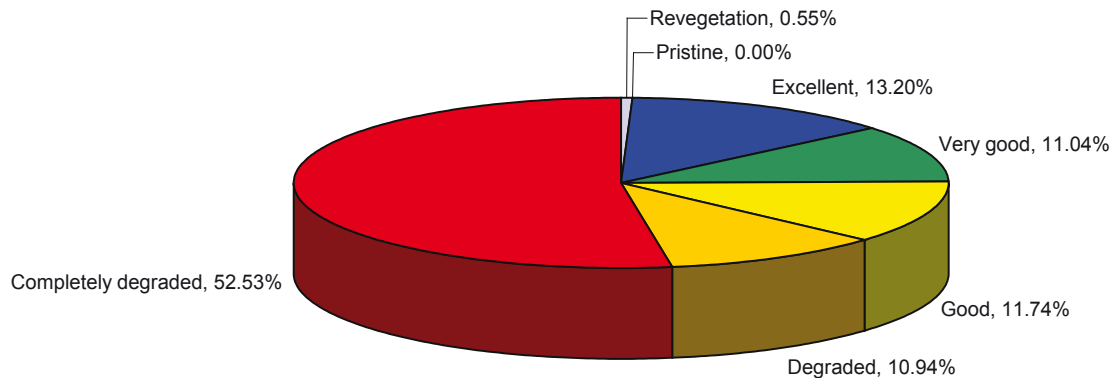


Figure 3 Estimated area of vegetation surveyed within each vegetation condition rating

The *degraded* and *completely degraded* vegetation of the low-lying landscapes indicates that significant changes affecting vegetation condition have occurred within the Camm River system, particularly the south-east Hyden tributary. Increases in 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 of 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*), York gum (*E. loxophleba* subsp. *loxophleba*), or mallee scrub.

Most of these vegetation types are still present.

3.2 Management issues

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

- increased salinity, raised watertables and increased periods of inundation on 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 Camm 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, AWC, 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 in the Camm River floodplain. These changed conditions have already affected vegetation condition, water quality, infrastructure and farm productivity on the Camm River 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: there is no one-size-fits-all solution. 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 Camm River is part of the Lockhart River catchment, which has low-gradient slopes (estimated as 0.4 m/km) 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 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 groundwater pumping.

The Department of Agriculture and Food (DAFWA) has published various best-practice management 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 better engineering approaches to managing salinity in the Wheatbelt. The main object of the EEI 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.

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 September 2009. Although the WDE's focus is on the Yenyening and Yarra Yarra catchments, other parts of the project include a review of Wheatbelt drainage governance and management, a study of options for treatment of acidic groundwater discharge and a project to classify Wheatbelt wetlands.

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

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 to rehabilitate marginally saline lands in the Wheatbelt (Ali et al. 2004). Deep drains are most effective where they intersect:

- permeable soils, including clay overlying permeable saprolite
- sandy sediments
- clays with preferred pathways such as sand seams.

Installing deep drains on soils of low hydraulic conductivity (e.g. heavy clays) may impact on as little as 10 m either side of the drain (Leoni & Murphy-White 2006).

The use of deep drains at break-of-slope may be useful in preventing groundwater rise, or on valley floors when the natural drainage system is unable to remove excess water and salt, resulting in lost agricultural production. However, drainage water in the eastern Wheatbelt can be acidic and contain high levels of iron, aluminium salt, metals and the rare earth elements lanthanum and cerium. The use of deep drainage is not recommended in areas where it will increase exposure of low quality groundwater and create downstream water quality and management problems.

The amount of excess water and salt delivered into the stream network by artificial drains is influenced by the method of disposal. Disposal options include the existing stream and lake network, bypassing existing lakes, or disposal to evaporation basins. 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. 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.

The environmental impacts of deep drains should also be considered. In the Wakeman subcatchment near Naremben, 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. This has had a negative impact on the diversity and species composition of macroinvertebrates (Stewart, Strehlow & Davis 2009).

Groundwater pumping

Groundwater pumping to reverse salinisation processes is generally considered to be uneconomic. It is only considered viable to protect small localised sites. Appropriate design, the potential for land degradation and the safe disposal of pumped water need to be considered before well construction. 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 Camm River catchment have yielded highly saline water (3000 mS/m) (Farmer 2007b). Disposal of such saline water involves the same issues noted previously for deep drainage.

Constructed sumps may be viable where the excavation of artificial billabongs provides the dual benefit of a focal point for water to accumulate and evaporate, and additional spoil material that could be used for revegetation. One example in the Camm River catchment is a billabong immediately east of Nicholl Road which has stabilised the local area and has a reasonably healthy saline weed and microfaunal community (Farmer 2007a).

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. If surface runoff is relatively fresh, it can be intercepted to augment farm water supplies.

Installation of shallow interceptor drains has been promoted to accelerate the removal of surface waters and to some extent drain shallow perched aquifers. However, recent modelling of the hydrological impacts of artificial drainage in the Avon catchment indicates 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, salt loads are predicted to more than double by 2100 and for the Lockhart system to increase from 8 g/L to 74 g/L 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).

A shallow channel approach has been recommended to reduce waterlogging in the flat valleys of the Camm River catchment (Farmer 2007b). It involves provision of accurately levelled, broad, shallow channels along the primary flow lines in waterlogged inundation areas. Removal of spoil from channel areas is also recommended to eliminate the levee effect, which tends to aggravate downstream flooding. This could be used to establish a defined shoreline, but works should not reduce the net width of the river valley. Drainage is not recommended because it results in unnecessary exposure of the underlying saline watertable and can create significant downstream and disposal issues (Farmer 2007b).

The Camm River drainage project proposal (Farmer 2007a, 2007b), from east of Graham Rock Nature Reserve, terminating at Lovering Road and including the Hyden Tourist Precinct north of Wave Rock, is not expected to increase inflow into the Camm River. It is designed to move water more rapidly through the modified drainage channels and prevent water accumulation in low-lying areas, which is a major cause of declining vegetation health in the waterway. At the time of the field survey this project proposal was unfunded, had no formal approvals, and no works had begun. However, local support from private individuals has indicated that some of the proposed works on private property are likely to be implemented – without external funding – including infill of low-lying areas to prevent ponding and harvesting of some of the surface waters for use in Lake Magic.

Revegetation

Vegetation intercepts surface flows in recharge areas and uses soil water reserves, thus reducing discharge. Revegetating with native species (preferably local species) has the benefit of restoring and enhancing natural biodiversity. Economic benefits can be realised through agroforestry (planting species that can be harvested for timber) or fodder crops.

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. In degraded valley areas, samphire can successfully colonise areas if waterlogging is addressed. Once established, samphire will reduce surface moisture, as well as trap sediment and wind-blown material; thus providing a more favourable habitat for establishment of other species.

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. 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 range 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 away from the plantation (George et al. 1999). 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 native species (preferably those sourced locally) 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 Camm 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 fuelwood; *Melaleuca* species for brushwood fencing; and sandalwood (*Santalum spicatum*) for oil. Trials were established in 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.). Understorey plants can 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 and native grasses 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 including salinity, fertility and the availability of water. Oil mallees rely on processing plants and a market for oil, while the market for brushwood fencing is limited. 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, construction of a valley-floor waterway and ongoing monitoring of water movement and the condition of biodiversity assets. Strategic revegetation is being used to reduce recharge and

includes planting native species with commercial potential (oil mallees) and for carbon sequestration. The valley-floor 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 (DEC 2008).

The Camm River drainage proposal (Farmer 2007a) was based on the surface-water management strategies developed for the Lake Bryde catchment. The Camm River catchment differs in having higher surface-water salinity in the lakes, and high surface-water acidity in some parts of the catchment, particularly near Hyden. Disposal of excess water, salt and minerals will therefore present a greater management challenge.

Recommendations for the management of salinity and waterlogging

Salinity and waterlogging are processes that require management at the catchment level. It is noted that some catchment-scale planning has been undertaken for the south-east Hyden catchment (Farmer 2007a). 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 that the impacts of management practices can be assessed.

3.4 Flows being impeded by road crossings

Low gradients contribute to slow flows through the Camm River study area. However, road crossings can add significantly to this problem, exacerbating waterlogging problems 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 ponding problems.

Approximately 0.12 per cent of main roads and 2 per cent of local roads in the Lockhart catchment are within low-lying areas and may be susceptible to flooding, waterlogging and salinity. 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).

There are many road crossings within the Camm River study area, including Willeby Road, Henderer Road, Kondinin–Hyden Road, Spurr Road, Aggis Road, Karlgarin Lake Road, Worland Hill Road, Notting–Karlgarin Road, Hyden–Mount Walker Road, Lovering Road, East Hyden Bin Road, Sharps Road, Nicholl Road, Graham Rock Road, Pederah Road, Di Russo Road, Hyden–Lake Varley Road and Hyden–Lake King Road. Not all road crossings were examined for evidence that water flows were being impeded; however, ponding was observed in several sites, including the Nicholls Road East road crossing (site CR11). This road had been degraded by past flooding.

It is unlikely that any of the road crossings restrict flow during normal rainfall years. However, during flood events they appear to cause impediment of water flow, resulting in ponding and structural damage to the roads. In some cases there is evidence that vegetation has been affected by ponding. For example, in the Graham Rock Reserve, Lake Varley Road intrudes into the valley flow line and impedes drainage, resulting in expanding scald areas (Farmer 2007b).

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
- where the road intrudes into the valley flow line; for example, the Hyden–Lake Varley Road, realignment may be necessary (Farmer 2007b).

3.5 Tributaries

Inflows to the Camm River study area arise from the north-east (King Rocks Road inflow), the east (Lake Carmody valley) and the south-east (South-East Hyden inflow). There are also numerous small, unnamed tributaries. It is recognised that additional salinisation is expected to occur in the tributary valleys that lie perpendicular to and converge into the main valleys due to poor surface drainage and waterlogging (Leoni & Murphy-White 2006).

Most tributaries in the study area are not well defined, and tend to be broad flat expanses covered with samphire (*Tecticornia* spp.). The south-east Hyden tributary shows evidence of sedimentation and silting. Impeded drainage has resulted in degradation and loss of native vegetation. This is evident in the Graham Rock Reserve where low-lying areas act as spreading areas for inflows and degradation is active within the main flow zone from Nicholl Road to the south-east Hyden confluence (Farmer 2007b). Continued or increased inflows from the south-east Hyden system are expected to increase degradation without management.

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, followed by revegetation. Plant roots would then stabilise the soil and plant stems would slow water flow into the tributary, thereby reducing bank erosion. Rocks or logs placed in the channel may 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 local species to:
 - reduce soil erosion and sedimentation
 - provide vegetation corridors linking areas of remnant vegetation higher in the landscape with riparian areas
- fence tributary floodplains to exclude livestock and prevent soil erosion and compaction
- install riffles, where appropriate, to reduce flow velocity and trap sediments before they reach the floodplain.
- construct shallow drainage channels to redirect small flows away from areas where vegetation decline is evident, to more degraded valley areas (Farmer 2007b).

3.6 Management of remnant vegetation

Remnant vegetation in the Camm 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 including salinity and waterlogging. Three of the study sites are vested for conservation (Kondinin Salt Marsh Nature Reserve CRO1; Lake Gounter Nature Reserve, CR07 and CR08).

Excellent condition vegetation was observed at eight of the 12 sites. Five were privately owned and three were on public land vested for conservation.

Recommendations for remnant vegetation management

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

- fence *good or better condition* vegetation to exclude livestock
- strategically enhance 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 Camm 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 shrublands 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 Camm River catchment are listed in Appendix 4. It is important to tailor selection of revegetation species in riparian areas to the current site conditions. This must 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 them are relevant to the Camm River floodplain.

Soil-structure decline, wind erosion of fine soil particles and water erosion 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 is 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 and 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 the two sites on the south-east Hyden tributary (CR11, CR12). Foxes are likely to be present in all remnants – as are feral cats (*Felis catus*), which were not observed. Evidence of wild dogs was also noted at the two sites in Lake Gounter Nature Reserve (CR07, CR08).

Introduced plant pests (weeds) were present on all sites: 30 species were identified during the field survey. While there were no serious weeds as declared by the DAFWA (2007), there was one weed listed as high risk by the *Environmental weed strategy of Western Australia* (CALM 1999): wild turnip (*Brassica tournefortii*).

Field observations indicated that the most serious and common weeds were wild turnip (*Brassica tournefortii*), slender iceplant (*Mesembryanthemum nodiflorum*), red brome (*Bromus rubens*), annual ryegrass (*Lolium rigidum*), coast barbgrass (*Parapholis incurva*), stinking Roger (*Monoculus monstrosus*) and capeweed

(*Arctotheca calendula*). Weed species are often a result of soil disturbance, and their presence can limit natural regeneration of native species. Slender iceplant and coast barbrgrass are indicators of a salinising landscape, and will persist in salty environments.

A list of all pest species encountered during the field survey can be found in Appendix 6.

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
- remove weeds from an area before revegetation using appropriate soil preparation and weed control methods in the year before planting.

3.10 Flora and fauna

A total of 176 native plants 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 six 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.), salmon gum (*Eucalyptus salmonophloia*), swamp mallee (*Eucalyptus spathulata* and relatives), gorada (*Melaleuca lateriflora*), boree (*Melaleuca pauperiflora*), quandong (*Santalum acuminatum*), *Hakea kippistiana*, goldfields daisy (*Olearia dampieri*), Australian boxthorn (*Lycium australe*), round-leaved pigface (*Disphyma crassifolium*), ruby saltbush (*Enchylaena tomentosa*), rhagodia (*Rhagodia preissii*), grey copper-burr (*Sclerolaena diacantha*) and scented matrush (*Lomandra effusa*).

One plant species (*Sclerolaena costata*) was identified (CR03) that was outside its geographic range, as recorded in Florabase. One Declared Rare Flora species (*Ptilotus fasciculatus*) was recorded at Kondinin Salt Marsh Nature Reserve (CR01).

Forty bird species were recorded during the field survey. The most commonly observed birds were Australian ringneck parrots (*Platycercus zonarius*), grey butcherbirds (*Cracticus torquatus*), Australian ravens (*Corvus coronoides*) and galahs (*Cacatua roseicapilla*), all of which are common farmland species.

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*), inland thornbill (*Acanthiza apicalis*), southern scrub-robin (*Drymodes brunneopygia*), 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*), striated pardalote (*Pardalotus striatus*), common bronzewing (*Phaps chalcoptera*), white-browed babbler (*Pomatostomus superciliosus*) and weebill (*Smicrornis brevirostris*) are described as remnant dependent, which means they are likely to decline in number if remnant vegetation is lost or becomes degraded (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*) and the short-beaked echidna (*Tachyglossus aculeatus*), which are described as abundant by Van Dyck & Strahan (2008). The western grey kangaroo was observed, or signs of its presence were seen, on 10 sites, although it is likely to occur on all sites; and signs of echidnas were recorded at three sites.

No reptiles were observed, which is not surprising given the sites were surveyed in wet, cool spring conditions.

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 plants and native animal species
- identify areas suitable for revegetation to provide links between areas of *good* quality remnant vegetation
- use native species, including trees, understorey and groundcover plants, preferably those sourced locally or species adapted to present environmental conditions
- 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 pest 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 properties 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 and building materials 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. Any 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. Kondinin and Kulin shire councils participate in *drumMUSTER* and can be contacted for details.

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 steeper 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 (m ³ /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 floodfringe 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 microrelief 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 (m ³ /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 CR01 – Kondinin Salt Marsh Nature Reserve

General Details

Site name	Kondinin Salt Marsh Reserve
Landholder	DEC
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date	25.08.2008

Site Description

Landform	The site is a valley floor and consists of discontinuous channels and rises on the north and south of the site with an elevated sandy rise across the centre, on an east-west orientation, approximately 1 m elevation above the valley floor.
Site size	265 ha

Beard Vegetation Description

Beard vegetation association 959: Succulent steppe with woodland and thicket; yorrell (*E. gracilis*) and 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%	<i>Eucalyptus spathulata</i>
Mallees	2–10%	<i>Eucalyptus horistes</i>
Shrubs	10–3%	<i>Melaleuca pauperiflora</i> , <i>M. laxiflora</i> , <i>Rhagodia preissii</i>
Grasses	< 2%	<i>Neurachne alopecuroidea</i> , mixed annual species
Herbs	10–30%	<i>Tecticornia</i> spp., <i>Spergularia marina</i> , <i>Disphyma crassifolium</i>
Rushes and sedges	< 2%	<i>Lepidosperma</i> sp.
Litter	< 2%	
Bare Ground	> 70%	
Rock Outcrop	0	

Summary

The channel areas are sparse samphire. On the rises are variously *Melaleuca thyoides* on the edges, *Melaleuca* spp./*Hakea kippistiana*/chenopods, and on higher rises *Eucalyptus spathulata* (occasionally *E. kondininensis*). The central rise is *E. horistes* woodland over *Acacia* spp. and sedges. On the south side of the rise, on elevated clayey soil is melaleuca shrubland.

Individual vegetation association descriptions

- Vegetation 1 *Eucalyptus spathulata* Open Low Woodland over *Melaleuca latifolia*, *Melaleuca pauperiflora* and *Rhagodia preissii* Scrub to 3 m over mixed annual Herbs
- Vegetation 2 *Tecticornia* sp. Dwarf Scrub to 0.3 m over *Senecio* sp., *Spergularia marina* and *Disphyma crassifolium* Very Open Herbs
- Vegetation 3 *Eucalyptus horistes* Very Open Tree Mallee over *Olearia dampieri* and *Acacia erinacea* Low Scrub
- Vegetation 4 *Tecticornia* spp. Dwarf Scrub
-

Native species

Scientific name	Common name
<i>Acacia acanthoclada</i>	harrow wattle
<i>Acacia acuminata</i>	jam
<i>Acacia erinacea</i>	spiny wattle
<i>Acacia hemiteles</i>	tan wattle
<i>Atriplex hymenotheca</i>	saltbush
<i>Atriplex</i> sp.	saltbush
<i>Baeckea</i> sp.	myrtle
<i>Brachycome iberidifolia</i>	Swan River daisy
<i>Caladenia longicauda</i>	common white spider orchid
<i>Calandrinia</i> sp.	parakeelya
<i>Cotula coronopifolia</i>	waterbuttons
<i>Cryptandra</i> sp.	
<i>Darwinia halophila</i>	darwinia
<i>Desmocladius asper</i>	
<i>Dianella revoluta</i>	blueberry lily
<i>Didymanthus roei</i>	
<i>Disphyma crassifolium</i>	round-leaved pigface
<i>Drosera</i> sp.	sundew
<i>Eremophila decipiens</i>	slender fuchsia
<i>Eucalyptus horistes</i>	white flowered mallee
<i>Eucalyptus kondininensis</i>	Kondinin blackbutt
<i>Eucalyptus spathulata</i>	swamp mallet
<i>Exocarpos aphyllus</i>	leafless ballart
<i>Frankenia</i> sp.	frankenia
<i>Grevillea</i> sp.	grevillea
<i>Gunniopsis septifraga</i>	
<i>Hakea kippistiana</i>	hakea
<i>Lepidosperma</i> sp.	sword sedge
<i>Leptospermum erubescens</i>	roadside tea-tree
<i>Leucopogon</i> sp.	beard heath
<i>Lomandra effusa</i>	scented matrush
<i>Lycium australe</i>	Australian boxthorn
<i>Maireana carnosa</i>	cottony bluebush
<i>Melaleuca lateriflora</i>	gorada
<i>Melaleuca laxiflora</i>	
<i>Melaleuca pauperiflora</i>	boree
<i>Melaleuca thyoides</i>	honey myrtle

Native species (continued)

Scientific name	Common name
<i>Neurachne alopecuroidea</i>	foxtail mulga grass
<i>Olearia dampieri</i>	daisy bush
<i>Podolepis capillaris</i>	wiry podolepis
<i>Ptilotus fasciculatus</i>	mulla mulla
<i>Rhagodia preissii</i>	rhagodia
<i>Santalum acuminatum</i>	quandong
<i>Senecio</i> sp.	groundsel
<i>Spergularia marina</i>	spurry
<i>Tecticornia</i> spp.	samphire (3 species)
<i>Templetonia sulcata</i>	centipede bush
<i>Westringia rigida</i>	stiff westringia

+ No Regeneration noted

Weed species

Scientific name	Common name
<i>Arctotheca calendula</i>	capeweed
<i>Bromus rubens</i>	red brome
<i>Lolium rigidum</i>	annual ryegrass
<i>Mesembryanthemum nodiflorum</i>	slender ice-plant
<i>Monoculus monstrosus</i>	stinking Roger

Other plant lists for the general area

Beard (1980)
 Grein (1994)
 Lefroy, Hobbs & Atkins (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	6
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	4
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	55

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			
Waterlogging	x			Plant disease			
Ponding from road crossing				Erosion			
Drainage			x	Service corridors			
Clearing				Feral animals			x
Fire risk				Recreation			
Weed invasion			x	Point source discharge			
Stock access				Other			
Vehicle access			x				

Comments

Most areas do not have signs of recent plant deaths indicating stable hydrology/salinity.

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
Kondinin Salt Marsh Nature Reserve	2828	Part of reserve
CR23366	939	5.0 km NE
CR15385	105	6.0 km S
CR18698	150	6.0 km S

Management

The site is part of a DEC-managed estate (Nature Reserve). Any management recommendations that may improve the condition of the Nature Reserve would require implementation at the catchment scale.

Fauna

Scientific name	Common name
Birds	
<i>Acanthiza</i> spp.	thornbills
<i>Artamus cinereus</i>	black-faced woodswallow
<i>Epthianura albifrons</i>	white-fronted chat
<i>Erythrogonys cinctus</i>	red-kneed dotterel
<i>Falco cenchroides</i>	Australian kestrel
<i>Grallina cyanoleuca</i>	magpie-lark
<i>Lichenostomus virescens</i>	singing honey-eater
<i>Platycercus zonarius</i>	Australian ringneck parrot

Fauna

Scientific name**Common name**

Mammals

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:

DRF and Priority 2 flora previously recorded, not within reserve, but in the same broad vegetation type

One previously unrecorded DRF was located during the survey.



Photo A1.1: CR01

Very good condition vegetation association 1: *Eucalyptus spathulata* Open Low Woodland over *Melaleuca latifolia*, *Melaleuca pauperiflora* and *Rhagodia preissii* Scrub over mixed annual Herbs.



Photo A1.2: CR01

Good condition vegetation association 2: *Tecticornia* sp. Dwarf Scrub over *Senecio* sp., *Spergularia marina* and *Disphyma crassifolium* Very Open Herbs.



Photo A1.3: CR01

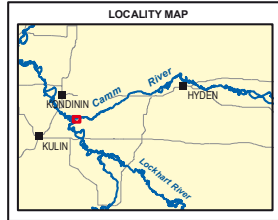
Excellent condition vegetation association 3: *Eucalyptus horistes* Very Open Tree Mallee over *Olearia dampieri*, *Acacia erinacea* Low Scrub.



Photo A1.4: CR01

Good condition vegetation association 4: *Tecticornia* spp. Dwarf Scrub.

Map A1
Vegetation condition for
survery site CR01
Kondinin Salt Marsh
Nature Reserve



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: Melanie Webb
 Task ID: 7114
 Filepath: J:\gis\projects\ProjectB_Series\B410C\002.mxd
 Filename: MapA1_Veg_cond_survery_site_CR01.mxd
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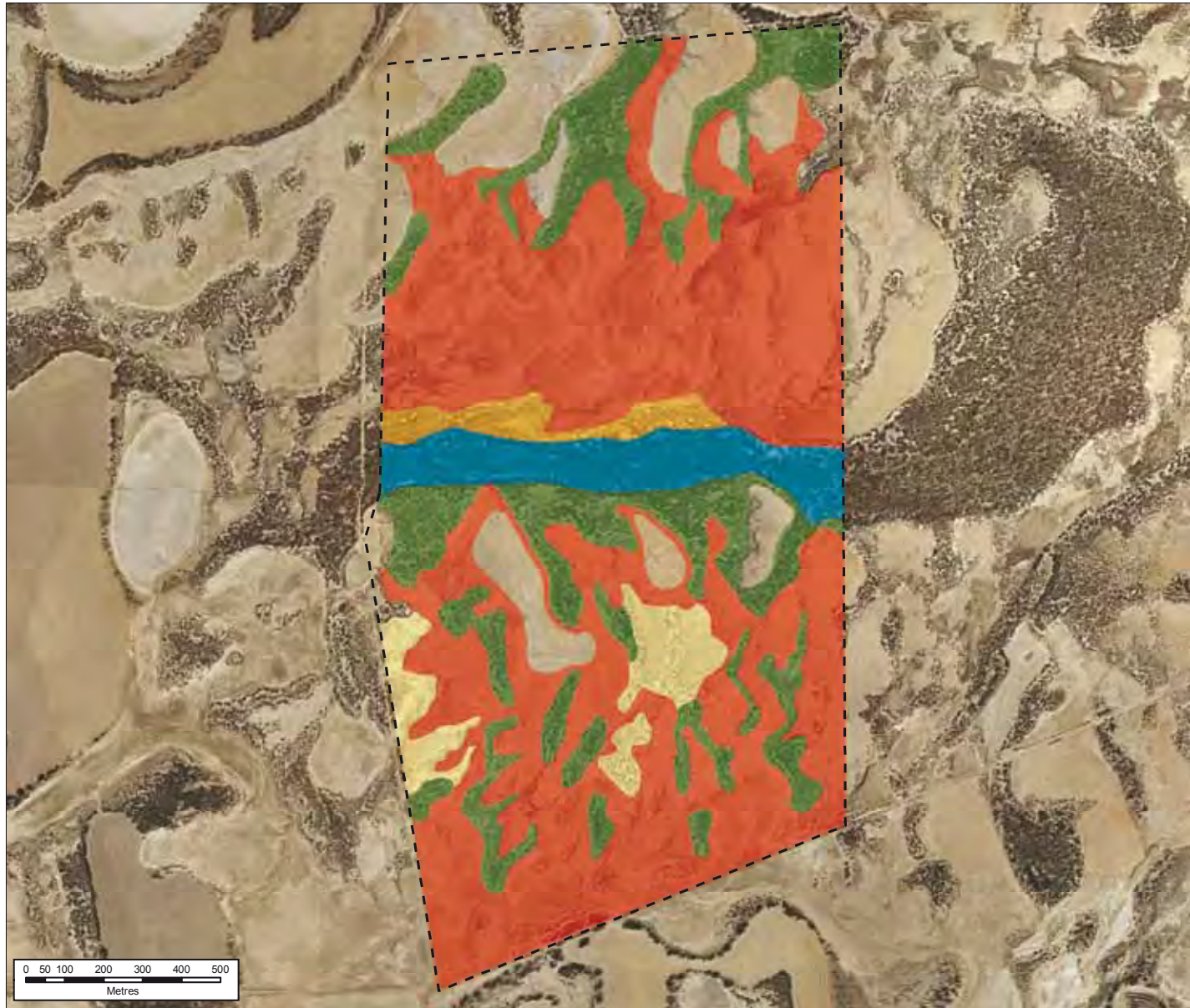
SOURCES
 The Department of Water acknowledges the following datasets and their custodians in the production of this map:
 Corrigin South Orthomosaic – Landgate – 2000

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 Upper Camm River mapping project at the scale of 1:13 000.

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 CR02 – Hardy's

General Details

Site name	Hardy's
Landholder	Jennifer Hardy
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date	25.08.2008

Site Description

Landform	The site is on the valley floor and consists of discontinuous channels and a small playa lake on the north side of a small rise approximately 30 cm above the valley floor. The southern side is largely flat with some standing water and appears to have been cleared. The elevation over the site is less than 1 m.
Site size	102 ha

Beard Vegetation Description

Beard vegetation association 37: Shrublands; teatree thicket

Beard vegetation association 131: Mosaic: Medium woodland; salmon gum and gimlet / Shrublands; mallee scrub, redwood & black marlock

Overall vegetation structure and cover (for vegetated areas only)

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	<i>Eucalyptus kondininensis</i> , <i>Acacia acuminata</i>
Mallees	0	
Shrubs	30–70%	<i>Tecticornia</i> spp., <i>Melaleuca pauperiflora</i> , <i>Dodonaea viscosa</i> , <i>Rhagodia preissii</i>
Grasses	< 2%	<i>Eragrostis dielsii</i> , mixed annual species
Herbs	< 2%	Mixed annual species
Rushes and sedges	0	
Litter	< 2%	
Bare Ground	30–70%	
Rock Outcrop	0	

Summary

The low areas are largely samphire with dead *Melaleuca* spp. and (probably) *Eucalyptus* stems/trunks (largely to the north). The rise is *Melaleuca* (various species) and occasional *Eucalyptus spathulata* and *E. kondininensis*.

Individual vegetation association descriptions

Vegetation 1	<i>Tecticornia</i> spp. Low Heath (dead stems indicate different vegetation in the past)
Vegetation 2	<i>Melaleuca hamata</i> Low Woodland to 5 m over <i>Rhagodia preissii</i> Low Open Low Scrub
Vegetation 3	<i>Eucalyptus kondininensis</i> Open Woodland over <i>Acacia acuminata</i> Open Low Woodland over <i>Melaleuca pauperiflora</i> , <i>Dodonaea viscosa</i> Open Scrub to 4 m over Open Herbs.

Native species

Scientific name	Common name
+ <i>Acacia acuminata</i>	jam
<i>Austrodanthonia</i> sp.	wallaby grass
<i>Baeckea</i> sp.	myrtle
<i>Brachyscome</i> sp.	daisy
<i>Cotula coronopifolia</i>	waterbuttons
<i>Darwinia halophila</i>	darwinia
<i>Didymanthus roei</i>	
<i>Disphyma crassifolium</i>	round leaved pigface
<i>Dodonaea viscosa</i>	sticky hopbush
<i>Enchylaena tomentosa</i>	ruby saltbush
<i>Eragrostis dielsii</i>	mallee lovegrass
<i>Eremophila decipiens</i>	slender fuchsia
<i>Eucalyptus kondininensis</i>	Kondinin blackbutt
<i>Eucalyptus spathulata</i>	swamp mallet
<i>Lycium australe</i>	Australian boxthorn
<i>Maireana brevifolia</i>	small-leaf bluebush
+ <i>Melaleuca hamata</i>	brushwood
<i>Melaleuca lateriflora</i>	gorada
<i>Melaleuca pauperiflora</i>	boree
<i>Mirbelia spinosa</i>	
<i>Podolepis lessonii</i>	
<i>Podotheca gnaphalioides</i>	golden longheads
<i>Rhagodia preissii</i>	rhagodia
<i>Senecio</i> sp.	groundsel
<i>Tecticornia lylei</i>	samphire
<i>Tecticornia</i> spp.	samphire (2 species)
<i>Waitzia acuminata</i>	orange immortelle

+ Regeneration noted

Weed species

Scientific name	Common name
<i>Arctotheca calendula</i>	capeweed
<i>Bromus rubens</i>	red brome
<i>Cotula bipinnata</i>	ferry cotula
<i>Lolium rigidum</i>	annual ryegrass
<i>Mesembryanthemum nodiflorum</i>	slender ice-plant
<i>Monoculus monstrosus</i>	stinking Roger
<i>Moraea setifolia</i>	thread iris
<i>Parapholis incurva</i>	coast barbgrass
<i>Raphanus raphanistrum</i>	wild radish

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	1
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	11
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	22
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	65

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			x	Service corridors			
Clearing		x		Feral animals		x	
Fire risk				Recreation			
Weed invasion			x	Point source discharge			
Stock access		x		Other			
Vehicle access			x				

Comments

Feral animals are present on the site; mainly rabbits. The site has been previously cleared in parts, but is regenerating in some areas.

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
CR23366	939	1.5 km NE
Kondinin Salt Marsh Nature Reserve	2828	2.0 km E

Management

It is recommended that the floodplain is fenced to exclude grazing and protect regenerating vegetation. Some of the site, particularly along the southern and eastern sides may be suitable for saltland grazing, with planting of shade trees using local species that grow adjacent to salt lakes. Rabbit control is recommended, however any management recommendations that may improve the condition of the site would require implementation at the catchment scale.

Fauna

Scientific name	Common name
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Birds

<i>Acanthiza</i> spp.	thornbills
<i>Cacatua roseicapilla</i>	galah
<i>Corvus coronoides</i>	Australian raven
<i>Cracticus torquatus</i>	grey butcherbird
<i>Neophema elegans</i>	elegant parrot
<i>Platycercus zonarius</i>	Australian ringneck parrot
<i>Pomatostomus superciliosus</i>	white browed babbler

Mammals

<i>Macropus fuliginosus</i>	western grey kangaroo
<i>Oryctolagus cuniculus</i>	European wild rabbit*
<i>Vulpes vulpes</i>	European red fox*

* *Introduced species*

Other fauna lists for the general area

Greening Australia Western Australia (2004)

Grein (1994)

Lefroy et al. (1991)

Notes:

Photo A1.5: CR02
Degraded condition vegetation association 1: Tecticornia spp.
Low Heath (dead stems indicate different vegetation in the past).



Photo A1.6: CR02
Good condition vegetation association 2: Melaleuca hamata
Low Woodland over *Rhagodia preissii* Low Open Low Scrub.



Photo A1.7: CR02
Very good condition vegetation association 3: Eucalyptus kondininensis Open Woodland over *Acacia acuminata* Open Low Woodland over *Melaleuca pauperiflora* and *Dodonaea viscosa* Open Scrub over Open Herbs.

Map A2
Vegetation condition for
survery site CR02
Hardy's



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: Melanie Webb
 Task ID: 7114
 Filepath: J:\gis\projects\ProjectB_Series\B410C0002.mxd
 Filename: MapA2_Veg_cond_survery_site_CR02.mxd
 Compilation date: June 2009
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SOURCES

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 Corrigin South Orthomosaic – Landgate – 2000

Government of Western Australia
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Site CR03 – Henderer’s

General Details

Site name	Henderer’s
Landholder	David Henderer
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date	26.08.2008

Site Description

Landform	The site is on the valley floor. Most of the site is within the drainage channel. The elevation is less than 30 cm.
Site size	150 ha

Beard Vegetation Description

Beard vegetation association 37: Shrublands; teatree thicket

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

Overall vegetation structure and cover (for vegetated areas only)

Vegetation layer	Canopy cover class	Dominant species
Trees	< 2%	<i>Eucalyptus spathulata</i>
Mallees	2–10%	<i>Eucalyptus horistes</i>
Shrubs	10–30%	<i>Melaleuca lateriflora</i> , <i>M. pauperiflora</i> , <i>Lycium australe</i> , <i>Tecticornia</i> spp.
Grasses	2–10%	<i>Neurachne alopecuroidea</i> , mixed annual species
Herbs	2–10%	<i>Lomandra effusa</i> , <i>Mesembryanthemum nodiflorum</i>
Rushes and sedges	< 2%	
Litter	< 2%	
Bare Ground	> 70%	
Rock Outcrop	0	

Summary

The majority of the site is within the drainage channel, and is covered by samphire and dead stems. Raised areas have melaleuca shrubland, occasionally with emergent *Eucalyptus spathulata* trees and a small area of mallee.

Individual vegetation association descriptions

Vegetation 1	<i>Tecticornia</i> spp. Dwarf Scrub over <i>Mesembryanthemum nodiflorum</i> Very Open Herbs
Vegetation 2	<i>Melaleuca pauperiflora</i> Open Scrub to 4 m with scattered <i>Eucalyptus spathulata</i> over <i>Lycium australe</i> Open Low Scrub to 2 m over <i>Tecticornia</i> spp. (2) Dwarf Scrub over Open Herbs
Vegetation 3	<i>Melaleuca lateriflora</i> and <i>Melaleuca pauperiflora</i> Scrub to 4 m over <i>Mesembryanthemum nodiflorum</i> Very Open Herbs
Vegetation 4	<i>Eucalyptus horistes</i> Very Open Tree Mallee over <i>Lomandra effusa</i> and mixed annual Very Open Herbs over <i>Neurachne alopecuroidea</i> Very Open Low Grass

Native species

Scientific name	Common name
<i>Alyxia buxifolia</i>	dysentery bush
<i>Calandrinia eremaea</i>	twining purslane
<i>Clematis delicata</i>	clematis
<i>Comesperma integerrimum</i>	milkwort
<i>Disphyma crassifolium</i>	round leaved pigface
<i>Eucalyptus calycogona</i>	gooseberry mallee
<i>Eucalyptus horistes</i>	white flowered mallee
<i>Eucalyptus spathulata</i>	swamp mallet
<i>Hakea kippistiana</i>	hakea
<i>Juncus</i> sp.	rush
<i>Lomandra effusa</i>	scented matrush
<i>Lycium australe</i>	Australian boxthorn
<i>Maireana carnosae</i>	cottony bluebush
<i>Melaleuca acuminata</i>	
<i>Melaleuca adnata</i>	
<i>Melaleuca hamata</i>	brushwood
<i>Melaleuca lateriflora</i>	gorada
<i>Melaleuca pauperiflora</i>	boree
<i>Neurachne alopecuroidea</i>	foxtail mulga grass
<i>Ptilotus manglesii</i>	pom poms
<i>Rhagodia preissii</i>	rhagodia
<i>Santalum acuminatum</i>	quandong
<i>Sclerolaena costata</i>	
<i>Senecio</i> sp.	groundsel
<i>Siloxerus multiflorus</i>	
<i>Tecticornia</i> spp.	samphire (2 species)
<i>Wilsonia humilis</i>	silky wilsonia

Weed species

Scientific name	Common name
<i>Arctotheca calendula</i>	capeweed
<i>Brassica tournefortii</i>	wild turnip
<i>Hypochaeris glabra</i>	flatweed
<i>Lolium</i> sp.	rye grass
<i>Mesembryanthemum nodiflorum</i>	sender ice-plant

Weed species (continued)

Scientific name	Common name
<i>Monoculus monstrosus</i>	stinking Roger
<i>Parapholis incurva</i>	coast barbgrass
<i>Trifolium subterraneum</i>	subterranean clover
<i>Vulpia myuros</i>	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	7
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	25
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	10
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	51

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

The site is grazed.

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
CR23366	939	Adjacent to site
Karlgarin Nature Reserve	469	1.0 km NE

Management

It is recommended that rubbish be removed from the site. Fencing could be erected to exclude grazing on the floodplain. Rabbits and other feral animals should be controlled. Barer areas on the rises should be revegetated with shrub species. Management of salinity and waterlogging should be on a catchment scale.

Fauna

Scientific name	Common name
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Birds

<i>Acanthagenys rufogularis</i>	spiny-cheeked honeyeater
<i>Acanthiza</i> sp.	thornbill
<i>Corvus coronoides</i>	Australian raven
<i>Cracticus tibicen</i>	magpie
<i>Cracticus torquatus</i>	grey butcherbird
<i>Epthianura albifrons</i>	white-fronted chat
<i>Grallina cyanoleuca</i>	magpie-lark
<i>Lichenostomus virescens</i>	singing honey-eater
<i>Neophema elegans</i>	elegant parrot
<i>Pardalotus striatus</i>	striated pardalote
<i>Platycercus varius</i>	mulga parrot
<i>Platycercus zonarius</i>	Australian ringneck parrot
<i>Pomatostomus superciliosus</i>	white browed babbler
<i>Rhipidura leucophrys</i>	willy wagtail

Mammals

<i>Macropus fuliginosus</i>	western grey kangaroo
<i>Oryctolagus cuniculus</i>	European wild rabbit*

* Introduced species

Other fauna lists for the general area

Greening Australia Western Australia (2004)
 Grein (1994)
 Lefroy et al. (1991)

Notes:

Photo A1.8: CR03
 Degraded condition vegetation association 1: *Tecticornia* spp. Dwarf Scrub over *Mesembryanthemum nodiflorum* Very Open Herbs.



Photo A1.9: CR03
 Good condition vegetation association 2: *Melaleuca pauperiflora* Open Scrub with scattered *Eucalyptus spathulata* over *Lycium australe* Open Low Scrub over *Tecticornia* spp. Dwarf Scrub over Open Herbs.

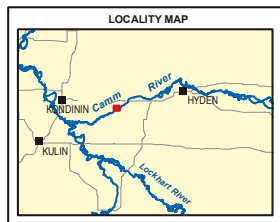


Photo A1.10: CR03
 Good condition vegetation association 3: *Melaleuca lateriflora* and *Melaleuca pauperiflora* Scrub over *Mesembryanthemum nodiflorum* Very Open Herbs.



Photo A1.11: CR03
 Very good condition vegetation association 4: *Eucalyptus horistes* Very Open Tree Mallee over *Lomandra effusa* and mixed annual Very Open Herbs and *Neurachne alopecuroidea* Very Open Low Grass.

Map A3
Vegetation condition for
survery site CR03
Henderer's



LEGEND


Vegetation condition

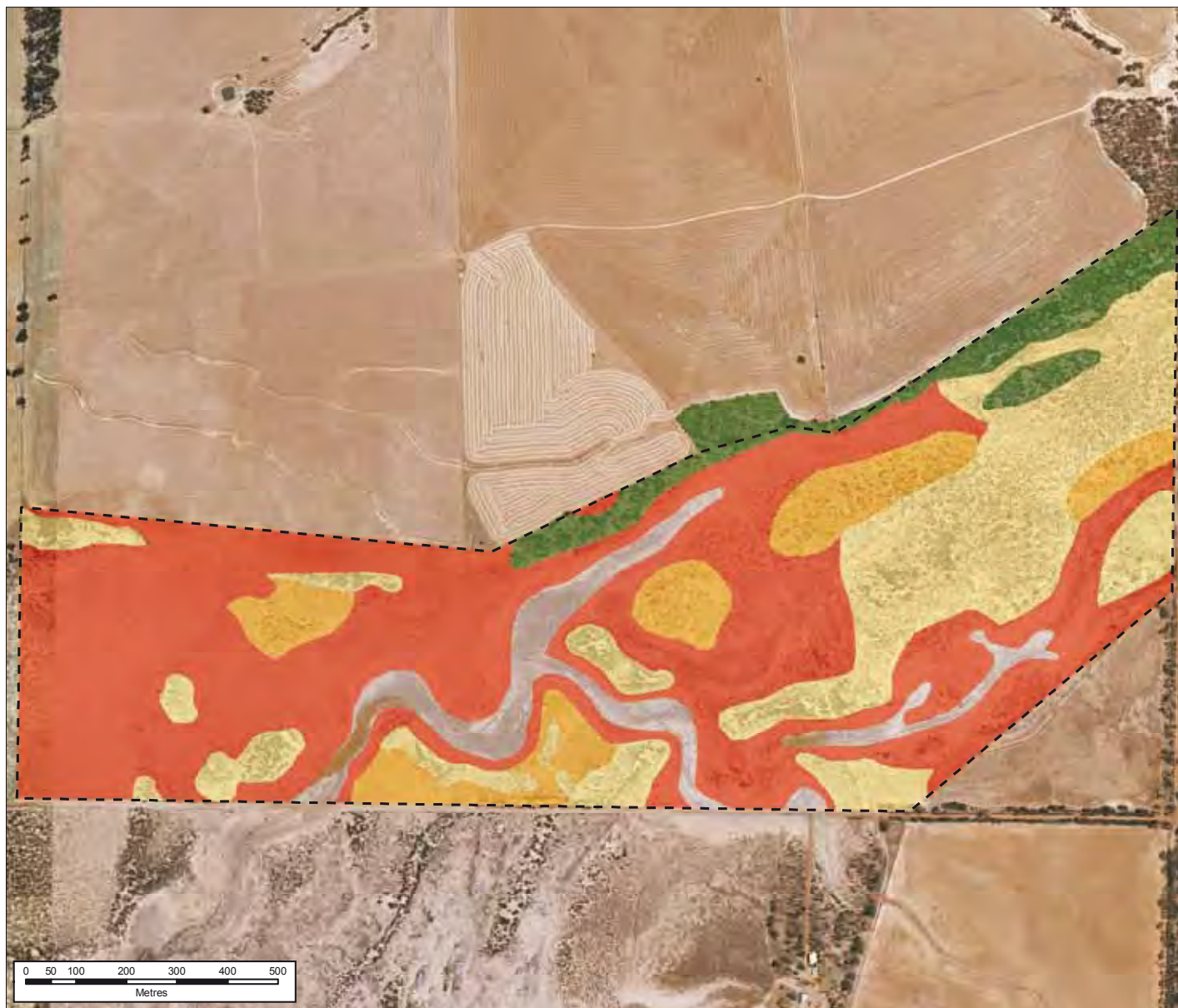
	Revegetation
	Pristine
	Excellent
	Very good
	Good
	Degraded
	Completely degraded

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: Melanie Webb
 Task ID: 7114
 Filepath: J:\gis\projects\ProjectB_Series\B410C\0002.mxd
 Filename: MapA3_Veg_cond_survery_site_CR03.mxd
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SOURCES
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Site CR04 – Weewarra

General Details

Site name	Weewarra
Landholder	Kevin Thompson, Weewarra Nominees Pty Ltd
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date	26.08.2008

Site Description

Landform	The site is within the valley floor; the northern side is on the lower slopes of the valley, with elevation more than 1 m above the valley floor. The main channel and tributary are continuous channels with low-lying overflow areas. The northern bank of the drainage line is rocky for most of the site. There are three semi-permanent pools on the site.
Site size	100 ha

Beard Vegetation Description

Beard vegetation association 41: Shrublands; teatree scrub

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

Overall vegetation structure and cover (for vegetated areas only)

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	<i>Eucalyptus myriadena</i> , <i>E. longicornis</i> , <i>E. salmonophloia</i> , <i>E. salubris</i> , <i>E. kondininensis</i>
Mallees	2–10%	<i>E. loxophleba</i> subsp. <i>gratae</i>
Shrubs	10–30%	<i>Melaleuca pauperiflora</i> , <i>Acacia acuminata</i> , <i>Allocasuarina campestris</i> , <i>Exocarpos aphyllus</i>
Grasses	2–10%	<i>Amphipogon strictus</i> , mixed annual species
Herbs	2–10%	<i>Borya constricta</i>
Rushes and sedges	0	
Litter	2–10%	
Bare Ground	30–70%	
Rock Outcrop	< 2% (concretionary laterite and granite)	

Summary

The south-eastern portion of the site has been cleared and cultivated, but has since been abandoned and has become samphire. The south-west corner is melaleuca shrubland, sometimes with emergent trees. The northern bank of the drainage line supports various woodlands and shrublands on laterite. Two of the three semi-permanent pools support an aquatic herb.

Individual vegetation association descriptions

Vegetation 1	<i>Melaleuca pauperiflora</i> Open Scrub to 4 m over Open Herbs
Vegetation 2	<i>Acacia acuminata</i> and <i>Allocasuarina campestris</i> Scrub to 5 m over <i>Amphipogon strictus</i> Very Open Low Grass over <i>Borya constricta</i> Very Open Herbs
Vegetation 3	<i>Eucalyptus myriadena</i> and <i>E. longicornis</i> Open Woodland over <i>Melaleuca pauperiflora</i> and <i>Exocarpos aphyllus</i> Open Low Woodland to 5 m over Very Open Herbs (mostly introduced)
Vegetation 4	<i>Eucalyptus salmonophloia</i> , <i>E. longicornis</i> , <i>E. salubris</i> , <i>E. kondininensis</i> and <i>E. myriadena</i> Open Woodland over <i>Melaleuca pauperiflora</i> , <i>Exocarpos aphyllus</i> Open Low Woodland to 5 m over Very Open Herbs
Vegetation 5	<i>Tecticornia</i> spp. Open Dwarf Scrub over <i>Mesembryanthemum nodiflorum</i> Very Open Herbs

Native species

Scientific name	Common name
<i>Acacia acuminata</i>	jam
<i>Acacia</i> sp.	wattle
<i>Allocasuarina campestris</i>	tamma
<i>Amphipogon strictus</i>	greybeard grass
<i>Angianthus tomentosus</i>	camel-grass
<i>Atriplex hymenotheca</i>	saltbush
<i>Borya constricta</i>	pin-grass
<i>Drosera macrantha</i>	bridal rainbow
<i>Enchylaena tomentosa</i>	ruby saltbush
<i>Erymophyllum tenellum</i>	everlasting
<i>Erodium cygnorum</i>	blue heron's-bill
<i>Eucalyptus kondininensis</i>	Kondinin blackbutt
<i>Eucalyptus longicornis</i>	red morrell
<i>Eucalyptus loxophleba</i> subsp. <i>gratae</i>	Lake Grace gum
<i>Eucalyptus myriadena</i>	eucalypt
<i>Eucalyptus salmonophloia</i>	salmon gum
<i>Eucalyptus salubris</i>	gimlet
<i>Exocarpos aphyllus</i>	leafless ballart
<i>Leptospermum erubescens</i>	roadside tea-tree
<i>Lycium australe</i>	Australian boxthorn
<i>Maireana brevifolia</i>	small-leaf bluebush
<i>Maireana carnosia</i>	cottony bluebush
<i>Melaleuca adnata</i>	
<i>Melaleuca brevifolia</i>	
<i>Melaleuca lateriflora</i>	gorada
<i>Melaleuca pauperiflora</i>	boree
Potamogetonaceae (<i>Ruppia</i> sp. or <i>Lepilaena</i> sp.)	
<i>Rhagodia</i> sp.	rhagodia
<i>Rhodanthe manglesii</i>	pink sunray
<i>Santalum acuminatum</i>	quandong
<i>Sclerolaena diacantha</i>	grey copper-burr
<i>Tecticornia</i> spp.	samphire (2 species)

Weed species

Scientific name	Common name
<i>Brassica tournefortii</i>	wild turnip
<i>Bromus rubens</i>	red brome
<i>Hordeum leporinum</i>	barley grass
<i>Lolium</i> sp.	rye grass
<i>Medicago</i> sp.	medic
<i>Mesembryanthemum nodiflorum</i>	slender ice-plant
<i>Moraea setifolia</i>	thread iris
<i>Sonchus</i> sp.	sow thistle
<i>Trifolium subterraneum</i>	subterranean clover
<i>Vulpia myuros</i>	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	16
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	1
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	9
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	70

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			
Weed invasion				Point source discharge			
Stock access	x			Other			
Vehicle access			x				

Comments

The area is currently not grazed, however previous grazing has contributed to the vegetation condition of the site.

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
Scriveners Nature Reserve	906	6.0 km NE
Lake Gounter Nature Reserve	3283	9.0 km E

Management

It is recommended that rubbish be removed from the site. Feral animals should be controlled. The south-east area may be suitable for saltland grazing species, however the main drainage channel should be fenced to exclude livestock if this occurs. Management of salinity and waterlogging would be required on a catchment scale.

Fauna

Scientific name	Common name
Birds	
<i>Acanthiza</i> spp.	thornbill
<i>Artamus cinereus</i>	black-faced woodswallow
<i>Cacatua roseicapilla</i>	galah
<i>Corvus coronoides</i>	Australian raven
<i>Cracticus tibicen</i>	magpie
<i>Cracticus torquatus</i>	grey butcherbird

<i>Dromaius novaehollandiae</i>	emu
<i>Lichenostomus virescens</i>	singing honey-eater
<i>Ocyphaps lophotes</i>	crested pigeon
<i>Hirundo nigricans</i>	tree martin
<i>Platycercus varius</i>	mulga parrot
<i>Platycercus zonarius</i>	Australian ringneck parrot
<i>Pomatostomus superciliosus</i>	white browed babbler
<i>Rhipidura leucophrys</i>	willy wagtail
<i>Smicromnis brevirostris</i>	weebill
<i>Tadorna tadornoides</i>	Australian shelduck (mountain duck)

Mammals

<i>Macropus fuliginosus</i>	western grey kangaroo
<i>Oryctolagus cuniculus</i>	European wild rabbit*

* *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 landholder:

- The cleared area was cleared in 1926
- The landholder does not believe the condition has changed much in 35 years
- The site is no longer grazed (the landholder is not currently running livestock).

From observations on site:

- Water sampled at the northern pool had pH 8.2 and temperature of 17.2°C. The conductivity was 43.6 mS/cm.



Photo A1.12: CR04
 Very good condition vegetation
 association 1: *Melaleuca pauperiflora*
 Open Scrub over Open Herbs.



Photo A1.13: CR04
Excellent condition vegetation association 2: *Acacia acuminata* and *Allocasuarina campestris* Scrub over *Amphipogon strictus* Very Open Low Grass over *Borya constricta* Very Open Herbs.



Photo A1.14: CR04
Very good condition vegetation association 3: *Eucalyptus myriadena* and *E. longicornis* Open Woodland over *Melaleuca pauperiflora* and *Exocarpos aphyllus* Open Low Woodland over Very Open Herbs (mostly introduced).



Photo A1.15: CR04
Very good to Excellent condition vegetation association 4: *Eucalyptus salmonophloia*, *E. longicornis*, *E. salubris*, *E. kondininensis*, *E. loxophleba* subsp. *gratae* and *E. myriadena* Open Woodland over *Melaleuca pauperiflora* and *Exocarpos aphyllus* Open Low Woodland over Very Open Herbs.



Photo A1.16: CR04
Completely degraded vegetation association 5: *Tecticornia* sp. Open Dwarf Scrub over *Mesembryanthemum nodiflorum* Very Open Herbs.

Map A4
Vegetation condition for
survery site CR04
Weewarra Nominees



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: Melanie Webb
 Task ID: 7114
 Filepath: J:\gis\projects\ProjectB_Series\B410C\002.mxd
 Filename: MapA4_Veg_cond_survery_site_CR04.mxd
 Compilation date: June 2009
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SOURCES

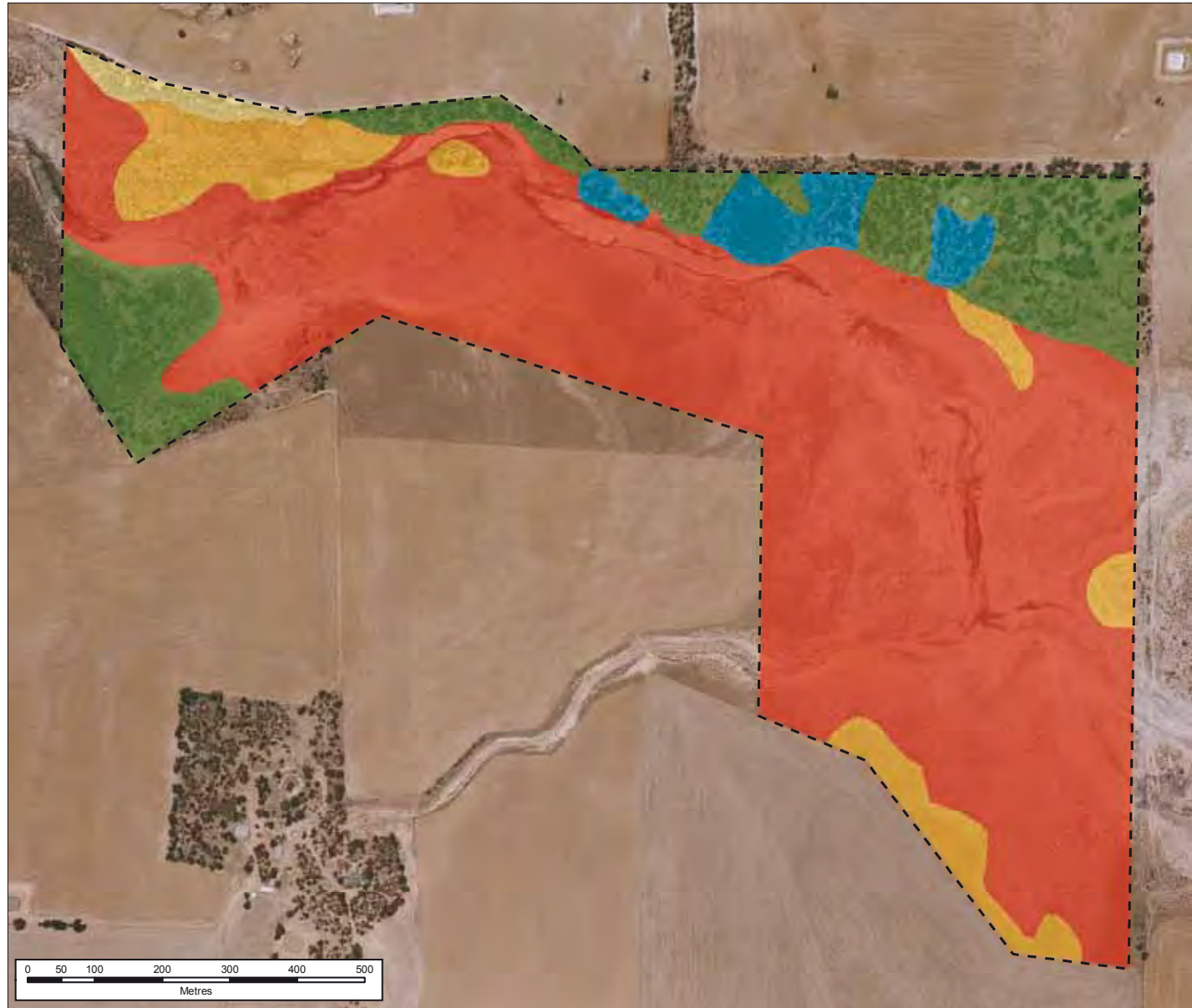
The Department of Water acknowledges the following datasets and their custodians in the production of this map:
 Corrigin South Orthomosaic – Landgate – 2000

Government of Western Australia
 Department of Water

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Site CR05 – Richter's

General Details

Site name	Richter's
Landholder	Ronald Richter
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date	26.08.2008

Site Description

Landform The site is a valley floor which is largely flat with the main drainage channel a continuous channel through the centre of the site, and discontinuous channels largely to the north. The north and southern edges are gently sloping.

Site size 254 ha

Beard Vegetation Description

Beard vegetation association 41: Shrublands; teatree scrub

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

Overall vegetation structure and cover (for vegetated areas only)

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	<i>Eucalyptus loxophleba</i> , <i>E. salmonophloia</i>
Mallees	0	
Shrubs	10–30%	<i>Melaleuca pauperiflora</i> , <i>M. lateriflora</i> , <i>M. acuminata</i> , <i>Tecticornia</i> spp., <i>Maireana brevifolia</i> , <i>Atriplex paludosa</i> , <i>Santalum acuminatum</i> , <i>Hakea kippistiana</i> , <i>Scaevola spinescens</i> , <i>Rhagodia preissii</i>
Grasses	< 2%	Mixed annual species
Herbs	10–30%	<i>Mesembryanthemum nodiflorum</i> , <i>Lomandra effusa</i>
Rushes and sedges	0	
Litter	2–10%	
Bare Ground	> 70%	
Rock Outcrop	0	

Summary

The south-west and north-east sections of the site have been cleared and have since been abandoned. They are now largely samphire with some saltbush and bluebush. Uncleared areas adjacent to the stream channel are melaleuca shrubland or patches of woodland.

Individual vegetation association descriptions

Vegetation 1	Previously cleared area <i>Tecticornia</i> spp., <i>Maireana brevifolia</i> and <i>Atriplex paludosa</i> Open Dwarf Scrub over <i>Mesembryanthemum nodiflorum</i> Open Herbs
Vegetation 2	Melaleuca fringing waterway <i>Melaleuca pauperiflora</i> and <i>M. lateriflora</i> Scrub over mixed annual Open Herbs
Vegetation 3	Samphire in drainage line/valley floor <i>Tecticornia</i> spp. Dwarf Scrub over <i>Mesembryanthemum nodiflorum</i> Open Herbs
Vegetation 4	<i>Eucalyptus loxophleba</i> and <i>E. salmonophloia</i> Open Woodland over <i>Melaleuca pauperiflora</i> , <i>M. acuminata</i> , <i>Hakea kippistiana</i> and <i>Santalum acuminatum</i> Open Low Woodland to 4 m over <i>Scaevola spinescens</i> and <i>Rhagodia preissii</i> Open Low Scrub to 1.5 m over <i>Lomandra effusa</i> Very Open Herbs

Native species

Scientific name	Common name
<i>Atriplex bunburyana</i>	silver saltbush
<i>Austrostipa elegantissima</i>	feather speargrass
<i>Austrostipa</i> sp.	speargrass
<i>Comesperma integerrimum</i>	milkwort
<i>Eucalyptus loxophleba</i>	York gum
<i>Eucalyptus myriadena</i>	eucalypt
<i>Eucalyptus salmonophloia</i>	salmon gum
<i>Exocarpos aphyllus</i>	leafless ballart
+ <i>Hakea kippistiana</i>	hakea
<i>Lycium australe</i>	Australian boxthorn
<i>Maireana brevifolia</i>	small-leaf bluebush
<i>Melaleuca lateriflora</i>	gorada
<i>Melaleuca pauperiflora</i>	boree
<i>Rhagodia preissii</i>	rhagodia
<i>Santalum acuminatum</i>	quandong
+ <i>Scaevola spinescens</i>	currant bush
<i>Sclerolaena diacantha</i>	grey copper-burr
<i>Senecio</i> sp.	groundsel
<i>Spergularia marina</i>	spurry
<i>Tecticornia</i> spp.	samphire (2-3 species)

+ *Regeneration noted*

Weed species

Scientific name	Common name
<i>Arctotheca calendula</i>	capeweed
<i>Brassica tournefortii</i>	wild turnip
<i>Bromus rubens</i>	red brome
<i>Cotula bipinnata</i>	ferry cotula
<i>Mesembryanthemum nodiflorum</i>	slender ice-plant
<i>Monoculus monstrosus</i>	stinking Roger
<i>Moraea setifolia</i>	thread iris
<i>Parapholis incurva</i>	coast barbgrass

Weed species (continued)

Scientific name	Common name
<i>Pentaschistis airoides</i>	false hair-grass
<i>Vulpia myuros</i>	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	2
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	7
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	77

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			
Waterlogging			x	Plant disease			
Ponding from road crossing				Erosion			
Drainage				Service corridors			
Clearing		x		Feral animals		x	
Fire risk				Recreation			
Weed invasion			x	Point source discharge			
Stock access			x	Other			
Vehicle access			x				

Comments

Rabbits were present on the site. It is not known if the site is currently grazed.

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
Scriveners Nature Reserve	906	5.0 km N
Lake Gounter Nature Reserve	3283	6.0 km E

Management

The site is fenced and revegetation was noted in the south-east corner near the road. The south-west and north-eastern parts of the site may be suitable for saltland grazing species or may be currently grazed, however the main channel should be protected from livestock to prevent soil erosion and permit regeneration of vegetation. Any management that improves salinity or waterlogging would require implementation at a catchment scale.

Fauna

Scientific name
Common name

Birds

<i>Acanthagenys rufogularis</i>	spiny-cheeked honeyeater
<i>Acanthiza apicalis</i>	inland thornbill
<i>Anthus australis</i>	pipit
<i>Cacatua roseicapilla</i>	galah
<i>Coracina novaehollandiae</i>	black-faced cuckoo-shrike
<i>Cracticus nigrogularis</i>	piebald butcher bird
<i>Cracticus torquatus</i>	grey butcher bird
<i>Epthianura albifrons</i>	white-fronted chat
<i>Lichenostomus virescens</i>	singing honey-eater
<i>Pardalotus striatus</i>	striated pardalote
<i>Phaps chalcoptera</i>	common bronzewing
<i>Platycercus zonarius</i>	Australian ringneck parrot

Mammals

<i>Oryctolagus cuniculus</i>	European wild rabbit*
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* *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 landholder:

- Vegetation and waterway condition has declined steadily since the 1940s with no noticeable changes after flood events.



Photo A1.17: CR05
Completely degraded vegetation association 1: *Tecticornia* sp., *Maireana brevifolia*, *Atriplex paludosa* Open Dwarf Scrub over *Mesembryanthemum nodiflorum* Open Herbs on a previously cleared area.



Photo A1.18: CR05
Very good condition vegetation association 2: *Melaleuca pauperiflora* and *M. lateriflora* Scrub over mixed annual Open Herbs.



Photo A1.19: CR05
Completely degraded vegetation association 3: *Tecticornia* spp. Dwarf Scrub over *Mesembryanthemum nodiflorum* Open Herbs.



Photo A1.20: CR05
Excellent condition vegetation Association 4: *Eucalyptus loxophleba* and *E. salmonophloia* Open Woodland over *Melaleuca pauperiflora*, *M. acuminata*, *Hakea kippistiana* and *Santalum acuminatum* Open Low Woodland over *Scaevola spinescens* and *Rhagodia preissii* Open Low Scrub over *Lomandra effusa* Very Open Herbs.

Map A5
Vegetation condition for
survery site CR05
Richter's



LEGEND

Vegetation condition

Red	Completely degraded
Yellow	Degraded
Green	Very good
Blue	Excellent
Grey	Pristine
Brown	Revegetation

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

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Government of Western Australia
 Department of Water

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Site CR06 – Karlgarin Lake

General Details

Site name	Karlgarin Lake
Landholder	Shire of Kondinin
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date	26.08.2008

Site Description

Landform The site is largely occupied by Lake Karlgarin, which is mostly bare soil and open water, with a few samphire-covered former shoreline lunettes emergent from the lake bed. The eastern shore of the lake has lunettes in series, roughly parallel with the current shoreline. The western tip of the lake appears to be the exit site for water, with some areas of lunettes. Drainage lines to the west are discontinuous. Northwest of the lake is raised to several metres above the valley floor.

Site size 570 ha

Beard Vegetation Description

Beard vegetation association 41: Shrublands; teatree thicket.

Beard vegetation association 125: Shrublands; teatree scrub.

Beard vegetation association 945: Mosaic; Medium woodland; salmon gum (*E. salmonophloia*)/shrubland; mallee scrub, redwood (*E. transcontinentalis*) and black marlock (*E. redunca*).

Overall vegetation structure and cover (for vegetated areas only)

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	<i>Eucalyptus spathulata</i> , <i>E. loxophleba</i> , <i>E. salicola</i> , <i>E. salmonophloia</i> , <i>E. longicornis</i>
Mallees	10–30%	<i>Eucalypts subangusta</i> , <i>E. modesta</i> , <i>E. myriadena</i>
Shrubs	10–30%	<i>Tecticornia</i> spp., <i>Melaleuca pauperiflora</i> , <i>M. lateriflora</i> , <i>M. uncinata</i> , <i>M. viminea</i> , <i>Darwinia halophila</i> , <i>Grevillea anethifolia</i> , <i>Santalum acuminatum</i> , <i>Acacia acuminata</i> , <i>Allocasuarina campestris</i> , <i>Alyxia buxifolia</i> , <i>Hakea kippistiana</i>
Grasses	< 2%	Mixed annual weeds
Herbs	< 2%	<i>Borya sphaerocephala</i> , <i>B. laciniata</i> , <i>Drosera</i> sp., <i>Lomandra effusa</i>
Rushes and sedges	< 2%	<i>Desmocladus asper</i> , <i>Lepidobolus chaetocephalus</i>
Litter	2–10%	
Bare Ground	30–70%	
Rock Outcrop	2–10% (granite)	

Summary

The lunettes are covered by eucalypt woodland, largely *Eucalyptus salicola*. The lower-lying former lake beds are samphire. South of the lake is woodland, variously salmon gum, morrell, yorrell, York gum mallee or gimlet, except for the south-west corner which is low-lying, covered by samphire or melaleuca (slightly up-slope). The western tip of the lake is samphire. The north-western side is largely a mosaic of vegetation types, including Lake Grace mallee/jam on deeper soils, shrubland around granite outcrops and *Borya* herblands on very shallow soils. There are also extensive areas of mallee with a dense understorey.

Individual vegetation association descriptions

Vegetation 1	<i>Tecticornia</i> spp. Dwarf Scrub over mixed introduced annual Very Open Herbs
Vegetation 2	<i>Melaleuca lateriflora</i> and <i>M. pauperiflora</i> Scrub to 4 m with scattered <i>Eucalyptus spathulata</i> over mixed annual Herbs
Vegetation 3	<i>Grevillea anethifolia</i> , <i>Melaleuca uncinata</i> , <i>M. viminea</i> , <i>Darwinia halophila</i> Low Scrub over <i>Desmocladius asper</i> and <i>Lepidobolus chaetocephalus</i> Very Open Low Sedges
Vegetation 4	<i>Eucalyptus spathulata</i> Open Woodland A over <i>Acacia acuminata</i> and <i>Santalum acuminatum</i> Open Low Woodland over <i>Rhagodia preissii</i> , <i>Leptospermum erubescens</i> Open Low Scrub
Vegetation 5	Mosaic of <i>Eucalyptus loxophleba</i> Open Tree Mallee over <i>Acacia acuminata</i> Scrub over mixed annual Open Herbs (on deeper soils) <i>Acacia acuminata</i> Open Low Scrub over <i>Verticordia chrysanthella</i> Open Dwarf Scrub over <i>Borya sphaerocephala</i> , <i>B. laciniata</i> and <i>Drosera</i> spp. Herbs (on soil around rocks) <i>Allocasuarina campestris</i> , <i>Melaleuca elliptica</i> , <i>Grevillea anethifolia</i> Scrub to 4 m over mixed annual Open Herbs
Vegetation 6	<i>Eucalyptus subangusta</i> and <i>E. moderata</i> Open Shrub Mallee over <i>Melaleuca coronicarpa</i> , <i>M. adnata</i> and <i>Daviesia benthamii</i> Heath
Vegetation 7	<i>Eucalyptus salicola</i> Open Low Woodland over <i>Dodonaea viscosa</i> ssp. <i>angustissima</i> , <i>Alyxia buxifolia</i> and <i>Hakea kippistiana</i> Scrub to 3 m over <i>Rhagodia preissii</i> Open Dwarf Scrub over <i>Lomandra effusa</i> Very Open Herbs
Vegetation 8	<i>Tecticornia</i> spp., <i>Atriplex</i> sp Open Dwarf Scrub over <i>Disphyma crassifolium</i> Open Herbs. Many dead tree stumps, possibly <i>E. myriadena</i>
Vegetation 9	<i>Eucalyptus salmonophloia</i> , <i>E. longicornis</i> and <i>E. myriadena</i> Open Woodland over <i>Atriplex</i> sp., <i>Olearia muelleri</i> , <i>Scaevola spinescens</i> , <i>Rhagodia drummondii</i> and <i>Exocarpos aphyllus</i> Dwarf Scrub

Native species

Scientific name	Common name
<i>Acacia acuminata</i>	jam
<i>Allocasuarina campestris</i>	tamma
<i>Allocasuarina huegeliana</i>	rock sheoak
<i>Atriplex</i> sp.	saltbush
<i>Austrostipa</i> sp.	speargrass

Native species (continued)

Scientific name	Common name
<i>Borya laciniata</i>	pin-grass
<i>Borya sphaerocephala</i>	pincushions
<i>Brachycome iberidifolia</i>	Swan river daisy
<i>Calytrix leschenaultii</i>	purple starflower
<i>Chamaescilla corymbosa</i>	blue squill
<i>Darwinia halophila</i>	darwinia
<i>Daviesia benthamii</i>	bitter pea
<i>Desmocladius asper</i>	
<i>Dodonaea viscosa</i> subsp. <i>angustissima</i>	sticky hop bush
<i>Dianella revoluta</i>	blueberry lily
<i>Disphyma crassifolium</i>	round-leaved pigface
<i>Drosera</i> spp.	sundews (many)
<i>Enchylaena tomentosa</i>	ruby saltbush
<i>Erymophyllum tenellum</i>	everlasting
<i>Eucalyptus longicornis</i>	red morrell
<i>Eucalyptus loxophleba</i> subsp. <i>gratae</i>	Lake Grace gum
<i>Eucalyptus moderata</i>	eucalypt
<i>Eucalyptus myriadena</i>	eucalypt
<i>Eucalyptus salmonophloia</i>	salmon gum
<i>Eucalyptus spathulata</i>	swamp mallet
<i>Eucalyptus subangusta</i>	black marlock
<i>Exocarpos aphyllus</i>	leafless ballart
<i>Gahnia ancistrophylla</i>	hooked-leaf saw sedge
<i>Grevillea anethifolia</i>	grevillea
<i>Grevillea acuaria</i>	grevillea
<i>Grevillea huegelii</i>	black toothbrush grevillea
+ <i>Hakea kippistiana</i>	hakea
<i>Hypoxis</i> sp.	
<i>Lepidobolus chaetocephalus</i>	bristle-headed chaff rush
<i>Lepidosperma drummondii</i>	sword sedge
<i>Leptospermum erubescens</i>	roadside tea-tree
<i>Lomandra effusa</i>	scented matrush
<i>Lycium australe</i>	Australian boxthorn
<i>Melaleuca acuminata</i>	
<i>Melaleuca adnata</i>	
+ <i>Melaleuca brevifolia</i>	
<i>Melaleuca coroncarpa</i>	
<i>Melaleuca elliptica</i>	granite bottlebrush
+ <i>Melaleuca hamata</i>	brushwood
<i>Melaleuca lateriflora</i>	gorada
<i>Melaleuca pauperiflora</i>	boree

Native species (continued)

Scientific name	Common name
<i>Melaleuca uncinata</i>	brushwood
+ <i>Melaleuca viminea</i>	mohan
<i>Olearia dampieri</i>	daisy bush
<i>Olearia muelleri</i>	dusky daisy bush, goldfields daisy
<i>Pittosporum angustifolium</i>	native apricot, native willow
<i>Podolepis lessonii</i>	
<i>Podotheca gnaphalioides</i>	golden longheads
<i>Rhagodia drummondii</i>	rhagodia
<i>Rhagodia preissii</i>	rhagodia
<i>Santalum acuminatum</i>	quandong
<i>Santalum spicatum</i>	sandalwood
<i>Scaevola spinescens</i>	currant bush
<i>Sclerolaena diacantha</i>	grey copper-burr
<i>Senecio</i> sp.	groundsel
<i>Siloxerus multiflorus</i>	
<i>Stylidium repens</i>	matted triggerplant
<i>Trachymene</i> sp.	coogan
<i>Tecticornia</i> spp.	samphire (2 species)
<i>Verticordia chrysanthella</i>	feather flower
<i>Waitzia acuminata</i>	orange immortelle
+ <i>Regeneration was noted</i>	

Weed species

Scientific name	Common name
<i>Arctotheca calendula</i>	capeweed
<i>Brassica tournefortii</i>	wild turnip
<i>Bromus rubens</i>	red brome
<i>Cotula bipinnata</i>	ferny cotula
<i>Hypochaeris glabra</i>	flatweed
<i>Mesembryanthemum nodiflorum</i>	slender ice-plant
<i>Moraea setifolia</i>	thread iris
<i>Parapholis incurva</i>	coast barbgrass
<i>Ursinia anthemoides</i>	ursinia

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	30
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	2
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	12
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	7

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		x					

Comments

There is a Shire rubbish dump site on the south-east side of lake. Regeneration was noted

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
Lake Gounter Nature Reserve	3283	Adjacent to site
Scriveners Nature Reserve	906	3.5 km N
CR21705	156	9.0 km SE

Management

It is recommended that the rubbish tip be relocated and scattered rubbish along the tracks removed. Feral animals and weeds should be controlled. Although the small amount of vehicle use of existing tracks does not appear to be causing damage in most cases, it is recommended that the track along the eastern shore lunette is permanently closed. Any management recommendations that may be effective in reducing the effects of salinity or waterlogging must be conducted at a catchment scale.

Fauna

Scientific name

Common name

Birds

<i>Cacatua roseicapilla</i>	galah
<i>Corvus coronoides</i>	Australian raven
<i>Cracticus tibicen</i>	magpie
<i>Cracticus torquatus</i>	grey butcherbird
<i>Dromaius novaehollandiae</i>	emu
<i>Drymodes brunneopygia</i>	southern scrub-robin
<i>Epthianura albifrons</i>	white-fronted chat
<i>Hirundo neoxena</i>	welcome swallow
<i>Hirundo nigricans</i>	tree martin
<i>Lichenostomus virescens</i>	singing honey-eater
<i>Ocyphaps lophotes</i>	crested pigeon
<i>Pachycephala pectoralis</i>	golden whistler
<i>Petroica goodenovii</i>	red-capped robin
<i>Phaps chalcoptera</i>	common bronzewing
<i>Platycercus zonarius</i>	Australian ringneck parrot
<i>Polytelis anthopeplus</i>	regent parrot
Mammals	
<i>Macropus fuliginosus</i>	western grey kangaroo

* Introduced species

Other fauna lists for the general area

Greening Australia Western Australia (2004)

Grein (1994)

Lefroy et al. (1991)

Notes:

- Priority 1 flora have been recorded close to the site, within the same vegetation type but not within site.



Photo A1.21: CR06
 Completely degraded vegetation association 1: *Tecticornia* spp. Dwarf Scrub over mixed introduced annual Very Open Herbs.



Photo A1.22: CR06
 Very good condition vegetation association 2: *Melaleuca lateriflora* and *M. pauperiflora* Scrub to 4 m with scattered *Eucalyptus spathulata* over mixed annual Herbs.



Photo A1.23: CR06
 Excellent condition vegetation association 3: *Grevillea anethifolia*, *Melaleuca uncinata*, *M. viminea* and *Darwinia halophila* Low Scrub over *Desmocladius asper* and *Lepidobolus chaetocephalus* Very Open Low Sedges.



Photo A1.24:
 Very good condition vegetation association 4: *Eucalyptus spathulata* Open Woodland A over *Acacia acuminata* and *Santalum acuminatum* Open Low Woodland over *Rhagodia preissii* and *Leptospermum erubescens* Open Low Scrub.



Photo A1.25: CR06

Excellent condition vegetation association 5: Mosaic of:

- *Eucalyptus loxophleba* Low Woodland over *Acacia acuminata* Scrub over mixed annual Open Herbs on deeper soils
- *Acacia acuminata* Open Low Scrub over *Verticordia chrysanthella* Open Dwarf Scrub over *Borya sphaerocephala*, *B. laciniata* and *Drosera* spp. Herbs on soil around rocks
- *Allocasuarina campestris*, *Melaleuca elliptica* and *Grevillea anethifolia* Scrub over mixed annual Open Herbs.



Photo A1.26: CR06

Excellent condition vegetation Association 6: *Eucalyptus*

subangusta and *E modesta* Open Shrub Mallee over

Melaleuca coronicarpa, *M.*

adnata and *Daviesia benthamii*

Heath.



Photo A1.27: CR06
Excellent condition vegetation association 7: *Eucalyptus salicola* Open Low Woodland over *Dodonaea viscosa* subsp. *angustissima*, *Alyxia buxifolia* and *Hakea kippistiana* Scrub over *Rhagodia preissii* Open Dwarf Scrub over *Lomandra effusa* Very Open Herbs.



Photo A1.28: CR06
Degraded condition vegetation association 8: *Tecticornia* spp. and *Atriplex* sp Open Dwarf Scrub over *Disphyma crassifolium* Open Herbs (many dead tree stumps, possibly *E. myriadena*).



Photo A1.29: CR06
Very good condition vegetation Association 9: *Eucalyptus salmonophloia*, *E. longicornis* and *E. myriadena* Open Woodland over *Atriplex* sp., *Olearia muelleri*, *Scaevola spinescens*, *Rhagodia drummondii* and *Exocarpos aphyllus* Dwarf Scrub.

Map A6
Vegetation condition for
survery site CR06
Kalgarin Lake



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: Melanie Webb
 Task ID: 7114
 Filepath: J:\gis\projects\ProjectB_Series\B410C\0002.mxd
 Filename: MapA6_Veg_cond_survery_site_CR06.mxd
 Compilation date: June 2009
 Edition: 1

SOURCES

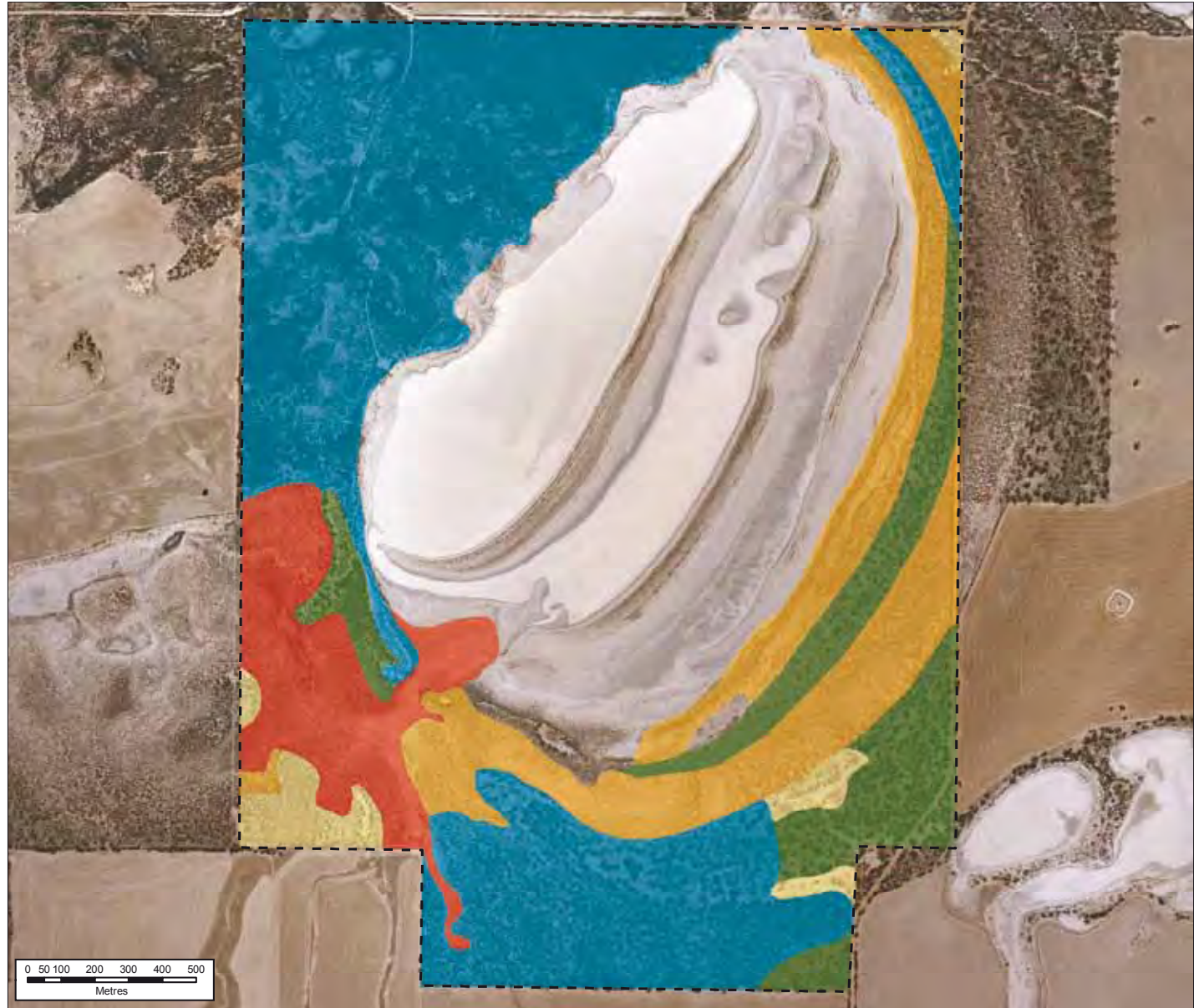
The Department of Water acknowledges the following datasets and their custodians in the production of this map:
 Corrigin South Orthomosaic – Landgate – 2000

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 Upper Camm River mapping project at the scale of 1:15 000.

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 CR07 – Lake Gounter Nature Reserve A

General Details

Site name	Lake Gounter Nature Reserve A
Landholder	DEC
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date	27.08.2008

Site Description

Landform	The site consists of a series of low-lying areas where water ponds and flows in discontinuous channels, separated by raised island areas. Elevation is generally < 1 m above the valley floor.
Site size	175 ha

Beard Vegetation Description

Beard vegetation association 41: Shrublands; teatree thicket.

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

Overall vegetation structure and cover (for vegetated areas only)

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	<i>Eucalyptus spathulata</i> , <i>E. sargentii</i> , <i>E. salicola</i>
Mallees	2–10%	<i>E. horistes</i>
Shrubs	10–30%	<i>Melaleuca uncinata</i> , <i>M. hamata</i> , <i>Dodonaea viscosa</i> subsp. <i>angustissima</i> , <i>Alyxia buxifolia</i> , <i>Exocarpos aphyllus</i> , <i>Rhagodia drummondii</i> , <i>Hakea preissii</i> , <i>Tecticornia</i> spp., <i>Westringia rigida</i> , <i>Maireana amoena</i> , <i>Platysace effusa</i> , <i>Olearia dampieri</i>
Grasses	< 2%	<i>Austrostipa</i> spp.
Herbs	2–10%	<i>Disphyma crassifolia</i> , <i>Lomandra effusa</i>
Rushes and sedges	< 2%	<i>Lepidosperma</i> spp.
Litter	2–10%	
Bare Ground	> 70%	
Rock Outcrop	0	

Summary

The low-lying areas are bare, with slightly raised areas having samphire. The islands are either melaleuca shrubland, sometimes with emergent eucalypts or eucalypt woodland – *E. salicola* on larger islands and *E. spathulata*, fringed by *E. sargentii* on smaller islands.

Individual vegetation association descriptions

- Vegetation 1 Island
Eucalyptus spathulata and *E. sargentii* Open Low Woodland over *Melaleuca uncinata* and *Melaleuca hamata* Open Scrub to 5 m over *Dodonaea viscosa* subsp. *angustissima*, *Alyxia buxifolia* and *Exocarpos aphyllus* Open Scrub over *Rhagodia drummondii* Open Dwarf Scrub over *Disphyma crassifolia* Very Open Herbs
- Vegetation 2 Melaleuca Island
Melaleuca uncinata Scrub to 4 m over *Rhagodia drummondii* and *Maireana amoena* Open Dwarf Scrub over mixed Open Herbs
- Vegetation 3 *Tecticornia* spp. (2) Dwarf Scrub
- Vegetation 4 Lunette
Eucalyptus salicola Open Low Woodland over *Dodonaea viscosa* subsp. *angustissima* and *Hakea preissii* Open Scrub over *Olearia dampieri*, *Westringia rigida* and *Platysace effusa* Dwarf Scrub over *Lomandra effusa* Very Open Herbs
- Vegetation 5 Lunette
Eucalyptus salicola Open Low Woodland over *E. horistes* Very Open Tree Mallee over *Dodonaea viscosa* subsp. *angustissima*, *Trymalium daphnifolium* and *Baeckea* sp. Open Low Scrub over *Platysace effusa* and *Rhagodia drummondii* Dwarf Scrub over *Lomandra effusa* Very Open Herbs

Native species

Scientific name	Common name
+ <i>Acacia acuaria</i>	wattle
+ <i>Acacia hemiteles</i>	tan wattle
<i>Alyxia buxifolia</i>	dysentery bush
<i>Argyrolottis turbinata</i>	
<i>Atriplex bunburyana</i>	saltbush
<i>Atriplex hymenotheca</i>	saltbush
<i>Austrostipa elegantissima</i>	feather speargrass
<i>Austrostipa pycnostachya</i>	speargrass
<i>Austrostipa</i> sp.	speargrass
<i>Baeckea</i> sp.	myrtle
Chenopodiaceae sp.	
<i>Crassula colorata</i>	dense stonecrop
<i>Darwinia halophila</i>	darwinia
<i>Dianella revoluta</i>	blueberry lily
<i>Disphyma crassifolium</i>	round-leaved pigface
<i>Dodonaea viscosa</i> subsp. <i>angustissima</i>	sticky hop bush
<i>Eremophila decipiens</i>	slender fuchsia
<i>Eremophila</i> sp.	emu bush
<i>Eucalyptus horistes</i>	white flowered mallee
+ <i>Eucalyptus salicola</i>	salt gum
<i>Eucalyptus sargentii</i>	salt river gum

Native species (continued)

Scientific name	Common name
<i>Eucalyptus spathulata</i>	swamp mallet
<i>Exocarpos aphyllus</i>	leafless ballart
<i>Frankenia</i> sp.	frankenian
<i>Hakea kippistiana</i>	hakea
<i>Hakea preissii</i>	needle tree
<i>Juncus</i> sp.	rush
<i>Lepidosperma drummondii</i>	sword sedge
<i>Lepidosperma</i> sp. A2 Island Flat	sword sedge
<i>Lomandra effusa</i>	scented matrush
<i>Lycium australe</i>	Australian boxthorn
<i>Maireana amoena</i>	bluebush
<i>Maireana erioclada</i>	bluebush
<i>Melaleuca cuticularis</i>	saltwater paperbark
<i>Melaleuca hamata</i>	brushwood
+ <i>Melaleuca lateriflora</i>	gorada
<i>Melaleuca pauperiflora</i>	boree
<i>Melaleuca uncinata</i>	brushwood
<i>Microcybe multiflora</i>	
<i>Neurachne alopecuroidea</i>	foxtail mulga grass
<i>Olearia dampieri</i>	daisy bush
<i>Platysace effusa</i>	
<i>Rhagodia drummondii</i>	rhagodia
<i>Sclerolaena diacantha</i>	grey copper-burr
<i>Senecio</i> sp.	groundsel
<i>Tecticornia</i> spp.	samphire (2 species)
<i>Trymalium daphnifolium</i>	
<i>Waitzia acuminata</i>	orange immortelle
<i>Westringia cephalantha</i>	westringia
<i>Wilsonia humilis</i>	silky wilsonia

+ Regeneration noted.

Recruitment of melaleuca and eucalypt seedlings noted.

Weed species

Scientific name	Common name
<i>Arctotheca calendula</i>	capeweed
<i>Carpobrotus edulis</i>	hottentot fig
<i>Cotula bipinnata</i>	fenny cotula
<i>Hypochaeris glabra</i>	flatweed
<i>Mesembryanthemum nodiflorum</i>	slender ice-plant
<i>Monoculus monstrosus</i>	stinking Roger
<i>Ursinia anthemoides</i>	ursinia

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	18
Very good	Vegetation structure altered, obvious signs of disturbance	15
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	10
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	24

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			x				

Comments

The site is dissected by a road. Whilst there was no evidence of water ponding, it is possible that it may occur after high flow events.

A pack of dogs was observed chasing kangaroos.

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
Lake Gounter Nature Reserve	3283	Part of reserve
CR21705	156	7.5 km SE
Roe Nature Reserve	1242	10 km NW

Management

There has been some rehabilitation in the south of the site. Recruitment of *Eucalyptus* spp. and *Melaleuca* spp. was noted. It is recommended that weeds and feral animals be controlled. Rubbish should be removed from the site. Installation of culverts may assist in controlling ponding from the road crossing. Management recommendations that may affect salinity and waterlogging would need to be implemented at a catchment scale.

Fauna

Scientific name	Common name
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Birds

<i>Chrysococcyx lucidus</i>	shining bronze cuckoo
<i>Corvus coronoides</i>	Australian raven
<i>Cuculus pallidus</i>	pallid cuckoo
<i>Neophema elegans</i>	elegant parrot
<i>Pachycephala pectoralis</i>	golden whistler
<i>Platycercus zonarius</i>	Australian ringneck parrot

Mammals

<i>Macropus fuliginosus</i>	western grey kangaroo
<i>Canis lupus familiaris</i>	wild dogs*

* Introduced species

Other fauna lists for the general area

Greening Australia Western Australia (2004)

Grein (1994)

Lefroy et al. (1991)

Notes:

- DRF have previously been recorded within the site.



Photo A1.30: CR07

Very good condition vegetation association 1: *Eucalyptus spathulata* and *E. sargentii* Open Low Woodland over *Melaleuca uncinata* Open Scrub over *Dodonaea viscosa* subsp. *angustissima*, *Alyxia buxifolia* and *Exocarpos aphyllus* Open Scrub over *Rhagodia drummondii* Open Dwarf Scrub over *Disphyma crassifolia* Very Open Herbs.



Photo A1.31: CR07

Very good condition vegetation association 2: *Melaleuca uncinata* Scrub over *Rhagodia drummondii* and *Maireana amoena* Open Dwarf Scrub over mixed Open Herbs.



Photo A1.32: CR07

Degraded condition vegetation association 3: *Tecticornia* spp. Dwarf Scrub.



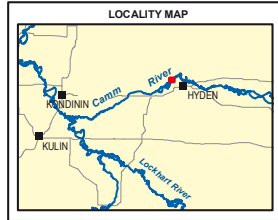
Photo A1.33: CR07

Excellent condition vegetation association 4: *Eucalyptus salicola* Open Low Woodland over *Dodonaea viscosa* subsp. *angustissima* and *Hakea preissii* Open Scrub over *Olearia dampieri*, *Westringia rigida* and *Platysace effusa* Dwarf Scrub over *Lomandra effusa* Very Open Herbs.



Photo A1.34: CR07
Excellent condition vegetation association 5: Eucalyptus salicicola Open Low Woodland over E. horistes Very Open Tree Mallee over Dodonaea viscosa subsp. angustissima, Trymalium daphnifolium and Baeckea sp. Open Low Scrub over Platysace effusa and Rhagodia drummondii Dwarf Scrub over Lomandra effusa Very Open Herbs.

Map A7
Vegetation condition for
survery site CR07
Lake Gounter
Nature Reserve A



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: Melanie Webb
 Task ID: 7114
 Filepath: J:\gis\projects\ProjectB_Series\B410C0002.mxd
 Filename: MapA7_Veg_cond_survey_site_CR07.mxd
 Compilation date: June 2009
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SOURCES

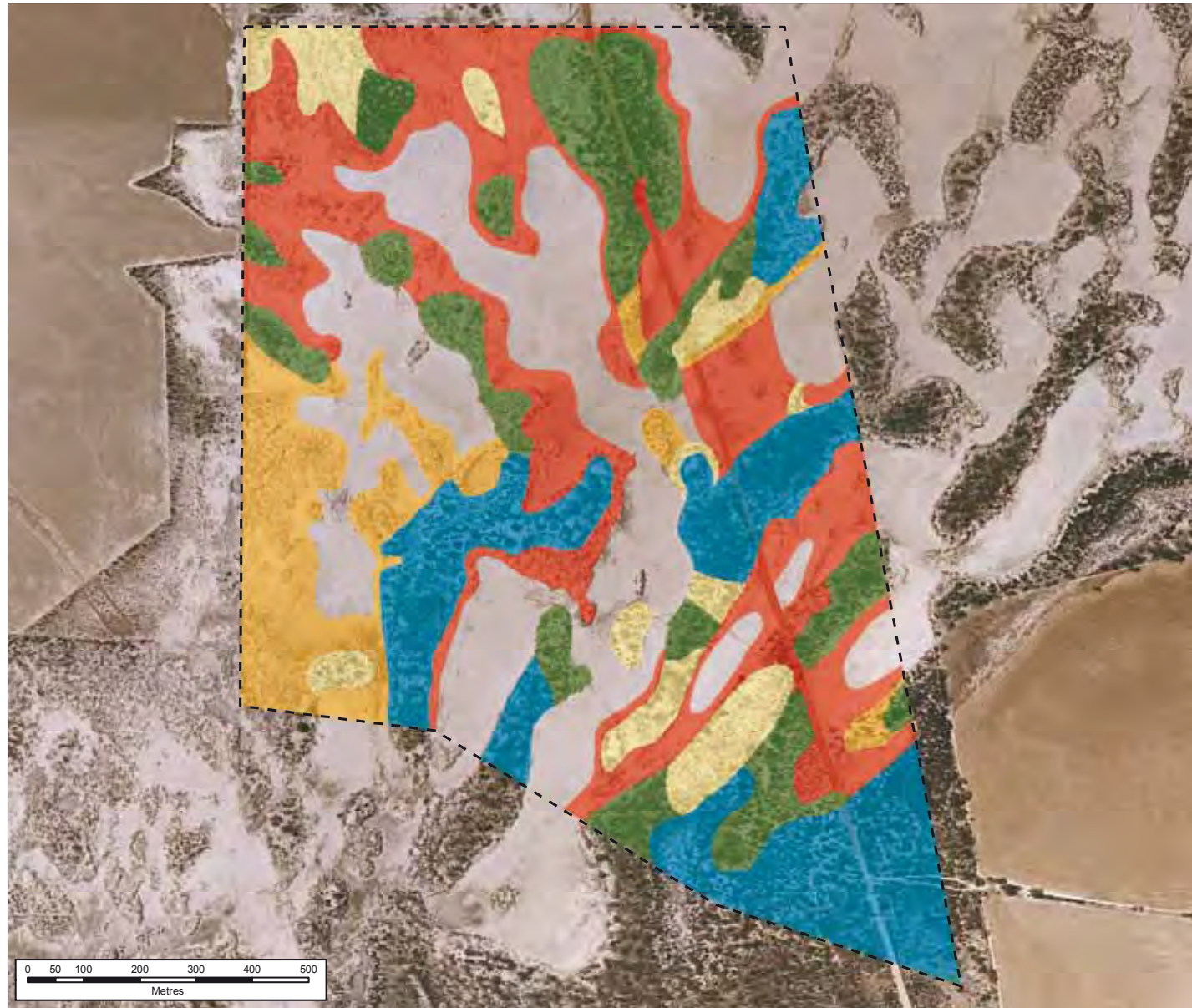
The Department of Water acknowledges the following datasets and their custodians in the production of this map:
 Corrigin South Orthomosaic – Landgate – 2000

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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 Upper Camm River mapping project at the scale of 1:9 000.

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 CR08 – Lake Gounter Nature Reserve

General Details

Site name	Lake Gounter Nature Reserve
Landholder	DEC
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date	27.08.2008

Site Description

Landform	The site consists of a series of channels on the eastern two thirds, but with no clear exit for water to the west, which is low-lying. There are two surface drains through the paddock near the north-east corner that terminate in the paddock, but drain into the reserve. There are two surface drains from farmland on the southern side that terminate in the reserve. The drains had water ponding at their ends. A deep drain drains the paddock to the south, runs parallel to the reserve for some distance, before entering the reserve and continuing for some distance (unknown terminus). The western end of the study site, on the northern edge, has an area where water ponds but could not be accessed for further examination due to deep drains isolating the area and flat land not permitting viewing from a distance.
Site size	290 ha

Beard Vegetation Description

Beard vegetation association 41: Shrublands; teatree thicket.

Beard vegetation association 125: Bare areas; salt lakes.

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

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

Overall vegetation structure and cover (for vegetated areas only)

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	<i>Eucalyptus myriadena</i> , <i>E. salmonophloia</i> , <i>E. salubris</i>
Mallees	2–10%	<i>E. loxophleba</i> subsp. <i>gratae</i> , <i>E. horistes</i>
Shrubs	2–10%	<i>Melaleuca lateriflora</i> , <i>M. acuminata</i> , <i>M. adnata</i> , <i>Olearia muelleri</i> , <i>Olearia dampieri</i> , <i>Tecticornia</i> spp., <i>Dodonaea</i> sp., <i>Acacia hemiteles</i> , <i>Grevillea acuaria</i> , <i>Leptospermum erubescens</i>
Grasses	2–10%	<i>Amphipogon</i> sp., <i>Austrostipa</i> sp.
Herbs	2–10%	<i>Angianthus tomentosus</i> , <i>Lomandra effusa</i>
Rushes and sedges	2–10%	<i>Lepidosperma drummondii</i> , <i>L. leptostachyum</i>
Litter	2–10%	
Bare Ground	> 70%	
Rock Outcrop	< 2%	

Summary

The eastern two thirds of the site are low lying samphire and melaleuca shrublands with occasional *Eucalyptus* sp. The islands on the eastern two thirds are either melaleuca shrubland, mallee or woodland, with low-lying channels bare or with fringing samphire. The southern section is a mosaic of woodland (largely gimlet), York gum, mallee and melaleuca or sheoak shrubland with occasional herblands (*Borya* in undisturbed areas) on shallow soil.

Individual vegetation association descriptions

Vegetation 1	<i>Melaleuca lateriflora</i> and <i>M. acuminata</i> Open Scrub to 4 m over <i>Tecticornia</i> spp. Open Dwarf Scrub over mixed annual Open Herbs
Vegetation 2	<i>Eucalyptus myriadena</i> , <i>E. salmonophloia</i> and <i>E. loxophleba</i> Open Woodland over <i>Olearia muelleri</i> Open Low Scrub over <i>Angianthus tomentosus</i> and <i>Brassica tournefortii</i> Very Open Herbs over <i>Austrostipa</i> sp. Very Open Tall Grass
Vegetation 3	<i>Eucalyptus horistes</i> Very Open Tree Mallee over <i>Olearia dampieri</i> Open Low Scrub over <i>Lomandra effusa</i> Very Open Herbs
Vegetation 4	<i>Tecticornia</i> spp. (3-4 species) Dwarf Scrub over <i>Mesembryanthemum nodiflorum</i> and <i>Cotula bipinnata</i> Very Open Herbland and <i>Parapholis incurva</i> Very Open Low Grass
Vegetation 5	<i>Eucalyptus salubris</i> Open Low Woodland over <i>Melaleuca acuminata</i> , <i>M. adnata</i> and <i>Dodonaea viscosa</i> subsp. <i>angustissima</i> Open Scrub over <i>Acacia hemiteles</i> , <i>Grevillea acuaria</i> and <i>Olearia muelleri</i> Open Dwarf Scrub
Vegetation 6	<i>Eucalyptus loxophleba</i> subsp. <i>gratae</i> Very Open Tree Mallee over <i>Acacia acuminata</i> Open Low Woodland over <i>Melaleuca adnata</i> and <i>Leptospermum erubescens</i> Open Scrub over <i>Lepidosperma</i> spp. Very Open Low Sedges over <i>Amhipogon strictus</i> Very Open Low Grass over mixed annual Very Open Herbs

Native species (continued)

Scientific name	Common name
<i>Acacia acuminata</i>	Jam
<i>Acacia erinacea</i>	spiny wattle
<i>Acacia hemiteles</i>	tan wattle
<i>Acacia mackeyana</i>	Wattle
<i>Acacia merrallii</i>	Merrall's wattle
<i>Amhipogon strictus</i>	grey beard grass
<i>Angianthus tomentosus</i>	camel-grass
<i>Atriplex bunburyana</i>	silver saltbush
<i>Atriplex hymenotheca</i>	Saltbush
<i>Atriplex paludosa</i>	marsh saltbush
<i>Austrostipa</i> sp.	Speargrass
<i>Borya sphaerocephala</i>	pin-grass
<i>Brachyscome iberidifolia</i>	Swan River daisy
<i>Disphyma crassifolium</i>	round-leaved pigface
<i>Dodonaea viscosa</i> subsp. <i>angustissima</i>	sticky hopbush
<i>Dodonaea stenozyga</i>	hop bush
<i>Drosera macrantha</i>	bridal rainbow
<i>Enchylaena tomentosa</i>	ruby saltbush
<i>Eragrostis dielsii</i>	mallee lovegrass
<i>Eremophila decipiens</i>	slender fuchsia

Native species (continued)

Scientific name	Common name
<i>Erymophyllum tenellum</i>	Everlasting
<i>Eucalyptus alipes</i>	Swamp mallet
<i>Eucalyptus horistes</i>	white flowered mallee
<i>Eucalyptus longicornis</i>	red morrell
<i>Eucalyptus loxophleba</i> subsp. <i>gratiae</i>	Lake Grace gum
<i>Eucalyptus myriadena</i>	Eucalypt
<i>Eucalyptus salicola</i>	salt gum
+ <i>Eucalyptus salmonophloia</i>	salmon gum
<i>Eucalyptus salubris</i>	Gimlet
<i>Grevillea acuaria</i>	Grevillea
<i>Hakea kippistiana</i>	Hakea
<i>Lepidosperma drummondii</i>	sword sedge
<i>Lepidosperma leptostachyum</i>	sword sedge
<i>Lepidosperma</i> sp.	sword sedge
<i>Leptospermum erubescens</i>	roadside tea-tree
<i>Lomandra effusa</i>	scented matrush
<i>Lycium australe</i>	Australian boxthorn, water bush
<i>Maireana amoena</i>	Bluebush
<i>Maireana brevifolia</i>	small-leaf bluebush
<i>Maireana carnosa</i>	cottony bluebush
<i>Maireana</i> sp.	Bluebush
+ <i>Melaleuca acuminata</i>	
+ <i>Melaleuca adnata</i>	
<i>Melaleuca atroviridis</i>	Brushwood
+ <i>Melaleuca hamata</i>	Brushwood
<i>Melaleuca lateriflora</i>	Gorada
<i>Melaleuca pauperiflora</i>	Boree
+ <i>Melaleuca uncinata</i>	Brushwood
<i>Microcybe multiflora</i>	
<i>Olearia dampieri</i>	daisy bush
<i>Olearia muelleri</i>	dusky daisy bush, goldfields daisy
<i>Pittosporum angustifolium</i>	native apricot, native willow
<i>Platysace effusa</i>	
<i>Podotheca gnaphalioides</i>	golden longheads
<i>Rhagodia preissii</i>	Rhagodia
<i>Scaevola spinescens</i>	currant bush
<i>Sclerolaena diacantha</i>	grey copper-burr
<i>Senecio</i> sp.	Groundsel
<i>Tecticornia lylei</i>	Samphire
<i>Tecticornia</i> spp.	samphire (3-4 species)
<i>Tecticornia undulata</i>	Samphire
<i>Templetonia sulcata</i>	centipede bush
<i>Threlkeldia diffusa</i>	coast bonefruit

+ *Regeneration noted*

Weed species

Scientific name	Common name
<i>Arctotheca calendula</i>	Capeweed
<i>Brassica tournefortii</i>	wild turnip
<i>Bromus rubens</i>	red brome
<i>Cotula bipinnata</i>	ferry cotula
<i>Lolium rigidum</i>	annual ryegrass
<i>Mesembryanthemum nodiflorum</i>	slender ice-plant
<i>Monoculus monstrosus</i>	stinking Roger
<i>Moraea setifolia</i>	thread iris
<i>Parapholis incurva</i>	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	17
Very good	Vegetation structure altered, obvious signs of disturbance	12
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	5
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	23
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	20

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	x			Service corridors			
Clearing			x	Feral animals			x
Fire risk				Recreation			
Weed invasion		x		Point source discharge			
Stock access			x	Other			
Vehicle access			x				

Comments

Some rubbish was observed, probably blown from the Shire tip

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
Lake Gounter Nature Reserve	3283	Part of reserve
CR28833	101	Adjacent to site (E)
CR21705	156	7.0 km S
Graham Rock Nature Reserve	2163	6 km E

Management

The site is part of a nature reserve which has been fenced in the past. Some fences were in poor condition and may permit occasional grazing on the site. There was evidence of revegetation on part of the site. Management recommendations include removing drains and rubbish, repairing fences and control of weeds. Salinity and waterlogging must be managed on a catchment scale.

Fauna

Scientific name	Common name
Birds	
<i>Acanthiza</i> spp.	Thornbills
<i>Cacatua roseicapilla</i>	Galah
<i>Coracina novaehollandiae</i>	black-faced cuckoo-shrike
<i>Corvus coronoides</i>	Australian raven
<i>Cracticus torquatus</i>	grey butcherbird
<i>Platycercus zonarius</i>	Australian ringneck parrot
<i>Pomatostomus superciliosus</i>	white browed babbler

Fauna (continued)	
Scientific name	Common name
Mammals	
<i>Canis lupus familiaris</i>	dog*
<i>Macropus fuliginosus</i>	western grey kangaroo
<i>Oryctolagus cuniculus</i>	European wild rabbit*

* Introduced species

Other fauna lists for the general area

Greening Australia Western Australia (2004)

Grein (1994)

Lefroy et al. (1991)

Notes:

- Access to the site was complicated by drains (and wet weather)
- The drain water was not accessible for sampling
- Priority 3 flora have been previously recorded within the site
- Priority 4 flora have been recorded close to the site in the same broad vegetation type
- This portion of Lake Gounter Nature Reserve is the receival point for the discharge water from the proposed Camm River drainage project.



Photo A1.35: CR08
Degraded condition vegetation
Association 1: *Melaleuca lateriflora*
and *M. acuminata* Open Scrub over
Tecticornia spp. Open Dwarf Scrub over
mixed annual Open Herbs.



Photo A1.36: CR08
Very good vegetation association
2: *Eucalyptus myriadena*,
E. salmonophloia and *E. loxophleba*
Open Woodland over *Olearia muelleri*
Open Low Scrub over *Angianthus*
tomentosus and *Brassica tournefortii*
Very Open Herbs over *Austrostipa* sp.
Very Open Tall Grass.



Photo A1.37: CR08
Excellent condition vegetation association 3: *Eucalyptus horistes* Very Open Tree Mallee over *Olearia dampieri* Open Low Scrub over *Lomandra effusa* Very Open Herbs.



Photo A1.38: CR08
Degraded condition vegetation association 4: *Tecticornia* spp. Dwarf Scrub over *Mesembryanthemum nodiflorum*, *Cotula bipinnata* Very Open Herbs and *Parapholis incurva* Very Open Low Grass.



Photo A1.39: CR08
Excellent condition vegetation association 5: *Eucalyptus salubris* Open Low Woodland over *Melaleuca acuminata*, *M. adnata* and *Dodonaea viscosa* subsp. *angustissima* Open Scrub over *Acacia hemiteles*, *Grevillea acuaria* and *Olearia muelleri* Open Dwarf Scrub.



Photo A1.40: CR08
Excellent condition vegetation association 6: *Eucalyptus loxophleba* subsp. *gratiae* Very Open Tree Mallee over *Acacia acuminata* Open Low Woodland over *Melaleuca adnata* and *Leptospermum erubescens* Open Scrub over *Lepidosperma* spp. Very Open Low Sedges over *Amphipogon strictus* Very Open Low Grass over mixed annual Very Open Herbs.

Map A8
Vegetation condition for
survery site CR08
Lake Gounter
Nature Reserve B



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: Melanie Webb
 Task ID: 7114
 Filepath: J:\gis\projects\ProjectB_Series\B410C\0002.mxd
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SOURCES

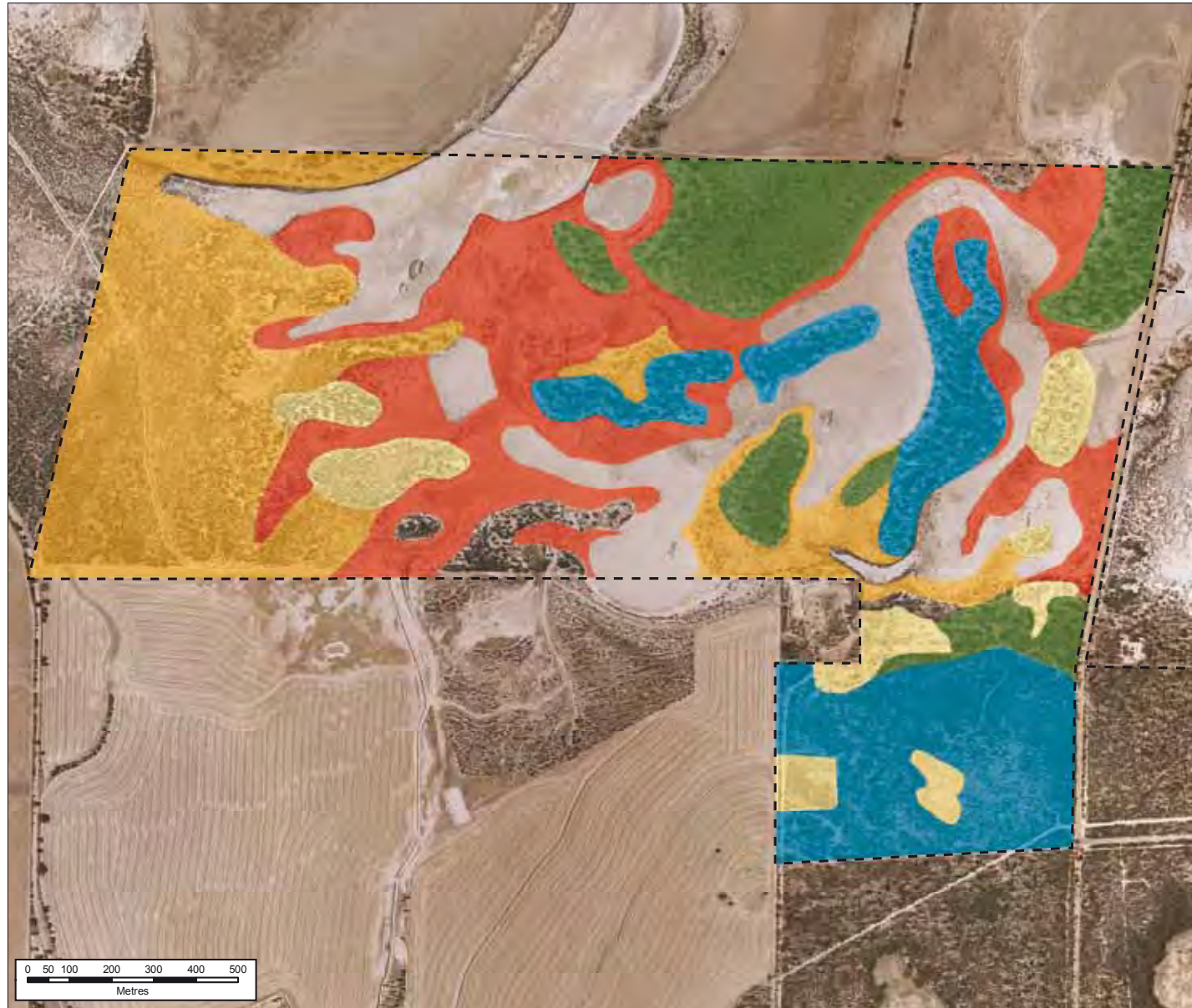
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 Corrigin South Orthomosaic – Landgate – 2000

Department of Water, Australia
 Department of Water

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Site CR09 – Lake Magic

General Details

Site name	Lake Magic
Landholder	Dennis Collins
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date	28.08.2008

Site Description

Landform	The site is on the main channel of the Camm River which is indistinct and winding between 'islands' of raised land and lunettes around playa lakes. Lake Magic is an off-channel gypsum lake.
Site size	220 ha

Beard Vegetation Description

Beard vegetation association 41: Shrublands; teatree thicket.

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	2–10%	<i>Eucalyptus alipes</i> , <i>E. celastroides</i> , <i>E. myriadena</i> , <i>E. salmonophloia</i>
Mallees	< 2%	<i>Eucalyptus</i> sp.
Shrubs	10–30%	<i>Melaleuca atroviridis</i> , <i>Acacia multispicata</i> , <i>A. hemiteles</i> , <i>Rhagodia drummondii</i> , <i>Darwinia halophila</i> , <i>Olearia dampieri</i> , <i>Tecticornia</i> spp., <i>Lycium australe</i> , <i>Maireana carnososa</i>
Grasses	< 2%	Mixed annual species
Herbs	2–10%	<i>Hyalochlamys globifera</i> , <i>Senecio</i> sp., <i>Disphyma crassifolia</i> , <i>Lomandra effusa</i> , <i>Sclerolaena diacantha</i> , <i>Maireana carnososa</i>
Rushes and sedges	2–10%	<i>Gahnia trifida</i>
Litter	2–10%	
Bare Ground	> 70%	
Rock Outcrop	0	

Summary

The islands are variously woodland, mallee or less often melaleuca shrublands, with the lower-lying areas samphire with dead sticks.

Individual vegetation association descriptions

Vegetation 1	<i>Eucalyptus alipes</i> Open Low Woodland over <i>Melaleuca atroviridis</i> Scrub to 4 m over <i>Lycium australe</i> and <i>Rhagodia preissii</i> Open Low Scrub over Very Open Herbs
Vegetation 2	<i>Tecticornia</i> spp. (2) Dwarf Scrub over <i>Mesembryanthemum nodiflorum</i> , <i>Senecio</i> sp. and <i>Hyalochlamys globifera</i> Open Herbs
Vegetation 3	<i>Eucalyptus celastroides</i> Open Low Woodland over <i>Acacia multispicata</i> and <i>Rhagodia drummondii</i> Open Low Scrub over <i>Darwinia halophila</i> Dwarf Scrub over <i>Lomandra effusa</i> and <i>Disphyma crassifolia</i> Very Open Herbs and <i>Gahnia trifida</i> Very Open Tall Sedges
Vegetation 4	<i>Eucalyptus</i> sp. Open Low Woodland over <i>Maireana brevifolia</i> and <i>Enchylaena</i> sp. Open Dwarf Scrub over <i>Sclerolaena diacantha</i> , <i>Maireana carnososa</i> and <i>Mesembryanthemum nodiflorum</i> Open Herbs
Vegetation 5	<i>Eucalyptus myriadena</i> and <i>Eucalyptus salmonophloia</i> Open Woodland over <i>Olearia dampieri</i> and <i>Acacia hemiteles</i> Open Dwarf Scrub over Very Open Herbs

Native species

Scientific name	Common name
<i>Acacia hemiteles</i>	tan wattle
<i>Acacia multispicata</i>	Wattle
<i>Acacia</i> spp.	Wattle
<i>Alyxia buxifolia</i>	dysentery bush
<i>Angianthus tomentosus</i>	camel-grass
<i>Brachyscome</i> sp.	Daisy
<i>Carpobrotus modestus</i>	inland pigface
<i>Darwinia halophila</i>	Darwinia
<i>Disphyma crassifolium</i>	round-leaved pigface
<i>Enchylaena tomentosa</i>	ruby saltbush
<i>Eremophila decipiens</i>	slender fuchsia
+ <i>Eucalyptus alipes</i>	Swamp mallet
<i>Eucalyptus celastroides</i>	Mirret
<i>Eucalyptus myriadena</i>	Eucalyptus
<i>Eucalyptus salicola</i>	salt gum
<i>Eucalyptus salmonophloia</i>	salmon gum
<i>Eucalyptus salubris</i>	Gimlet
<i>Eucalyptus sargentii</i>	salt river gum
<i>Eucalyptus</i> sp.	Eucalyptus
<i>Exocarpos aphyllus</i>	leafless ballart
<i>Gahnia trifida</i>	coast saw sedge
<i>Hakea kippistiana</i>	Hakea
<i>Hakea preissii</i>	needle tree
<i>Hyalochlamys globifera</i>	
<i>Juncus</i> sp.	Rush
<i>Lomandra effusa</i>	scented matrush

Native species (continued)

Scientific name	Common name
<i>Lycium australe</i>	Australian boxthorn
<i>Maireana brevifolia</i>	small-leaf bluebush
<i>Maireana carnos</i>	cottony bluebush
+ <i>Melaleuca atroviridis</i>	Brushwood
<i>Melaleuca brevifolia</i>	
<i>Melaleuca hamata</i>	Brushwood
<i>Melaleuca lateriflora</i>	Gorada
<i>Melaleuca pauperiflora</i>	Boree
<i>Melaleuca thyoides</i>	
<i>Olearia dampieri</i>	daisy bush
<i>Platysace maxwellii</i>	Karno
<i>Podolepis capillaris</i>	wiry podolepis
<i>Rhagodia drummondii</i>	Rhagodia
<i>Rhagodia preissii</i>	Rhagodia
<i>Santalum acuminatum</i>	Quandong
<i>Scaevola spinescens</i>	currant bush
<i>Sclerolaena diacantha</i>	grey copper-burr
<i>Senecio</i> sp.	Groundsel
<i>Siloxerus multiflorus</i>	
<i>Tecticornia lylei</i>	Samphire
<i>Tecticornia</i> spp.	samphire (3 species)
<i>Trachymene</i> sp.	Coogan

+ Regeneration noted

Weed species

Scientific name	Common name
<i>Arctotheca calendula</i>	Capeweed
<i>Brassica tournefortii</i>	wild turnip
<i>Bromus rubens</i>	red brome
<i>Dittrichia graveolens</i>	Stinkwort
<i>Hordeum leporinum</i>	barley grass
<i>Hypochaeris glabra</i>	Flatweed
<i>Lolium rigidum</i>	annual ryegrass
<i>Medicago</i> sp.	Medic
<i>Mesembryanthemum nodiflorum</i>	slender ice-plant
<i>Monoculus monstrosus</i>	stinking Roger

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	5
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	10
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	14
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	1
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				Recreation			x
Weed invasion			x	Point source discharge			
Stock access				Other			
Vehicle access			x				

Comments

Rabbits are present on the site. Whilst evidence of ponding from road crossing was not observed, it is possible after high rainfall events.

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
Lake Gounter Nature Reserve	3283	Adjacent to site (west)
Graham Rock Nature Reserve	2136	3.0 km E
CR28833	101	Adjacent to site (south)
CR21705	156	7.0 km S

Management

Recommend removal of rubbish and control of weeds and rabbits. The site is part of the proposed Camm River drainage project, which aims to improve vegetation condition by increasing the speed that water drains from the site and prevent local ponding. Some revegetation is proposed as part of this scheme, particularly in the tourist precinct area. The Camm River drainage project is at sub-catchment scale.

Fauna

Scientific name
Common name

Birds

<i>Acanthiza chrysorrhoa</i>	yellow-rumped thornbill
<i>Artamus cinereus</i>	black-faced woodswallow
<i>Platycercus zonarius</i>	Australian ringneck parrot
<i>Cacatua roseicapilla</i>	Galah
<i>Corvus coronoides</i>	Australian raven
<i>Cracticus torquatus</i>	grey butcherbird
<i>Dromaius novaehollandiae</i>	Emu
<i>Epthianura albifrons</i>	white-fronted chat
<i>Grallina cyanoleuca</i>	magpie-lark
<i>Hirundo neoxena</i>	welcome swallow
<i>Lichenostomus virescens</i>	singing honey-eater
<i>Neophema elegans</i>	elegant parrot
<i>Oryctolagus cuniculus</i>	European wild rabbit*
<i>Pachycephala rufiventris</i>	rufus whistler
<i>Pardalotus striatus</i>	striated pardalote
<i>Petroica goodenovii</i>	red-capped robin
<i>Pomatostomus superciliosus</i>	white browed babbler
<i>Smicromnis brevirostris</i>	Weebill
<i>Tadorna tadornoides</i>	Australian shelduck (mountain duck)

Mammals

<i>Macropus fuliginosus</i>	western grey kangaroo
<i>Oryctolagus cuniculus</i>	European wild rabbit*

* *Introduced species*

Other fauna lists for the general area

Greening Australia Western Australia (2004)

Grein (1994)

Lefroy et al. (1991)

Notes:

- Historically Lake Magic was fresh water
- Clearing commenced in the 1920s and continued into the 1980s, although salinity problems were evident before this
- The area affected by salt is still increasing
- There is a dam on the south-west corner and the site contains part of an airstrip, a firebreak, the Lake Magic Resort chalets, roads and walkways

There are extensive areas with no vegetation

- Water sampled from Lake Magic was pH 5.2, temperature 18.6°C and conductivity 44.1 mS/cm
- The site is part of the proposed Camm River drainage project that aims to increase the rate that water moves through the drainage system and prevent water accumulation in low lying areas. It is anticipated that some of the water that will flow through the site as a result of this project can be redirected into Lake Magic, increasing the lake's potential use for water sports.



Photo A1.41: CR09

Very good condition vegetation association 1: *Eucalyptus alipes* Open Low Woodland over *Melaleuca atroviridis* Scrub over *Lycium australe* and *Rhagodia preissii* Open Low Scrub over Very Open Herbs.



Photo A1.42: CR09

Completely degraded vegetation association 2: *Tecticornia* spp. Dwarf Scrub over *Mesembryanthemum nodiflorum*, *Senecio* sp. and *Hyalochlamys globifera* Open Herbs.



Photo A1.43: CR09

Very good condition vegetation association 3: *Eucalyptus celastroides* Open Low Woodland over *Acacia multispicata* and *Rhagodia drummondii* Open Low Scrub over *Darwinia halophila* Dwarf Scrub over *Lomandra effusa* and *Disphyma crassifolia* Very Open Herbs and *Gahnia trifida* Very Open Tall Sedges.



Photo A1.44: CR09

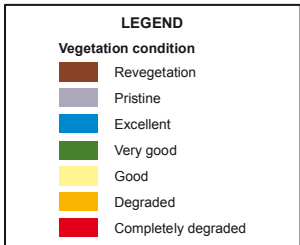
Good condition vegetation association 4: *Eucalyptus* sp. Open Low Woodland over *Maireana brevifolia* and *Enchylaena* sp. Open Dwarf Scrub over *Sclerolaena diacantha*, *Maireana carnososa* and *Mesembryanthemum nodiflorum* Open Herbs.



Photo A1.45: CR09

Very good condition vegetation association 5: *Eucalyptus myriadena* and *Eucalyptus salmonophloia* Open Woodland over *Olearia dampieri* and *Acacia hemiteles* Open Dwarf Scrub over Very Open Herbs.

Map A9
Vegetation condition for
survey site CR09
Lake Magic




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: Melanie Webb
 Task ID: 7114
 Filepath: J:\gis\projects\ProjectB_Series\B410C\0002.mxd
 Filename: MapA9_Veg_cond_survey_site_CR09.mxd
 Compilation date: June 2009
 Edition: 1

SOURCES

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 Corrigin South Orthomosaic – Landgate – 2000

 **Department of Water, Australia**
 Department of Water

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

This map was produced with the intent that it be used for the Upper Camm River mapping project at the scale of 1:15 000.

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 CR10

General Details

Site name	CR10
Landholder	Not specified
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date	29.08.2008

Site Description

Landform The site is on the valley floor and lower valley slopes. The waterway consists of a series of playa lakes connected by a series of lower-lying areas, generally with flow into the lakes on the north-east and exiting to the south-west, around lunettes.

Site size 205 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%	<i>Eucalyptus celastroides</i> , <i>E. kondininensis</i> , <i>E. salubris</i> , <i>E. myriadena</i>
Mallees	2–10%	<i>E. loxophleba</i> subsp. <i>Gratae</i>
Shrubs	10–30%	<i>Platysace maxwellii</i> , <i>Pultenaea</i> sp., <i>Rinzia crassifolia</i> , <i>Melaleuca thyoides</i> , <i>Tecticornia</i> spp., <i>Rhagodia drummondii</i> , <i>Scaevola spinescens</i> , <i>Exocarpos aphyllus</i> , <i>Santalum acuminatum</i> , <i>Enchylaena tomentosa</i> , <i>Melaleuca pauperiflora</i> , <i>M. lateriflora</i> , <i>M. acuminata</i>
Grasses	< 2%	<i>Eragrostis dielsii</i>
Herbs	2–10%	<i>Lomandra effusa</i> , <i>Gunniopsis septifraga</i> , <i>Crassula colorata</i> , <i>Senecio</i> sp.
Rushes and sedges	2–10%	<i>Gahnia trifida</i>
Litter	10–30%	
Bare Ground	30–70%	
Rock Outcrop	0	

Summary

Low-lying areas are generally samphire or drowned *Melaleuca* spp. and samphire, occasionally with live *Melaleuca* spp. fringing some areas. Woodlands occupy the lunettes and lower slopes.

Individual vegetation association descriptions

Vegetation 1	<i>Eucalyptus celastroides</i> Open Tree Mallee over <i>Platysace maxwellii</i> , <i>Pultenaea</i> sp. and <i>Rinzia crassifolia</i> Dwarf Scrub and <i>Gahnia trifida</i> Very Open Tall Sedges over <i>Lomandra effusa</i> Open Herbs
Vegetation 2	<i>Melaleuca thyoides</i> Open Scrub to 3 m over <i>Tecticornia</i> spp. Dwarf Scrub over <i>Gunniopsis septifraga</i> , <i>Crassula colorata</i> and <i>Senecio</i> sp. Open Herbs
Vegetation 3	<i>Eucalyptus kondininensis</i> Low Woodland over <i>Rhagodia drummondii</i> Open Dwarf Scrub over Very Open Herbs
Vegetation 4	<i>Eucalyptus salmonophloia</i> and <i>E. kondininensis</i> Woodland over <i>Exocarpos aphyllus</i> and <i>Santalum acuminatum</i> Low Open Woodland over <i>Atriplex paludosa</i> and <i>Scaevola spinescens</i> Dwarf Scrub
Vegetation 5	<i>Tecticornia</i> spp. Dwarf Scrub over <i>Disphyma crassifolia</i> and annuals Open Herbs
Vegetation 6	<i>Eucalyptus myriadena</i> Open Low Woodland over <i>Eucalyptus loxophleba</i> ssp. <i>gratiae</i> Open Tree Mallee over <i>Lomandra effusa</i> Open Herbs
Vegetation 7	<i>Eucalyptus salubris</i> Open Woodland over <i>Melaleuca pauperiflora</i> and <i>Exocarpos aphyllus</i> Open Low Woodland to 4 m over mixed species Very Open Herbs
Vegetation 8	<i>Melaleuca pauperiflora</i> , <i>M. lateriflora</i> and <i>M. acuminata</i> Thicket to 3 m over <i>Enchylaena tomentosa</i> , <i>Tecticornia</i> spp. and <i>Maireana</i> sp. Open Dwarf Scrub over <i>Mesembryanthemum nodiflorum</i> Herbs

Native species

Scientific name	Common name
<i>Acacia acuminata</i>	Jam
<i>Acacia hemiteles</i>	tan wattle
<i>Acacia merrallii</i>	Merrall's wattle
<i>Alyxia buxifolia</i>	dysentery bush
<i>Amphipogon strictus</i>	grey beard grass
<i>Amyema miraculosa</i>	Mistletoe
<i>Atriplex amnicola</i>	swamp saltbush
<i>Atriplex hymenotheca</i>	Saltbush
<i>Atriplex paludosa</i>	marsh saltbush
<i>Borya laciniata</i>	pin-grasses
<i>Brachyscome</i> sp.	Daisy
<i>Caladenia reptans</i>	little pink fairy orchid
<i>Calandrinia eremaea</i>	twining purslane
<i>Calandrinia polyandra</i>	parakeelia
<i>Calotis hispidula</i>	bindy eye
<i>Carpobrotus modestus</i>	inland pigface
<i>Crassula colorata</i>	dense stonecrop
<i>Daucus glochidiatus</i>	Australian carrot
<i>Daviesia incrassata</i>	
<i>Disphyma crassifolium</i>	round-leaved pigface
<i>Dodonaea viscosa</i>	sticky hop bush
<i>Eragrostis dielsii</i>	mallee lovegrass
<i>Erymophyllum tenellum</i>	Everlasting
<i>Eucalyptus celastroides</i>	Mirret
<i>Eucalyptus kondininensis</i>	Kondinin blackbutt

Native species (continued)

Scientific name	Common name
<i>Eucalyptus myriadena</i>	Eucalypt
<i>Eucalyptus phenax</i>	Mallee
<i>Eucalyptus salicola</i>	salt gum
<i>Eucalyptus salmonophloia</i>	salmon gum
<i>Eucalyptus salubris</i>	Gimlet
<i>Eucalyptus spathulata</i>	swamp mallet
<i>Exocarpos aphyllus</i>	leafless ballart
<i>Frankenia drummondii</i>	frankenian
<i>Frankenia</i> sp.	frankenian
<i>Gahnia trifida</i>	coast saw sedge
<i>Gunniopsis septifraga</i>	
<i>Juncus</i> sp.	rush
<i>Leptospermum erubescens</i>	roadside tea-tree
<i>Lomandra effusa</i>	scented matrush
<i>Lycium australe</i>	Australian boxthorn, water bush
<i>Maireana amoena</i>	bluebush
<i>Maireana carnososa</i>	cottony bluebush
<i>Maireana triptera</i>	three winged bluebush
<i>Melaleuca acuminata</i>	
<i>Melaleuca atroviridis</i>	brushwood
<i>Melaleuca brevifolia</i>	
<i>Melaleuca lateriflora</i>	gorada
<i>Melaleuca scalena</i>	brushwood
<i>Melaleuca thyoides</i>	
<i>Neurachne alopecuroidea</i>	foxtail mulga grass
<i>Olearia dampieri</i>	daisy bush
<i>Olearia muelleri</i>	dusky daisy bush, goldfields daisy
<i>Pittosporum angustifolium</i>	native apricot, native willow
<i>Platysace maxwellii</i>	karno
<i>Podolepis capillaris</i>	wiry podolepis
<i>Podotheca gnaphalioides</i>	golden longheads
<i>Pultenaea</i> sp.	pea
<i>Rhagodia drummondii</i>	rhagodia
<i>Rhodanthe pygmaea</i>	
<i>Rinzia crassifolia</i>	
<i>Roycea spinescens</i>	
<i>Santalum acuminatum</i>	quandong
<i>Sarcocornia blackiana</i>	samphire
<i>Scaevola spinescens</i>	currant bush
<i>Sclerolaena diacantha</i>	grey copper-burr
<i>Senecio</i> sp.	groundsel
<i>Siloxerus multiflorus</i>	
<i>Tecticornia</i> spp.	samphire (3-4 species)
<i>Waitzia acuminata</i>	orange immortelle

+ Regeneration noted

Weed species

Scientific name	Common name
<i>Mesembryanthemum nodiflorum</i>	slender ice-plant
<i>Arctotheca calendula</i>	capeweed
<i>Cotula bipinnata</i>	fenny cotula
<i>Hypochaeris glabra</i>	flatweed
<i>Ursinia anthemoides</i>	ursinia

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	6
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	32
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	2

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			
Waterlogging		x		Plant disease			
Ponding from road crossing				Erosion			
Drainage			x	Service corridors			
Clearing			x	Feral animals			
Fire risk				Recreation			
Weed invasion				Point source discharge			
Stock access	x			Other			
Vehicle access			x				

Comments

Much of the low-lying vegetation is degraded due to salinity and waterlogging, however the vegetation on the lower slopes is often in relatively healthy condition.

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
Graham Rock Nature Reserve	2163	Adjacent to site
CR34295	934	7.0 km N

Management

It is recommended that stock be excluded from the floodplain. The large lake on this site currently receives some of the waters originating to the north from the Kings Rock tributary, and may be included in the proposed Camm River drainage project as a receival point for additional water. Unless this water drains away quickly, as currently appears to occur, there may be a significant impact on the vegetation health in some areas.

Fauna

Scientific name	Common name
Birds	
<i>Acanthiza</i> spp.	Thornbill
<i>Anthochaera carunculata</i>	red wattlebird
<i>Artamus cinereus</i>	black faced woodswallow
<i>Platycercus zonarius</i>	Australian ringneck parrot
<i>Chrysococcyx basalis</i>	Horsfield's bronze cuckoo
<i>Cracticus torquatus</i>	grey butcherbird

Fauna (continued)	
Scientific name	Common name
Birds	
<i>Dromaius novaehollandiae</i>	emu
<i>Grallina cyanoleuca</i>	magpie-lark
<i>Neophema elegans</i>	elegant parrot
<i>Pachycephala rufiventris</i>	rufus whistler
<i>Pardalotus striatus</i>	striated pardalote
<i>Petroica goodenovii</i>	red-capped robin
<i>Phaps chalcoptera</i>	common bronzewing
<i>Pomatostomus superciliosus</i>	white browed babbler
<i>Tadorna tadornoides</i>	Australian shelduck (mountain duck)
Mammals	
<i>Oryctolagus cuniculus</i>	European wild rabbit*
<i>Tachyglossus aculeatus</i>	short-beaked echidna
<i>Vulpes vulpes</i>	European red fox*

* 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 landholder:

- The site was already deteriorating in 1971
- In the 1960s, million acre clearing started and the system declined soon after
- In 1963/64 it rained all summer
- In 1965/66 150 mm of rain fell in one night
- Droughts occurred in 1969 and 1972
- The site has not been burnt in over sixty years although fires have occurred on the adjacent Nature Reserve. The landholder attributes the lack of bushfires to livestock grazing reducing the fuel load.

From previous reports:

- DRF have been recorded within the adjacent Nature Reserve but in a different vegetation type
- the main lake on the site is considered a key factor in protection of the valley directly north of Graham Rock (Farmer 2007b).



Photo A1.46: CR10
Excellent condition vegetation association 1: *Eucalyptus celastroides* Open Tree Mallee over *Platysace maxwellii*, *Pultenaea* sp. and *Rinzia crassifolia* Dwarf Scrub and *Gahnia trifida* Very Open Tall Sedges over *Lomandra effusa* Open Herbs.



Photo A1.47: CR10
Degraded condition vegetation association 2: *Melaleuca thyoides* Open Scrub over *Tecticornia* spp. Dwarf Scrub over *Gunniopsis septifraga*, *Crassula colorata* and *Senecio* sp. Open Herbs.



Photo A1.48: CR10
Very good condition vegetation Association 3: *Eucalyptus kondininensis* Low Woodland over *Rhagodia drummondii* Open Dwarf Scrub over Very Open Herbs.



Photo A1.49: CR10
Excellent condition vegetation Association 4: *Eucalyptus salmonophloia* and *E. kondininensis* Woodland over *Exocarpos aphyllus* and *Santalum acuminatum* Low Open Woodland over *Atriplex paludosa* and *Scaevola spinescens* Dwarf Scrub.



Photo A1.50: CR10
 Degraded condition vegetation association 5: *Tecticornia* spp. Dwarf Scrub over *Disphyma crassifolia* and annuals Open Herbs.



Photo A1.51: CR10
 Good condition vegetation association 6: *Eucalyptus myriadena* Open Low Woodland over *Eucalyptus loxophleba* subsp. *gratiae* Open Tree Mallee over *Lomandra effusa* Open Herbs.



Photo A1.52: CR10
 Good condition vegetation association 7: *Eucalyptus salubris* Open Woodland over *Melaleuca pauperiflora* and *Exocarpos aphyllus* Open Low Woodland over Very Open Herbs.



Photo A1.53: CR10
 Good condition vegetation association 8: *Melaleuca pauperiflora*, *M. lateriflora* and *M. acuminata* Thicket over *Enchylaena tomentosa*, *Tecticornia* spp. and *Maireana* sp. Open Dwarf Scrub over *Mesembryanthemum nodiflorum* Herbs.

Map A10
Vegetation condition for
survey site CR10



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: Melanie Webb
 Task ID: 7114
 Filepath: J:\gis\projects\ProjectB_Series\B410C\0002.mxd
 Filename: MapA10_Veg_cond_survey_site_CR10.mxd
 Compilation date: June 2009
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Government of Western Australia
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Site CR11

General Details

Site name	CR11
Landholder	Not specified
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date	28.08.2008

Site Description

Landform	The site contains a creek line that has been 'enhanced' (deepened) for part of its length. It forms a convoluted but largely continuous channel.
Site size	30 ha

Beard Vegetation Description

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	2–10%	<i>Eucalyptus salubris</i> , <i>E. salmonophloia</i>
Mallees	2–10%	<i>E. sheathiana</i> , <i>E. celastroides</i>
Shrubs	10–30%	<i>Melaleuca acuminata</i> , <i>M. pauperiflora</i>
Grasses	0	
Herbs	10–30%	<i>Lomandra effusa</i> , <i>Waitzia acuminata</i>
Rushes and sedges	0	
Litter	2–10%	
Bare Ground	> 70%	
Rock Outcrop	0	

Summary

The vegetated part of the site is a mosaic of densities of woodland with shrubby understorey and shrubs without overstorey. It is mostly gimlet woodland over melaleuca, or melaleuca, with a strip of mallee.

Individual vegetation association descriptions

Vegetation 1	<i>Eucalyptus salubris</i> Open Woodland over <i>Melaleuca pauperiflora</i> Low Woodland to 6 m over <i>Melaleuca acuminata</i> Open Scrub over Very Open Herbs
Vegetation 2	<i>Eucalyptus sheathiana</i> and <i>E. celastroides</i> Open Shrub Mallee over <i>Lomandra effusa</i> and <i>Waitzia acuminata</i> Open Herbs

Native species

Scientific name**Common name**

<i>Austrostipa elegantissima</i>	feather speargrass
<i>Blennospora drummondii</i>	
<i>Caladenia pulchra</i>	red spider orchid
<i>Drosera glanduligera</i>	pimpernel sundew
<i>Enchylaena tomentosa</i>	ruby saltbush
<i>Erymophyllum tenellum</i>	Everlasting
<i>Eucalyptus celastroides</i>	Mirret
<i>Eucalyptus horistes</i>	white flowered mallee
<i>Eucalyptus myriadena</i>	Eucalypt
<i>Eucalyptus salmonophloia</i>	salmon gum
<i>Eucalyptus salubris</i>	Gimlet
<i>Eucalyptus sheathiana</i>	ribbon-barked gum
<i>Eucalyptus spathulata</i>	swamp mallet
<i>Leptospermum erubescens</i>	roadside tea-tree
<i>Lomandra effusa</i>	scented matrush
<i>Melaleuca acuminata</i>	
<i>Melaleuca adnata</i>	
<i>Melaleuca lateriflora</i>	Gorada
<i>Melaleuca pauperiflora</i>	Boree
<i>Millotia tenuifolia</i>	soft millotia
<i>Olearia dampieri</i>	daisy bush
<i>Podolepis capillaris</i>	wiry podolepis
<i>Rhodanthe laevis</i>	
<i>Rhodanthe manglesii</i>	pink sunray
<i>Santalum acuminatum</i>	Quandong
<i>Stylidium repens</i>	matted triggerplant
<i>Trachymene</i> sp.	Coogan
<i>Waitzia acuminata</i>	orange immortelle

Weed species**Scientific name****Common name**

<i>Mesembryanthemum nodiflorum</i>	slender ice-plant
<i>Arctotheca calendula</i>	Capeweed
<i>Cotula bipinnata</i>	ferny cotula
<i>Hypochaeris glabra</i>	Flatweed
<i>Ursinia anthemoides</i>	Ursinia

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	5
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	50
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	12
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	34

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			x
Clearing			x	Feral animals			x
Fire risk				Recreation			
Weed invasion				Point source discharge			
Stock access		x		Other – clearing for fence posts			x
Vehicle access			x				

Comments
The creek has been modified. Powerlines are present and fence posts have been left on the site.

Links to protected areas of remnant vegetation		
Name	Area (ha)	Approximate distance and direction from site
Graham Rock Nature Reserve	2163	Adjacent to site
CR34295	934	8.5 km NW

Management

The creekline along the edge of the site has been modified to increase the rate that water drains through the site: this is the SE Hyden tributary of the Camm River and is included in the proposed Camm River Drainage project.

Fauna

Scientific name

Common name

Birds

<i>Acanthiza</i> sp.	Thornbill
<i>Platycercus zonarius</i>	Australian ringneck parrot
<i>Corvus coronoides</i>	Australian raven
<i>Cracticus nigrogularis</i>	piebald butcher bird
<i>Pardalotus striatus</i>	striated pardalote
<i>Polytelis anthopeplus</i>	regent parrot
<i>Rhipidura leucophrys</i>	willy wagtail
<i>Strepera versicolor</i>	grey currawong

Mammals

<i>Macropus fuliginosus</i>	western grey kangaroo
<i>Tachyglossus aculeatus</i>	short-beaked echidna

Other fauna lists for the general area

Greening Australia Western Australia (2004)

Grein (1994)

Lefroy et al. (1991)

Notes:

From observations:

- Water was flowing through the site after 11.5 mm rain the previous day
- Water sampled was pH 5, temperature 15°C and conductivity 63.5 mS/cm
- A power line corridor runs through the site.
- The drainage line has been 'enhanced' – deepened to increase surface flow.
- Priority 1 flora has previously been recorded near the site, within the same broad vegetation type.

From discussions with the landholder:

- The site has not been burnt in over sixty years although fires have occurred on the adjacent Nature Reserve. The landholder attributes the lack of bushfires to livestock grazing reducing the fuel load.



Photo A1.54: CR11
 Good condition (grazed) vegetation association 1: *Eucalyptus salubris* Open Woodland over *Melaleuca pauperiflora* Low Woodland over *Melaleuca acuminata* Open Scrub over Very Open Herbs.



Photo A1.55: CR11
 Excellent condition vegetation association 2: *Eucalyptus sheathiana* and *E. celastroides* Open Shrub Mallee over *Lomandra effusa* and *Waitzia acuminata* Open Herbs.



Photo A1.56: CR11
 Enhanced drainage line through site looking to the east.



Photo A1.57: CR11
 Enhanced drainage line through site looking to the west.

Map A11
Vegetation condition for
survey site CR11



LEGEND


Vegetation condition

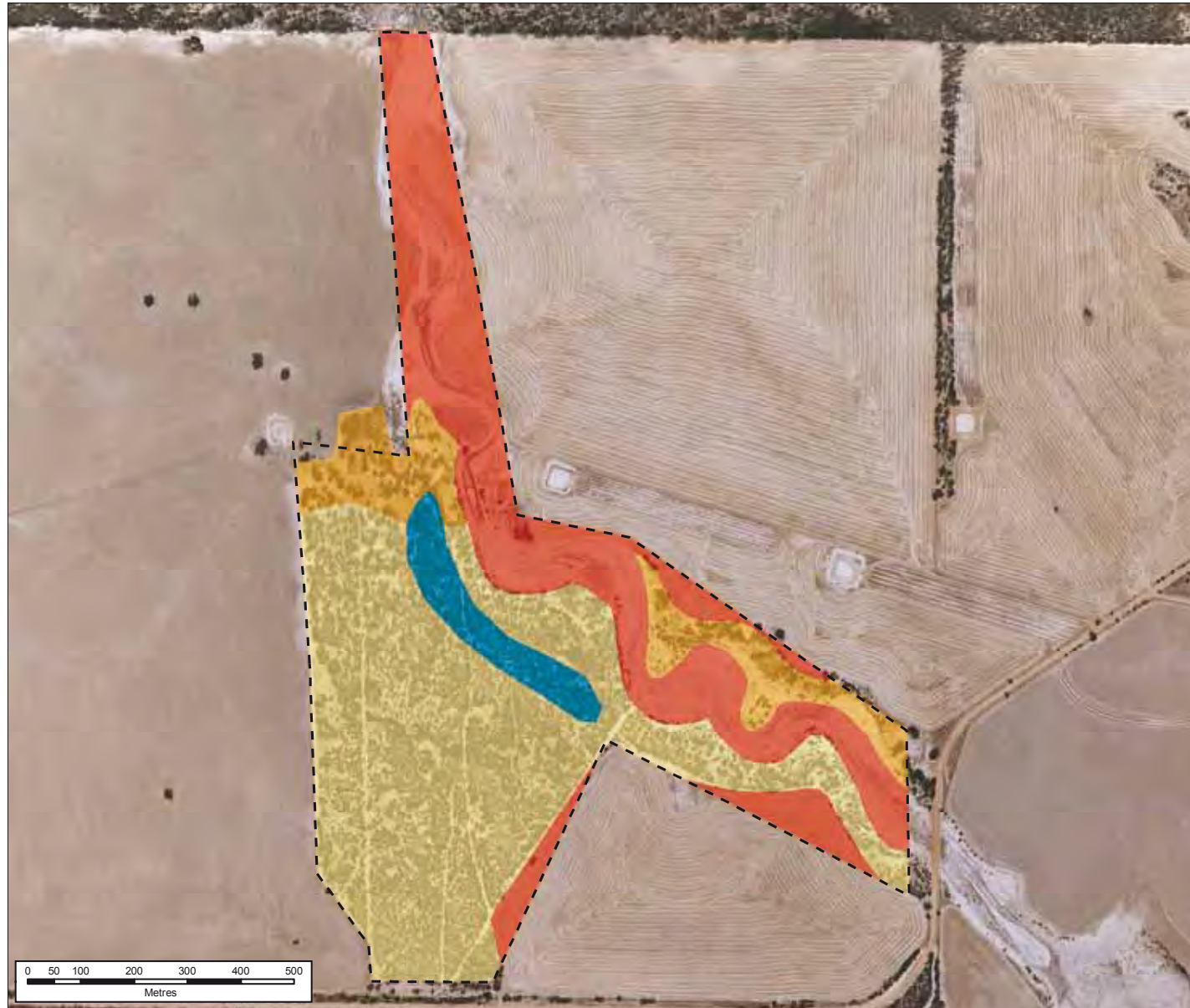
	Revegetation
	Pristine
	Excellent
	Very good
	Good
	Degraded
	Completely degraded

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: Melanie Webb
 Task ID: 7114
 Filepath: J:\gis\projects\ProjectB_Series\B410C0002.mxd
 Filename: MapA11_Veg_cond_survey_site_CR11.mxd
 Compilation date: June 2009
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Site CR12 – Di Russo

General Details

Site name	Di Russo
Landholder	Tony Di Russo
Surveyed by	Lyn Atkins and Natalie Randall (Ecoscape)
Date	19.11.2008

Site Description

Landform	The site contains braided channels and is mainly floodplain.
Site size	290 ha

Beard Vegetation Description

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	0	
Mallees	0	
Shrubs	10–30%	<i>Maireana brevifolia</i> , <i>Tecticornia</i> (3 spp.)
Grasses	30–70%	<i>Lolium rigidum</i> , <i>Parapholis incurva</i>
Herbs	2–10%	<i>Mesembryanthemum nodiflorum</i>
Rushes and sedges	0	
Litter	2–10%	
Bare Ground	> 70%	
Rock Outcrop	0	

Summary

The site is almost entirely samphire (some bluebush) with a herb understorey dominated by introduced species.

Individual vegetation association descriptions

Vegetation 1	<i>Maireana brevifolia</i> Dwarf Scrub over <i>Mesembryanthemum nodiflorum</i> Open Herbs and <i>Lolium</i> sp. Low Grass
Vegetation 2	<i>Tecticornia</i> spp. (3) Dwarf Scrub over <i>Mesembryanthemum nodiflorum</i> Very Open Herbs and <i>Parapholis incurvata</i> Very Open Low Grass

Native species

Scientific name	Common name
<i>Atriplex semibaccata</i>	berry saltbush
<i>Atriplex</i> sp.	saltbush
<i>Austrodanthonia</i> sp.	wallaby grass
<i>Chloris truncata</i>	windmill grass
<i>Crassula colorata</i>	dense stonecrop
<i>Didymanthus roei</i>	
<i>Enchylaena tomentosa</i>	ruby saltbush
<i>Eragrostis dielsii</i>	mallee lovegrass
+ <i>Maireana brevifolia</i>	small-leaf bluebush
<i>Spergularia marina</i>	spurry
<i>Tecticornia</i> spp.	samphire (3 species)

+ *Regeneration noted*

Weed species

Scientific name	Common name
<i>Arctotheca calendula</i>	capeweed
<i>Avena barbata</i>	bearded oats
<i>Bromus rubens</i>	red brome
<i>Hordeum leporinum</i>	barley grass
<i>Hypochaeris glabra</i>	flatweed
<i>Lolium rigidum</i>	annual ryegrass
<i>Medicago truncatula</i>	barrel medic
<i>Mesembryanthemum nodiflorum</i>	slender ice-plant
<i>Parapholis incurva</i>	coast barb grass
<i>Pentaschistis airoides</i>	false hair-grass
<i>Plantago</i> sp.	plantain
<i>Polygonum aviculare</i>	wireweed
<i>Sonchus oleraceus</i>	common sow thistle
<i>Trifolium arvense</i>	hare's foot clover
<i>Trifolium glomeratum</i>	cluster clover
<i>Trifolium tomentosum</i>	woolly clover

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	0
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate	0
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition requires intensive management	0
Completely degraded	Vegetation structure no longer intact and the area is without/almost without native species	98

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	x			Feral animals			x
Fire risk				Recreation			
Weed invasion	x			Point source discharge			
Stock access	x			Other			
Vehicle access			x				x

Comments

The site appears to have been cleared in the past: the only clue to the former vegetation is a narrow degraded strip of *Melaleuca* spp. and eucalypts on the southern edge.

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
Dragon Rocks Reserve	32084	8.0 km SW
Graham Rock Nature Reserve	2163	7.5 km N
CR20341	546	10 km SE

Management

The entire site is completely degraded. Fencing and surface drains are present on the site. It is unlikely that the site is well suited for planting to saltland grazing species due to the highly saline soil, although mounding may assist with saltbush establishment if desired. Management recommendations that may affect salinity and waterlogging must be at the catchment scale.

Fauna

Scientific name	Common name
-----------------	-------------

Birds

<i>Anthus australis</i>	Australian pipit
<i>Cacatua roseicapilla</i>	galah
<i>Epthianura albifrons</i>	white-fronted chat

Mammals

<i>Macropus fuliginosus</i>	western grey kangaroo
<i>Vulpes vulpes</i>	European red fox*

* *Introduced species*

Other fauna lists for the general area

Greening Australia Western Australia (2004)

Grein (1994)

Lefroy et al. (1991)

Notes:

- Both the eastern and western sides of the site have surface drains along the edges
- The site appears to have been completely cleared.



A1.58: CR12

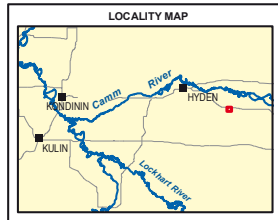
Completely degraded condition
vegetation association 1: *Maireana
brevifolia* Dwarf Scrub over
Mesembryanthemum nodiflorum Open
Herbs and *Lolium rigidum* Low Grass.



A1.59: CR12

Completely degraded vegetation
Association 2: *Tecticornia* spp. Dwarf
Scrub over *Mesembryanthemum
nodiflorum* Very Open Herbs and
Parapholis incurvata Very Open Low
Grass.

Map A12
Vegetation condition for
survery site CR12
Di Russo's



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

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 Map Author: Melanie Webb
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Government of Western Australia
 Department of Water

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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

- | | |
|---------------------------------------|--|
| <input type="checkbox"/> Valley floor | <input type="checkbox"/> Uplands |
| <input type="checkbox"/> Valley slope | <input type="checkbox"/> 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

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: Excellent condition woodland, Karlgarin Lake (CR06 Vegetation Association 7).



Photo A3.2: Very good condition open woodland, Lake Gounter Nature Reserve (CR07 Vegetation Association 1).



Photo A3.3: Good condition open woodland, CR10 (Vegetation Association 7).



Photo A3.4: Degraded condition scrub, Henderer's (CR03 Vegetation Association 1).



Photo A3.5: Completely degraded dwarf scrub, Di Russo's (CR12 Vegetation Association 1).



Photo A3.6: Completely degraded vegetation (formerly samphire), Weewarra (CR04 Vegetation Association 5).

Appendix 4 Examples of local native species suitable for revegetation

Table A4 Examples of local species suitable for revegetation in valley floors in the Camm 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		
Understorey								
<i>Atriplex amnicola</i> (river saltbush)	Very	Moderate (when mature)	Moderate	Yes	Yes	Yes	Dec–Feb	
+ <i>Atriplex semibaccata</i> creeping saltbush	Slightly	Not	Very	Yes	Yes		Jan–Mar	Grows naturally near salt lakes and in woodlands. Short-lived but regenerates well.
<i>Cyperus gymnocaulos</i> 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.
+ <i>Eragrostis dielsii</i> mallee lovegrass	Moderate	Moderate	Moderate	Yes	Yes			Prefers lighter soils.
+ <i>Gahnia trifida</i> 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.
+ * <i>Maireana brevifolia</i> 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		
+ <i>Rhagodia drummondii</i> lake fringe rhagodia	Very	Slightly	Very	Yes	Yes			Grows in a wide variety of soils, especially sand.
<i>Sporobolus virginicus</i> native marine couch	Moderate	Very		Yes		Yes	Jan–Mar	Prefers lighter soils.
+ <i>Tecticornia</i> species samphire	Various	Very	Very			Yes	Yes	
Midstorey								
+* <i>Acacia acuminata</i> jam	Slightly	Slightly	Very	Yes	Yes		Nov–Dec	Grows in a wide variety of soil types.
<i>Acacia microbotrya</i> manna wattle	Slightly	Slightly		Yes	Yes		Oct–Dec	Grows in a wide variety of soil types.
<i>Callistemon phoeniceus</i> lesser bottlebrush	High-Mod	High-Moderate	High-Mod	Yes	Yes		All year	Grows in a wide variety of soil types.
<i>Grevillea paniculata</i>	Not	Not		Yes				Suitable for fresh flood fringes
+ * <i>Hakea kippistiana</i>								Found naturally regenerating on the edge of salt lakes.
+ <i>Hakea preissii</i> 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		
+* <i>Melaleuca adnata</i>								Grows in floodplains
+ * <i>Melaleuca acuminata</i>								Grows in floodplains
+ * <i>Melaleuca brevifolia</i>								Grows in floodplains
+ <i>Melaleuca cuticularis</i> saltwater paperbark								Grows in saline floodplains and on the edge of lakes.
+ * <i>Melaleuca hamata</i> brushwood								One of the brushwood melaleucas (formerly included with <i>M. uncinata</i>). Found near the edge of salt lakes.
+ <i>Melaleuca thyoides</i>								Grows on the edge of salt lakes.
+* <i>Melaleuca uncinata</i> brushwood	Variable	Variable						Grows in a wide variety of soil types.
Overstorey								
<i>Casuarina obesa</i> swamp sheoak	Very	Very		Yes	Yes			Grows in many soil types.
+ <i>Eucalyptus horistes</i> white flowered mallee								Grows on dunes near salt lakes and waterways . Includes the mallee formerly called <i>Eucalyptus hypochlamydea</i> .

Species	Tolerance			Propagation			Seed harvested	Notes
	Salt	Water-logging	Drought	Direct seeding	Tubestock	Cuttings/transplanting		
+ <i>Eucalyptus kondininensis</i> Kondinin blackbutt								Prefers loamy soils near salt lakes.
+ <i>Eucalyptus longicornis</i> red morrell								Grows in saline fine-textured loams and clays on valley floors.
<i>Eucalyptus loxophleba</i> York gum	Some moderate	Not		Yes	Yes			All year Grows in many soil types. Both mallee (subsp. <i>gratiae</i>) and tree (subsp. <i>loxophleba</i>) suitable.
+ <i>Eucalyptus myriadena</i>								Similar in appearance to yorrell. Prefers clay soils near salt lakes.
+ * <i>Eucalyptus salmonophloia</i> salmon gum	Moderate	Not						Grows in loams and duplex soils on lower slopes and valley floors.
+ <i>Eucalyptus salubris</i> gimlet	Moderate							Grows in loams and duplex soils on lower slopes and valley floors.
+ <i>Eucalyptus sargentii</i> Salt River gum	Mod-High	Some		Yes	Yes			All year Grows in a wide variety of soils associated with salt lakes and saline waterways.
+* <i>Eucalyptus spathulata</i> swamp mallet								Grows close to salt lakes.
<i>Eucalyptus yilgarnensis</i> 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										
<i>Atriplex amnicola</i> river saltbush	Local	Very	Moderate (when mature)	Moderate	Yes	Yes	Yes		Dec–Feb	Good forage with up to 10% protein. Recovers well from grazing.
<i>Atriplex cinerea</i> grey saltbush	WA	On saline seeps	Moderate		Yes		Yes			Palatability varies
<i>Atriplex nummularia</i> old man saltbush	Australia	Moderate	Sensitive		Yes	Yes			Sept–Oct	Not as palatable as other species, brittle and easily damaged by trampling.
<i>Atriplex semibaccata</i> creeping saltbush	Local	Slightly	Not	Very	Yes	Yes			Jan–Mar	Short-lived but regenerates well. Very palatable and prone to being eaten out.
<i>Atriplex undulata</i> wavy-leaf saltbush	Introduced	Yes	Moderate		Yes			Yes		Palatable. Recovers well from grazing.

Species	Tolerance			Propagation				Seed harvested	Notes
	Origin	Salt	Water-logging	Drought	Direct seeding	Tubestock	Cuttings		
samphire									
<i>Tecticornia</i> 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									
<i>Maireana brevifolia</i> 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.
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
<i>Acacia acanthoclada</i>	harrow wattle
<i>Acacia acuaria</i>	wattle
<i>Acacia acuminata</i>	jam
<i>Acacia erinacea</i>	spiny wattle
<i>Acacia hemiteles</i>	tan wattle
<i>Acacia</i> sp.	wattle
<i>Allocasuarina campestris</i>	tamma
<i>Allocasuarina huegeliana</i>	rock sheoak
<i>Alyxia buxifolia</i>	dysentery bush
<i>Amphipogon strictus</i>	grey beard grass
<i>Amyema miraculosa</i>	mistletoe
<i>Angianthus tomentosus</i>	camel-grass
<i>Argyrolottis turbinata</i>	
<i>Atriplex amnicola</i>	swamp saltbush
<i>Atriplex bunburyana</i>	silver saltbush
<i>Atriplex hymenotheca</i>	saltbush
<i>Atriplex paludosa</i>	marsh saltbush
<i>Atriplex semibaccata</i>	berry saltbush
<i>Atriplex</i> sp.	saltbush
<i>Austrodanthonia</i> sp.	wallaby grass
<i>Austrostipa elegantissima</i>	feather speargrass
<i>Austrostipa pycnostachya</i>	speargrass
<i>Austrostipa</i> sp.	speargrass
<i>Baeckea</i> sp.	myrtle
<i>Blennospora drummondii</i>	
<i>Borya constricta</i>	pin-grass
<i>Borya laciniata</i>	pin-grass
<i>Borya sphaerocephala</i>	pincushions
<i>Brachyscome iberidifolia</i>	Swan River daisy
<i>Brachyscome</i> sp.	daisy
<i>Caladenia pulchra</i>	red spider orchid
<i>Caladenia longicauda</i>	common white spider orchid
<i>Caladenia reptans</i>	little pink fairy orchid
<i>Calandrinia eremaea</i>	twining purslane
<i>Calandrinia polyandra</i>	parakeelya
<i>Calandrinia</i> sp.	parakeelya
<i>Calotis hispidula</i>	bindy eye
<i>Calytrix leschenaultii</i>	purple starflower
<i>Carpobrotus modestus</i>	inland pigface
<i>Chamaescilla corymbosa</i>	blue squill

Species	Common name
<i>Chloris truncata</i>	windmill grass
<i>Clematis delicata</i>	clematis
<i>Comesperma integerrimum</i>	milkwort
<i>Cotula coronopifolia</i>	waterbuttons
<i>Crassula colorata</i>	dense stonecrop
<i>Cryptandra</i> sp.	
<i>Darwinia halophila</i>	darwinia
<i>Daucus glochidiatus</i>	Australian carrot
<i>Daviesia benthamii</i>	
<i>Daviesia incrassata</i>	
<i>Desmocladius asper</i>	
<i>Dianella revoluta</i>	blueberry lily
<i>Didymanthus roei</i>	
<i>Disphyma crassifolium</i>	round leaved pigface
<i>Dodonaea stenozyga</i>	hop bush
<i>Dodonaea viscosa</i>	sticky hop bush
<i>Drosera glanduligera</i>	pimpernel sundew
<i>Drosera macrantha</i>	bridal rainbow
<i>Drosera</i> sp.	sundew
<i>Enchylaena tomentosa</i>	ruby saltbush
<i>Eragrostis dielsii</i>	mallee lovegrass
<i>Eremophila decipiens</i>	slender fuchsia
<i>Eremophila</i> sp.	emu bush
<i>Erodium cygnorum</i>	blue heron's-bill
<i>Erymophyllum tenellum</i>	everlasting
<i>Eucalyptus alipes</i>	Swamp mallet
<i>Eucalyptus calycogona</i>	gooseberry mallee
<i>Eucalyptus celastroides</i>	mirret
<i>Eucalyptus horistes</i>	white flowered mallee
<i>Eucalyptus kondininensis</i>	Kondinin blackbutt
<i>Eucalyptus longicornis</i>	red morrell
<i>Eucalyptus loxophleba</i>	York gum
<i>Eucalyptus loxophleba</i> subsp. <i>gratiae</i>	Lake Grace gum
<i>Eucalyptus moderata</i>	eucalypt
<i>Eucalyptus myriadena</i>	eucalypt
<i>Eucalyptus phenax</i>	mallee
<i>Eucalyptus salicola</i>	salt gum
<i>Eucalyptus salmonophloia</i>	salmon gum
<i>Eucalyptus salubris</i>	gimlet
<i>Eucalyptus sargentii</i>	salt river gum
<i>Eucalyptus sheathiana</i>	ribbon-barked gum
<i>Eucalyptus</i> sp.	eucalypt
<i>Eucalyptus spathulata</i>	swamp mallet

Species	Common name
<i>Eucalyptus subangusta</i>	black marlock
<i>Exocarpos aphyllus</i>	leafless ballart
<i>Frankenia drummondii</i>	frankenian
<i>Frankenia</i> sp.	frankenian
<i>Gahnia ancistrophylla</i>	hooked-leaf saw sedge
<i>Gahnia trifida</i>	coast saw sedge
<i>Grevillea acuaria</i>	grevillea
<i>Grevillea anethifolia</i>	grevillea
<i>Grevillea huegelii</i>	grevillea
<i>Grevillea</i> sp.	grevillea
<i>Gunniopsis septifraga</i>	
<i>Hakea kippistiana</i>	hakea
<i>Hakea preissii</i>	needle tree
<i>Hyalochlamys globifera</i>	
<i>Hypoxis</i> sp.	
<i>Juncus</i> sp.	rush
<i>Lepidobolus chaetocephalus</i>	bristle-headed chaff rush
<i>Lepidosperma drummondii</i>	sword sedge
<i>Lepidosperma leptostachyum</i>	sword sedge
<i>Lepidosperma</i> sp.	sword sedge
<i>Lepidosperma</i> sp. A2 Island Flat	sword sedge
<i>Leptospermum erubescens</i>	roadside tea-tree
<i>Leucopogon</i> sp.	beard-heath
<i>Lomandra effusa</i>	scented matrush
<i>Lycium australe</i>	Australian boxthorn, water bush
<i>Maireana amoena</i>	bluebush
<i>Maireana brevifolia</i>	small-leaf bluebush
<i>Maireana carnososa</i>	cottony bluebush
<i>Maireana erioclada</i>	bluebush
<i>Maireana triptera</i>	three-winged bluebush
<i>Melaleuca acuminata</i>	
<i>Melaleuca adnata</i>	
<i>Melaleuca atroviridis</i>	brushwood
<i>Melaleuca brevifolia</i>	
<i>Melaleuca coronicarpa</i>	
<i>Melaleuca cuticularis</i>	saltwater paperbark
<i>Melaleuca elliptica</i>	granite bottlebrush
<i>Melaleuca hamata</i>	brushwood
<i>Melaleuca lateriflora</i>	gorada
<i>Melaleuca laxiflora</i>	
<i>Melaleuca pauperiflora</i>	boree
<i>Melaleuca scalena</i>	brushwood
<i>Melaleuca thyoides</i>	

Species	Common name
<i>Melaleuca uncinata</i>	brushwood
<i>Melaleuca viminea</i>	mohan
<i>Microcybe multiflora</i>	
<i>Millotia tenuifolia</i>	soft millotia
<i>Mirbelia spinosa</i>	
<i>Neurachne alopecuroidea</i>	foxtail mulga grass
<i>Olearia dampieri</i>	daisy bush
<i>Olearia muelleri</i>	goldfields daisy, dusky daisy bush
<i>Pittosporum angustifolium</i>	native apricot, native willow
<i>Platysace effusa</i>	platysace
<i>Platysace maxwellii</i>	karno
<i>Podolepis capillaris</i>	wiry podolepis
<i>Podolepis lessonii</i>	
<i>Podotheca gnaphalioides</i>	golden longheads
<i>Ptilotus fasciculatus</i>	mulla mulla
<i>Ptilotus manglesii</i>	pom poms
<i>Pultenaea</i> sp.	pea
<i>Rhagodia drummondii</i>	rhagodia
<i>Rhagodia preissii</i>	rhagodia
<i>Rhagodia</i> sp.	rhagodia
<i>Rhodanthe laevis</i>	
<i>Rhodanthe manglesii</i>	pink sunray
<i>Rhodanthe pygmaea</i>	
<i>Rinzia crassifolia</i>	
<i>Roycea spinescens</i>	
<i>Santalum acuminatum</i>	quandong
<i>Santalum spicatum</i>	sandalwood
<i>Sarcocornia blackiana</i>	samphire
<i>Sarcocornia</i> sp.	samphire
<i>Scaevola spinescens</i>	currant bush
<i>Sclerolaena diacantha</i>	grey copper-burr
<i>Sclerolaena ?costata</i>	
<i>Senecio</i> sp.	groundsel
<i>Siloxerus multiflorus</i>	
<i>Spergularia marina</i>	spurry
<i>Stylidium repens</i>	matted triggerplant
<i>Tecticornia lylei</i>	samphire
<i>Tecticornia undulata</i>	samphire
<i>Tecticornia</i> spp. (3)	samphire
<i>Templetonia sulcata</i>	centipede bush
<i>Threlkeldia diffusa</i>	coast bonefruit
<i>Trachymene</i> spp.	coogan
<i>Trymalium daphnifolium</i>	

Species	Common name
<i>Verticordia chrysanthella</i>	featherflower
<i>Waitzia acuminata</i>	orange immortelle
<i>Westringia cephalantha</i>	westringia
<i>Westringia rigida</i>	stiff westringia
<i>Wilsonia humilis</i>	silky wilsonia

Table A6.2 Weed species recorded during the survey

Species	Common name
<i>Arctotheca calendula</i>	capeweed
<i>Avena barbata</i>	bearded oats
<i>Brassica tournefortii</i>	wild turnip
<i>Bromus rubens</i>	red brome
<i>Carpobrotus edulis</i>	hottentot fig
<i>Cotula bipinnata</i>	ferry cotula
<i>Dittrichia graveolens</i>	stinkwort
<i>Hordeum leporinum</i>	barley grass
<i>Hypochaeris glabra</i>	flatweed
<i>Lolium rigidum</i>	annual ryegrass
<i>Lolium</i> sp.	rye grass
<i>Medicago</i> sp.	medic
<i>Medicago truncatula</i>	barrel medic
<i>Mesembryanthemum nodiflorum</i>	slender ice-plant
<i>Monoculus monstrosus</i>	stinking Roger
<i>Moraea setifolia</i>	thread iris
<i>Parapholis incurva</i>	coast barbgrass
<i>Pentaschistis airoides</i>	false hair-grass
<i>Plantago</i> sp.	plantain
<i>Polygonum aviculare</i>	wireweed
<i>Raphanus raphanistrum</i>	wild radish
<i>Sonchus oleraceus</i>	common sowthistle
<i>Sonchus</i> sp.	sow thistle
<i>Spergularia</i> sp.	spurry
<i>Trifolium arvense</i>	hare's foot clover
<i>Trifolium glomeratum</i>	cluster clover
<i>Trifolium subterraneum</i>	subterranean clover
<i>Trifolium tomentosum</i>	woolly clover
<i>Ursinia anthemoides</i>	ursinia
<i>Vulpia myuros</i>	silver grass

Table A6.3 Birds found during the survey

Species	Common name
<i>Acanthagenys rufogularis</i>	spiny-cheeked honeyeater
<i>Acanthiza apicalis</i>	inland thornbill
<i>Acanthiza chrysorrhoa</i>	yellow-rumped thornbill
<i>Acanthiza</i> sp.	thornbills
<i>Anthochaera carunculata</i>	red wattlebird
<i>Anthus australis</i>	Australian pipit
<i>Artamus cinereus</i>	black-faced woodswallow
<i>Cacatua roseicapilla</i>	galah
<i>Chrysococcyx basalis</i>	Horsfield's bronze cuckoo
<i>Coracina novaehollandiae</i>	black-faced cuckoo-shrike
<i>Corvus coronoides</i>	Australian raven
<i>Cracticus nigrogularis</i>	pie'd butcher bird
<i>Cracticus tibicen</i>	magpie
<i>Cracticus torquatus</i>	grey butcherbird
<i>Cuculus pallidus</i>	pallid cuckoo
<i>Dromaius novaehollandiae</i>	emu
<i>Drymodes brunneopygia</i>	southern scrub-robin
<i>Epthianura albifrons</i>	white-fronted chat
<i>Erythrogonys cinctus</i>	red-kneed dotterel
<i>Falco cenchroides</i>	Australian kestrel
<i>Grallina cyanoleuca</i>	magpie-lark
<i>Hirundo neoxena</i>	welcome swallow
<i>Hirundo nigricans</i>	tree martin
<i>Lichenostomus virescens</i>	singing honey-eater
<i>Neophema elegans</i>	elegant parrot
<i>Ocyphaps lophotes</i>	crested pigeon
<i>Pachycephala pectoralis</i>	golden whistler
<i>Pachycephala rufiventris</i>	rufous whistler
<i>Pardalotus striatus</i>	striated pardalote
<i>Petroica goodenovii</i>	red-capped robin
<i>Phaps chalcoptera</i>	common bronzewing
<i>Platycercus varius</i>	mulga parrot
<i>Platycercus zonarius</i>	Australian ringneck parrot
<i>Polytelis anthopeplus</i>	regent parrot
<i>Pomatostomus superciliosus</i>	white browed babbler
<i>Rhipidura leucophrys</i>	willy wagtail
<i>Smicromnis brevirostris</i>	weebill
<i>Strepera versicolor</i>	grey currawong
<i>Tadorna tadornoides</i>	Australian shelduck (mountain duck)

Table A6.4 Mammals recorded during the survey

Species	Common name
<i>Canis lupus familiaris</i>	dog*
<i>Macropus fuliginosus</i>	western grey kangaroo
<i>Oryctolagus cuniculus</i>	European wild rabbit*
<i>Tachyglossus aculeatus</i>	short-beaked echidna
<i>Vulpes vulpes</i>	European red fox*

*introduced species

