Department of **Water**
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Riparian condition of the Salt River

Waterway assessment in the zone of ancient drainage

Water resource management series

Report No. WRM 46
January 2008

Department of Water
Government of Western Australia

Riparian condition of the Salt River

Waterway assessment in the zone of ancient drainage

AVON CATCHMENT COUNCIL

Government of Western Australia

Australian Government

Funded by
the Avon Catchment Council, the Government of Western Australia
and the Australian Government through the Natural Heritage Trust
and the National Action Plan for Salinity and Water Quality

AVON RIVERCARE PROJECT

Department of Water

Water resource management series

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Cover photograph: The colours in these playa lakes on the Salt River are the result of algal blooms and microbial mats (Photo Kate Gole)

All photographs have been taken by Kate Gole unless otherwise stated.

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Abbreviations

ACC	Avon Catchment Council
ANDA	Avon Natural Diversity Alliance
AWC	Avon Waterways Committee
DAF	Department of Agriculture and Food
DEC	Department of Environment and Conservation
EEI	Engineering Evaluation Initiative
GAWA	Greening Australia Western Australia
NAP	National Action Plan for Salinity and Water Quality
NRM	Natural Resource Management
RRP	River Recovery Plan
SPA	Saltland Pastures Association
WDE	Wheatbelt Drainage Evaluation
WWF	WWF-Australia

Summary

Management of water resources in the Avon River Basin is a high priority under the Avon Catchment Council's Avon River Basin Natural Resource Management Strategy and Investment Plans (Avon Catchment Council, 2005a, b). 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. The Salt River project is the first of these waterway assessments.

The Salt River study area extends 40 km upstream from the Quairading–Corrigin Rd to Glenluce Rd at the Caroline Gap, where the Yilgarn and Lockhart rivers converge, and includes the channels and salt lakes of the Salt River, its floodplain and areas of remnant vegetation close to the floodplain.

The purpose of the Salt River waterway assessment is to investigate its current condition, identify threatening processes and propose management recommendations for improving its condition. Sources of advice and funding are also identified to enable the implementation of the proposed management recommendations.

The key management issues in the Salt River floodplain are

- increasing salinity and waterlogging in the valley floor
- loss of riparian vegetation fringing the Salt River and its tributaries
- management of flood flows
- impedance of flood flows by road crossings
- increased stream flow causing erosion and sedimentation in tributaries
- pest species degrading riparian vegetation
- lack of corridors linking areas of remnant vegetation
- fire risk
- dumping of rubbish in floodplain areas.

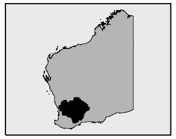
Of these, the most crucial are increasing salinity levels and waterlogging in the valley floor. These are processes that need to be managed at a catchment scale, through partnerships between landholders, all levels of government and non-government agencies.

Information gained through the Salt River waterway assessment will be used by waterway managers, including the Avon Catchment Council, the Department of Water, the Department of Environment and Conservation, the Avon Waterways Committee, local shires and landholders, to plan and prioritise for the future management of the waterway.

Kate Gole, Natural Resource Management Officer
Department of Water, Swan Avon Region, Avon District

Map 1
AVON RIVER BASIN AND SUBCATCHMENTS

LOCALITY MAP



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LEGEND

- Major town/city
- Town
- Major road
- River
- AVON — Avon River Basin Subcatchment

25 0 25 50 75

Kilometres

Datum and Projection Information

Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA 94 Zone 50

Project Information

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Map Author: Judit Bonisch
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Filename: map1_avon_river_basin_and_subcatchments
Date: 31/08/2006

SOURCES

DOW acknowledges the following datasets and their Custodians in the production of this map:

Dataset Name	CUSTODIAN ACRONYM	Metadata Date
Towns	DLI	08/2004
Roads, 1M, GA	GA	30/05/2002
WA Coastline 1M, GA	GA	30/06/2001
Hydrographic Catchments-Catchments	DoE	23/03/2005

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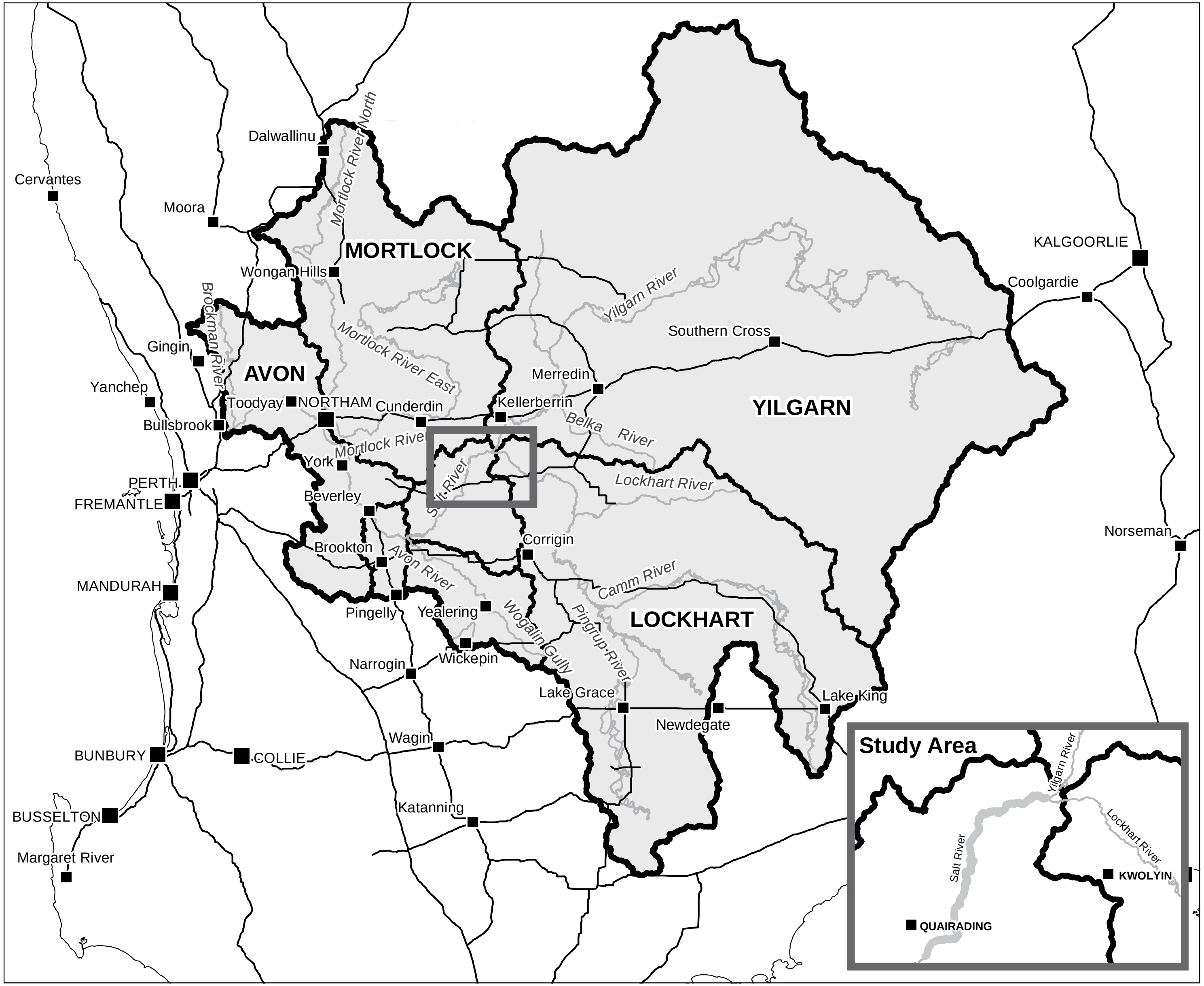
This map is a product of the Department of Water, Water Resources Business Operations Division, and was created on 31/08/2006.

This map was produced with the intent that it be used for the Salt River Reconnaissance Study at the scale of 1:3,000,000.

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



1 Introduction

1.1 Avon River Basin

The Avon River Basin is one of Western Australia's most extensive river systems, draining approximately 120 000 km^2 from Dalwallinu in the north, Southern Cross in the north-east and Lake King in the south-east.

There are four main subcatchments within the Avon River Basin.

- The Yilgarn River catchment, which drains an area of approximately 55 900 km^2. It originates north-east of Southern Cross from Lake Seabrook and Lake Deborah and flows to the south-west past Merredin until its confluence with the Lockhart River at the Caroline Gap, south of Kellerberrin.
- The Lockhart River catchment, which drains an area of approximately 32 400 km^2. It originates at Lake Magenta, south of Newdegate, and flows north-west through Kondinin, Corrigin and Bruce Rock to the Caroline Gap. The catchment also includes the Pingrup River, which originates at Chinocup Lake, south of Lake Grace, and the Camm River, which originates at Lake King.
- The Mortlock River System, which drains an area of approximately 16 770 km^2. It 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 catchment, which drains an area of approximately 15 500 km^2 and includes the Salt River, Avon River South Branch, Dale River, Mackie River, Toodyay Brook, Brockman River and Wooroloo Brook catchments.

Map 1 shows the major subcatchments of the Avon River Basin and the location of the Salt 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 has recently completed the *Avon River Basin NRM Strategy* (Avon Catchment Council 2005a) and the *Avon Investment Plan* (Avon Catchment Council 2005b), which provide direction and priorities for investment into actions to bring about change in the condition of water, land, vegetation and other landscape assets.

Supporting the Avon NRM Strategy, the Ballardong NRM Working Group (2006) has completed *Ballardong Noongar Budjar: 'Healthy Country – Healthy People'* which presents the Noongar perspective on caring for Country and involving the Ballardong people in natural resource management in the Avon River Basin.

The Avon Natural Diversity Alliance (ANDA) was formed to facilitate the delivery of projects from the *Avon Investment Plan*. The Department of Water, the 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. 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. The Salt River study is the first of these waterway assessments.

1.3 The need for waterway assessment in the zone of ancient drainage

As part of the Avon Rivercare Project, River Recovery Plans (RRP) have been completed along the length of the Avon River, from Walyunga National Park to Lake Yealering, as well as for several major tributaries, the Avon River South Branch and the Dale River.

Foreshore and channel assessments have been completed for major tributaries of the Avon, including Toodyay Brook, Spencers Brook, Talbot Brook, the Mortlock River system, the Mackie River and the Dale River, and work has begun on studies of other tributaries, including Jimperding Brook, near Toodyay.

In recognition of the importance of the Yenyening Lakes, an initial management strategy was completed in 1996 (Yenyening Lakes Management Group 1996) and reviewed and updated in 2002 (Water and Rivers Commission 2002). The strategy covers the area from Qualandary Crossing upstream to the Quairading–Corrigin Rd.

However, few studies of these types have been completed for waterways in the Avon River Basin within the zone of ancient drainage. There is a need to gain an understanding of the current condition of waterways and riparian zones in the Yilgarn and Lockhart catchments and the best ways in which to manage them.

The geomorphology of waterways within the zone of ancient drainage differs from that of waterways in the zone of rejuvenated drainage, such as the main channel of the Avon River and parts of the Mortlock River System. Waterway assessment methods, such as the foreshore and channel assessment method developed by Pen and Scott (1995), are therefore not appropriate for waterways in the zone of ancient drainage. Hence, there is a need for a new methodology to assess the riparian condition of these waterways.

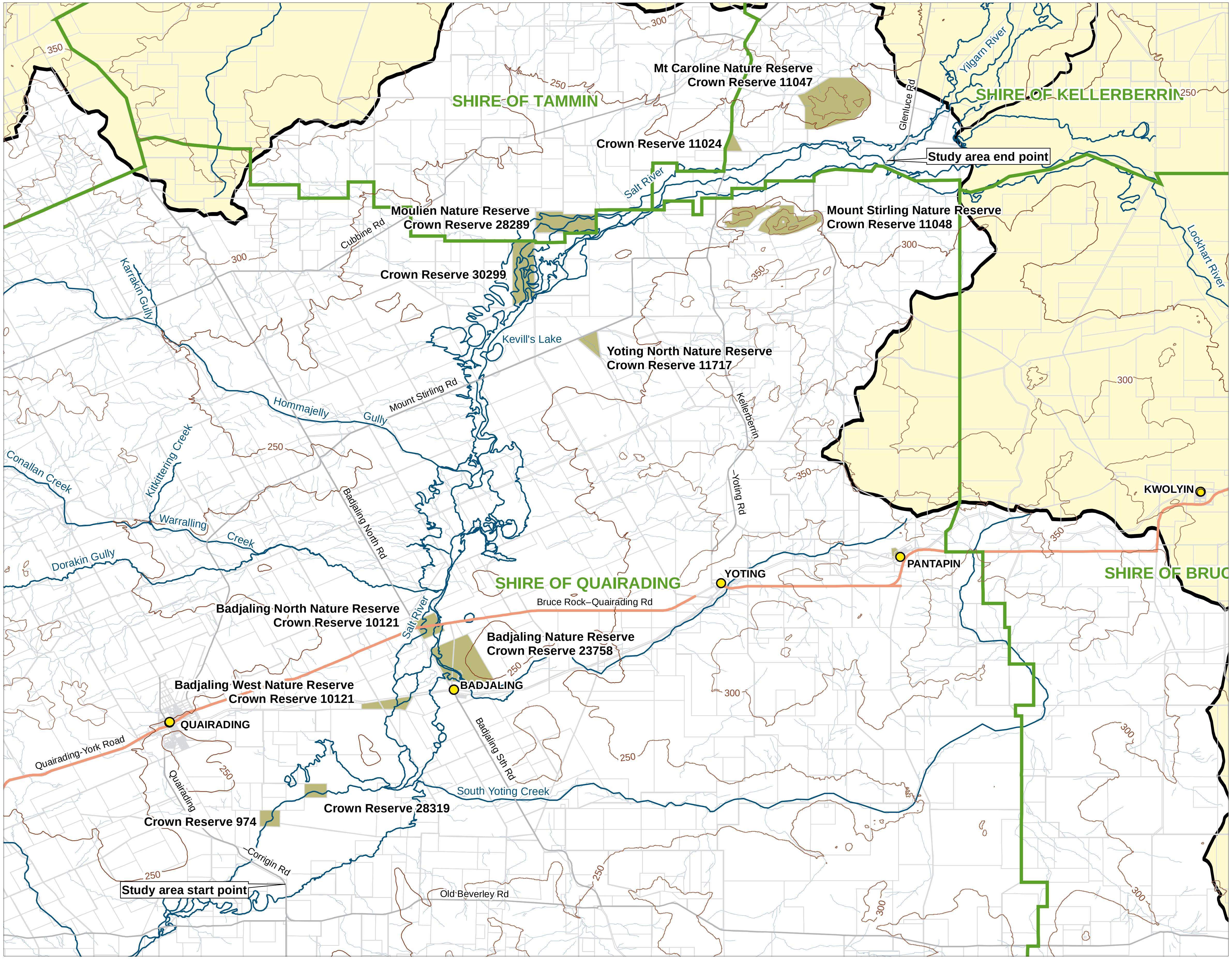
The main aims of the Salt River study are to:

- develop and field test a method for assessing the riparian condition and management needs of waterways in the zone of ancient drainage
- gain an understanding of the current riparian condition of the Salt River
- provide river managers with information on the current state of the Salt River to aid in decision-making processes
- provide landholders and land managers with information on best practice waterways management.

Information gained through the assessment of the Salt River will be used by waterways managers, such as the Department of Water, the DEC, the ACC, the Avon Waterways Committee (AWC), landholders and local shires, to plan and prioritise for future management, for example the allocation of funding for waterway restoration and revegetation, and the allocation of materials through the Avon Fencing Project.

Map 2
SALT RIVER STUDY AREA

LOCALITY MAP



LEGEND

- Major town/city (>5000)
- Town (>500)
- Minor town (<500)
- Contour
- LGA boundary
- Main roads
- Hydrography, linear
- Cadastre
- Nature reserve

N

0 5

Kilometres

Datum and Projection Information

Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA 94 Zone 50

Project Information

Requestee:Kate Gole
Map Author:Judit Bonisch
Task ID:6549
Filename J:\RS\Sn\96299\0002
Date:30/08/2006

SOURCES

DoW acknowledges the following datasets and their custodians in the production of this map:

Dataset Name	CUSTODIAN ACRONYM	Metadata Date
Towns	DLI	08/2004
Road Centrelines, DLI	DLI	01/04/2004
Cadastre	DLI	01/12/2005
Topographic Contours	DLI	12/09/2002
LM_salinitymap_00_25m_ll	DLI	2000
Local Government Authorities	DLI	08/07/2004
Geographic Names	DLI	15/07/2005
Hydrography, Linear	DoE	01/02/2004

Department of Water
Government of Western Australia

This map is a product of the Department of Water, Regional Operation, and was printed on 30/08/2006.

This map was produced with the intent that it be used for the Salt River Reconnaissance Study at a scale of 1:150,000.

2 Nature of the Salt River study area

2.1 Salt River study area

The Salt River and Yenyening Lakes form the connection between the salt-lake chains in the broad valleys of the zone of ancient drainage in the east and the rejuvenated Avon River in the west. The study area for this project includes the channels and salt lakes of the Salt River, its floodplain and areas of remnant vegetation close to the floodplain, from the Quairading–Corrigin Rd approximately 40 km upstream to the Caroline Gap, where the Yilgarn and Lockhart rivers converge. Map 2 shows the location of the study area.

2.2 Nature of the Salt River landscape

The Salt River system lies within the zone of ancient drainage. The landscape is characterised by broad, flat valley floors linked by chains of salt lakes and long, gently-sloped valley sides punctuated by rocky outcrops that rise to an undulating sandplain, the last remnants of the ancient lateritic profile that once covered the entire landscape (Lantzke 1992).

The Salt River study area falls within the Mt Caroline Vegetation System of the Avon Botanical District (Beard 1980). Soil types, landscape features and vegetation associations within the catchment are closely linked (Figure 1).

2.2.1 Broad valley floors

The broad valley floors are characterised by salt lakes (playas), braided, discontinuous channels bordered by lunettes (wind-blown sediment deposits) and flat to undulating saline plains (Commander et al. 2001). These landscape features correspond to the Merredin, Baandee, Nangeenan and Belka landscape units shown in Figure 1 (Lantzke 1992).

The lakes themselves tend to be bare of vegetation and fringed by salt-tolerant species such as samphire (*Halosarcia* species), saltbush (*Atriplex* species) and bluebush (*Maireana* species). Bordering the lakes are flats dominated by *Melaleuca* thickets, including broom bush (*Melaleuca uncinata*), grading into woodlands of York gum (*Eucalyptus loxophleba*), salmon gum (*Eucalyptus salmonophloia*), gimlet (*Eucalyptus salubris*) and morrel (*Eucalyptus longicornis*) over *Melaleucas* and succulents (Weaving 1997; Lantzke 1992).

Lunettes form on the lee side of the lakes from saline, wind-blown deposits of sands and clays. Vegetation associations vary, but often mallee woodlands can be found growing just above the salt flats.

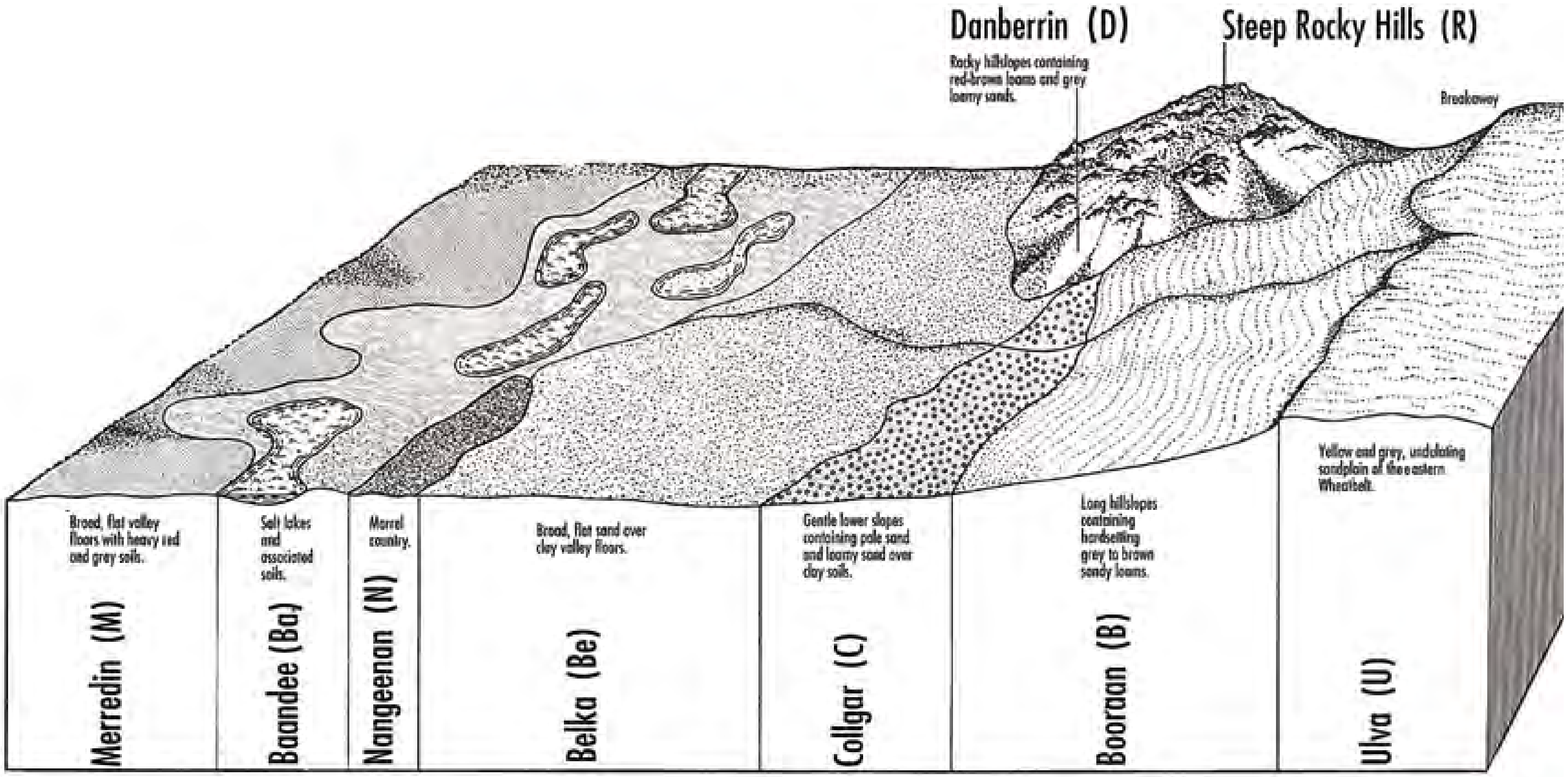
Photo 1 *The diversity of salt-tolerant species within the Salt River floodplain*

2.2.2 Valley slopes and uplands

Very gentle slopes, corresponding to the Collgar landscape unit (see Figure 1), fringe the broad alluvial floodplain and are dominated by woodlands of York gum (*Eucalyptus loxophleba*), salmon gum (*Eucalyptus salmonophloia*) and gimlet (*Eucalyptus salubris*) over jam (*Acacia acuminata*) and sheoak (*Allocasuarina* species). The Booraan unit comprises long hillslopes of hardsetting sandy loams associated with salmon gum (*Eucalyptus salmonophloia*), wandoo (*Eucalyptus wandoo*) and gimlet (*Eucalyptus salubris*) woodlands over a sparse understorey of *Acacia* species (Weaving 1997; Weaving & Grein 1994; Lantzke 1992).

The Ulva landscape unit is an undulating sandplain above lateritic breakaways. This unit is all that remains of the old lateritic profile that once covered the entire landscape. The Booraan and Collgar units are formed from the dissection of this surface. The sandplain soils are characterised by kwongan communities of acorn banksia (*Banksia prionotes*), sandplain woody pear (*Xylomelum angustifolium*) and sheoak (*Allocasuarina* species) over an open understorey of *Hakea* and *Acacia* species. Tamma (*Allocasuarina campestris*) thickets with scattered wandoo (*Eucalyptus wandoo*) occur on the laterite breakaways (Weaving 1997; Weaving & Grein 1994; Lantzke 1992).

The steep rocky hills of the Danberrin unit include the red-streaked granites of Mt Caroline and Mt Stirling, which together define the Caroline Gap, where the Yilgarn



SOIL LANDSCAPE UNIT	Merredin	Baandee	Nangeenan	Belka	Collgar	Danberrin	Steep Rocky Hills	Booraan	Ulva
MAJOR SOIL TYPES	Red-brown sandy loam over clay valley soil. Red clay valley soil. Grey clay valley soil Grey to brown cracking clay.	Salt lake and channels. Soils fringing the salt lakes.	Powdery surfaced calcereous soil.	Deep sandy surfaced valley soil. Shallow sandy surfaced valley soil.	Loamy sand over clay	Rocky red-brown loamy sand/sandy loam. Brownish grey granitic loamy sand. Red-brown doleritic clay loam.	Steep rocky hill soils.	Sandy loam over clay. Shallow hardsetting grey sandy loam over clay. Loamy sand over clay.	Yellow gradational loamy sand. Deep yellow sand. Pale sand over gravel/loamy sand. Deep pale sand. Shallow mottled zone. Deep yellow acid sand.
VEGETATION	Salmon gum Gimlet	Barley grass Bluebush Saltbush Samphire Bare ground	Morrel	Salmon gum York gum White gum Gimlet	Mallee species	York gum Jam Sheoak White gum Salmon gum	Jam York gum Sheoak White gum	Salmon gum White gum Mallee Gimlet	Banksia Sandplain pear Tammar Sandplain mallee Woodjil Flame grevillea Christmas tea

Figure 1 Soil landscape units of the zone of ancient drainage (adapted from Lantzke, 1992)

***Photo 2** Glistening, coppery bark and elegantly fluted branches make gimlet (*Eucalyptus salubris*) easy to recognise*

Photo 3 *The distinct orange flowers of* Banksia prionotes*, which characterises the kwongan vegetation of the sandy uplands*

and Lockhart rivers converge. The granite outcrops support low open woodlands of York gum (*Eucalyptus loxophleba*) and salmon gum (*Eucalyptus salmonophloia*) over *Acacia* and sheoak (*Allocasuarina*) species shrubland with an understorey of grasses and annual herbs. Pockets of soil on the slopes and summits of the outcrops support a range of sedges and herbs, including *Borya* species, under jam (*Acacia acuminata*) and *Grevillea* species (Weaving 1997; Weaving & Grein 1994; Lantzke 1992).

2.2.3 Post-clearing changes to vegetation communities

While the Salt River is naturally saline, widespread clearing has fragmented remnant vegetation and increased waterlogging and salinity levels across the floodplain. The native riparian vegetation is adapted to natural waterlogging and salinity levels; however, the increased salinity and frequency of inundation has led to a decline in vegetation condition and caused deaths in some areas. The overall result is a simplification of the vegetation communities, as the *Melaleuca* thickets and *Eucalyptus* woodlands that once covered the floodplain are replaced by salt-tolerant plants such as samphire (*Halosarcia*).

2.3 Hydrology and water quality

The Salt River receives streamflow from the Yilgarn and Lockhart catchments upstream and numerous tributaries, including:

- South Yoting Creek, which flows west from Pantapin South Rd and joins the Salt River floodplain near Stacey Bus Rd
- Warraling Creek, which channels flows from Dorakine Gully, Conallan Creek and Kitkittering Creek and joins the floodplain in the vicinity of Yoting Rd
- Hommajelly Gully, which joins the floodplain in the vicinity of Mt Stirling Rd
- further 11 unnamed subcatchments of differing sizes.

The gradient along the Salt River is very low. It has been estimated at between 0.26 m/km (Figure 2) and 0.35 m/km (Salama 1997). A key feature of this grade is that it is interrupted by large relatively flat salt lakes that store large volumes of water before they fill and overflow.

The low gradient and the nature of the waterway, with braided, disconnected channels punctuated by salt lakes, means that the river does not flow as one linked system unless major summer rainfall events or prolonged wet winters occur.

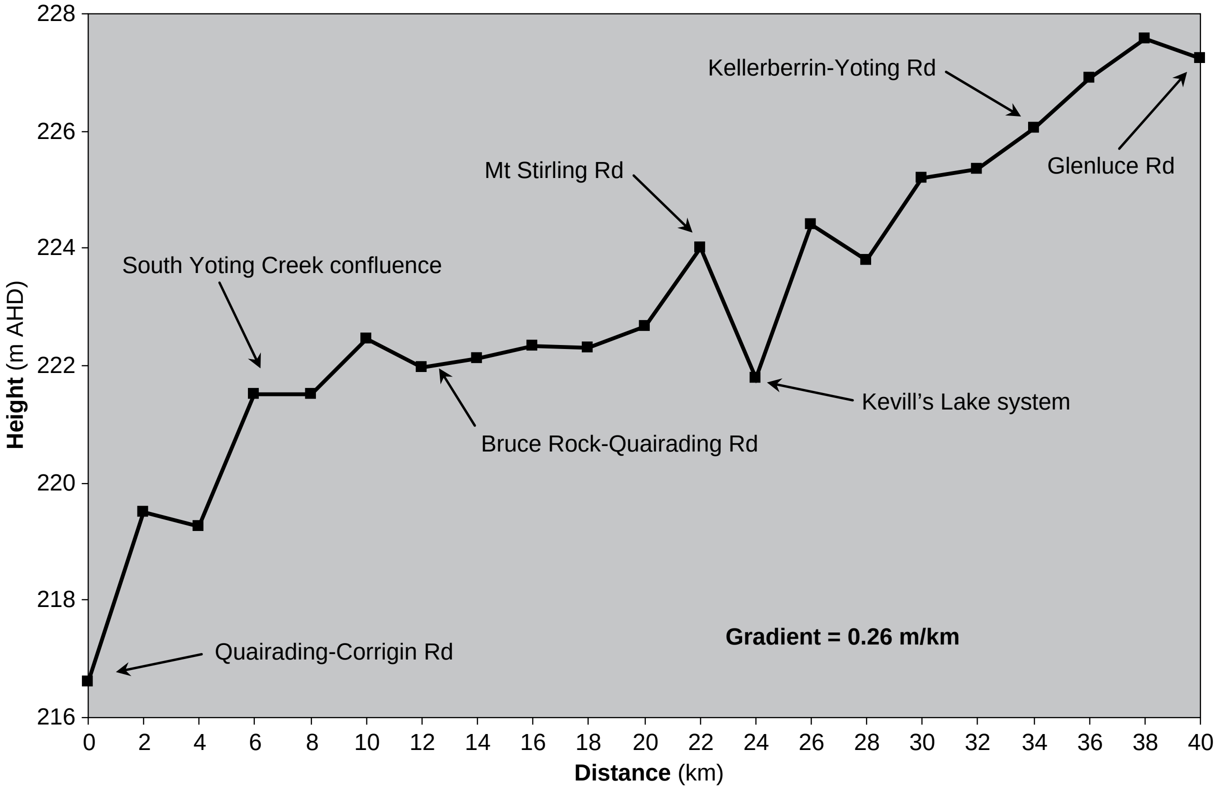


Figure 2 *Gradient along the Salt River from the Quairading–Corrigin Rd to Glenluce Rd*

Annual average rainfall across the study area is between 320 and 350 mm and is highly seasonal, with approximately 80 per cent of the annual total falling between April and September (Australian Bureau of Meteorology 2006) and is also highly variable between years.

The low gradient of the valley floor, the geomorphology of the waterway, particularly storage in salt-lake chains, and rainfall variability result in highly variable streamflow in the Salt River.

Summer rainfall events tend to be the most extreme events, resulting in large flows. Cyclonic rainfall between 21 and 22 January 2000, for example, exceeded 100 mm at a number of locations across the Lockhart catchment, with subsequent flood flows in the Lockhart and Salt rivers. Cyclone Claire, which passed through the Wheatbelt in March 2006, also resulted in summer flows, albeit significantly smaller than those in 2000.

There is no gauging station within the study area; however, Figure 3 shows the variability in total annual discharge at two Department of Water gauging stations situated immediately upstream from the Salt River: Kwolyn Hill on the Lockhart River and Gairdners Crossing on the Yilgarn River.

Salt loads are also highly variable. Between 1993 and 2002 the Yilgarn River contributed an average of 4 gigalitres (GL) of annual flow to Yenyening Lakes and an annual salt load of 64 kilotonnes (kt). During that time, annual flow varied from 0 to 29 GL and salt load from 0 to 377 kt. In comparison, the Lockhart River contributed an average of 13 GL of annual flow and an annual salt load of 99 kt. Annual flows varied from 0 to 90 GL and salt loads from 0 to 343 kt (Mayer et al. 2005).

Limited nutrient sampling has been undertaken at the two Department of Water gauging stations. These have been snapshot samples, which only indicate nutrient concentrations on the day of sampling and therefore make it difficult to draw conclusions about long-term trends. The available results are detailed in Appendix 1 along with a summary of water-quality data from both gauging stations to date.

At the Kwolyn Hill gauging station, total nitrogen ranged from 0.2 to 4.4 mg/L (21 samples collected between 10 June 1997 and 31 January 2006) and total phosphorus from 0.0 to 0.8 mg/L (22 samples collected between 27 July 1994 and 31 January 2006). At the Gairdners Crossing gauging station, total nitrogen ranged from 0.5 to 3.7 mg/L (10 samples collected between 27 July 1994 and 31 January 2006) and total phosphorus from 0 to 0.1 mg/L (10 samples collected between 24 September 1996 and 30 January 2006).

At Kwolyn Hill, pH ranged from 3.2 (moderately acidic) to 8.7 (slightly alkaline) with an average of 5.9 (slightly acidic). At Gairdners Crossing, pH ranged from 6.2 (slightly acidic) to 8.9 (slightly alkaline) with an average of 7.5 (neutral). Again, these are snapshot samples that indicate pH on the day of sampling and it is therefore difficult to draw conclusions about long-term trends.

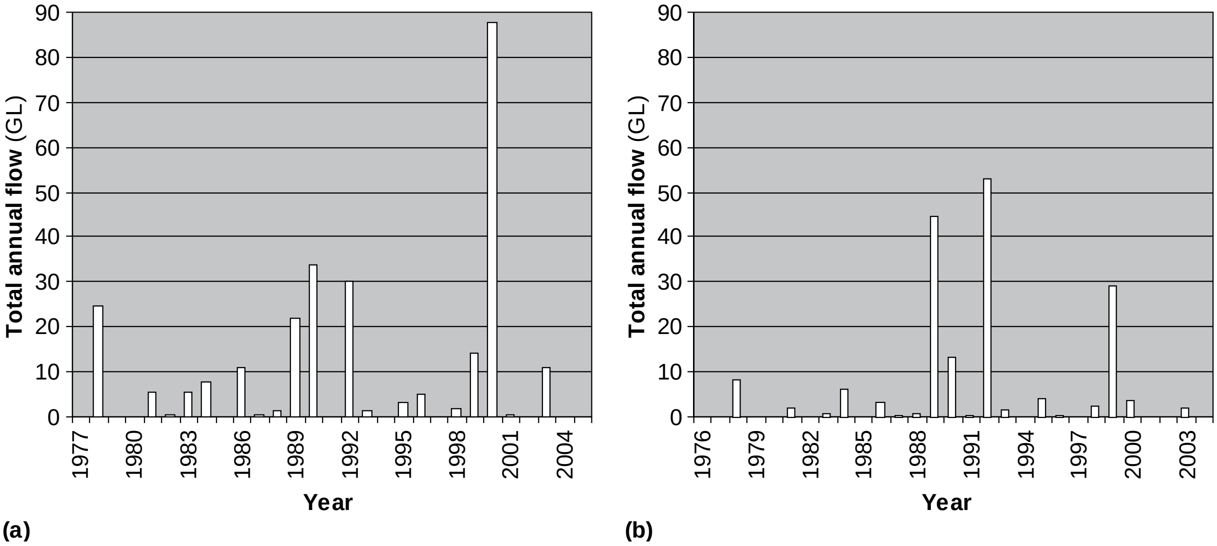


Figure 3 *Total annual discharge in gigalitres (GL) measured at (a) Kwolyn Hill gauging station 615012 on the Lockhart River and (b) Gairdners Crossing gauging station 615015 on the Yilgarn River.*

While water in the salt lakes and channels of the Salt River is largely unsuitable for stock, there are a number of dams and soaks within the floodplain that supply stock-quality water for at least part of the year (Photo 4). Some of these soaks are filled with groundwater seeping from sandhills adjacent to the floodplain.

Photo 4 *Soaks within the Salt River floodplain provide stock-quality water*

2.4 Land tenure

The majority of the land in the Salt River floodplain is freehold land used for agricultural purposes, although there are also a number of Crown reserves within, or in close proximity to the Salt River floodplain. These reserves are mostly vested for conservation purposes (Table 1).

The reserves vary in conservation value. Mt Stirling, Mt Caroline and Badjaling nature reserves have the highest conservation values. Remnant vegetation communities are in good to pristine condition and the reserves are home to protected flora and fauna. These reserves are under pressure from a number of threats, including increasing salinity levels and waterlogging, fragmentation due to land clearing and weed invasion.

Other reserves located fully within the Salt River floodplain, such as Badjaling North, Badjaling West and Moulien Nature Reserves, are degrading from increasing salinity levels and waterlogging.

Table 1 Crown reserves in close proximity to the Salt River floodplain

Reserve name	Reserve number	Vesting	Proprietor	Date vested
Unnamed	CR 28319	Conservation of flora and fauna	CC	1966
Unnamed	CR 974	Resting place; waterway	Unknown	1893
Badjaling West Nature Reserve	CR 28318	Conservation of flora and fauna	CC	1966
Badjaling Nature Reserve	CR 23758	Conservation of flora and fauna	CC	1953
Badjaling North Nature Reserve	CR 10121	Conservation of flora and fauna	CC	1906
Unnamed	CR 30299	Conservation of flora and fauna	CC & DPI	1970
Yoting North Nature Reserve	CR 11717	Conservation of flora and fauna; waterway	DPI & WRC	1927
Moulien Nature Reserve	CR 28289	Conservation of flora and fauna	DPI & CC	1966
Unnamed	CR 11024	Conservation of flora and fauna	CC	1908
Mt Stirling Wildlife Sanctuary	CR 11048	Conservation of flora and fauna	CC	1908
Mt Caroline Nature Reserve	CR 11047	Conservation of flora and fauna	CC	1908

Abbreviations: CR – Crown Reserve; CC – Conservation Commission of Western Australia; DPI – Department of Planning and Infrastructure; WRC – Water and Rivers Commission (now Department of Water)

Photo 5 *Chains of seasonal playa lakes, provide important habitat in a landscape with very little permanent water, as well as a vital recreation area for the local community*

2.5 Valleys of salt, channels of water, pools of life

Professor Jenny Davis of Murdoch University describes naturally saline waterways in the western Wheatbelt as 'valleys of salt, channels of water, pools of life' (Davis 2004). There is a perception in some parts of the community that these waterways have little value; however, many people – the traditional owners, scientists, conservationists and landholders included – appreciate the fact that these waterways retain heritage, social, economic and environmental values, even in the face of the degradation resulting from increasing salinity and waterlogging levels. However current waterway condition needs to improved, or at least maintained, for these values to continue in the face of increasing degradation.

2.5.1 Natural values

Biodiversity

As an example of the diversity that naturally saline waterways support, the vegetation survey undertaken by the Wildflower Society of Western Australia of Yenyening Lakes Nature Reserve, downstream of the Salt River study area, described 22 vegetation units with 294 plant species, including 2 Declared Rare Flora and 8 Priority Flora species (Wildflower Society of Western Australia 2003).

There are also a number of Declared Rare and Priority flora species within the Salt River study area. The following species are found within, or adjacent to, the Salt River floodplain:

- Declared Rare: *Banksia cuneata* (Quairading or matchstick banksia), which is found in low woodlands of acorn banksia (*Banksia prionotes*) and woody pear (*Xylomen angustifolium*) growing on yellow sands
- Declared Rare: *Ptilotus fasciculatus*, which grows on the saline flats of the Salt River in the Caroline Gap
- Declared Rare: *Tetratheca dettiodea* (granite tetratheca), which grows in loamy soils associated with granite outcrops
- Declared Rare: *Roycea pyncnophylloides* (saltmat), which grows in sandy and clay soils on the saline flats of the Salt River in the Caroline Gap
- Priority 2: *Acacia cowaniana*, which is associated with soil pockets on granite outcrops
- Priority 2: *Eremophila brevifolia* (spotted eremophila)
- Priority 4: *Gastrolobium callistachys* (rock poison), which is associated with sandy soils on the margins of granite outcrops (Weaving 1997; Department of Conservation and Land Management 2006).

The species-rich plant communities provide habitat for a myriad of insect, reptile, frog, bird and mammal species. An amazing diversity of insects, including ants, spiders, butterflies, native bees and beetles provides a food source for reptiles such as skinks, goannas and snakes. Several species of burrowing frog, such as the western spotted frog (*Heleioporus albopunctatus*) and the turtle frog (*Myobactrachus gouldii*), live in Wheatbelt woodlands, burying themselves deep in the soil during the day to avoid the heat and feeding at night (Bamford 1995).

The woodland and kwongan vegetation supports many bird species, such as the white-browed babbler (*Pomatostomus temporalis*), red-capped robin (*Petroica goodenovii*), mulga parrot (*Psephotus haematonotus*) and a variety of honeyeaters that make the most of nectar from the diversity of flowering plants. Many wetland birds, such as the grey teal (*Anas gibberifrons*), black swan (*Cygnus atratus*), pink-eared duck (*Malacorhynchus membranaceus*) and black-winged stilt (*Himantopus himantopus*) rely on Wheatbelt lakes to feed and breed. Migratory birds, such as the curlew sandpiper (*Calidris ferruginea*), red-necked stint (*Calidris ruficollis*) and common greenshank (*Tringa nebularia*), use saline wetlands as resting and feeding stopovers during annual migrations.

These birds are supported by rich invertebrate assemblages. A recent survey of 223 Wheatbelt wetlands found 957 species of aquatic invertebrates. The wetlands varied in water quality from fresh (< 500 mg/L) to hypersaline (> 30 000 mg/L) and included naturally saline playas and coastal lakes, freshwater wetlands such as claypans and pools on granite outcrops, secondary salinised wetlands, rivers and palaeodrainage flats. While the vast majority of species occur in fresh water, 134 species are adapted to naturally saline wetlands (Pinder et al. 2005; Halse et al. 2004).

Habitat loss and predation have led to a decline in the numbers of native mammals in the Wheatbelt, with the exception of some species such as red and grey kangaroos (*Macropus rufus* and *M. fuliginous*) and euros (*Macropus robustus*). Some species of bat (*Nyctophilus* species) are still relatively common, sheltering by day in hollow logs and hunting insects at night. Short-beaked echidna (*Tachyglossus aculeatus*) are relatively common. One was seen at Badjaling North Nature Reserve during the survey and they are known to occur in Badjaling Nature Reserve (W. McHenry pers. comm. 2006).

The black-flanked rock-wallaby (*Psephotus haematonotus*) is found within a small number of reserves within the Wheatbelt, including Mt Caroline and Mt Stirling nature reserves. It is listed as vulnerable under both the *Wildlife Conservation Act 1950* (WA) and the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth). Fox-baiting programs undertaken by the Department of Environment and Conservation through the Western Shield program have been very successful. Population numbers have increased to the point where, in 2001 and 2002, animals were translocated from Mt Caroline and Querekin to Walyunga National Park, Avon Valley National Park and Paruna Wildlife Sanctuary.

Water balance and flood control

The chains of salt lakes and braided channels in the broad valley floors of the eastern Wheatbelt provide natural drainage and play an essential role in flood conveyance and storage of flood waters.

Saline lakes are an integral part of the balance between surface and groundwater, and act as both recharge and discharge areas (Coleman 2003).

Widespread clearing of native vegetation has led to increases in streamflow, which has changed water balances and flood control (Hatton et al. 2003).

2.5.2 Heritage and spiritual values

Ballardong Noongar *Budjar* lies over the Avon River Basin and has been home to the Ballardong Noongar people for thousands of years. *Budjar* is the Noongar word for Country, and it encompasses everything associated with the land, including attachment and cultural, physical and spiritual aspects. Traditionally, Ballardong Noongar people knew their *Budjar* intimately. *Budjar* not only provided them with their needs and wants but connected them spiritually to their inheritance and obligations to the land (Ballardong NRM Working Group 2006).

In traditional times Noongar people lived in complete harmony with the land, waterways and sky. The six seasons, described by the prevailing weather conditions, indicated the best times to hunt particular animals and gather certain plants and medicines.

Waterways (*Gogulgar*) were, and still are, sacred places. Salt River and other *Gogulgar* in the catchment were important for spiritual reasons and because they provided water and foods – waterbirds, eggs, fish, plants and medicines. The adjacent woodlands also provided food and medicines. Birds such as bush turkeys, reptiles such as goannas and bobtails and mammals such as kangaroos (*Yonga*) and echidna were all good tucker. Mallee hen were sought after for their eggs. Care was always taken to leave some eggs in the nest (Ballardong NRM Working Group 2006; W. McHenry pers. comm. 2006).

Berries, nuts and seeds were gathered from a variety of plants, and still are today. Seeds were gathered from *Acacia* plants, such as jam (*Mangart*). Quandong berries are still used to make jam, and the flowers from the black toothbrush grevillea are a sweet treat. Betadine bush (sandplain cypress) provides a sticky sap to treat minor cuts and bites (W. McHenry pers. comm. 2006).

The traditional custodians of Salt River *Budjar* have seen many changes to the river, the surrounding country and the plants and animals that depend on them. Water in the lakes used to be relatively fresh and the lakes were home for fish and waterbirds such as swans. Now the tea-tree shrublands that used to fringe the lakes and cover the floodplain have largely been replaced with samphire flats, and the fish and many of the birds are gone (W. McHenry pers. comm. 2006).

> Ballardong Noongar people today want to have a healthy Country. This means growing a variety of trees, having abundant wildlife, seeing the return of native plants and animals that used to be here, restoring waterways and landscapes and having people interacting with and enjoying the natural environment (Ballardong NRM Working Group 2006).

This quote is from *Ballardong Noongar Budjar: 'Healthy Country – Healthy People'*, a document prepared by the Ballardong NRM Working Group, a standing committee of the Avon Catchment Council, as a supporting document to the Avon NRM Strategy. The document represents the Ballardong Noongar perspective on caring for Country and reconnecting with the land. The document also puts forward a vision and blueprint for Noongar people to be involved in managing their Country:

> For all people to respect and understand Noongar culture and from there have a greater attachment to the land (*Budjar*), and to work in partnerships to create a positive and sustainable future for all (Ballardong NRM Working Group 2006).

2.5.3 Recreation values

Lakes are important recreational areas for local communities, providing opportunities for canoeing, birdwatching and photography. Some lakes are used for waterskiing. Kevill's Lake, Lakes Mears, Lake Baandee and several lakes in the Yenyening system including Ski, Ossigs and Racecourse lakes, are all used for skiing, both by members of the local communities and by others in the region.

2.5.4 Economic values

Floodplains also have economic value, with some areas being utilised for cropping and grazing. In many places, reasonable yields are produced by crops and pastures grown up to the edge of the samphire (*Halosarcia* species) and saltbush (*Atriplex* species) flats, and in and around the salt lakes (Photo 6).

For many landholders, the samphire and saltbush flats, in conjunction with stubble on surrounding paddocks, provide valuable summer and autumn grazing for sheep. Shallow soaks and dams within the floodplain provide stock-quality water for part of the year.

Photo 6 *Cropping in the Salt River floodplain*

2.6 Post-clearing changes to naturally saline waterways

While naturally saline waterways still retain many natural, social, heritage and economic values, they are under increasing pressure from widespread land clearing.

2.6.1 Changes in hydrology

Land clearing in the Wheatbelt has been widespread. Only 3.6 per cent of the original extent of native vegetation remains in the Shire of Quairading, with 5.5 per cent in the Shire of Tammin and 7.4 per cent in the Shire of Kellerberrin (Shepherd et al. 2002).

The pre-clearing vegetation pattern persists in the upper landscape; however, the remnant vegetation is now highly fragmented, and in the valley floors increasing salinity and waterlogging continue to modify these communities.

With clearing, the water balance has changed to one of reduced annual evaporation and increased runoff and groundwater recharge. Runoff through and into river valleys has increased fivefold, and increased groundwater recharge is filling deep sedimentary materials and bringing highly saline water to the surface (Davis 2004; Hatton et al. 2003).

Prior to clearing, virtually all of the annual rainfall was evaporated or transpired, and during dry periods the vegetation drew on groundwater. There was little surface runoff and there were few defined drainage lines in areas that now have well-defined streamlines (Davis, 2004; Hatton et al. 2003).

Before widespread land clearing, salt lakes generally contained water for several months through late winter and spring, although they occasionally flooded in summer or autumn from cyclonic rain. Salinity levels tended to be low when the lakes filled and increased as the lakes dried (Halse et al. 2003). Increased surface runoff and groundwater discharge resulting from land clearing mean that salt lakes are now wetter for much longer periods of the year.

2.6.2 Acidification

Increased discharge of acidic groundwater is another post-clearing threat to Wheatbelt wetlands and waterways that has only recently been recognised. While surface waters, on average, tend to be neutral to alkaline (pH 7–8), groundwaters in the eastern Wheatbelt valleys and other areas with abundant salt lakes can be acidic, with pH readings less than 4.5 (Rogers & George 2005). With watertables continuing to rise in these areas, there is a threat of increasing interaction of acidic groundwaters with surface environments.

Acidic groundwaters discharge naturally through seeps and into waterways. However, activities such as deep drainage and groundwater pumping can accelerate discharge rates (Fitzpatrick et al. 2005).

The causes of the acidification are only broadly known. Most acid in groundwaters is due to a process called ferrolysis (or iron hydrolysis), which is where high concentrations of dissolved iron react with oxygen in the atmosphere producing iron precipitates (commonly iron oxy-hydroxides) and acidic hydrogen ions (Fitzpatrick et al. 2005; Gray 2001).

$$2Fe^{2+} + \frac{1}{2}O_2 + 5H_2O \Leftrightarrow 2Fe(OH)_3 + 4H^+$$

Ferric ions + Oxygen + Water ⇔ Iron oxy-hydroxide + Acid

In many groundwaters in the Wheatbelt this appears to have already occurred, possibly because of recent rises in groundwater levels due to land clearing. However, further acidification is also possible when shallow groundwaters with high concentrations of dissolved iron are exposed to the air by drainage or groundwater pumping.

Another source of acidity is the oxidation of pyritic materials in soils, where sulphide-containing materials are exposed to air, releasing significant amounts of sulphuric acid (Fitzpatrick et al. 2005; Gray 2001). The high concentrations of dissolved iron that now exist in many groundwaters may be the result of pyrite oxidation in deep underlying sediments during previous climatic periods.

$$2FeS_2 + 7O_2 + 2H_2O \Leftrightarrow 2Fe^{2+} + 4SO_4^{2-} + 4H^+$$

Pyrite + Oxygen + Water ⇔ Ferric ions + Sulphuric acid

However, the contribution of this process to groundwater acidity, prior to drainage, is unclear, since the release of such acidity is generally thought to occur after drainage. 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 the subsequent release of acid from such materials.

Few plant and animal communities are adapted to acidic conditions. Secondary acidification poses a significant threat to biodiversity, both in aquatic and riparian ecosystems. Low pH waters can leach high concentrations of naturally occurring heavy metals such as aluminium, cobalt, copper, zinc and lead from soils (Fitzpatrick et al. 2005), which can be transported to, and accumulate in, aquatic environments.

2.6.3 Impacts on fringing vegetation

The long history of naturally saline lakes and waterways in the south-west of Western Australia has led to the evolution of a rich diversity of saline-adapted flora and fauna. The threat to these species posed by secondary salinisation is often discounted because species are perceived to be salt-tolerant (Halse et al. 2003).

Increased salinity and waterlogging, changes in hydroperiod, increased nutrient loads and acidification have wrought changes to the fringing and aquatic vegetation and their associated fauna.

The increased depth and duration of waterlogging is responsible for many plant deaths and, as is the case in the rejuvenated waterways to the west, loss of fringing vegetation has had an impact on the ecology. The vegetation itself, as well as fallen branches, twigs and leaf litter, provide habitat, food and nesting sites for a range of terrestrial and aquatic fauna.

As well as an increase in depth and duration of waterlogging, secondary salinisation has had a significant effect on the ecology of saline wetlands and waterways. Plant communities adjacent to naturally saline wetlands and waterways have adapted to seasonal fluctuations in salinity and waterlogging levels. The presence of permanent saline groundwater close to the surface under valley floors and adjacent slopes has caused a decline in vegetation health, changed the species composition of vegetation communities and affected regeneration rates.

Prior to the changes resulting from land clearing and secondary salinisation, wetlands were covered by sheoak (*Allocasuarina* species), paperbark (*Melaleuca* species) and tea tree (*Leptospermum* species), forming a dense canopy over low shrubs. Many wetlands supported beds of rushes and sedges and some had aquatic vegetation, such as nardoo (*Marsillea* species) (Sanders 1991).

Increasing waterlogging and salinity levels have led to the death of fringing vegetation. Salt- and waterlogging-tolerant species such as samphire (*Halosarcia* species) have colonised large areas, where previously they were restricted to small patches. Saline-adapted aquatic plants (*Ruppia* and *Lepilaena* species) have replaced the freshwater nardoo (*Marsillea* species) (Sanders 1991). Sharp rush (*Juncus acutus*) has replaced native rush and sedge species, invading saline and waterlogged areas on the edges of the floodplain, tributaries and groundwater seeps.

2.6.4 Impacts on aquatic communities

Generally, the species richness of macroinvertebrate communities decreases with increased salinity; however, the trend is not always that simple. Changes in hydrology, in combination with other threats such as greater nutrient loads, acidification, sedimentation and simplified vegetation communities, have also significantly influenced the biota of saline waterways (Pinder et al. 2005; Timms 2005; Halse et al. 2003).

As salinities increase, the aquatic vegetation communities dominated by salt-tolerant submerged macrophytes, such as *Ruppia* and *Lepilaena*, give way to phytoplankton-dominated communities and then to benthic-microbial-mat-dominated communities characterised by cyanobacteria and halophilic (salt-tolerant) bacteria (Strehlow et al. 2005; Davis et al. 2003).

The biodiversity of aquatic fauna seems strongly linked to the type of aquatic vegetation present in the wetland. A richer and more abundant macroinvertebrate fauna tends to be associated with wetlands containing submerged aquatic vegetation. Therefore, as salinity increases drive changes in aquatic vegetation communities, there tends to be a simplification of the macroinvertebrate community with a flow-on effect to other fauna in the food web (Strehlow et al. 2005; Davis 2004).

3 Waterway assessment in the zone of ancient drainage

3.1 Aims of waterway assessment in the zone of ancient drainage

The main aim of the waterway assessment is to gain a ‘snapshot’ understanding of the current riparian condition and management needs of waterways, and their associated floodplains, in the zone of ancient drainage 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.

In the context of this study, riparian condition is the current condition of the riparian vegetation compared to a pristine state with all vegetation layers intact, no impacts from threatening processes and all natural processes operating.

3.2 What is different about waterways in the zone of ancient drainage?

The first step in the project was to review a number of existing methods, listed in Table 2, developed to assess riparian condition for their suitability for application in the zone of ancient drainage. All of the methods reviewed have been developed for waterways that are characterised by chains of deep pools linked by a well-defined channel or series of braided channels, such as those found in the south-west of Western Australia (Photos 7 and 8).

The geomorphology of waterways in the zone of ancient drainage is very different, being characterised by chains of salt lakes, or playas, linked by shallow, braided, discontinuous channels set within broad floodplains that can be kilometres wide (Photos 9 and 10). Consequently, none of the assessment methods reviewed were applicable without major changes.

A new method, described in Chapter 4, is therefore proposed to gain an understanding of the current riparian condition and managements needs of waterways in the zone of ancient drainage.

Table 2 Methods used to assess waterway health (Nevill 2005; Parsons et al. 2002)

Method	Reference	Description of the method	Application
Foreshore and channel assessment	Pen & Scott 1995	Grades foreshore condition following the general process of river valley degradation.	Used to: • assess foreshore condition • determine priorities for management.
Rapid appraisal of riparian condition (RARC)	Jansen et al. 2005	Assesses ecological condition of riparian habitats using indicators that reflect functional aspects of the physical, plant community and landscape components of the riparian zone.	Used to: • determine relationships between riparian condition and land management practices • Determine priorities for management.
Tropical RARC	Land and Water Australia, Canberra	Assesses ecological condition of riparian habitats in tropical areas using indicators that reflect functional aspects of the physical, plant community and landscape components of the riparian zone.	Used to: • determine relationships between riparian condition and land management practices • Determine priorities for management.
AUSRIVAS	National River Health Program	Assesses biological condition using macroinvertebrate data. Individual site data are compared against data from reference sites and the differences between them are used as an indication of site condition.	Used to: • assess river health • infer environmental impacts • provide an indirect 'river type' reference.
Index of stream condition	Department of Sustainability and Environment 2004	Uses a rating system to measure stream condition and the degree of disturbance on the basis of a comparison to a reference state. Compares hydrology, physical form, riparian vegetation, water quality and macroinvertebrate populations to what would be expected in a pristine system.	Used to: • benchmark stream condition • assess the effectiveness of intervention policies.
Geomorphic river styles	Brierley & Fryirs 2000	Uses regional-scale method for defining river types based on geomorphic characteristics, by comparison of contemporary stream condition with undisturbed condition, and predicting future condition.	Used to: • assess geomorphic value and condition • assign conservation values.

Photo 7 *A typical reach of the Avon River*

Photo 8 *A braided section of the Dale River, a major tributary of the Avon River*

Photo 9 *Chains of playa lakes that characterise this reach of the Salt River*

Photo 10 *Salt River, just upstream from the Yenyening Lakes, characterised by braided, discontinuous channels set within a broad floodplain*

4 Waterway assessment method

This chapter describes a new method that is proposed for gaining an understanding of the current riparian condition and management needs of waterways in the zone of ancient drainage, as it was used to assess the condition of the Salt River.

The waterway assessment method has been developed to be relatively quick and easy to carry out. As there is no reliance on water-quality data, the surveys can be carried out at any time of year.

4.1 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.

For the Salt River assessment, 10 survey sites were selected using aerial photography, at a scale of 1:20 000. Sites were selected that met one or more of the following criteria:

- represented the full range of geomorphological features within the study area
- had high environmental, social and/or cultural value, such as nature reserves or lakes used for waterskiing
- contained vegetation communities in good or degraded condition.

Bushland sites in close proximity to the Salt River floodplain were chosen as well as riparian sites. In a highly fragmented landscape, and in the absence of reference sites where riparian vegetation is largely intact and in pristine condition, bushland sites were considered to be important reference sites.

The locations of the 10 study sites within the Salt River study area are shown on Maps 3.1 and 3.2 and described in each site report in Appendix 3.

4.2 Recording of survey information

To ensure consistency, information collected during the site surveys was recorded on a survey form, included as Appendix 2. Information collected for the 10 sites surveyed during the Salt River waterway assessment is summarised in Appendix 3.

4.3 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 form, lunettes, tributaries, drains and dams.

4.4 Description of the riparian vegetation

Healthy, undisturbed riparian vegetation is vital to waterway health. The plant species that comprise the fringing vegetation are quite diverse and, together with the many species of insects, birds and mammals that this vegetation shelters, the riparian ecosystems contain significant biodiversity. Fringing vegetation also drops leaf litter and small twigs into the water. As well as providing habitat for aquatic animals, this litter is an important part of the aquatic food web.

A comparison of the current condition and structure of riparian vegetation with a pristine reference state indicates how waterway condition has changed over time. Identification of threatening processes impacting on vegetation condition gives an indication of why vegetation condition and structure have changed, and how they might change in the future.

The description of riparian vegetation has been adapted and modified from relevant sections of the *Bushland Plant Survey* method developed by Keighery (1994). The method was initially developed to document vegetation communities on the Swan Coastal Plain in order to provide information needed for decisions on the conservation status of bushland areas and for determining management priorities. The survey method does not require a high level of technical knowledge and can be easily modified for use in regions other than the Swan Coastal Plain (Keighery 1994).

4.4.1 Pre-European vegetation types

Information collected during the surveys, and anecdotal information from landholders are used to gain an understanding of the original vegetation type(s) at each survey site. Pre-European vegetation types are listed in each site report in Appendix 3.

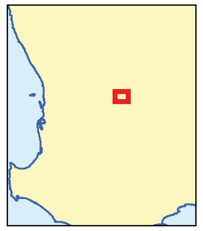
Beard vegetation associations are broad vegetation types mapped at a scale of 1:250 000. The vegetation associations identified for each survey site fit under the Mt Caroline Vegetation System described in Section 2.2.

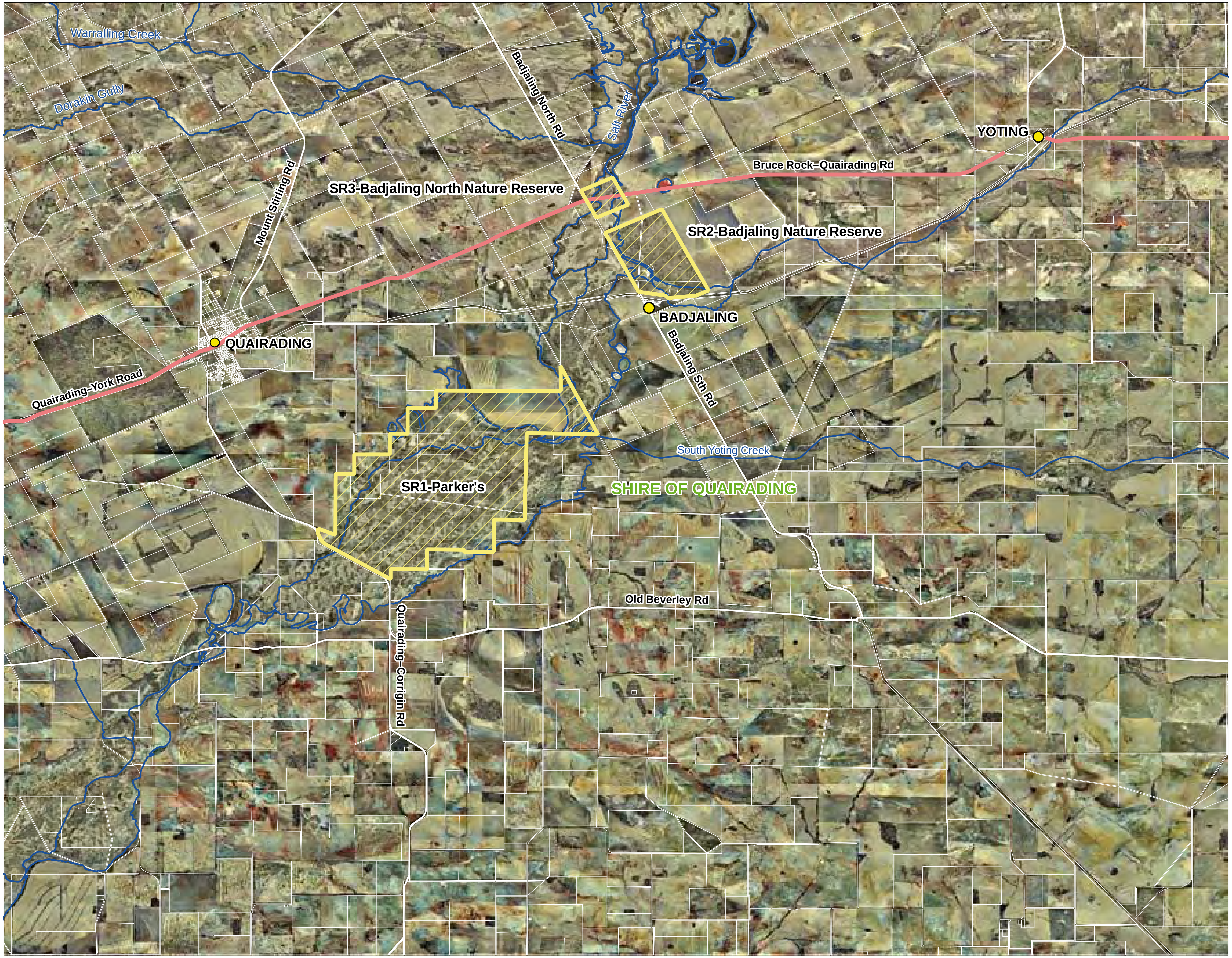
4.4.2 Vegetation structure and cover

For each vegetation layer present within the site, an estimation of crown cover is used to record plant cover. Crown cover is the total area under an imaginary line bounding the extremities of all plants in each layer. Rather than attempt to determine an exact percentage of cover, a simplified estimation process, using cover classes,

Map 3.1
SALT RIVER SURVEY SITES
SR1 - SR3

LOCALITY MAP





LEGEND

- Survey sites
- LGA Boundaries
- Freeway
- Highway
- Main roads
- Hydrography, linear
- Cadastre
- Major town/city (> 5000)
- Town (> 500)
- Minor town (< 500)

N

0 4

Kilometres

Datum and Projection Information

Vertical Datum: AHD
Horizontal Datum: GDA 94
Projection: MGA 94 Zone 50

Project Information

Requestee:Kate Gole
Map Author:Judit Bonisch
Task ID:6549
Filename, J:\RS\Sn\96299\0002
Date:30/08/2006

SOURCES

DOW acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - CUSTODIAN ACRONYM - Metadata Date

Towns	DLI	08/2004
Road Centrelines, DLI	DLI	01/04/2004
Cadastre	DLI	01/12/2005
Topographic Contours	DLI	12/09/2002
LM_salinitymap_00_25m_ll	DLI	2000
Local Government Authorities	DLI	08/07/2004
Geographic Names	DLI	15/07/2005
Hydrography, Linear	DoE	01/02/2004

Department of Water
Government of Western Australia

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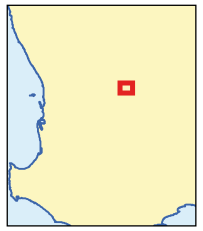
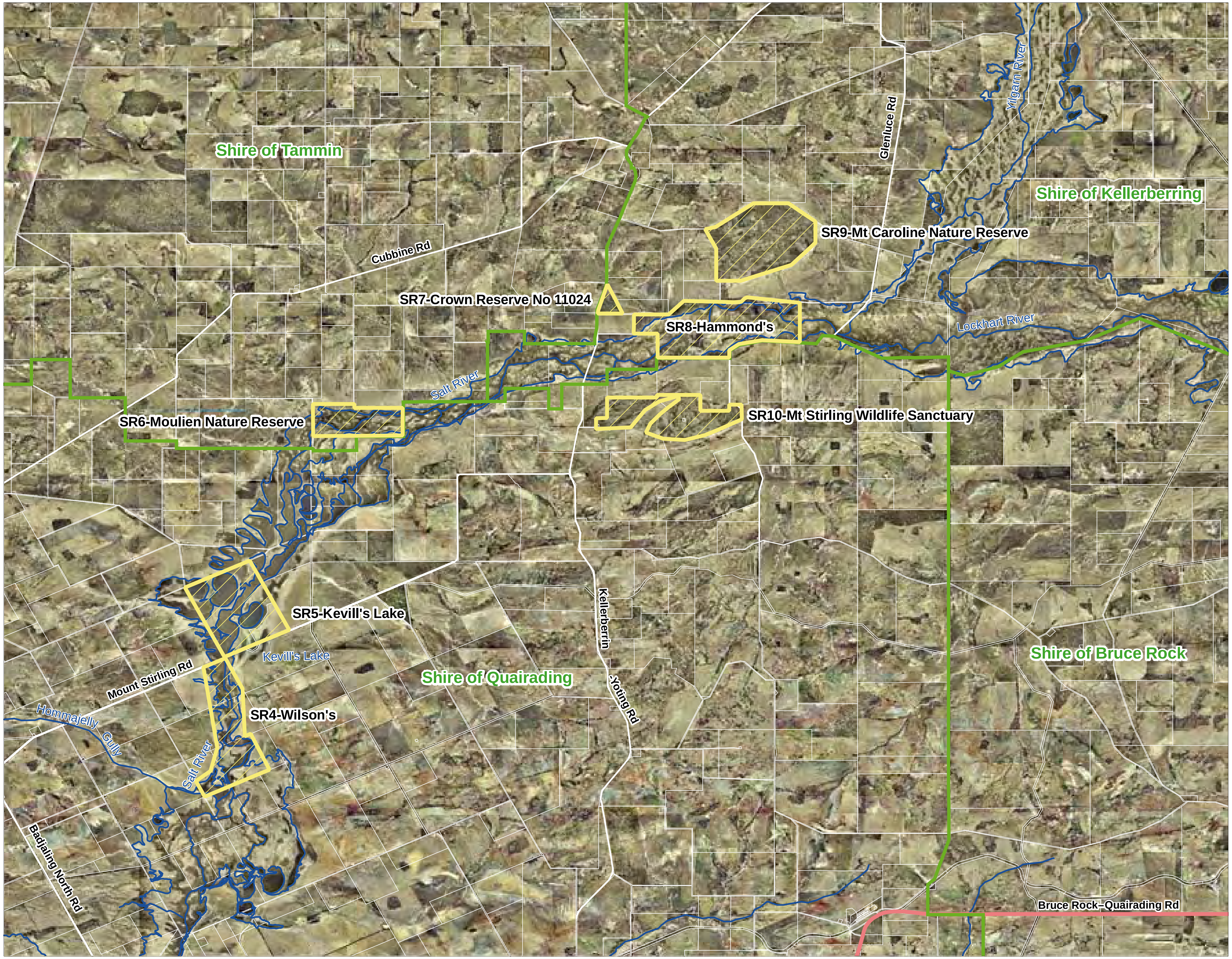
This map was produced with the intent that it be used for the Salt River Reconnaissance Study at a scale of 1:100,000.

Map 3.2
SALT RIVER SURVEY SITES
SR4 - SR10





LEGEND

- Survey sites
- Local Government Authorities
- Freeway
- Highway
- Main roads
- Hydrography, linear
- Cadastre
- Major town/city (> 5000)
- Town (> 500)
- Minor town (< 500)

N

0 4

Kilometres

Datum and Projection Information

Vertical Datum: AHD
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Geographic Names	DLI	15/07/2005
Hydrography, Linear	DoE	01/02/2004

Department of Water
Government of Western Australia

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

Table 3 Vegetation condition (adapted from Keighery 1994)

Condition	Description
Revegetation	–
Pristine	No obvious signs of disturbance.
Excellent	Vegetation structure intact; disturbance affecting individual species and weeds are non-aggressive species.
Very good	Vegetation structure altered; obvious signs of disturbance.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate.
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition would require intensive management.
Completely degraded	Vegetation structure no longer intact and the area is without / almost without native species.

was adopted. Because of the presence of extensive areas of rock outcrop in several of the sites, an additional layer was added and the percentage cover estimated using the same concept as for vegetation layers. The dominant species in each layer are identified and, if more than three species dominate, the layer is described as mixed.

4.4.3 Vegetation condition

The percentage of the survey site that falls within each vegetation category is recorded. Due to the presence of revegetated areas within several survey sites, an additional category was added to those adapted from Keighery 1994.

The vegetation condition rating (Table 3) is related to vegetation structure, the impact of disturbance on each vegetation layer and the ability of the community to regenerate. Linked to the vegetation condition rating is a description of disturbance factors and the degree of threat they pose to gain an understanding of why vegetation condition has declined. Examples include salinity and waterlogging, clearing, weed invasion, fire risk, prevalence of feral animals and stock access.

4.4.4 Species presence

Native and introduced plant species are also identified as an indication of species diversity. Where plants cannot be identified to species or genus level they are identified as, for example, ‘Shrub 1’. Regeneration of overstorey and middlestorey species is also noted.

It must be noted that extensive flora surveys are not undertaken. Like other information collected as part of the surveys, the species lists for each site represent a snapshot of the species present at the time of the survey, and it is highly likely that plant species occur within each site that are not identified during the survey.

Species found at each site are listed in the individual site reports in Appendix 3, and a full species list for all survey sites is summarised in Appendix 4.

4.5 Links to protected remnant vegetation

In highly fragmented landscapes, such as those in the Salt River catchment, the remaining remnant vegetation acts as a living link between adjacent habitats, allowing fauna and flora to move around the landscape.

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

4.6 Aquatic vegetation

Aquatic ecosystems in Wheatbelt lakes are characterised either by salt-tolerant submerged macrophyte communities, phytoplankton-dominated communities or benthic-microbial-mat-dominated communities. The biodiversity of aquatic macroinvertebrates seems strongly linked to the type of aquatic vegetation present. A richer, more abundant macroinvertebrate fauna tends to be associated with submerged macrophyte communities, such as those characterised by *Ruppia* and *Lepilaena* species (Strehlow et al. 2005; Davis 2004).

In the absence of long-term macroinvertebrate monitoring within the study area, the type of aquatic vegetation present is identified, where possible, as an indication of the relative abundance of the macroinvertebrate fauna.

4.7 Water quality data

Where possible, water quality data, including pH, salinity and temperature, are collected. With the exception of lakes, water quality is sampled only when water is flowing. Data collected during the survey comprise a ‘snapshot’ of water quality at the time of sampling and cannot be used to make comments on long-term trends.

4.8 Management

Information is collected on any current management activities, such as fencing, revegetation and groundwater and surface-water management. Any issues in need of management, such as weed control, revegetation and surface water management, are also identified.

4.9 Fauna species

Native and introduced fauna species are also identified, with a focus on identifying bird species. Birds are easier to find and identify than many other native fauna species, they are a major component of most ecosystems and they are sensitive to many kinds of disturbance (Birds Australia 2005). Where possible, birds are classified as remnant-dependent or priority species, based on a classification used by Greening Australia Western Australia (GAWA 2004) as an indication of the importance of the remnant for birds.

It must be noted that extensive fauna surveys are not undertaken. Like other information collected as part of the surveys, the species lists for each site represent a snapshot of those present at the time of the survey, and it is highly likely that within each site species occur that were not identified.

Species recorded at each site are listed in the individual site reports in Appendix 3, and a full species list for all survey sites is presented in Appendix 4.

4.10 How is the information that is collected used?

In Chapter 5, the information collected during the surveys is used to:

- draw conclusions about current riparian condition
- identify issues impacting on current condition
- make recommendations for management.

5 Main findings and management recommendations

This chapter presents the main findings from the surveys along with management recommendations and possible sources of advice and funding for their implementation.

5.1 Vegetation condition

There have been significant changes to the original vegetation communities associated with the Salt River study area. Widespread clearing, and the subsequent increase in salinity and associated waterlogging, have altered the original vegetation communities and continue to degrade the remnant valley-floor vegetation.

Information from mapping of the pre-European vegetation communities (Hopkins et al. 2001; Beard 1980), observations made during the field surveys and anecdotal information from landholders indicate that the playa lakes and floodplain were once fringed with samphire (*Halosarcia* species) grading into *Melaleuca* and tea tree (*Leptosperma*) species thickets with a saltbush understorey and *Eucalyptus* woodlands

***Photo 11** Salt-tolerant species have colonised extensive areas where* Melaleuca *thickets used to occur*

characterised by York gum (*Eucalyptus loxophleba*), salmon gum (*Eucalyptus salmonophloia*) and gimlet (*Eucalyptus salubris*).

The field survey showed that the most degraded vegetation communities tend to occur where there are few or no lunettes or where the lunettes are relatively small or low (less than 1 m above the lake bed). In these areas vegetation condition has declined significantly, and the original shrublands are being replaced with salt-tolerant species. The vegetation in the best condition tends to occur where the lunettes are relatively large or high (more than 1 m above the lake bed). In these areas vegetation is still in relatively good condition.

Surveys of the valley-floor sites show that most of the valley floor is degraded or completely degraded (Figure 4). In some areas, *Melaleuca* thickets in varying condition remain, but in most reaches numerous stags (dead trees) indicate the previous extent of the original vegetation communities.

Clearing has also fragmented the *Eucalyptus* woodlands on the floodplain fringes. Most of these remnants are still in good to very good condition and provide habitat for birds and other fauna; however, their small size and rising salinity and waterlogging levels are significant threats.

There are some exceptions to the generally degraded nature of the vegetation (Figure 4). Patches of the remnant shrublands and woodlands within the Badjaling North Nature Reserve (SR03), and the Wilson's (SR04), Kevill's Lake (SR05) and Hammond's (SR08) sites are in good to very good condition.

There are several larger remnants on the valley slopes and upland areas of the Salt River catchment, such as the Mt Caroline Nature Reserve (SR09), the Mt Stirling Nature Reserve (SR10) and parts of the Badjaling Nature Reserve (SR02), that are in good to pristine condition and have significant conservation values.

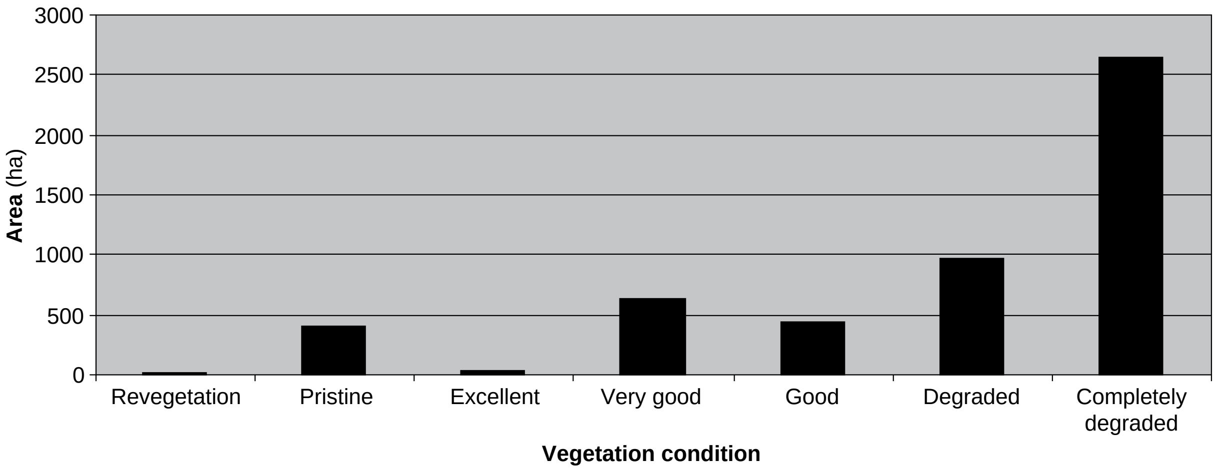

***Figure 4** The area of vegetation surveyed within each vegetation condition rating*

5.2 Management issues

The management issues impacting on the Salt River that were identified from the site surveys are:

- increasing salinity and waterlogging in the valley floor
- loss of riparian vegetation fringing the Salt River and its tributaries
- management of flood flows
- impedance of flood flows by road crossings
- increased streamflow causing erosion and sedimentation in tributaries
- pest species degrading riparian vegetation
- lack of corridors linking areas of remnant vegetation
- fire risk
- dumping of rubbish in floodplain areas.

Management recommendations addressing these issues are detailed below. Many of these recommendations have multiple benefits. For example, revegetating and fencing tributaries of the Salt River will improve bank stability, reduce sedimentation, improve water quality and contribute to biodiversity conservation by facilitating the movement of flora and fauna through the landscape.

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

5.3 Salinity and waterlogging

Increasing salinity levels and waterlogging are the most significant threats in the Salt River floodplain. Streamflow salinity in the Salt River is influenced by the salt loads from the Yilgarn and Lockhart rivers and tributaries, fresher seepage from sand lenses adjacent to the floodplain and saline seepage from rising groundwater beneath the valley floor.

Salinity, waterlogging and changes to the hydroperiod have already had an effect on vegetation condition and water quality, impacting on the ecological, economic and social values of the Salt River.

Research has shown that different approaches need to be taken for different types of salinity impacts, depending on catchment characteristics and the types of assets that are impacted – land, water, biodiversity or infrastructure. There is no ‘one-size-fits-all’ approach, and not all management strategies are suitable for all situations.

The following sections give a brief overview of some of the options for salinity management, including engineering works and revegetation. In the engineering options section, details are provided about two major programs: the Engineering

Evaluation Initiative (EEI) and Wheatbelt Drainage Evaluation (WDE). Both programs are evaluating engineering options for the Wheatbelt, and findings from the programs may influence salinity management in the Salt River catchment.

5.3.1 Engineering options

Increasing numbers of land managers are considering engineering works, including deep drainage, groundwater pumping and surface-water management, to reduce waterlogging problems and lower soil salinities.

There are widely differing opinions about the scale at which engineering options should be implemented. Some consider that all water should be retained 'on-farm' and others that significant arterial drainage networks, including deep drains and groundwater pumping, should be used for ocean discharge.

Pressure for widespread implementation of engineering options is matched by concerns about downstream impacts, particularly from regional arterial drainage schemes, on water quality, changes to the natural hydroperiod and increased flood risk, and their impacts on natural waterway values and built assets, such as roads.

It is within this context that the EEI and WDE programs were developed.

Engineering evaluation and implementation in the Wheatbelt

The EEI and the WDE aim to evaluate the suite of issues associated with implementing engineering solutions to salinity in the Wheatbelt. These programs are being delivered under the National Action Plan for Salinity and Water Quality (NAP) through partnerships between government departments, catchment groups, research bodies and regional NRM groups, including the ACC.

The EEI program (December 2002 to June 2007) aimed at finding and demonstrating better ways to implement engineering to tackle salinity without damaging the environment. It focused on the:

- engineering options, such as deep drainage, groundwater pumping and surface water management, at farm scale
- social, economic and environmental aspects of regional arterial drainage
- downstream impacts of drainage and safe disposal options.

The WDE program (July 2005 to June 2008) is using learnings from EEI projects in the following four main implementation areas. It changes the focus from a science-based drainage evaluation under the EEI to a planning phase for drainage as part of broader catchment-water management:

- drainage management and governance, which will provide greater certainty to regional NRM groups, drainage proponents and the State Government as to how catchment – and regional – scale drainage projects should be implemented

Photo 12 *Deep drain in the Salt River catchment*

- regional drainage evaluation, which will provide a framework from which catchment – and farm – scale drainage can occur
- catchment feasibility studies, investigating drainage options for priority catchments including the Yenyening Lakes catchment
- wetland assessment, which involves the classification of potential receiving environments (Ruprecht et al. 2004).

Deep drainage

Deep drains collect and transport groundwater, and at times surface water, across the landscape to detention basins or into natural wetlands and waterways. They are typically used where the natural drainage system is unable to remove excess water and salt, and the resultant waterlogging and salinity significantly impact on agricultural production.

Groundwater pumping

Groundwater pumping can be an effective method of disposing of saline water. It is most effective in soils with lighter textures that drain water more freely and leach salts more quickly.

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, reducing recharge to valley floors. Harvested water is usually relatively fresh and can be used for farm water supply. Techniques such as modified tillage, use of perennial crops and revegetation can be used in conjunction with engineered structures to manage recharge.

Earthworks are used extensively in the Salt River catchment for surface-water management. Fresher flows are captured in dams for on-farm use, but significant amounts of saline surface water are directed into tributaries, such as South Yoting Creek, Hommajelly Gully and Warraling Creek, and into the Salt River. Due to low gradients and impedance of flows by road crossings, this excess surface water is likely to contribute to waterlogging problems in the valley floor.

5.3.2 Revegetation

Revegetation options for salinity management involve planting recharge and/or discharge areas. At a local scale, the re-introduction of perennials is effective in reducing groundwater recharge. However, there is less evidence that revegetation is an effective and economically viable strategy at a catchment scale, unless most or all of the catchment is revegetated. Using perennial plants to reduce recharge remains a challenge, and research efforts are focusing on developing new perennial options that are profitable in their own right as well as effective in impacting on watertable levels (Pannell & Ewing 2006; Ruprecht et al. 2004; Hatton 2002).

The overall aim of revegetation – to improve soil productivity and lower watertables – can be achieved in a number of ways. Planting local native species for salinity control on either recharge or discharge areas also has benefits for conservation and biodiversity. Planting species that can be harvested for timber or used as fodder crops can have economic benefits.

Perennial plants have benefits beyond recharge control. Depending on the species, they can play a vital role in controlling soil erosion, they can act as wind breaks to protect stock and crops and they can have biodiversity benefits. Revegetated landscapes also have improved aesthetics.

Biodiversity plantings

Planting local native species for conservation and biodiversity is discussed in Section 5.7.

Commercial plantings

There are a number of perennial species suitable for planting on Wheatbelt recharge areas including various *Eucalyptus* species, tagasaste (*Chamaecytisus prolifer*), *Acacia* species, *Melaleuca* species and sandalwood (*Santalum spicatum*). All of these species have economic benefits, either from harvesting of wood or use as fodder.

Site conditions, such as waterlogging, salinity, fertility and acidity, largely determine species selection for discharge areas. Slightly to moderately saline sites are suitable for saltland pasture. Saltbush (*Atriplex*) and bluebush (*Maireana*) species are commonly planted for saltland pasture. Understorey plants such as puccinellia (*Puccinellia ciliata*) and tall wheat grass (*Thinopyrum elongatum*) have also successfully been introduced into saltland pastures to increase the nutritional value of the fodder (Pannell & Ewing 2006; Barrett-Lennard & Malcolm 1995). However, these grasses can become weeds very easily, and native grasses should be used where possible. Appendix 5 provides some details on species that may be suitable for the Salt River catchment.

Saltland pastures can provide valuable feed for maintaining stock condition during the feed gap in summer and autumn. The protein content varies between species but tends to be quite high (10–22 per cent). However, most species are relatively low in energy and high in salt, and higher quality forage also needs to be provided, either from supplementary feeding, access to crop stubbles in adjacent paddocks or the establishment of salt-tolerant understorey species (Pannell & Ewing 2006; Phelan 2004; Barrett-Lennard & Malcolm 1995).

5.3.3 Recommendations for the management of salinity and waterlogging

Salinity and waterlogging are processes that need to be managed at a catchment scale. Given this, and the fact that salinity management needs to be tailored for different salinity impacts, the following general management recommendations are proposed:

- the detention of surface water, water quality permitting, higher in the catchment to slow recharge to valley floors
- revegetation of tributaries to slow movement of surface water on to valley floors without increasing flood risk
- evaluation of commercial revegetation options, including agroforestry and saltland pasture
- identification of recharge areas, such as sand lenses, suitable for revegetation for local watertable control, with either local native or commercial species
- groundwater and surface water quality and quantity to continue to be monitored as part of Department of Water’s ongoing water quality monitoring programs.

Engineering options for the catchment are being evaluated as part of the Yenyening Catchment Engineering, Salinity and Water Management Feasibility Study.

5.4 Flood management

Low gradients, braided, discontinuous channels and road crossings all contribute to slow flows through the Salt River, exacerbating widespread waterlogging problems across the floodplain.

Landholders are concerned about the impacts of large, saline flows and waterlogging on the productivity of floodplain areas and adjacent paddocks.

There are also some concerns that sediment and vegetation are blocking channels and causing localised ponding and flooding. Sediment slugs may be removed, provided that disturbance to the channel is minimised.

Logs and branches in waterways play an important role in providing habitat and protecting banks from erosion; in some circumstances logs and branches may be causing problems. Landholders who are planning to move any materials in waterways are encouraged to contact the Department of Water.

Large flood flows cannot be avoided; however, strategies may exist to reduce ponding in smaller events. The function of the floodplain for flood management needs to be maintained, but there may be opportunities to improve pipes and culverts at road crossings to reduce ponding or enhance floodways to improve flow continuity through the construction of shallow surface-water conveyance structures. Both these options would require detailed on-site assessment and full consideration of downstream flooding risk.

Road crossings are major control points for flood flows. There are eight road crossings across the Salt River floodplain: Quairading–Corrigin Rd, Solomon South Rd, Badjaling North Rd, Badjaling South Rd, Bruce Rock–Quairading Rd, Mt Stirling Rd, Kellerberrin–Yoting Rd and Glenluce Rd.

As well as physically impeding surface flows, subsurface compaction to create a stable road base interferes with subsurface flows, further contributing to ponding problems.

Bruce-Rock–Quairading Rd is a major road, and a substantial bridge crosses the main channel. The floodplain is relatively narrow at this point (approximately 100 m) and the crossing is unlikely to contribute to localised flooding in normal flow events. A culvert conducts flows from a secondary channel.

The Quairading–Corrigin Rd is another major road crossing. The floodplain is approximately 2.5 km wide at this point and has 3 culverts, one on the main channel and two on smaller channels. Roads such as Glenluce and Mt Stirling have culverts or pipes to carry low to moderate flows, with larger flows flooding over the road in most years. Even during normal years these roads cause ponding problems, are exacerbated in larger events, such as the flood of 2000.

The Badjaling South Rd crossing is another crossing associated with flooding problems. The two small culverts under the road cannot cope with the volume of flow through the drain. Additionally the channel and floodplain of the drain close to the road crossing are choked with sediment and vegetation, including samphire (*Halosarcia* species) and sharp rush (*Juncus acutus*), further impeding flows. Low gradients also contribute to the problem.

Flows backing up from the crossing flood local roads and the Badjaling Aboriginal Community almost every year. Shrublands and woodlands surrounding the community and within the adjacent Badjaling Nature Reserve are also being affected. Periodic inundation has killed the original vegetation and it has been replaced with sharp rush (*Juncus acutus*) and samphire (*Halosarcia*) species.

Options for improving flow continuity during small to medium flood events include upgrading culverts and pipes. However, even in large flood events, some roads will still act to impede flows. It may be possible to modify some roads so that they act as causeways, with small to medium flows conducted through pipes or culverts and larger flows flooding over the road.

Relocation of roads has been considered in other Wheatbelt catchments, such as the Lake Bryde Recovery Catchment. However this is very costly and would result in access problems. This option would only be worth considering to protect high-value assets.

Photo 13 *Water from Tropical Cyclone Clare ponding behind the Kellerberrin–Yoting Rd crossing*

5.4.1 Recommendations for the management of flood flows

It is the nature of waterways in the zone of ancient drainage to retain water in the braided valley floors; however, road crossings contribute significantly to localised flooding. The recommendations proposed for flood management are:

- evaluation of road crossings in terms of flood risk
- analysis of the costs and benefits associated with upgrading pipes and culverts to increase conveyance through road crossings and thus forestall significant flooding problems.

5.5 Tributaries

Tributaries in the Salt River catchment start higher in the landscape as depressions and salt scalds and become more incised down the long valley slopes.

All of the major tributaries have gradients that far exceed that of the Salt River (Table 4). When tributaries reach the broad, flat floodplain they tend to spread out through shallow undefined channels causing localised ponding.

Most tributaries are linked to networks of contour or grade banks and some have been modified to carry saline surface flows away more quickly. In some cases alternative channels have been cut to define the confluence with the Salt River and reduce localised flooding.

Reaches of some tributaries, such as South Yoting Creek, have been fenced and revegetated; however, most are unfenced and have little or no fringing vegetation.

Table 4 Gradients for selected tributaries of the Salt River*

Tributary name	**Relief** (m AHD)	**Length** (km)	**Gradient** (m/km)
South Yoting Creek	220–260	30.0	1.3
Unnamed – ‘Badjaling’	220–290	13.0	5.4
Warraling Creek	220–250	8.5	3.5
Dorakin Gully**	230–280	13.5	3.7
Conallan Gully**	250–260	7.0	1.3
Hommajelly Gully	220–250	14.5	1.4
Salt River	–	–	0.26[1]–0.35[2]

* *Gradients are for the main channel of each tributary, which has been defined as the third order stream channel*

** *Dorakin and Connallan gullies are tributaries of Warraling Creek*

1 *Robin Smith, Department of Water, pers. comm.*

2 *Beard (1999) and Salama (1997)*

Consequently, most carry significant sediment loads.

Tributaries can be managed to improve bank stability and reduce sediment loads, as well as to provide benefits for biodiversity, without increasing flood risk.

Fencing and revegetation with local native species would have many benefits. Plant roots physically bind banks together, so revegetation would increase bank stability and reduce erosion. Fringing vegetation would also slow the velocity of runoff entering tributaries from surrounding paddocks, not only reducing erosion but also filtering out sediment and nutrients.

Riffles have been installed on South Yoting Creek to reduce flow velocity and encourage sediment deposition, and could be used in other tributaries to help manage sediment loads.

Given that many tributaries carry excess surface water diverted by contour or grade banks, retaining some of this surface water higher in the catchment would also ameliorate erosion and reduce waterlogging problems in the valley floor.

Photo 14 *Sediment-laden tributary with no fringing vegetation to control bank erosion and filter surface runoff*

5.5.1 Recommendations for tributary management

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

- revegetation of the riparian zones of tributaries with local native species to provide corridors linking areas of remnant vegetation higher in the landscape with riparian areas
- improvement of bank stability to reduce bank erosion and sedimentation, through revegetation with local native species
- fencing of revegetated areas to control stock access
- installation of riffles, where appropriate, to reduce flow velocity and trap sediments before they reach the floodplain.

5.6 Management of remnant vegetation

As is the case in much of the Wheatbelt, remnant vegetation in the Salt River catchment is highly fragmented and remains in patches of varying size, shape and condition on both private and public lands.

Riparian vegetation fringing the Salt River and its tributaries has been significantly altered by the combined effects of land clearing, salinity and waterlogging. In many areas of the floodplain the original *Melaleuca* and *Leptospermum* shrublands have been replaced with samphire (*Halosarcia*) and saltbush (*Atriplex*) species. Remnant *Melaleuca* shrublands and *Eucalyptus* woodlands are under threat from waterlogging, rising salinity levels, fragmentation and weed invasion.

In some areas, the remaining riparian vegetation is closely linked to large areas of good-quality, protected remnant vegetation. The patches of *Eucalyptus* woodland and *Melaleuca* shrubland on Hammond's property, adjacent to Gardiner Rd, have good links to other areas of remnant vegetation such as the Mt Caroline and Mt Stirling nature reserves. In other areas, the links are more fragmented due to the altered nature of the riparian vegetation and lack of vegetation along tributaries and road reserves.

There has been much debate over whether a single large area of remnant vegetation has more value for conservation and biodiversity than several small areas. In general, larger remnants are likely to contain more species than smaller remnants, tend to be more resilient in terms of recovery following disturbances, such as fires and floods, and are better able to maintain ecological functions such as nutrient cycling. Larger remnants are also more resistant to edge effects, such as weed invasion.

However, the number of species also depends on the variety of habitat within each remnant. Because of the high level of species diversity in the Wheatbelt, small remnants can have high conservation values. In our highly fragmented landscape, all remnant vegetation, from isolated paddock trees to large nature reserves, has some conservation value.

Connectivity between remnants is very important to allow species to disperse across the landscape. All of the survey sites have protected remnants within a radius of 10 km; however, in most areas there is little linkage between them, via either 'stepping stones' or corridors, such as road reserves. The Salt River itself is not a significant corridor, due to clearing and degradation of the riparian vegetation. There are, however, some exceptions, with remnant vegetation in good condition linking Hammond's (study site SR8) with both Mt Caroline Nature Reserve (study site SR9) and Crown Reserve 11024 (study site SR7). Badjaling Nature Reserve (study site SR2) and Badjaling North Nature Reserve (study site SR3) are also linked.

Remnant vegetation within Crown reserves vested for conservation is protected; however, where good-quality remnant vegetation remains on private land it needs to be protected and, if possible, linked to nearby remnants. Examples in the Salt River study area include the salmon gum (*Eucalyptus salmonophloia*) and gimlet (*Eucalyptus salubris*) woodland adjacent to Gardiner Road on the Hammonds' property (study site SR8), the vegetation communities associated with Kevill's Lake (study site SR5) and those growing on groundwater seeps at the base of the sandhills on the Parkers' property (study site SR1). These vegetation communities are regarded as endangered, with less than 10 per cent of the pre-European extent remaining (Department of Natural Resources and Environment 2002).

5.6.1 Recommendations for remnant vegetation management

To manage remnant vegetation, including riparian vegetation, and improve landscape linkages to facilitate the movement of fauna and flora in the Salt River catchment, the following recommendations are proposed:

- fence remnant vegetation to exclude stock and allow natural regeneration
- control priority pest species
- identify areas on private land that can be revegetated to create or strengthen links between good quality remnants
- investigate reconstruction of landscape links on public lands such as road reserves.

5.7 Riparian revegetation

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

- localised salinity control
- conservation and biodiversity benefits
- filtering of nutrients and sediment from surface runoff
- improved aesthetics.

Revegetation projects, whether large or small, need to be practical and realistic in terms of both establishment and maintenance especially in altered landscapes. Rising groundwater and salinity levels, declining water quality and changes to the natural hydroperiod mean that some local native species may not be suitable for revegetation in some areas. Plant species selected for revegetation projects need to be suited to the current site conditions.

Some factors to take into consideration when planning revegetation could include the objectives of the revegetation project, position of the site in the landscape, soil condition, water quality and weed species and cover as well as budget.

Appendix 6 lists some species considered suitable for revegetation projects in the Salt River catchment. The list includes species found during the survey and those known to be local native species suited to saline waterways.

5.7.1 Recommendations for riparian revegetation

To create or strengthen links with good-quality riparian and bushland remnants, the following recommendations are proposed:

- investigate riparian areas to be revegetated with local native species
- fence areas of good quality riparian vegetation to exclude stock and promote natural regeneration
- fence revegetated areas to exclude stock.

5.8 Fencing and stock access

In some areas, stock have access to the Salt River floodplain for several months of the year during the summer and autumn feed gaps to graze on saltbush in conjunction with stubble from surrounding paddocks. On the whole, stock impacts on the river and its floodplain are minimal, although, in areas where remnant woodlands and shrublands remain, stock are likely to be impacting on natural regeneration.

5.8.1 Recommendations for fencing

The following recommendations are proposed:

- good quality remnant vegetation to be fenced to exclude stock and to allow natural regeneration
- revegetation to be fenced to exclude stock
- tributaries to be fenced to exclude stock and improve bank stability.

5.9 Pest species

Introduced plant species and signs of feral animals were noted at all of the survey sites. A total of 32 introduced plant species and 3 fauna species were identified. Common weeds include sharp rush (*Juncus acutus*), puccinellia (*Puccinellia ciliata*), wild oats (*Fatua avena*) and barley grass (*Hordeum leporinum*). The floodplain area is too salty and waterlogged for many weed species, and sharp rush and puccinellia are the only weeds seen during the survey that could cause significant problems. Both have the potential to spread and suppress natural regeneration. In the nature reserves and woodland areas on the edge of the floodplain a variety of agricultural weeds are invading the understorey, suppressing natural regeneration in some areas.

Rabbits (*Oryctolagus cuniculus*) and foxes (*Vulpes vulpes*) are very common pest species in the Wheatbelt, and signs of both were seen in almost all survey sites. Regular fox baiting is carried out within Mt Caroline Nature Reserve.

While native to the area, kangaroos (*Macropus* species) are also of concern as they can damage crops, fences and native vegetation. Kangaroos can be managed under certain circumstances. More information is available from the DEC’s Merredin office on (08) 9041 2488 or (08) 9041 2408.

A full list of the introduced flora and fauna species identified during the survey is detailed in Appendix 4. This list is not complete, and it is highly likely that species are present in the local area that were not recorded.

5.9.1 Recommendations for the management of pest species

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

- the occurrence of priority pest species to be mapped to identify priority areas for their control
- pressure from rabbit (*Oryctolagus cuniculus*) grazing on private and public lands to be managed through a coordinated baiting program
- local kangaroo (*Macropus* species) population to be managed to reduce grazing pressure on native vegetation, crops and pastures
- eradication techniques for sharp rush (*Juncus acutus*) to be trialled, their effectiveness to be monitored and the results to be communicated to landholders.

5.10 Flora and fauna

The landscape within the Salt River catchment is highly fragmented, with only a few large areas of remnant vegetation remaining, including Badjaling, Mt Stirling, Mt Caroline and Charles Gardner nature reserves and the bushland area surrounding Quairading.

There is a high diversity of species within this remnant vegetation. A total of 164 native plant species were identified during the surveys. The remaining remnant vegetation also provides habitat for fauna, including black-flanked rock-wallaby (*Petrogale lateralis*) and echidna (*Tachyglossus aculeatus*), both of which were seen during the surveys, as well as a number of bird species.

During the surveys there was a focus on identifying bird species rather than other types of fauna, such as mammals, as birds are generally easier to find and identify.

Up to 60 per cent of Wheatbelt bird species are in decline, in either range and/or abundance, including species such as the scarlet robin (*Petroica boodang*), grey shrike thrush (*Colluricincla harmonica*) and white-browed babbler (*Pomatostomus temporalis*), which only occur in largely intact remnants. The yellow plumed honeyeater (*Lichenostomus ornatus*), once the most common woodland honeyeater in Western Australia, has almost disappeared from the Wheatbelt. Many wetland species have also been affected, and the ranges of both the Australasian bittern (*Botaurus poiciloptilus*) and purple swamphen (*Porphyrio porphyrio*) have contracted. Other species, such as the Australian ringneck (*Barnardius zonarius*) and Australian raven (*Corvus coronoides*), have benefited from land clearing and increased in numbers while some, such as the galah (*Eolophus roseicapilla*) and crested pigeon (*Ocyphaps lophotes*), have extended their range into the Wheatbelt from the more open areas to the north (Birds Australia 2005).

A total of 41 bird species were identified during the surveys. The most common species are the Australian ringneck (*Barnardius zonarius*), commonly known as the twenty-eight parrot, Australian raven (*Corvus coronoides*), yellow-throated miner (*Manorina flavigula*) and galah (*Eolophus roseicapilla*). These are all species whose main habitat is in farmland areas.

Several priority and remnant-dependent species were identified during the surveys. Priority species are those that have been identified as being at threat of local extinction if remnant vegetation is lost or degraded, and include the rufous whistler (*Pachycephala rufiventris*) and red-capped robin (*Petroica goodenovii*). Remnant-dependent species are those likely to decline in number if remnant vegetation is lost or degrades, and include yellow-rumped thornbill (*Acanthiza chrysorrhoa*), white-browed babbler (*Pomatostomus temporalis*) and western gerygone (*Gerygone fusca*) (GAWA 2004). In broad terms, the presence of these species indicates that remaining remnant vegetation, including bushland and riparian vegetation, is important on both local and regional scales for bird habitat.

A full list of the flora and fauna species identified during the survey is detailed in Appendix 4. This list is not complete, and it is highly likely that species are present in the local area that were not recorded.

5.10.1 Recommendations for flora and fauna conservation

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

- identification of priority areas, on both private and public lands, for the reconstruction of landscape links between areas of remnant vegetation
- revegetation for fauna and flora conservation to include local native middlestorey and understorey species
- retention of fallen logs and branches within remnants to provide fauna habitat, especially for birds and reptiles
- eradication of introduced plant species, particularly sharp rush (*Juncus acutus*), and their replacement with local native species.

5.11 Fire risk

Fire risk in the floodplain area itself is relatively low, as most areas are dominated by samphire (*Halosarcia* species) flats. Fire risk is much more significant in areas such as the Badjaling, Mt Caroline and Mt Stirling nature reserves. The DEC maintains fire breaks and fire access tracks on DEC-managed lands adjacent to private property (Department of Conservation and Land Management 2005). The main threat is from stubble fires on farmland. In most areas, access to the floodplain area for fire-fighting is relatively good and, due to a lack of fringing vegetation, fires would be relatively easy to contain.

5.12 Rubbish

During the survey, several rubbish dumps were identified within the Salt River floodplain, including old fencing materials and household rubbish. Rubbish in river environments is unsightly; however, most materials do not pose a significant threat. Dumping of chemicals and oils, and the containers used to store them, does pose a threat to the river environment and should be avoided.

5.12.1 Advice for rubbish management

Under Western Australia's *Litter Act 1979*, dumping of rubbish on crown lands, such as road reserves, council lands and nature reserves, is illegal and can be reported to a local shire or DEC office.

Clean empty containers used to store crop production, and on-farm animal-health chemicals, can be disposed of through the drumMUSTER program. For more details, including collection points and the date of the next scheduled collection, contact your local shire:

- Shire of Quairading on (08) 9645 1001
- Shire of Kellerberrin on (08) 9045 4006
- Shire of Tammin on (08) 9637 1101.

6 Glossary

Acid(ic)	See pH.
Alkaline	See pH.
Alluvial	Transported by water flow processes, for example 'alluvial plain'.
Alluvium	Sediment deposited by flowing water.
Aquifer	A layer of rock or soil capable of receiving, storing and transmitting quantities of water.
Catchment	The area of land that intercepts rainfall and contributes the collected water to a common point through surface and groundwater.
Confluence	A flowing together or intermingling, for example where a tributary joins the main channel.
Discharge	Volumetric outflow rate of water, typically measured in cubic metres per second. Applies to both groundwater and surface water.
Discharge area or zone	An area where groundwater discharges to the surface.
Ecosystem	A biological community of interacting organisms and their physical environment.
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 that 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).
Groundwater	Water that occupies the pores and crevices of rock or soil.

Hydrology	The study of water, its properties, distribution and utilisation, on and below the earth's surface.
Kilolitre (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 indicating the acidity or alkalinity. A pH value of 7 is neutral, above 7 is alkaline and below 7 is acidic.
Recharge	Volumetric inflow rate of water to an aquifer, typically measured in cubic metres per second.
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.
Riparian zone	An area including 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. Refer to Appendix 1 for a salinity classification in relation to sea water.
Salinisation	An increase in the concentration of soluble salts in soil or water.
Sediment load	The amount of sediment reaching a waterway from its catchment area over a given time period. Also refers to the amount of sediment being transported by a waterway.
Surface water	Water flowing or held in waterways.
Tributary	A waterway that flows into a larger waterway.
Verge	Upland area adjacent to the floodplain.
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: Water quality data for Kwolyn Hill and Gairdners Crossing gauging stations

Total nitrogen and total phosphorus concentrations at the Department of Water's Kwolyn Hill gauging station 615012 on the Lockhart River

Date collected	Total N (mg/L)	Classification	Total P (mg/L)	Classification*
27 July 1994	–	–	0.5	Very high/Extreme
10 June 1997	1.5	Moderate	0.0	Low
22 July 1997	3.1	Very high	0.0	Low
26 August 1997	2.9	High	0.0	Low
3 September 1998	0.2	Low	0.0	Low
22 March 1999	2.0	Moderate/High	0.0	Low
20 May 1999	0.8	Low	0.0	Low
21 July 1999	2.0	Moderate/High	0.0	Low
22 September 1999	1.3	Moderate	0.0	Low
24 January 2000	4.4	Extreme	0.2	Moderate/High
10 February 2000	1.9	Moderate	0.1	Low/Moderate
9 March 2000	2.5	High	0.1	Low/Moderate
30 March 2000	2.3	High	0.1	Low/Moderate
5 April 2000	2.4	High	0.0	Low
23 January 2001	3.3	Very high	0.0	Low
23 February 2001	2.6	High	0.0	Low
31 July 2001	1.7	Moderate	0.1	Low/Moderate
18 February 2003	2.5	High	0.3	High/Very high
2 August 2004	2.0	Moderate/High	0.1	Low/Moderate
15 August 2005	3.3	Very high	0.0	Low
31 January 2006	0.6	Low	0.0	Low

** Refer to nutrient classification table below*

Total nitrogen and total phosphorus concentrations at Department of Water's Gairdners Crossing gauging station 615015 on the Yilgarn River

Date collected	Total N (mg/L)	Classification	Total P (mg/L)	Classification*
24 September 1996	1.1	Moderate	0.1	Low/Moderate
3 September 1998	1.6	Moderate	0.1	Low/Moderate
22 March 1999	0.7	Low	0.1	Low/Moderate
20 May 1999	1.3	Moderate	0.1	Low/Moderate
20 July 1999	2.4	High	0.0	Low
24 January 2000	3.7	Very high	0.1	Low/Moderate
31 July 2001	0.5	Low	0.0	Low
18 February 2003	1.8	Moderate	0.1	Low/Moderate
2 August 2004	1.2	Moderate	0.1	Low/Moderate
30 January 2006	0.7	Low	0.1	Low/Moderate

** Refer to nutrient classification table below*

Nutrient classification (adapted from Swan River Trust 1999)

Classification	Total nitrogen concentration (mg/L)	Total phosphorus concentration (mg/L)
Extreme	> 4	> 0.5
Very high	3 – 4	0.3 – 0.5
High	2 – 3	0.2 – 0.3
Moderate	1 – 2	0.1 – 0.2
Low	< 1	< 0.1

Salinity classification with a comparison to sea water (adapted from Mayer et al. 2005 and Department of Fisheries 2007)

Classification	mg/L	mS/m	mS/cm	grains/gallon
Fresh	0 – 500	0 – 91	0 – 0.9	0 – 35
Marginal	500 – 1000	91 – 182	0.9 – 1.8	35 – 70
Brackish	1 000 – 2 000	182 – 364	1.8 – 3.6	70 – 140
Moderately saline	2 000 – 5 000	364 – 909	3.6 – 9.1	140 – 350
Saline	5 000 – 10 000	909 – 1818	9.1 – 18.2	350 – 700
Highly saline	10 000 – 35 000	1818 – 6363	18.2 – 63.6	700 – 2450
Brine	> 35 000	> 6 363	> 63.6	> 2 450

Summary of water quality and streamflow data for Department of Water's Kwolyn Hill gauging station 615012 on the Lockhart River

Variable	Unit	Min.	Max.	Average	No. of readings	First reading	Last reading
Acidity ($CaCO_3$)	mg/L	6.8	320.0	163.4	2	24 Jan 00	15 Aug 05
Acidity ($CaCO_3$) (H_2O_2 pretreat.)	mg/L	570.0	570.0	570.0	1	15 Aug 05	15 Aug 05
Acidity to pH 8.3 ($CaCO_3$)	mg/L	140.0	160.0	150.0	2	02 Aug 04	02 Aug 04
Ag (tot.)	mg/L	0.0	0.0	0.0	1	15 Aug 05	15 Aug 05
Ag (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Al (sol.)	mg/L	21.0	56.0	38.5	2	02 Aug 04	15 Aug 05
Al (tot.)	mg/L	0.2	56.0	18.8	3	12 Sept 96	15 Aug 05
Al (unfilt. undig.)	mg/L	22.0	22.0	22.0	1	02 Aug 04	02 Aug 04
Alkalinity (CO_3-CO_3)	mg/L	0.0	2.0	0.4	16	05 Jun 81	18 Aug 88
Alkalinity (CO_3-$CaCO_3$)	mg/L	1.0	1.0	1.0	2	24 Jan 00	15 Aug 05
Alkalinity (HCO_3-$CaCO_3$)	mg/L	1.0	22.0	11.5	2	24 Jan 00	15 Aug 05
Alkalinity (HCO_3-HCO_3)	mg/L	0.0	66.0	31.8	16	05 Jun 81	18 Aug 88
Alkalinity (tot.) ($CaCO_3$)	mg/L	0.0	192.0	29.2	22	23 Sept 74	15 Aug 05
As (tot.)	mg/L	0.0	0.0	0.0	1	15 Aug 05	15 Aug 05
As (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
B (tot.)	mg/L	4.7	4.7	4.7	1	15 Aug 05	15 Aug 05
B (unfilt. undig.)	mg/L	1.6	1.6	1.6	1	02 Aug 04	02 Aug 04
Ba (tot.)	mg/L	0.1	0.1	0.1	1	15 Aug 05	15 Aug 05
Ba (unfilt. undig.)	mg/L	0.1	0.1	0.1	1	02 Aug 04	02 Aug 04
Br (sol.)	mg/L	140.0	140.0	140.0	1	15 Aug 05	15 Aug 05

Variable	Unit	Min.	Max.	Average	No. of readings	First reading	Last reading
Br (unfilt. undig.)	mg/L	89.0	89.0	89.0	1	02 Aug 04	02 Aug 04
C (sol. org.) {DOC}	mg/L	5.4	15.0	10.2	5	12 Sept 96	02 Aug 04
Ca (sol.)	mg/L	23.0	1700.0	598.6	21	05 Jun 81	15 Aug 05
Ca (tot.)	mg/L	1800.0	1800.0	1800.0	1	15 Aug 05	15 Aug 05
Ca (unfilt. undig.)	mg/L	1100.0	1100.0	1100.0	1	02 Aug 04	02 Aug 04
Cd (sol.)	mg/L	0.0	0.0	0.0	2	02 Aug 04	02 Aug 04
Cd (tot.)	mg/L	0.0	0.0	0.0	1	15 Aug 05	15 Aug 05
Cl (sol.)	mg/L	780.0	130000.0	25100.8	54	28 Aug 73	15 Aug 05
Colour (TCU)	TCU	3.0	100.0	31.0	8	20 May 99	17 Apr 00
Colour (hazen)	Hu	17.0	45.0	29.4	5	26 Jul 77	23 Aug 78
Colour (true)	Hu	5.0	310.0	13.8	190	28 Aug 73	22 Mar 99
Cond comp 25°C (lab.)	µS/m	190000.0	13000000.0	6792857.1	7	10 Jun 97	15 Aug 05
Cond uncomp (in situ)	µS/m	117600.0	13700000.0	4685735.7	28	06 Oct 83	31 Jan 06
Cond uncomp (lab.)	µS/m	160000.0	18700000.0	4829356.9	232	28 Aug 73	15 Aug 05
Cr (tot.)	mg/L	0.0	0.0	0.0	1	15 Aug 05	15 Aug 05
Cr (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Cs (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Cu (tot.)	mg/L	0.0	0.0	0.0	1	15 Aug 05	15 Aug 05
Cu (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Discharge rate	m^3/s	0.2	0.2	0.2	1	28 Aug 73	28 Aug 73
F (sol.)	mg/L	0.8	1.4	1.1	2	02 Aug 04	15 Aug 05
Fe (sol.)	mg/L	0.8	1.6	1.2	2	02 Aug 04	15 Aug 05
Fe (tot.)	mg/L	0.0	2.3	0.6	14	25 May 92	15 Aug 05
Fe (unfilt. undig.)	mg/L	0.8	0.8	0.8	1	02 Aug 04	02 Aug 04
Hardness (tot.) ($CaCO_3$) {Ca+Mg}	mg/L	1145.8	41030.0	8150.0	21	23 Sept 74	09 Jul 98
Hg (tot.)	mg/L	0.0	0.0	0.0	1	15 Aug 05	15 Aug 05
Hg (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
K (sol.)	mg/L	12.0	420.0	207.3	3	24 Jan 00	15 Aug 05
K (tot.)	mg/L	28.0	655.0	135.8	18	05 Jun 81	09 Jul 98
Mg (sol.)	mg/L	49.0	9060.0	1789.0	21	05 Jun 81	15 Aug 05
Mn (sol.)	mg/L	2.6	5.9	4.3	2	02 Aug 04	15 Aug 05
Mn (tot.)	mg/L	0.0	5.9	1.1	14	25 May 92	15 Aug 05
Mn (unfilt. undig.)	mg/L	3.0	3.0	3.0	1	02 Aug 04	02 Aug 04
Mo (tot.)	mg/L	0.0	0.0	0.0	1	15 Aug 05	15 Aug 05
Mo (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
N (sum sol. ox.) {NOx-N, TON}	mg/L	0.0	1.0	0.4	12	27 Jul 94	15 Aug 05
N (tot kjel) {TKN}	mg/L	0.2	3.3	1.7	9	27 Jul 94	15 Aug 05
N (tot.) {TN, pTN}	mg/L	0.2	4.4	2.1	21	10 Jun 97	31 Jan 06
NH_3-N/NH_4-N (sol.)	mg/L	1.7	2.1	1.9	3	27 Jul 94	26 Aug 97
NO_2-N (sol.)	mg/L	0.0	0.0	0.0	2	02 Aug 04	15 Aug 05
NO_3 (sol.)	mg/L	1.0	11.0	2.0	16	05 Jun 81	18 Aug 88

Variable	Unit	Min.	Max.	Average	No. of readings	First reading	Last reading
NO_3-N (sol.)	mg/L	3.0	3.0	3.0	1	24 Jan 00	24 Jan 00
Na (sol.)	mg/L	430.0	67500.0	13785.2	21	05 Jun 81	15 Aug 05
Ni (sol.)	mg/L	0.1	0.1	0.1	1	02 Aug 04	02 Aug 04
Ni (tot.)	mg/L	0.1	0.1	0.1	1	15 Aug 05	15 Aug 05
Ni (unfilt. undig.)	mg/L	0.1	0.1	0.1	1	02 Aug 04	02 Aug 04
O - DO	mg/L	4.4	9.7	8.0	4	03 Sept 98	18 Feb 03
O - DO%	%	47.2	80.2	63.7	2	13 Aug 04	31 Jan 06
O - DO (in situ)	mg/L	3.2	12.2	7.6	9	21 Jul 99	31 Jan 06
P (tot.) {TP, pTP}	mg/L	0.0	0.8	0.1	22	27 Jul 94	31 Jan 06
PO_4-P (sol. react.) {SRP, FRP}	mg/L	0.0	0.1	0.0	5	27 Jul 94	15 Aug 05
Pb (sol.)	mg/L	0.1	0.1	0.1	1	02 Aug 04	02 Aug 04
Pb (tot.)	mg/L	0.3	0.3	0.3	1	15 Aug 05	15 Aug 05
Pb (unfilt. undig.)	mg/L	0.1	0.1	0.1	1	02 Aug 04	02 Aug 04
S(2-) (sol.)	mg/L	474.0	579.0	526.5	2	12 Sept 96	09 Jul 98
SO_4 (sol.)	mg/L	89.0	5200.0	2929.7	3	24 Jan 00	15 Aug 05
SO_4 (tot.)	mg/L	391.0	7140.0	2364.3	16	05 Jun 81	18 Aug 88
Sample depth (SLE)	m	10.3	10.3	10.3	1	22 Mar 99	22 Mar 99
Se (tot.)	mg/L	0.0	0.0	0.0	1	15 Aug 05	15 Aug 05
SiO_2 (sol. react.)	mg/L	1.0	77.0	11.8	19	05 Jun 81	02 Aug 04
SiO_2-Si (sol. react.)	mg/L	3.3	52.0	27.7	2	24 Jan 00	15 Aug 05
Start date-time	date				30	17 Jun 83	17 Jul 96
Suspended solids (EDI)	mg/L	30.8	30.8	30.8	1	28 Feb 78	28 Feb 78
Suspended solids (gulp)	mg/L	10.1	10.1	10.1	1	10 Jun 80	10 Jun 80
Suspended solids < 63u (gulp)	mg/L	19.4	350.0	115.8	4	25 Jul 83	18 Feb 03
TDSalts (sum of ions)	mg/L	6415.0	215920.0	44621.3	16	05 Jun 81	18 Aug 88
TDSolids (calc. @180°C-by cond.)	mg/L	16442.0	81714.0	53398.7	3	23 Sept 74	05 Jul 76
TDSolids (evap. @180°C)	mg/L	68000.0	101000.0	84500.0	2	02 Aug 04	15 Aug 05
TSS	mg/L	5.0	410.0	70.8	8	10 Jun 97	31 Jan 06
Th (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Turbidity	NTU	0.3	330.0	18.6	179	03 Aug 78	31 Jan 06
Turbidity (JCU)	JTU	25.0	25.0	25.0	3	23 Sept 74	05 Jul 76
U (tot.)	mg/L	0.0	0.0	0.0	1	15 Aug 05	15 Aug 05
U (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
V (tot.)	mg/L	0.0	0.0	0.0	1	15 Aug 05	15 Aug 05
V (unfilt. undig.)	mg/L	5.0	5.0	5.0	1	02 Aug 04	02 Aug 04
Water level (SLE)	m	9.9	11.5	10.3	192	29 May 75	13 Aug 04
Water level status	(none)	0.0	0.0	0.0	141	26 Jul 77	18 Feb 03
Water temperature (in situ)	°C	3.9	34.4	16.0	196	28 Aug 73	31 Jan 06
Water temperature (test)	°C	16.0	30.3	24.1	232	28 Aug 73	15 Aug 05
Zn (sol.)	mg/L	0.1	0.1	0.1	1	02 Aug 04	02 Aug 04

Variable	Unit	Min.	Max.	Average	No. of readings	First reading	Last reading
Zn (tot.)	mg/L	0.1	0.1	0.1	1	15 Aug 05	15 Aug 05
Zn (unfilt. undig.)	mg/L	0.1	0.1	0.1	1	02 Aug 04	02 Aug 04
pH	(none)	3.2	8.7	5.9	135	23 Sept 74	31 Jan 06
pH (in situ)	(none)	4.5	8.6	6.7	13	31 Aug 83	23 Feb 01

Summary of water quality and streamflow data for Department of Water's Gairdners Crossing gauging station 615015 on the Yilgarn River

Variable	Unit	Min.	Max.	Average	No. of readings	First reading	Last reading
Acidity ($CaCO_3$)	mg/L	4.5	4.5	4.5	1	24 Jan 00	24 Jan 00
Acidity to pH 8.3 ($CaCO_3$)	mg/L	18.0	18.0	18.0	1	02 Aug 04	02 Aug 04
Ag (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Al (sol.)	mg/L	0.1	0.1	0.1	1	02 Aug 04	02 Aug 04
Al (tot.)	mg/L	0.1	0.1	0.1	1	09 Jul 98	09 Jul 98
Al (unfilt. undig.)	mg/L	0.2	0.2	0.2	1	02 Aug 04	02 Aug 04
Alkalinity (CO_3-CO_3)	mg/L	0.0	5.0	1.0	19	05 Jun 81	18 Aug 88
Alkalinity (CO_3-$CaCO_3$)	mg/L	1.0	1.0	1.0	1	24 Jan 00	24 Jan 00
Alkalinity (HCO_3-$CaCO_3$)	mg/L	23.0	23.0	23.0	1	24 Jan 00	24 Jan 00
Alkalinity (HCO_3-HCO_3)	mg/L	3.0	198.0	65.3	19	05 Jun 81	18 Aug 88
Alkalinity (tot.) ($CaCO_3$)	mg/L	2.5	162.4	55.7	21	05 Jun 81	02 Aug 04
As (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
B (unfilt. undig.)	mg/L	1.8	1.8	1.8	1	02 Aug 04	02 Aug 04
Ba (unfilt. undig.)	mg/L	0.1	0.1	0.1	1	02 Aug 04	02 Aug 04
Br (unfilt. undig.)	mg/L	39.0	39.0	39.0	1	02 Aug 04	02 Aug 04
C (sol. org.) {DOC}	mg/L	8.4	15.0	11.8	4	09 Jul 98	02 Aug 04
Ca (sol.)	mg/L	120.0	832.0	405.9	22	05 Jun 81	02 Aug 04
Ca (unfilt. undig.)	mg/L	500.0	500.0	500.0	1	02 Aug 04	02 Aug 04
Cd (sol.)	mg/L	0.0	0.0	0.0	2	02 Aug 04	02 Aug 04
Cl (sol.)	mg/L	1615.6	27500.0	9149.7	42	29 Jul 76	02 Aug 04
Colour (TCU)	TCU	8.0	47.0	26.7	3	20 May 99	24 Jan 00
Colour (hazen)	Hu	17.0	50.0	29.0	3	30 Mar 78	23 Aug 78
Colour (true)	Hu	5.0	75.0	20.0	118	05 Jun 81	22 Mar 99
Cond comp 25°C (lab.)	µS/m	750000.0	4400000.0	2575000.0	2	31 Jul 01	02 Aug 04
Cond uncomp (in situ)	µS/m	663000.0	6710000.0	2969642.9	14	20 Jul 95	30 Jan 06
Cond uncomp (lab.)	µS/m	439000.0	6730000.0	2722142.0	162	29 Jul 76	02 Aug 04
Cr (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Cs (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Cu (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
F (sol.)	mg/L	0.8	0.8	0.8	1	02 Aug 04	02 Aug 04
Fe (sol.)	mg/L	0.1	0.1	0.1	1	02 Aug 04	02 Aug 04
Fe (tot.)	mg/L	0.1	0.8	0.4	4	22 Jul 92	24 Jan 00
Fe (unfilt. undig.)	mg/L	0.3	0.3	0.3	1	02 Aug 04	02 Aug 04

Variable	Unit	Min.	Max.	Average	No. of readings	First reading	Last reading
Hardness (tot.) ($CaCO_3$) {Ca+Mg}	mg/L	1325.2	8809.9	4247.1	20	05 Jun 81	09 Jul 98
Hg (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
K (sol.)	mg/L	30.0	120.0	75.0	2	24 Jan 00	02 Aug 04
K (tot.)	mg/L	42.0	173.0	97.9	20	05 Jun 81	09 Jul 98
Mg (sol.)	mg/L	170.0	1730.0	764.3	22	05 Jun 81	02 Aug 04
Mn (sol.)	mg/L	0.2	0.2	0.2	1	02 Aug 04	02 Aug 04
Mn (tot.)	mg/L	0.1	1.3	0.5	4	22 Jul 92	24 Jan 00
Mn (unfilt. undig.)	mg/L	0.4	0.4	0.4	1	02 Aug 04	02 Aug 04
Mo (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
N (sum sol. ox.) {NOx-N, TON}	mg/L	0.0	0.5	0.2	6	24 Sept 96	02 Aug 04
N (tot. kjel.) {TKN}	mg/L	0.3	1.6	1.0	4	24 Sept 96	20 May 99
N (tot.) {TN, pTN}	mg/L	0.5	3.7	1.5	10	24 Sept 96	30 Jan 06
NO_2-N (sol.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
NO_3 (sol.)	mg/L	1.0	7.0	2.5	19	05 Jun 81	18 Aug 88
NO_3-N (sol.)	mg/L	2.3	2.3	2.3	1	24 Jan 00	24 Jan 00
Na (sol.)	mg/L	1800.0	14800.0	6706.8	22	05 Jun 81	02 Aug 04
Ni (sol.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Ni (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
O - DO	mg/L	5.9	9.6	8.6	4	03 Sept 98	18 Feb 03
O - DO%	%	69.2	84.5	76.9	2	13 Aug 04	30 Jan 06
O - DO (in situ)	mg/L	5.1	10.6	7.9	4	20 Jul 99	30 Jan 06
P (tot.) {TP, pTP}	mg/L	0.0	0.1	0.1	10	24 Sept 96	30 Jan 06
Pb (sol.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Pb (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
S(2-) (sol.)	mg/L	570.0	570.0	570.0	1	09 Jul 98	09 Jul 98
SO_4 (sol.)	mg/L	360.0	1700.0	1030.0	2	24 Jan 00	02 Aug 04
SO_4 (tot.)	mg/L	482.0	2280.0	1229.6	19	05 Jun 81	18 Aug 88
SiO_2 (sol react)	mg/L	0.2	6.0	2.8	21	05 Jun 81	02 Aug 04
SiO_2-Si (sol react)	mg/L	2.8	2.8	2.8	1	24 Jan 00	24 Jan 00
Start date-time	date				31	17 Jun 83	24 Sept 96
Suspended solids (EDI)	mg/L	20.2	546.7	121.3	8	27 Feb 78	22 Mar 78
Suspended solids (ETR)	mg/L	38.8	38.8	38.8	1	14 Mar 78	14 Mar 78
Suspended solids < 63u (gulp)	mg/L	120.0	482.3	246.6	8	08 Jul 83	18 Feb 03
Suspended solids < 63u (pump)	mg/L	263.0	765.0	514.0	2	05 Aug 85	05 Mar 86
TDSalts (sum of ions)	mg/L	7246.0	47298.0	21764.4	19	05 Jun 81	18 Aug 88
TDSolids (evap @180°C)	mg/L	30000.0	30000.0	30000.0	1	02 Aug 04	02 Aug 04
TSS	mg/L	16.0	140.0	92.0	3	31 Jul 01	30 Jan 06
Th (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Turbidity	NTU	0.6	1650.0	85.8	105	03 Aug 78	30 Jan 06
U (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04

Variable	Unit	Min.	Max.	Average	No. of readings	First reading	Last reading
V (unfilt. undig.)	mg/L	0.5	0.5	0.5	1	02 Aug 04	02 Aug 04
Water level (SLE)	m	10.0	11.0	10.3	137	27 Feb 78	13 Aug 04
Water level (SLE) (maximum)	m	10.4	10.4	10.4	1	19 Aug 87	19 Aug 87
Water level status	(none)	0.0	0.0	0.0	116	27 Feb 78	18 Feb 03
Water temperature (in situ)	deg C	7.0	34.4	17.8	92	29 Jul 76	30 Jan 06
Water temperature (test)	deg C	17.5	25.2	23.9	163	29 Jul 76	02 Aug 04
Zn (sol.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
Zn (unfilt. undig.)	mg/L	0.0	0.0	0.0	1	02 Aug 04	02 Aug 04
pH	(none)	6.2	8.9	7.5	102	03 Aug 78	30 Jan 06
pH (in situ)	(none)	6.4	9.0	8.0	5	31 Aug 83	26 Jul 00

Appendix 2: Survey form

General details

Recorder's name: ………………………………………… Survey date: …………………………………...
Site number: ……………………………………………… Site name………………………………………
Landholder: ……………………………………………… Contact Number : ………………………………..

Property address: ……………………………………………………………………………………………...

Site position in landscape

❒ Valley floor
❒ Valley slope
❒ Uplands
❒ Rocky outcrop

Floodplain features

Natural features:
- ❒ Salt lakes (playas)
  - ❒ Permanent water
  - ❒ Seasonally wet
- ❒ Braided channel
  - ❒ Discontinuous
  - ❒ Continuous
- ❒ Lunettes (dunes)
- ❒ Tributary

Constructed features:
- ❒ Drain
- ❒ Dam
- ❒ Other…………………………….

Vegetation description (from Keighery, 1994)

Beard vegetation association

Number	Description
7	Medium woodland; York gum and wandoo
694	Shrublands; scrub-heath on yellow sandplain banksia-xylomelum association in the Geraldton Sandplain and Avon Wheatbelt Region
951	Succulent steppe with sparse woodland and thicket; York gum and Kondinin blackbutt over tea-tree thicket and samphire
954	Shrublands; thicket, jam and Allocasuarina huegeliana
1023	Medium woodland; York gum, wandoo and salmon gum
1041	Low woodland; Allocasuarina huegeliana and jam
1049	Medium woodland; wandoo, York gum, salmon gum, morrel and gimlet
1147	Shrublands; scrub-heath in the south-east Avon Wheatbelt Region

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 20-30% Open 30-70% Closed 70-100%
**More than 3 dominant species described as mixed

Native species list

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

Regeneration ❒ Yes ❒ No Species: ……………………

Weed species list

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

Vegetation condition (from Keighery, 1994)

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

Disturbance factors affecting vegetation condition score

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

Linkages to protected remnant vegetation

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

Aquatic vegetation (if water is present)

Is the aquatic environment dominated by:

- ❒ Macrophytes
- ❒ Phytoplankton
- ❒ Benthic microbial mats

Disturbance factors impacting on in-stream functions

Disturbance factor	Threat level		
	High	Medium	Low
Salinity			
Change in hydroperiod			
Drainage			
Clearing			
Sediment			
Rubbish			
Point source discharge			
Recreation			
Other			

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

Sample Number	pH	Conductivity mS/cm	Temperature ºC	Location

Evidence of management

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

Ideas for management

Tick the appropriate boxes:
❒ Prescribed burning
❒ Firebreak control
❒ Fencing
❒ Erosion control
❒ Saltland grazing
❒ Agroforestry
❒ Remnant vegetation management
❒ Weed control
❒ Drainage
❒ Sediment management
❒ Surface water management
❒ Road crossing
❒Other……………………………………………………………………………………….……………

Fauna list

Photographs

Number	Description

Appendix 3: Survey site reports

Site SR01 – Parker's

General details	
Site name	Parker's (private property)
Surveyed by	Kate Gole and Prue Dufty
Survey date	19.05.2006

Site description	
Landform	This site spans the Salt River floodplain. The main channel of the Salt River flows down the left-hand side of the site (facing upstream); however, numerous braided channels cover the floodplain. There are also small seasonally-inundated playa lakes in some areas.
Site size	Approximately 1656 ha.

Vegetation description
Beard vegetation association 951: Succulent steppe with sparse woodland and thicket – York gum and Kondinin blackbutt over tea-tree thicket and samphire

Vegetation structure and cover

Vegetation layer	**Canopy cover class**	**Dominant species**
Trees	2–10%	*Eucalyptus* species
Mallees	2–10%	*Eucalyptus* species
Shrubs	2–10%	*Melaleuca* species and *Santalum acuminatum*
Grasses	2–10%	Annual weed species, some native species
Herbs	30–70%	*Halosarcia* species and *Atriplex* species
Rushes and sedges	2–10%	*Typha domingensis*, *Garnia trifida* and *Cyperus gymnacaulos*
Litter	–	
Rock outcrop	–	
Bare ground	10–30%	

Summary

The vegetation in the floodplain area changes with small changes in topography. A brackish seep at the base of a slope with deep sandy soils is dominated by *Melaleuca* species, *Casuarina obesa* and *Santalum acuminatum* with an understorey of grassy annual weeds, native grasses and sedges such as *Typha domingensis*, *Cyperus gymnacaulos* and *Garnia trifida*. Large areas of the floodplain are covered by a variety of *Atriplex* and *Halosarcia* species. On gentle rises adjacent to, and approximately 0.5 m above, floodway areas, remnants of sparse *Melaleuca* and *Eucalyptus* woodlands are found. These areas are under significant pressure from salinity and waterlogging.

Native species	
Scientific name	**Common name**
Atriplex hymenotheca	Saltbush
Atriplex species	Saltbush (2 species)
Cassytha species	Dodder
Casuarina obesa	Swamp sheoak
Cyperus gymnacaulos	Spiny flat sedge
Eucalyptus species	Eucalypt (3 species)
Garnia trifida	Coast saw sedge
Halosarcia species	Samphire (3 species)
Melaleuca halmoaturorum	
Melaleuca species*	Melaleuca (2 species)
Poaceae species	Grass
Ptilotus polystachyus	Prince of Wales feather
Santalum acuminatum	Quandong
Typha domingensis	Native bulrush

** Regeneration of overstorey species was noted.*

Weed species	
Scientific name	**Common name**
Arctotheca calendula	Capeweed
Asteraceae species	A thistle
Avena fatua	Wild oats
Bromus species	Brome grass
Cucumis myriocarpus	Pie melon
Conzya bonariensis	Fleabane
Cotula coronopifolia	Waterbuttons
Dittrichia graveolens	Stinkwort
Hordeum leporinum	Barley grass
Juncus acutus	Sharp rush
Lupinus cosentinii	Blue lupin
Poaceae species	Grass (2 species)
Solanum species	Nightshade

Other plant lists for the general area
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

Vegetation condition		
Condition	**Description**	**% of site**
Pristine	No obvious signs of disturbance.	
Excellent	Vegetation structure intact; disturbance affecting individual species and weeds are non-aggressive species.	
Very good	Vegetation structure altered; obvious signs of disturbance.	
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate.	5
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition would require intensive management.	5
Completely degraded	Vegetation structure no longer intact and the area is without / almost without native species.	90

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		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				

Comments

The valley floor vegetation has been significantly altered due to clearing, both in the floodplain itself and in the wider catchment. Pockets of vegetation within the floodplain were first cleared and cropped in the early 1900s.

Increased salinity and waterlogging levels have resulted in the replacement of the original vegetation communities, comprising *Melaleuca* thickets and *Eucalyptus* woodland, with extensive samphire (*Halosarcia* species) and saltbush (*Atriplex* species) flats.

Stock have access to the floodplain area for several months of the year from November/December. The saltbush (*Atriplex* species), in conjunction with stubble in surrounding paddocks, provides reasonable quality fodder during the summer–autumn feed gap. Impacts from grazing on the floodplain appear to be relatively low. Relatively heavy grazing of saltbush helps to stimulate regrowth and maintains yields. It is possible that stock are impacting on regeneration of native species in the remaining patches of *Melaleuca* and *Eucalyptus*.

Ponding from the road crossing has also impacted on vegetation, especially following the 2000 flood. Saltbush species particularly were affected by prolonged waterlogging following the flood.

While weeds are invading the understorey, the salt and waterlogging levels mean that they are not significant threats, with the exception of sharp rush (*Juncus acutus*), which has the potential to colonise further areas if left uncontrolled.

Rabbits are in their highest numbers for approximately the last 10 years. Their control would benefit regeneration of native species in the remaining patches of remnant vegetation.

Links to protected areas of remnant vegetation

Name	**Area** (ha)	**Approximate distance and direction from site**
Quairading Springs Nature Reserve	29	1.5 km NW
Badjaling Nature Reserve	286	2.5 km NE
Quairading townsite	276	3 km NW
Badjaling North Nature Reserve	29	4 km NE
Quairading Nature Reserve and Crown Reserve	630	4.5 km NW

Aquatic vegetation

No water present.

Disturbance factors impacting on in-stream function							
Disturbance factor	**Level of threat**			**Disturbance factor**	**Level of threat**		
	H	**M**	**L**		**H**	**M**	**L**
Salinity	x			Rubbish			
Change in hydroperiod	x			Point source discharge			
Drainage				Recreation			
Clearing	x			Other			
Sediment							

Water quality

The brackish seep discharges groundwater on the edge of the floodplain all year, and consequently the main channel downstream of the seep also contains water all year. No water-quality readings were taken but the seep supports plant species that were not found anywhere else within the site. Water from a nearby soak, fed from the same groundwater source as the seep, tasted slightly salty and is of stock-water quality. This suggests that the salinity is approximately 1000–1500 mg/L (see Appendix 1 for a salinity classification table).

There are eight shallow soaks/dams across the floodplain that vary in water quality but are utilised for stock watering.

Management

The vegetation associated with the brackish seep at the base of the sandhill would benefit from being fenced from stock to enable natural regeneration; however, the seep is on the edge of the main channel, which presents difficulties for fence placement.

Fauna	
Scientific name	**Common name**
Birds	
Anthus australis	Richard’s pipit
Aquila audax	Wedge-tailed eagle
Artamus cyanopterus	Dusky woodswallow
Barnardius zonarius race *zonarius*	Australian ringneck (twenty-eight parrot)
Columba livia	Rock dove*
Corvus coronoides	Australian raven
Hirundo neoxena	Welcome swallow
Ocyphaps lophotes	Crested pigeon
Pomatostomus temporalis	White-browed babbler
Rhipidura rufiventris	Grey fantail
Rhipidura leucophrys	Willy wagtail
Psephotus haematonotus	Mulga parrot
Mammals	
Macropus rufus	Red kangaroo
Vulpes vulpes	European red fox*
Oryctolagus cuniculus	European wild rabbit*

* *Introduced species*

Other fauna lists for the general area

Lefroy et al. (1991)

Weaving, S. (1997)

Weaving, S. & Grein, S. (1994)

This reach of the main channel is groundwater-fed with seepage from the base of a sandhill. The channel is fringed by Melaleuca *and* Eucalyptus *over* Halosarcia *and* Atriplex

Vegetation growing on the groundwater seep on the edge of the Salt River floodplain

Site SR02 – Badjaling Nature Reserve

General details	
Site name	Badjaling Nature Reserve (Department of Environment and Conservation) Crown Reserve 23758
Surveyed by	Kate Gole, Prue Dufty and Chrystal King
Survey date	15.05.2006 and 08.06.2006

Site description	
Landform	Most of the site is dominated by uplands and hillslopes with deep yellow sands. A significant drain flows through the reserve, joining the Salt River floodplain in the southern corner of the reserve.
Site size	Approximately 286 ha.
Location	Located south of the Bruce Rock – Quairading Rd and bounded by the Badjaling North Rd to the west and the Badjaling Aboriginal Community to the south. Part of the reserve is located within the Salt River floodplain.

Vegetation description
Beard vegetation association 694: Shrublands – scrub-heath on yellow sandplain *banksia-xylomelum* association in the Geraldton Sandplain and Avon Wheatbelt Region
Beard vegetation association 951: Succulent steppe with sparse woodland and thicket – York gum and Kondinin blackbutt over tea-tree thicket and samphire
Beard vegetation association 1147: Shrublands – scrub-heath in the south-east Avon Whealtbelt Region

Vegetation structure and cover

Vegetation layer	**Canopy cover class**	**Dominant species**
Trees	2–10%	*Allocasuarina*, *Banksia prionotes*, *Eucalyptus* species
Mallees	–	
Shrubs	30–70%	*Casuarina*, *Melaleuca*, *Hakea* and *Xyolmelum*
Grasses	2–10%	*Puccinellia ciliata* and native species
Herbs	2–10%	Various native species
Rushes and sedges	2–10%	*Juncus acutus*
Litter	2–10%	
Rock outcrop	–	
Bare ground	20–30%	

Summary

The deep, yellow sandplain soils of the upland area and slopes are dominated by *Banksia prionotes*, *Allocasuarina* and *Xyolmelum* shrublands with a middlestorey of *Casuarina* and *Melaleuca* species and an understorey of native grasses, herbs and sedges. The native vegetation in waterlogged areas of the valley has been replaced with the introduced *Juncus acutus*, *Puccinellia ciliata* and *Halosarcia* and *Atriplex* species. On the southern fringe of the reserves there is a sparse *Eucalyptus* woodland with a middlestorey of *Melaleuca* species and *Santalum acuminatum*.

Native species	
Scientific name	**Common name**
*Acacia acuminata**	Jam
Acacia microbotrya	Manna wattle
Acacia tratmaniana	
Acacia species	Acacia (2 species)
Actinostrobus arenarius	Sandplain cypress
Allocasuarina huegeliana	Rock sheoak
Allocasuarina campestris	Tamma
Allocasuarina species	Sheoak (2 species)
Atriplex semibaccata	Berry saltbush
Atriplex species	Saltbush (3 species)
*Banksia prionotes**	Acorn banksia
Banksia cuneata	Quairading banksia
Borya species	Pincushions
Dianella revoluta	Blueberry lily
Eucalyptus loxophleba subsp. *loxophleba*	York gum
Eucalyptus salmonophloia	Salmon gum
Eremophila species	
Grevillea hookeriana	Black toothbrush
Grevillea eriostachya	Flame grevillea
Grevillea paniculata	
Hakea platysperma	Cricket ball hakea
Halosarcia pergranulata	Black-seeded samphire
Halosarcia species	Samphire (2 species)
Lycium australe	Australian boxthorn
Maireana brevifolia	Small leaf bluebush
Melaleuca species	
Melaleuca uncinata	Broom bush
Poaceae species	Grass (2 species)
Ptilotus polystachyus	Prince of Wales feather
Santalum acuminatum	Quandong
Xylomelum angustifolium	Sandplain woody pear
	Variety of rushes and sedges (5 species)
	Variety of annual herbs
	Variety of shrubs (10 species)

** Regeneration of overstorey species was noted.*

Weed species	
Scientific name	**Common name**
Arctotheca calendula	Capeweed
Avena fatua	Wild oats
Citrullus lanatus	Paddy melon
Cucumis myriocarpus	Pie melon
Dittrichia graveolens	Stinkwort
Heliotropium curassavicum	Smooth heliotrope
Hordeum leporinum	Barley grass
Hypochaeris species	Flat weed
Juncus acutus	Sharp rush
Oxalis pes-caprae	Soursob
Poacea species	Grass species
Puccinellia ciliata	Puccinellia

Other plant lists for the general area
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

Vegetation condition

Condition	Description	% of site
Pristine	No obvious signs of disturbance.	50
Excellent	Vegetation structure intact; disturbance affecting individual species and weeds are non-aggressive species.	10
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 would require intensive management.	
Completely degraded	Vegetation structure no longer intact and the area is without / almost without native species.	40

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

Comments

The valley floor vegetation is under pressure from increased waterlogging and salinity levels, and in some areas has been completely replaced by weed species. It is possible that ponding caused by Badjaling Rd North and Solomon South Rd is contributing to the waterlogging problems. The majority of the vegetation on the uplands and slopes is in pristine to excellent condition, with weeds impacting along Badjaling Rd and through the transition zone between the valley floor and hill slope.

Links to protected areas of remnant vegetation

Name	**Area** (ha)	Approximate distance and direction from site
Badjaling North Nature Reserve	29	0.5 km N
Crown Reserve 12333	40	1.8 km SE
Crown Reserve 13217	24	4.8 km SE
Quairading townsite	276	6.5 km NE
Crown Reserve 6775	14	8.5 km NW

Aquatic vegetation

No water present.

Disturbance factors impacting on in-stream function							
Disturbance factor	**Level of threat**			**Disturbance factor**	**Level of threat**		
	H	**M**	**L**		**H**	**M**	**L**
Salinity	x			Rubbish			
Change in hydroperiod	x			Point source discharge			
Drainage				Recreation			
Clearing				Other			
Sediment							

Water quality

No water quality data collected.

Management

Stock are excluded from the reserve. The reserve would benefit from the control of sharp rush (*Juncus acutus*) and puccinellia (*Puccinellia ciliata*) in the waterlogged areas of the valley floor and revegetation with local native species.

A significant drain flows through the reserve. Where it enters the reserve from private property the tributary has sandy banks, is incising and widening and carrying a significant sediment load from farmland upstream. Upstream from the reserve the tributary is almost entirely unvegetated. Within the reserve the tributary has some fringing vegetation, including acacia, samphire and saltbush species. The channel within the reserve has been modified and it has also been deepened and widened further upstream. Where the tributary joins the Salt River floodplain there is no defined channel, and water discharges into a wetland area, which is choked with puccinellia and sharp rush. It has been modified in its upper reaches, by deepening and widening.

Fauna	
Scientific name	**Common name**
Birds	
Anas superciliosa	Pacific black duck
Barnardius zonarius race *zonarius*	Australian ringneck (twenty-eight parrot)
Corvus coronoides	Australian raven
Egretta novaehollandiae	White-faced heron
Eolophus roseicapilla	Galah
Grallina cyanoleuca	Australian magpie-lark
Petroica goodenovii	Red-capped robin
Rhipidura leucophrys	Willy wagtail
Smicronis brevirostris race *occidentalis*	Weebill
Tadorna tadornoidies	Australian shelduck
Mammals	
Macropus rufus	Red kangaroo
Oryctolagus cuniculus	European wild rabbit*
Vulpes vulpes	European red fox*

* *Introduced species*

Other fauna lists for the general area

Lefroy et al. (1991)

Weaving, S. (1997)

Weaving, S. & Grein, S. (1994)

Sandplain vegetation in Badjaling Nature Reserve, with Banksia prionotes *in flower*

Santalum acuminatum *shrubland on the edge of Badjaling Nature Reserve*

Site SR03 – Badjaling North Nature Reserve

General details	
Site name	Badjaling North Nature Reserve (Department of Environment and Conservation) Crown Reserve 10121
Surveyed by	Kate Gole and Chrystal King
Survey date	07.06.2006

Site description	
Landform	The site is within the Salt River floodplain. Upstream of the Bruce Rock – Quairading Rd there is a well-defined channel, and downstream the floodplain widens and the channel becomes braided.
Site size	Approximately 29 ha.
Location	The site spans the Bruce Rock – Quairading Rd and Badjaling Rd North.

Vegetation description
Beard vegetation association 951: Succulent steppe with sparse woodland and thicket – York gum and Kondinin blackbutt over tea-tree thicket and samphire

Vegetation structure and cover		
Vegetation layer	**Canopy cover class**	**Dominant species**
Trees	–	–
Mallees	2–10%	*Eucalyptus* species
Shrubs	2–10%	*Melaleuca* species
Grasses	2–10%	
Herbs	20–30%	*Halosarcia* and *Atriplex*
Rushes and sedges	–	–
Litter	2–10%	
Bare ground	2–10%	
Rock outcrop	–	

Summary

A section of the site (approximately 25 per cent) that has previously been cleared has been revegetated with a variety of *Eucalyptus*, *Melaleuca* and *Allocasuarina* species. Some remnant *Eucalyptus* woodland and *Melaleuca* shrubland remains. *Halosarcia* and *Atriplex* species are common in the understorey, occurring as a thick fringe along the main channel of the Salt River.

Native species	
Scientific name	**Common name**
Remnant vegetation	
Acacia acuminata	Jam
Acacia species	
*Allocasuarina huegeliana**	Rock sheoak
Allocasuarina species	Sheoak
Atriplex semibaccata	Berry saltbush

Native species	
Scientific name	**Common name**
Remnant vegetation	
Atriplex species	Saltbush (4 species)
Carpobrotus species	Pigface
Chloris truncata	Windmill grass
Dianella revoluta	Blueberry lily
Eragrotis dielsii	Mallee lovegrass
Eucalyptus loxophelba subsp. *loxophelba**	York gum
Eucalyptus species	Eucalypt
Hakea pressii	Needle bush
Hakea species	
Halosarcia species	Samphire (3 species)
Lycium australe	Australian boxthorn
Melaleuca species	Melaleuca (3 species)
Poacea species	Grass (2 species)
Ptilotus polystachyus	Prince of Wales feather (local name bulla-mulla)
Santalum acuminatum	Quandong
	Unidentified shrubs (2 species)
Revegetation	
*Allocasuarina huegeliana**	Rock sheoak
Eucalyptus loxophelba subsp. *loxophelba**	York gum
Eucalyptus species	Eucalypt (2 species)
	Variety of shrub species (2 species)

** Regeneration of overstorey species was noted*

Weed species	
Scientific name	**Common name**
Avena fatua	Wild oats
Hordeum leporinum	Barley grass
Poacea species	Grass

Other plant lists for the general area
Lefroy et al. (1991)
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

Vegetation condition		
Condition	**Description**	**% of site**
–	Revegetation.	25
Pristine	No obvious signs of disturbance.	
Excellent	Vegetation structure intact; disturbance affecting individual species and weeds are non-aggressive species.	

Vegetation condition		
Condition	**Description**	**% of site**
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.	20
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition would require intensive management.	15
Completely degraded	Vegetation structure no longer intact and the area is without / almost without native species.	40

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

Comments

The site is being impacted by increasing salinity and waterlogging levels. Parts of the site have been cleared in the past, although they have now been revegetated with a variety of native species. The Bruce Rock – Quairading Rd passes through the site. There is a substantial bridge over the main channel of the Salt River, and ponding from the crossing in small to medium events does not appear to be an issue. The channel downstream from the road crossing has been deepened at some point. There are some weed species invading the vegetation from the road and some rubbish within the road reserve.

Links to protected areas of remnant vegetation		
Name	**Area** (ha)	**Approximate distance and direction from site**
Badjaling Nature Reserve	286	0.5 km S
Crown Reserve 12333	40	4.5 km S
Quairading townsite	276	7 km W
Crown Reserve 18155	7	7 km NW
Crown Reserve 13217	24	7.5 km S
Quairading Nature Reserve and Crown Reserve	630	10 km W
Quairading Springs Nature Reserve	29	10 km SW

Aquatic vegetation

No water present.

Disturbance factors impacting on in-stream function							
Disturbance factor	**Level of threat**			**Disturbance factor**	**Level of threat**		
	H	**M**	**L**		**H**	**M**	**L**
Salinity		x		Rubbish			
Change in hydroperiod		x		Point source discharge			
Drainage				Recreation			
Clearing		x		Other			
Sediment							

Water quality

No water quality data collected.

Management

The reserve would benefit from weed control, in particular of wild oats (*Avena fatua*), in the revegetated area. The revegetation is in good condition and understorey species have been established, either through direct seeding or natural regeneration. Part of the reserve is fenced and, although the fencing is in poor to moderate condition, there are no signs of stock access.

Fauna

Scientific name	**Common name**
Birds	
Barnardius zonarius race *zonarius*	Australian ringneck (twenty-eight parrot)
Eolophus roseicapilla	Galah
Manorina flavigula	Yellow-throated miner
Himantopus himantopus	Black-winged stilt
Hirundo species	Martin
Corvus coronoides	Australian raven
Rhipidura fuliginosa	Grey fantail
Ocyphaps lophotes	Crested pigeon
Mammals	
Macropus rufus	Red kangaroo
Oryctolagus cuniculus	European wild rabbit*
Tachyglossus aculeatus	Short-beaked echidna

* *Introduced species*

Other fauna lists for the general area

Lefroy et al. (1991)

Weaving, S. (1997)

Weaving, S. & Grein, S. (1994)

Revegetation in Badjaling North Nature Reserve

Shrublands in good condition in Badjaling North Nature Reserve

Site SR04 – Wilson's

General details	
Site name	Wilson's (private property)
Surveyed by	Kate Gole and Chrystal King
Survey date	07.06.2006

Site description	
Landform	This site sits within the Salt River floodplain. South of the Mt Stirling Rd the floodplain is broad, with a relatively well defined main channel. On the southern edge of the site, upstream from the Hommajelly Gully confluence, the main channel is more defined and the floodplain not as wide. Water is present in a reach of the main channel due to groundwater pumping.
Site size	Approximately 540 ha.

Vegetation description
Beard vegetation association 951: Succulent steppe with sparse woodland and thicket; York gum and Kondinin blackbutt over tea-tree thicket and samphire
Beard vegetation association 1049: Medium woodland; wandoo, York gum, salmon gum, morrel and gimlet

Vegetation structure and cover

Vegetation layer	Canopy cover class	Dominant species
Trees	–	-
Mallees	2–10%	*Eucalyptus*
Shrubs	2–10%	*Acacia* and *Melaleuca*
Grasses	2–10%	*Hordeum leporinum*
Herbs	30–70%	*Halosarcia* and *Atriplex*
Rushes and sedges	2–10%	Native species
Litter	–	
Bare ground	2–10%	
Rock outcrop	–	

Summary

There are several small patches (approximately 5 per cent of the site) characterised by sparse *Eucalypt* woodland over *Melaleuca* and *Acacia* species with a native understorey of *Halosarcia*, *Atriplex*, rush and sedge species. A diverse range of *Halosarcia* and *Atriplex* species dominates 95 per cent of the site.

Native species

Scientific name	Common name
Acacia acuminata	Jam
Acacia species	
Atriplex semibaccata	Berry saltbush
Atriplex species	Saltbush (2 species)
Borya species	Pincushions
Casuarina species	
Dianella revulata	Blueberry lily
Eremophila species	
Eucalyptus loxophelba subsp. *loxophelba*	York gum
Eucalyptus species	Eucalypt

Halosarcia lylei	Samphire
Halosarcia doleiformis	Samphire
Halosarcia species	Samphire (3 species)
Melaleuca species	
Newcastelia species	Lambs tail
Poacea species	Grass species
Ptilotus polystachyus	Prince of Wales feather
Santalum acuminatum	Quandong
	Variety of rushes and sedges (3 species)
	Variety of annual herbs

No regeneration of overstorey species was noted.

Weed species	
Scientific name	**Common name**
Hordeum leporinum	Barley grass

Other plant lists for the general area
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

Vegetation condition		
Condition	**Description**	**% of site**
Pristine	No obvious signs of disturbance.	
Excellent	Vegetation structure intact; disturbance affecting individual species and weeds are non-aggressive species.	
Very good	Vegetation structure altered; obvious signs of disturbance.	
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate.	5
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition would require intensive management.	
Completely degraded	Vegetation structure no longer intact and the area is without / almost without native species.	95

Disturbance factors contributing to vegetation condition score							
Disturbance factor	**Level of threat**				**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				Recreation			
Weed invasion			x	Point source discharge			
Stock access			x	Other			
Vehicle access			x				

Comments

The majority of the site is degraded from clearing, waterlogging and rising salinity levels. In one corner of the site, some remnant woodland remains, but over 95 per cent of the site, the original vegetation has been almost entirely replaced with samphire and saltbush species.

Stock have access to the floodplain for part of the year, to graze on saltbush during the summer/autumn feed gap.

There are very few weeds in the floodplain area.

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
Yoting North Nature Reserve	36	4 km E
Crown Reserve 18155	7	4.5 km W
Mooraning Nature Reserve	40	6 km W
Badjaling Nature Reserve	276	6 km S
Badjaling North Nature Reserve	29	5.5 km S

Aquatic vegetation

No water present.

Disturbance factors impacting on in-stream function

	Level of threat				Level of threat		
	H	M	L		H	M	L
Salinity	x			Rubbish			x
Change in hydroperiod	x			Point source discharge			
Drainage				Recreation			
Clearing	x			Other			
Sediment							

Water quality

No water quality data collected.

Management

Hommajelly Gully, a major tributary of the Salt River, has been significantly modified (refer to Photo 14). An extensive network of contour banks directs surface runoff into the gully. Water quality in the gully is mostly unsuitable for stock. Significant flows enter the Salt River from the gully every year, back flooding the Salt River when full. The gully did not flood during Deluge 2000.

The gully previously flooded over the floodplain area every winter, and the main channel frequently shifted alignment, making the area difficult to manage. Approximately 10 years ago the channel was deepened and widened from the Salt River confluence back approximately 2 km.

Fauna	
Scientific name	**Common name**
Anas superciliosa	Pacific black duck
Barnardius zonarius race *zonarius*	Australian ringneck (twenty-eight parrot)
Corvus coronoides	Australian raven
Elseyornis melanops	Black-fronted dotterel
Eolophus roseicapilla	Galah
Grallina cyanoleuca	Australian magpie-lark
Manorina flavigula	Yellow-throated miner
Tadorna tadornoidies	Australian shelduck
Mammals	
Macropus rufus	Red kangaroo
Oryctolagus cuniculus	European wild rabbit*
Vulpes vulpes	European red fox*

** Introduced species*

Other fauna lists for the general area
Lefroy et al. (1991)
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

Groundwater pumping feeds water into this reach of the Salt River for most of the year

Site SR05 – Kevill's Lake

General details	
Site name	Kevill's Lake (private property, leased by the Quairading Ski Club)
Surveyed by	Kate Gole and Shenaye Mehmet
Survey date	31.08.2006

Site description	
Landform	This site is within the Salt River floodplain and is characterised by a series of permanently inundated playa lakes bordered by lunettes.
Site size	Approximately 278 ha.

Vegetation description

Beard vegetation association 951: Succulent steppe with sparse woodland and thicket – York gum and Kondinin blackbutt over tea-tree thicket and samphire

Beard vegetation association 1023: Medium woodland – York gum, wandoo and salmon gum

Vegetation structure and cover

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	*Eucalyptus* species
Mallees	2–10%	*Eucalyptus* species
Shrubs	2–10%	Mixed species
Grasses	2–10%	Mixed native and annual species
Herbs	20–30%	*Halosarcia* species and *Atriplex* species
Rushes and sedges	2–10%	Mixed species
Litter	–	
Bare rock	–	

Summary

The vegetation is characterised by a diverse range of samphire (*Halosarcia* species), saltbush (*Atriplex* species) and bluebush (*Maireana* species) on the shores of the salt lakes, grading into shrubland, dominated by *Melaleuca*, *Leptospermum* and *Acacia* species, and *Eucalyptus* woodland.

Native species

Scientific name	Common name
Remnant vegetation	
*Acacia acuminata**	Jam
Acacia species	Acacia (6 species)
Acacia tratmaniana	
Amyema species	Mistletoe species
Atriplex semibaccata	Berry saltbush
Atriplex species	Saltbush (4 species)
Borya species	Pincushion
Caladenia flava	Cowslip orchid
Calytrix species	
Carpobrotus species	Pigface (2 species)
Cassytha species	Dodder species
Casuarina obesa	Swamp sheoak
Dampiera species	
Dianella revoluta	Blueberry lily
Drosera species	Sundew (2 species)

Eragrotis dielsii	Mallee lovegrass
Eucalyptus loxophelba subsp. *loxophelba*	York gum
Eucalytus species	Eucalypt (2 species)
Eremophila species	Eremophila (2 species)
Exocarpos aphyllus	Leafless ballart
Grevillea paniculata	
Grevillea hookeriana	Black toothbrush
Grimmea species	Moss species
Hakea recurva	
Hakea species	
Halosarcia lylei	
Halosarcia pergranulata subsp. *pergranulata*	Blackseed samphire
Halosarcia species	Samphire (5 species)
Hibbertia species	Hibbertia (2 species)
Leptospermum species	Leptospermum (2 species)
Lycium australe	Australian boxthorn
Maireana brevifolia	Small leaf bluebush
Maireana species	Bluebush (2 species)
Melaleuca species	Melaleuca (5 species)
*Melaleuca uncinata**	Broom bush
Newcastelia species	Lambs tail
*Pittosporum angustifolium**	Native willow
Poacea species	Grass (4 species)
Ptilotus polystachyus	Prince of Wales feather (local name bulla-mulla)
Santalum acuminatum	Quandong
Sclerolaena species	
Thysanotus species	Thysanotus (2 species)
	Lichen (3 species)
	Herb (10 species)
	Rush and sedge (4 species)
	Cowslip orchid
	Shrub (11 species)
	Aquatic species (probably *Ruppia* species)
Revegetation	
Acacia species	Acacia (2 species)
Eucalypt species	Eucalypt (2 species)
Hakea species	

* *Regeneration of overstorey species was noted.*

Weed species

Scientific name	**Common name**
Arctotheca calendula	Capeweed
Asteraceae species	Asteraceae (2 species)
Avena fatua	Wild oats
Cotula coronopifolia	Waterbuttons
Heliotropium curassavicum	Smooth heliotrope
Hypochaeris radicata	Flatweed
Tamarix aphylla	Tamarisk
Arctotheca calendula	Capeweed

Other plant lists for the general area

Weaving, S. (1997)

Weaving, S. & Grein, S. (1994)

Vegetation condition		
Condition	**Description**	**% of site**
–	Revegetation.	5
Pristine	No obvious signs of disturbance.	
Excellent	Vegetation structure intact; disturbance affecting individual species and weeds are non-aggressive species	
Very good	Vegetation structure altered; obvious signs of disturbance.	60
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate.	10
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition would require intensive management.	20
Completely degraded	Vegetation structure no longer intact and the area is without / almost without native species.	5

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

Comments

In some areas the vegetation is under pressure from increased salinity levels and changes in hydroperiod, resulting in deaths of the *Melaleuca* and *Leptospermum* shrublands.

With the exception of the samphire community immediately adjacent to the lakes, annual weeds, including wild oats (*Avena fatua*) and capeweed (*Arctotheca calendula*), have invaded the understorey. Native species still dominate the understorey, with a wide variety of small shrubs and herbs including *Dampiera*, *Drosera* and *Hibbertia* species.

The Quairading Ski Club is located on the edge of Kevill's Lake. There is some rubbish, but it is not impacting significantly on the vegetation. The water level in Kevill's Lake is regulated by a gate system that has changed the natural hydroperiod and impacted on fringing vegetation.

Links to protected areas of remnant vegetation		
Name	**Area** (ha)	**Approximate distance and direction from site**
Yoting North Nature Reserve	36	3 km E
Mooranning Nature Reserve	40	5 km NW
Crown Reserve 18155	7	6 km SW
Badjaling Nature Reserve	276	9 km S
Charles Gardner Nature Reserve	798	9 km N
Badjaling North Nature Reserve	29	10 km S
Crown Reserve 11024	22	10 km NE

Aquatic vegetation

One species of aquatic plant was found during the survey, probably a *Ruppia* species.

Disturbance factors impacting on in-stream function							
Disturbance factor	**Level of threat**			**Disturbance factor**	**Level of threat**		
	H	**M**	**L**		**H**	**M**	**L**
Salinity	x			Rubbish			
Change in hydroperiod	x			Point source discharge			
Drainage				Recreation		x	
Clearing				Other			
Sediment							

Water quality

No water quality data collected.

Management

An area of the site has been revegetated with a variety of species, including *Eucalyptus*, *Acacia* and *Hakea* species.

Weeds, including wild oats (*Avena fatua*) and capeweed (*Arctotheca calendula*), have invaded the understorey; however, the majority of the understorey species are native. Spot weed control would be beneficial in some areas, such as along the access tracks and in the revegetated area, to prevent the further spread of weed species.

Two gates and a pump control water levels and movement between Kevill's Lake and the adjacent lake, which receives the majority of the flow from upstream. It is likely that the change in the hydroperiod in Kevill's Lake has impacted on vegetation.

Fauna	
Scientific name	**Common name**
Birds	
Corvus coronoides	Australian raven
Anas gracilis	Grey teal
Anas superciliosa	Pacific black duck
Anthochaera carunculata	Red wattlebird
Barnardius zonarius race *zonarius*	Australian ringneck (twenty-eight parrot)
Cracticus torqutus	Grey butcherbird
Eoloptus roseicapillus	Galah
Falco cenchroides	Nankeen kestrel
Hirundo neoxena	Welcome swallow
Hirundo species	Martin
Malurus species	Wren
Polytelis anthopeplus	Regent parrot
Pomatostomus temporalis	White-browed babbler
Rhipidura leucophrys	Willy wagtail
Tadorna tadornoidies	Australian shelduck
Zosterops lateralis	Silvereye
	Honeyeater species
Mammals	
Macropus rufus	Red kangaroo
Oryctolagus cuniculus	European wild rabbit*
Vulpes vulpes	European red fox*

* *Introduced species*

Other fauna lists for the general area

Lefroy et al. (1991)
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

*A wide variety of samphire (*Halosarcia*), saltbush (*Atriplex*) and bluebush (*Maireana*) species fringe Kevill's Lake*

Dead Melaleuca *shrubs fringing one of the smaller playa lakes*

Site SR06 – Moulien Nature Reserve

General details	
Site name	Moulien Nature Reserve Crown (Department of Environment and Conservation) Crown Reserve No 28289
Surveyed by	Kate Gole and Chrystal King
Survey date	07.06.2006

Site description	
Landform	This site is within the Salt River floodplain and is characterised by a braided channel and seasonally inundated playa lakes.
Site size	Approximately 145 ha.
Location	Accessed through private property via Tammin South Rd.

Vegetation description
Beard vegetation association 951: Succulent steppe with sparse woodland and thicket – York gum and Kondinin blackbutt over tea-tree thicket and samphire

Vegetation structure and cover

Vegetation layer	Canopy cover class	Dominant species
Trees	–	
Mallees	2–10%	*Eucalyptus* species
Shrubs	2–10%	*Melaleuca* species
Grasses	2–10%	*Hordeum leporinum*
Herbs	30–70%	*Halosarcia* and *Atriplex* species
Rushes and sedges	–	
Litter	–	
Bare ground	20–30%	
Rock outcrop	–	

Summary

The original vegetation has almost entirely been replaced with *Halosarcia* and *Atriplex* species. There are a few small pockets of remnant *Eucalyptus* woodland and *Melaleuca* shrubland in poor condition. Significant numbers of stags are present.

Native species

Scientific name	Common name
Atriplex species	Saltbush (2 species)
Carpobrotus species	Pigface
Eucalyptus species	
Exocarpos aphyllus	Leafless ballart
Halosarcia species	Samphire (4 species)
Lycium australe	Australian boxthorn
Melaleuca species	

No regeneration of overstorey species was noted.

Weed species

Scientific name	Common name
Cucumis myriocarpus	Pie melon
Hordeum leporinum	Barley grass

Other plant lists for the general area
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

Vegetation condition

Condition	Description	% of site
Pristine	No obvious signs of disturbance.	
Excellent	Vegetation structure intact; disturbance affecting individual species and weeds are non-aggressive species.	
Very good	Vegetation structure altered; obvious signs of disturbance.	
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate.	
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition would require intensive management.	
Completely degraded	Vegetation structure no longer intact and the area is without / almost without native species.	100

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

Comments

The site is highly degraded from rising salinity and waterlogging levels. The original vegetation of *Eucalyptus* woodland over *Melaleuca* and tea tree (*Leptospermum*) species has been almost entirely replaced with *Halosarcia* and *Atriplex* species. Significant numbers of stags remain.

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
Yoting North Nature Reserve	36	4 km S
Charles Gardner Nature Reserve	798	4.5 km NW
Mt Stirling Nature Reserve	223	4.5 km E
Crown Reserve 11024	22	5 km NW
Gundaring Nature Reserve	128	6.5 km E
Moranning Nature Reserve	40	7.5 km W
Mt Caroline Nature Reserve	352	8 km NW

Aquatic vegetation
No water present.

Disturbance factors impacting on in-stream function							
Disturbance factor	**Level of threat**			**Disturbance factor**	**Level of threat**		
	H	**M**	**L**		**H**	**M**	**L**
Salinity	x			Rubbish			
Change in hydroperiod	x			Point source discharge			
Drainage				Recreation			
Clearing		x		Other			
Sediment							

Water quality
No water quality data collected.

Management
The landholder was unaware that the block was vested as a nature reserve and it is managed as part of their property. The block is fenced along the floodplain boundary and stock are entirely excluded from the floodplain but there are no boundary fences within the floodplain.

Fauna	
Scientific name	**Common name**
Macropus rufus	Red kangaroo
Oryctolagus cuniculus	European wild rabbit*

* *Introduced species*

Other fauna lists for the general area
Lefroy et al. (1991)
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

The original Melaleuca *shrublands in Moulien Nature Reserve have almost entirely been replaced with samphire (*Halosarcia *species) flats*

Site SR07 – Crown Reserve 11024

General details	
Site name	Nature Reserve (Department of Environment and Conservation) Crown Reserve 11024
Surveyed by	Kate Gole and Chrystal King
Survey date	06.06.2006

Site description	
Landform	This site is located on a long, gentle slope adjacent to the Salt River floodplain. A small tributary flows through the northern corner of the reserve.
Site size	Approximately 22 ha.
Location	Located on the corner of the Kellerberrin–Yoting Rd and Gardiner Rd, north of the Salt River

Vegetation description
Beard vegetation association 1049: Medium woodland – wandoo, York gum, salmon gum, morrel and gimlet

Vegetation structure and cover

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	*Eucalyptus loxophleba* and *Eucalyptus salmonophloia*
Mallees	–	–
Shrubs	2–10%	*Hakea pressii* and *Acacia* species
Grasses	20–30%	Mix of native species
Herbs	2–10%	Mix of native species
Rushes and sedges	–	–
Litter	2–10%	
Rock outcrop	–	
Bare ground	20–30%	

Summary

The site is characterised by a sparse woodland of *Eucalyptus salmonophloia* and *Eucalyptus loxophleba*, with a middlestorey of *Acacia* species and *Hakea pressii* over an understorey of *Atriplex* species and herbs. A number of *Halosarcia* species, *Atriplex* species and annual grassy weeds are associated with a minor tributary that flows through the top of the reserve.

Native species

Scientific name	Common name
Acacia acuminata	Jam
Acacia species	Wattle (3 species)
Atriplex species	Saltbush
Dianella revulata	Blueberry lily
Eucalyptus loxophleba subsp. *loxophleba**	York gum
*Eucalyptus salmonophloia**	Salmon gum
Grevillea paniculata	
Hakea pressii	Needle bush
Halosarcia species	Samphire (3 species)
Maireana breviflolia	Small leaf bluebush
Poacea species	Grass (5 species)
Ptilotus polystachyus	Prince of Wales feather (local name bulla-mulla)
Santalum acuminatum	Quandong
	Variety of herbs (3 species)
	Variety of shrubs (6 species)
	Lichen (2 species)

** Regeneration of overstorey species was noted*

Weed species	
Scientific name	**Common name**
Avena fatua	Wild oats
Bromus species	Brome grass
Cucumis myriocarpus	Pie melon
Erodium botrys	Corkscrew
Hordeum leporinum	Barley grass
Lactuca serriola	Prickly lettuce
Poacea species	Grass (2 species)

Other plant lists for the general area
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

Vegetation condition		
Condition	**Description**	**% of site**
Pristine	No obvious signs of disturbance.	
Excellent	Vegetation structure intact; disturbance affecting individual species and weeds are non-aggressive species.	
Very good	Vegetation structure altered; obvious signs of disturbance.	30
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate.	70
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition would require intensive management.	
Completely degraded	Vegetation structure no longer intact and the area is without / almost without native species.	

Disturbance factors contributing to vegetation condition score

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

Comments

There has been some clearing for soil removal, possibly for use as road base. There is significant regeneration of *Eucalyptus* species in these areas. Weeds have invaded the understorey in some disturbed areas, including around the track on the eastern side of the reserve and around the tributary. There are signs of rabbits (*Oryctolagus cuniculus*), with one warren found.

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
Mt Stirling Nature Reserve	223	2 km S
Mt Caroline Nature Reserve	352	2 km E
Gundaring Nature Reserve	128	5 km S
Glenluce Nature Reserve	243	6 km E
Nangeen Hill Wildlife Sanctuary	178	7.5 km SE

Management
The reserve is fenced off from farmland on the eastern boundary and bounded on the other sides by the Kellerberrin–Yoting Rd and Gardiner Rd. Some control of grassy annual weeds would be beneficial, especially around the tributary. The tributary is incised and eroding, with a number of unconsolidated sediment slugs in the channel. The sediment source is most likely erosion from surrounding paddocks. In most places the banks are relatively stable, being vegetated with samphire, saltbush and annual weeds. The tributary would benefit from weed control and revegetation to further stabilise the banks. The culvert at the Kellerberrin–Yoting Rd is choking with sediment.

Fauna	
Scientific name	**Common name**
Birds	
Barnardius zonarius race *zonarius*	Australian ringneck (twenty-eight parrot)
Cacatua species	Corella species
Corvus coronoides	Australian raven
Cracticus nigrogularis	Pied butcherbird
Eolophus roseicapilla	Galah
Gymnorhina tibicen	Australian magpie
Manorina flavigula	Yellow-throated miner
Mammals	
Macropus rufus	Red kangaroo
Mus musculus	House mouse*
Oryctolagus cuniculus	European wild rabbit*
Vulpes vulpes	European red fox*

* *Introduced species*

Other fauna lists for the general area
Lefroy et al. (1991)
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

*Salmon gum (*Eucalyptus salmonophloia*) woodlands in good to very good condition characterise this site*

Site SR08 – Hammond's

General details	
Site name	Hammond's (private property)
Surveyed by	Kate Gole and Chrystal King
Survey date	08.06.2006

Site description	
Landform	The site is situated within the Salt River floodplain and is characterised by braided channels and seasonally inundated playa lakes, bordered by lunettes.
Site size	Approximately 509 ha.

Vegetation description
Beard vegetation association 951: Succulent steppe with sparse woodland and thicket – York gum and Kondinin blackbutt over tea-tree thicket and samphire
Beard vegetation association 1049: Medium woodland – wandoo, York gum, salmon gum, morrel and gimlet

Vegetation structure and cover

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	*Eucalyptus* species
Mallees	2–10%	*Eucalyptus* species
Shrubs	2–10%	Mixed species
Grasses	2–10%	Mixed native and weed species
Herbs	30–70%	*Halosarcia* and *Atriplex* species
Rushes and sedges	–	
Litter	2–10%	
Bare ground	20–30%	
Rock outcrop	–	

Summary

Most of the site is dominated by *Halosarcia* species and *Atriplex* species flats, which are replacing the original *Melaleuca* and *Leptospermum* species shrublands on the edges of the playa lakes. There are several areas up to approximately 0.5 m above the valley floor where *Melaleuca* shrublands and *Eucalyptus salubris* and *Eucalyptus salmonophloia* woodlands remain.

Native species

Scientific name	Common name
*Acacia acuminata**	Jam
Acacia species	
Atriplex semibaccata	Berry saltbush
Atriplex species	Saltbush (4 species)
Carpobrotus species	Pigface
Cassytha species	Dodder
Dianella revulata	Blueberry lily
Eragrotis dielsii	Mallee lovegrass
Eucalyptus loxophelba subsp. *loxophelba**	York gum
*Eucalyptus salmonophloia**	Salmon gum
Eucalyptus salubris	Gimlet
Eucalyptus species	
Exocarpos aphyllus	Leafless ballart
Grevillea paniculata	

Native species	
Scientific name	**Common name**
Hakea species	
Halosarcia species	Samphire (3 species)
Lycium australe	Australian boxthorn
*Lysiana casuarinae (*on *Exocarpus aphyllus)*	Mistletoe
Maireana brevifolia	Small leaf bluebush
Melaleuca species	Melaleuca (3 species)
Poacea species	Grass (2 species)
Ptilotus polystachyus	Prince of Wales feather (local name bulla-mulla)
Santalum acuminatum	Quandong
	Lichen (2 species)
	Moss species
	Mistletoe (1 species)
	Variety of shrub species (14 species)
	Variety of annual herbs

** Regeneration of overstorey species was noted.*

Other plant lists for the general area
Lefroy et al. (1991)
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

Vegetation condition		
Condition	**Description**	**% of site**
Pristine	No obvious signs of disturbance.	
Excellent	Vegetation structure intact; disturbance affecting individual species and weeds are non-aggressive species.	
Very good	Vegetation structure altered; obvious signs of disturbance.	
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate.	15
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition would require intensive management.	15
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			
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 majority (70 per cent) of the site is highly degraded from salinity and waterlogging, and the original vegetation has been replaced with samphire (*Halosarcia*) and saltbush (*Atriplex*) species. There are several patches of remnant vegetation in degraded to good condition, characterised by *Eucalyptus* woodland and *Melaleuca* shrubland over saltbush (*Atriplex*) species grading into samphire and saltbush flats. Stock graze the site occasionally and are not likely to be impacting significantly on the vegetation, although they may be affecting regeneration of native species. Weeds are invading sections of the site, and control at this stage would be beneficial to prevent them colonising further. Signs of rabbits were noted, it is possible they may be affecting regeneration of native species.

Links to protected areas of remnant vegetation

Name	Area (ha)	Approximate distance and direction from site
Crown Reserve 11024	22	0.25 km W
Mt Caroline Nature Reserve	352	0.5 km N
Mt Stirling Nature Reserve	223	1 km S
Gundaring Nature Reserve	128	3 km S
Nangeen Hills Wildlife Sanctuary	178	3.5 km SE

Aquatic vegetation

No water present.

Disturbance factors impacting on in-stream function

Disturbance factor	Level of threat			Disturbance factor	Level of threat		
	H	M	L		H	M	L
Salinity	x			Rubbish			
Change in hydroperiod	x			Point source discharge			
Drainage				Recreation			
Clearing		x		Other			
Sediment							

Water quality

No water quality data collected.

Management

The boundary fences are in poor to moderate condition. Several areas of remnant vegetation, in particular the gimlet woodlands bordering Glenluce Rd, are in good condition and would benefit from fencing and protection from stock grazing. It is possible that ponding from the Kellerberrin–Yoting Rd crossing impacts on vegetation upstream. The Glenluce Rd crossing does not appear to be impacting on vegetation downstream.

Fauna	
Scientific name	**Common name**
Birds	
Barnardius zonarius race *zonarius*	Australian ringneck (twenty-eight parrot)
Columba livia	Rock dove*
Corvus coronoides	Australian raven
Cracticus nigrogularis	Pied butcherbird
Elanus notatus	Black-shouldered kite
Eolophus roseicapilla	Galah
Falco berigora	Brown falcon
Gymnorhina tibicen	Australian magpie
Hirundo species	Martin
Malurus species	Wren
Ocyphaps lophotes	Crested pigeon
	Honeyeater
Mammals	
Macropus rufus	Red kangaroo
Oryctolagus cuniculus	European wild rabbit*

* *Introduced species*

Other fauna lists for the general area
Lefroy et al. (1991)
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

*Gimlet (*Eucalyptus salubris*) woodland in good condition*

*Samphire (*Halosarcia*) flats where* Melaleuca *shrublands used to occur*

Site SR09 – Mt Caroline Nature Reserve

General details	
Site name	Mt Caroline Nature Reserve (Department of Environment and Conservation) Crown Reserve 11047
Surveyed by	Kate Gole and Chrystal King
Survey date	06.06.2006

Site description	
Landform	This site is dominated by granite outcrop and rocky hillslopes.
Site size	Approximately 352 ha.
Location	Located north of Gardiner Rd and east of the Kellerberin–Yoting Rd. Together with Mt Stirling to the south, forms the Caroline Gap, where the Yilgarn and Lockhart rivers converge.

Vegetation description

Beard vegetation association 1041: Low woodland – *Allocasuarina huegeliana* and jam

Beard vegetation association 1049: Medium woodland – wandoo, York gum, salmon gum, morrel and gimlet

Vegetation structure and cover

Vegetation layer	Canopy cover class	Dominant species
Trees	2–10%	*Eucalyptus loxophleba* and *Eucalyptus salmonophloia*
Mallees	–	–
Shrubs	20–30%	Mixed species
Grasses	2–10%	Mix of native and weed species
Herbs	2–10%	Annual herbs
Rushes and sedges	2–10%	Mixed species
Litter	2–10%	
Rock outcrop	30–70%	
Bare ground	2–10%	

Summary

The majority of the site is dominated by expanses of granite surrounded by sparse *Eucalyptus* woodland. *Eucalyptus loxophleba* and *Eucalyptus salmonophloia* are the dominant overstorey species, with a middle storey of mixed shrubs including *Acacia* and *Allocasurina* species and an understorey of rushes and sedges and a variety of native herb species. Weeds, including *Avena fatua*, are invading the understorey.

Native species

Scientific name	Common name
*Acacia acuminata**	Jam
Acacia species*	Wattle (2 species)
*Allocasuarina huegeliana**	Rock sheoak
Allocasuarina species*	Sheoak
Amyema miraculosa (growing on *Santalum acuminatum)*	Mistletoe
Borya species	Pincushions
Callistemon phoeniceus	Lesser bottlebrush
Cassytha species	Dodder species
Cheilanthes species	Rock fern

Native species	
Scientific name	**Common name**
Dianella revulata	Blueberry lily
Drosera species	Sundew
Eucalyptus loxophleba subsp. *loxophleba*	York gum
Eucalyptus salmonophloia	Salmon gum
Eucalyptus caesia subsp. *caesia*	Silver princess
Grevillea species	
Grimmea species	Moss species
Grevillea paniculata	
Melaleuca species*	
Poacea species	Grass species
Ptilotus polystachyus	Prince of Wales feather
Santalum acuminatum	Quandong
Solanum species	
	Lichen (2 species)
	Rush or sedge (1 species)
	Variety of shrubs (6 species)
	Variety of unidentified annual herbs

** Regeneration of overstorey species was noted.*

Weed species	
Scientific name	**Common name**
Arctotheca calendula	Capeweed
Asteraceae species	Daisy species
Avena fatua	Wild oats
Citrullus lanatus	Paddy melon
Cucumis myriocarpus	Pie melon
Hypochaeris species	Flatweed
Riza maxima	Blowfly grass
Solanum species	Nightshade

Other plant lists for the general area
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

Vegetation condition		
Condition	**Description**	**% of site**
Pristine	No obvious signs of disturbance.	
Excellent	Vegetation structure intact; disturbance affecting individual species and weeds are non-aggressive species.	
Very good	Vegetation structure altered; obvious signs of disturbance.	80
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate.	20
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition would require intensive management.	
Completely degraded	Vegetation structure no longer intact and the area is without / almost without native species.	

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

Comments

There has been some clearing up to 10 m from the fence line. Some of this area is regenerating naturally and a firebreak (1–2 vehicle widths wide) is well maintained. The fire risk is high, with annual grassy weeds such as wild oats (*Avena fatua*) in the understorey and a large load of woody debris on the ground. Grassy annual weeds have invaded the whole site, but are being kept under control through grazing from rabbits (*Oryctolagus cuniculus*), kangaroos (*Macropus rufus*) and black-flanked rock-wallabies (*Petrogale lateralis*); they are more prevalent in the disturbed area around the perimeter of the site. There is vehicle access through private property and on the firebreak. There is some rubbish, but this is not a significant management problem. Grazing from rabbits, kangaroos and wallabies may be impacting on regeneration of some species. There are signs of grazing on rush, sedge, grass and herb species.

Links to protected areas of remnant vegetation		
Name	**Area** (ha)	**Approximate distance and direction from site**
Crown Reserve 11024	22	2 km W
Glenluce Nature Reserve	243	2 km E
Mt Stirling Nature Reserve	223	3 km S
Nangeen Hill Wildlife Sanctuary	178	5 km SE
Gundaring Nature Reserve	128	5.5 km S

Management

The reserve is fox-baited every month to protect the black-flanked rock-wallaby (*Petrogale lateralis*), which is listed under the *Wildlife Protection Act 1950* (WA) and the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).

The whole reserve is fenced. On the southern boundary there is a very good netting fence to 2 m. Plain wire and rabbit netting fences in poor to moderate condition bound the other sides. Fence condition is not a significant issue, provided surrounding paddocks are not grazed. Currently, there are no signs of stock access in the reserve.

A well-maintained firebreak of 1–2 vehicle widths has been put in around the perimeter of the reserve. Grazing by rabbits, kangaroos and black-flanked rock-wallabies is reducing fire risk from annual weeds.

Vegetation is regenerating naturally in disturbed areas adjacent to the firebreak. Spot weed control along firebreaks would be beneficial to prevent weeds spreading into bushland.

Fauna	
Scientific name	**Common name**
Birds	
Acanthiza chrysorrhoa	Yellow-rumped thornbill
Barnardius zonarius race *zonarius*	Australian ringneck (twenty-eight parrot)
Corvus coronoides	Australian raven
Cracticus torqutus	Grey butcherbird
Gerygone fusca	Western gerygone
Ocyphaps lophotes	Crested pigeon
Petroica goodenovii	Red-capped robin
Psephotus haematonotus	Mulga parrot
Rhipidura fuliginosa	Grey fantail
Rhipidura leucophrys	Willy wagtail
	Honeyeater species
Mammals	
Macropus rufus	Red kangaroo
Oryctolagus cuniculus	European wild rabbit*
Petrogale lateralis	Black-flanked rock-wallaby
Reptiles	
	Dragon species

* *Introduced species*

Other fauna lists for the general area
Lefroy et al. (1991)
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

Melaleuca *and* Allocasuarina *shrubland growing in soil pockets on the Mt Caroline summit*

*Habitat for the black-flanked rock-wallaby (*Petrogale lateralis*)*

Site SR10 – Mt Stirling Wildlife Sanctuary

General details	
Site name	Mt Stirling Wildlife Sanctuary (Department of Environment and Conservation) Crown Reserve 11048
Surveyed by	Kate Gole and Prue Dufty
Survey date	15.05.2006

Site description	
Landform	This site is dominated by granite outcrops and rocky hillslopes.
Site size	Approximately 223 ha.
Location	Bounded by the Kellerberrin–Yoting Rd to the west, Glenluce Rd to the east and the Salt River floodplain to the north. Together with Mt Caroline to the north, forms the Caroline Gap, where the Yilgarn and Lockhart rivers converge.

Vegetation description

Beard vegetation association 954: Shrublands – thicket, jam and *Allocasuarina huegeliana*

Beard vegetation association 1023: Medium woodland – York gum, wandoo and salmon gum

Vegetation structure and cover

Vegetation layer	Canopy cover class	Dominant species
Trees	20–30%	*Eucalyptus loxophleba*
Mallees	–	–
Shrubs	2–10%	*Acacia acuminata*, *Acacia microbotrya*, *Grevillea* species
Grasses	30–70%	Annual grassy weeds including *Avena fatua*
Herbs	2–10%	Variety of native species
Rushes and sedges	2–10%	*Lepidosperma* species
Litter	2–10%	
Rock outcrop	70–100%	
Bare ground	2–10%	

Summary

The majority of the site is dominated by expanses of granite. Pockets of soil on the granite outcrops support small patches of sparse *Acacia acuminata* and *Grevillea* species shrubland. In damper areas, the understorey consists of a patchwork of moss, annual herbs, rush and sedge species. An open woodland of *Eucalyptus loxophleba*, *Acacia acuminata* and *Acacia microbotrya* surrounds the base of the outcrop with an understorey of annual grassy weeds, including *Avena fatua*.

Native species

Scientific name	Common name
*Acacia acuminata**	Jam
Acacia microbotrya	Manna wattle
Borya species	Pincushions
Callistemon species	Bottlebrush
Cassytha species	Dodder
Cheilanthes species	Rock fern
Eucalyptus loxophleba subsp. *loxophleba*	York gum
Grevillea species	
Grimmea species	Moss
Melaleuca species	

Native species	
Scientific name	**Common name**
Pterostylis species	Orchid
Ptilotus polystachyus	Prince of Wales feather
	Rush or sedge (1 species)

** Regeneration of overstorey species was noted*

Weed species	
Scientific name	**Common name**
Avena fatua	Wild oats
Citrullus lanatus	Paddy melon
Erodium botrys	Corkscrews
Fumaria capreolata	White fumitory
Hypochaeris species	Flatweed
Riza maxima	Blowfly grass
Rumex species	Dock
Schinus tererinthifolia	Pepper tree
Solanum species	Nightshade

Other plant lists for the general area
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

Vegetation condition		
Condition	**Description**	**% of site**
Pristine	No obvious signs of disturbance.	
Excellent	Vegetation structure intact; disturbance affecting individual species and weeds are non-aggressive species.	
Very good	Vegetation structure altered; obvious signs of disturbance.	80
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate.	20
Degraded	Basic vegetation structure severely impacted by disturbance. Regeneration to good condition would require intensive management.	
Completely degraded	Vegetation structure no longer intact and the area is without / almost without native species.	

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

Comments
The understorey of the York gum (*Eucalyptus loxophleba*) and Jam (*Acacia acuminata*) woodland at the base of the outcrops has been almost entirely replaced with grassy annual weeds such as wild oats (*Avena fatula*). Very little regeneration of shrub and *Eucalyptus* species was noted. Consequently the fire risk is moderate. There is vehicle access at two points, from the Kellerberrin–Yoting Rd and Glenluce Rd. Some rubbish has accumulated around the old church. Rabbit (*Oryctolagus cuniculus*) scats were noted.

Links to protected areas of remnant vegetation		
Name	**Area** (ha)	**Approximate distance and direction from site**
Gundaring Nature Reserve	128	1.5 km S
Crown Reserve 11024	22	2 km N
Mt Caroline Nature Reserve	352	3 km N
Nangeen Hill Wildlife Sanctuary	178	4.5 km E
Glenluce Nature Reserve	243	4.5 km NE
Yoting North Nature Reserve	36	6 km SW
Charles Gardner Nature Reserve	798	9 km SW

Management
The reserve is fenced on two sides, separating it from surrounding farmland. The fencing is in moderate to good condition and is stockproof. Weed control would be beneficial, reducing fire risk and assisting native species to re-establish in the understorey. Control of the rabbit population would also benefit the regeneration of native plant species.

Fauna	
Scientific name	**Common name**
Birds	
Barnardius zonarius race *zonarius*	Australian ringneck (twenty-eight parrot)
Corvus coronoides	Australian raven
Gymnorhina tibicen	Australian magpie
Lichenostomus virescens	Singing honeyeater
Pachycephala rufiventris	Rufous whistler
Petroica goodenovii	Red-capped robin
Pomatostomus temporalis	White-browed babbler
Rhipidura leucophrys	Willy wagtail
Mammals	
Macropus rufus	Red kangaroo
Oryctolagus cuniculus	European wild rabbit*

* *Introduced species*

Other fauna lists for the general area
Lefroy et al. (1991)
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

Mt Stirling from the air

The Caroline Gap, where the Lockhart and Yilgarn rivers converge, from Mt Stirling (photo taken by Prue Dufty, Department of Water Northam)

Appendix 4: Flora and fauna lists for the Salt River study area

Native plant species found during the survey*

Scientific name	Common name
Acacia acuminata	Jam
Acacia microbotrya	Manna wattle
Acacia species	Acacia (12 species)
Acacia tratmaniana	
Actinostrobus arenarius	Sandplain cypress
Allocasuarina campestris	Tamma
Allocasuarina huegeliana	Rock sheoak
Allocasuarina species	Sheoak (2 species)
Amyema species	Mistletoe (2 species)
Amyema species (growing on *Santalum acuminatum*)	Mistletoe species
Atriplex hymenotheca	Saltbush species
Atriplex semibaccata	Berry saltbush
Atriplex species	Saltbush (6 species)
Banksia cuneata	Quairading banksia
Banksia prionotes	Acorn banksia
Borya species	Pincushion
Caladenia flava	Cowslip orchid
Callistemon phoeniceus	Lesser bottlebrush
Carpobrotus species	Pigface (2 species)
Cassytha species	Dodder species
Casuarina obesa	Swamp sheoak
Casuarina species	
Cheilanthes species	Rock fern
Chloris truncata	Windmill grass
Cyperus gymnacaulos	Spiny flat sedge
Dampiera species	
Dianella revoluta	Blueberry lily
Drosera species	Sundew (2 species)
Eragrotis dielsii	Mallee lovegrass
Eremophila species	Eremophila (3 species)
Eucalyptus	Eucalypt (3 species)
Eucalyptus caesia subsp. *caesia*	Silver princess
Eucalyptus loxophelba subsp. loxophelba	York gum
Eucalyptus salmonophloia	Salmon gum
Eucalytpus salubris	Gimlet
Exocarpos aphyllus	Leafless ballart
Garnia trifida	Coast saw sedge
Grevillea eriostachya	Flame grevillea
Grevillea paniculata	

Scientific name	Common name
Grevillea hookeriana	Black toothbrush
Grevillea species	
Grimmea species	Moss species
Hakea pressii	Needle bush
Hakea recurva	
Hakea species	Hakea (3 species)
Halosarcia doleiformis	Samphire species
Halosarcia lylei	Samphire species
Halosarcia pergranulata	Black-seeded samphire
Halosarcia species	Samphire (9 species)
Hibbertia species	Hibbertia species (2 species)
Lycium australe	Australian boxthorn
Maireana brevifolia	Small leaf bluebush
Maireana species	Bluebush (3 species)
Melaleuca halmoaturorum	
Melaleuca species	Melaleuca (4 species)
Melaleuca uncinata	Broom bush
Newcastelia species	Lambs tail
Pittosporum angustifolium	Native willow
Poacea species	Grass (5 species)
Pterostylis species	Orchid species
Ptilotus polystachyus	Prince of Wales feather (local name bulla-mulla)
Santalum acuminatum	Quandong
Sclerolaena species	
Solanum species	
Typha domingensis	Native bulrush
Xylomelum angustifolium	Sandplain woody pear
	Lichen (3 species)
	Variety of annual herbs (up to 15 species)
	Variety of rushes and sedges (up to 6 species)
	Variety of shrubs (up to 30 species)

** Plant list is not complete. There are likely to be species within each site that were not identified during the survey.*

Introduced plant species found during the survey*

Scientific name	Common name
Arctotheca calendula	Capeweed
Asteraceae species	Asteraceae (4 species)
Avena fatua	Wild oats
Bromus species	Brome grass
Chenopodium species	Fat hen or goosefoot
Citrullus lanatus	Paddy melon
Conzya bonariensis	Fleabane
Cotula coronopifolia	Waterbuttons
Cucumis myriocarpus	Pie melon
Dittrichia graveolens	Stinkwort

Scientific name	Common name
Erodium botrys	Corkscrew
Fumaria capreolata	White fumitory
Geraniaceae species	Geranium
Heliotropium curassavicum	Smooth heliotrope
Hordeum leporinum	Barley grass
Hypochaeris radicata	Flatweed
Juncus acutus	Spiny rush
Lactuca serriola	Prickly lettuce
Lupinus cosentinii	Blue lupin
Oxalis pes-caprae	Soursob
Poaceae species	Grass (up to 4 species)
Puccinellia ciliata	Puccinellia
Riza maxima	Blowfly grass
Rumex species	Dock
Schinus tererinthifolia	Pepper tree
Solanum species	Nightshade
Tamarix aphylla	Tamarisk

** Plant list is not complete. There are likely to be species within each site that were not identified during the survey.*

Other plant lists for the general area
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

Native and introduced fauna species found during the survey*

Scientific name	Common name	Conservation status	Habitat type**
Birds			
Acanthiza chrysorrhoa	Yellow-rumped thornbill	Remnant-dependant	Woodland
Anas gracilis	Grey teal	Farmland	Farmland
Anas superciliosa	Pacific black duck		
Anthus australis	Richard’s pipit	Farmland	Farmland
Anthochaera carunculata	Red wattlebird	Remnant-dependant	Woodland
Aquila audax	Wedge-tailed eagle		Bird of prey
Artamus cyanopterus	Dusky woodswallow		
Barnardius zonarius race *zonarius*	Australian ringneck	Farmland	Woodland
Cacatua species	Corella species	Farmland	Farmland
Columba livia	Rock dove*	Introduced species	
Corvus coronoides	Australian raven	Farmland	Farmland
Cracticus nigrogularis	Pied butcherbird	Farmland	Woodland
Cracticus torqutus	Grey butcherbird	Remnant-dependant	Woodland
Egretta (Ardea) novaehollandiae	White-faced heron	Farmland	Farmland
Elanus notatus	Black-shouldered kite		Bird of prey
Elseyornis melanops	Black-fronted dotterel		
Eoloptus roseicapillus	Galah	Farmland	Woodland
Falco cenchroides	Nankeen kestrel		Bird of prey
Falco longipennis	Australian hobby		Bird of prey

Scientific name	Common name	Conservation status	Habitat type**
Birds			
Gerygone fusca	Western gerygone	Remnant-dependant	Woodland
Grallina cyanoleuca	Australian magpie-lark	Farmland	Woodland
Gymnorhina tibicen	Australian magpie	Farmland	Woodland
Himantopus himantopus	Black-winged stilt		
Hirundo neoxena	Welcome swallow	Farmland	Farmland
Hirundo species	Martin	Farmland	Farmland
Lichenostomus virescens	Singing honeyeater	Remnant-dependant	Shrubland
Malurus species	Wren		
Manorina flavigula	Yellow-throated miner	Farmland	Woodland
Ocyphaps lophotes	Crested pigeon	Farmland	Farmland
Pachycephala rufiventris	Rufous whistler	Priority	Woodland
Petroica goodenovii	Red-capped robin	Priority	Woodland
Polytelis anthopeplus	Regent parrot		
Pomatostomus temporalis	White-browed babbler	Remnant-dependant	Shrubland
Psephotus haematonotus	Mulga parrot	Farmland	Farmland
Rhipidura fuliginosa	Grey fantail	Remnant-dependant	Woodland
Rhipidura leucophrys	Willy wagtail	Farmland	Woodland
Smicronis brevirostris race occidentalis	Weebill	Remnant-dependant	Woodland
Tadorna tadornoidies	Australian shelduck	Farmland	Farmland
Zosterops lateralis	Silvereye		
	Honeyeater (2 species)		
Mammals			
Macropus rufus	Red kangaroo		
Mus musculus	House mouse*	Introduced species	
Oryctolagus cuniculus	European wild rabbit*	Introduced species	
Petrogale lateralis	Black-flanked rock-wallaby	Vulnerable***	
Tachyglossus aculeatus	Short-beaked echidna		
Vulpes vulpes	European red fox*	Introduced species	
Reptiles			
	Dragon species		

* *Plant list is not complete. There are likely to be species within each site that were not identified during the survey*

** *Greening Australia Western Australia (2004)*

*** Wildlife Conservation Act 1950 *(WA) and* Environment Protection and Biodiversity Conservation Act 1999 *(Cwlth)*

Other fauna lists for the general area
Lefroy et al. (1991)
Weaving, S. (1997)
Weaving, S. & Grein, S. (1994)

Appendix 5: Examples of suitable species for saltland pasture

Species suitable for saltland pasture (Sourced from: Oversby 2004; Phelan 2004; Butler 2001; Barrett-Lennard & Malcolm 1995; Mitchell & Wilcox 1994; Runciman & Malcolm 1989)

Species name	Occurrence and use
Saltbush species	
Berry (creeping) saltbush (*Atriplex semibaccata*)	Grows on fine-textured non-saline to moderately saline soils near salt lakes and in woodlands. Slightly salt-tolerant and very drought tolerant. Is introduced easily by direct seeding or tubestock. Seeds can be readily harvested from January to March. It is short-lived but regenerates easily. Must be managed carefully, as it is palatable to sheep and prone to being eaten out. Local native species.
Swamp (river) saltbush (*Atriplex amnicola*)	Grows on a variety of soil types that are irregularly inundated and waterlogged. Very salt-tolerant, moderately waterlogging (once mature) and moderately drought tolerant. Plants can be grown from tubestock, cuttings or direct seeded. Seed can be collected from December to February. Good forage for sheep (up to 10 per cent crude protein); recovers well from grazing. Local native species.
Wavy leaf saltbush (*Atriplex undulata*)	Grows on saline soils and is tolerant of waterlogging, but less so than swamp saltbush. Can be established through direct seeding and it self seeds. Palatable to stock and recovers well from grazing. Not native to Western Australia.
Old man saltbush (*Atriplex nummularia*)	Grows on alkaline moderately saline soils but is sensitive to waterlogging. Is not as palatable as other *Atriplex* species. Is long-lived and recovers from grazing but is brittle and easily damaged from trampling. Can be direct seeded or grown from tubestock but does not readily self seed. Seed can be collected from September to October. Native species of semi-arid and arid southern and central Australia.
Grey saltbush (*Atriplex cinerea*)	Grows on saline seepages and is moderately tolerant of waterlogging. Grows best from cuttings but can be direct seeded. Palatability varies with ecotype. Native species of coastal areas in southern Australia.
Samphire species	
Various species	Grow on a variety of highly saline soils. Very tolerant of salt and waterlogging. Can be grown from tubestock and cuttings or direct seeded and then allowed to spread naturally. Can survive moderate grazing but have high salt content so must be grazed in conjunction with crop stubbles or other feed sources. Sheep must also have access to fresh water.
Bluebush species	
Small leaf bluebush (*Maireana brevifolia*)	Grows on a wide variety of soil types on the drier end of the floodway and floodfringe. It is very tolerant of drought, salt-tolerant but only slightly tolerant of waterlogging. Plants can be grown from tubestock, direct seeded or self seeded. At up to 16 per cent crude protein, it is more palatable to sheep than *Atriplex* species and recovers well from grazing. Local native species.
Grass species	
Variety of native species	There are a number of summer-active native grass species considered suitable for pastures. They vary in palatability, nutrition and tolerance to saline conditions, waterlogging and grazing. Contact the Department of Agriculture and Food for more information.

Appendix 6: Examples of local native species suitable for revegetation

Local native species suitable for revegetating floodplain areas in the Salt River catchment (sourced from Oversby 2004; Mitchell & Wilcox 1994; Lefroy et al. 1991)

Species name	Revegetation tips
Understorey	
Berry (creeping) saltbush (*Atriplex semibaccata*)	Grows on fine-textured non-saline to moderately saline soils near salt lakes and in woodlands. Slightly salt-tolerant and very drought tolerant. Is introduced easily by direct seeding or tubestock. Seeds can be readily harvested from January to March. It is short-lived but regenerates easily.
Swamp (river) saltbush (*Atriplex amnicola*)	Grows on a variety of soil types that are irregularly inundated and waterlogged. Very salt-tolerant, moderately waterlogging (once mature) and moderately drought tolerant. Plants can be grown from tubestock or cuttings or direct seeded. Seed can be collected from December to February.
Small leaf bluebush (*Maireana brevifolia*)	Grows on a wide variety of soil types associated with the drier floodways and floodfringes of saline waterways. Slightly tolerant of waterlogging and very tolerant of drought and salinity. Plants can be grown from tubestock or direct seeded, with seeds collected between December and March. Also self seeds.
Lake fringe rhagodia (*Rhagodia drummondii*)	Grows on a variety of soil types, especially sandy soils, associated with salt lakes and saline waterways. Slightly tolerant of waterlogging and very tolerant of drought and salinity. Plants can be grown from tubestock or by direct seeding.
Spiny flat sedge (*Cyperus gymnocaulos*)	Grows on a variety of soil types associated with fresh to saline waterways, including floodways, seeps and lake edges, especially in disturbed areas or waterways with high nutrient levels. Moderately salt-tolerant but does not tolerate inundation for very long. Can be propagated by transplanting stems or by direct seeding with seed collected from January to February, however the most effective technique is to transplant the plantlets into damp soil.
Coast saw sedge (*Gahnia trifida*)	Grows on a variety of soils types associated with fresh to saline waterways including floodways, seeps, clay pans and lake edges. Moderately waterlogging and very salt-tolerant. Can be propagated successfully from creeping stems and less successfully by direct seeding, using seed collected between January and March.
Shore rush (*Juncus acutus*)	Grows on any moist soil type associated with brackish to saline waterways including floodways, seeps, swamps and lake edges. Very tolerant of waterlogging and salinity. Can be propagated successfully from creeping stems and by direct seeding, using seed collected between December and February.
Native marine couch (*Sporobolus virginicus*)	Grows on a variety of soil types but prefers lighter soils associated with fresh to moderately saline waterways including floodways and lake edges. Very tolerant of waterlogging and moderately salt-tolerant. Easily propagated by transplanting creeping stems and also by direct seeding with seed collected from January to March.
Mallee lovegrass (*Erogrostis dielssii*)	Grows on a variety of soil types but prefers lighter soils associated with saline waterways including floodways and lake edges. Moderately tolerant of waterlogging, salinity and drought. Can be grown from tubestock or direct seeded.
Samphire species (*Halosarcia* species)	*Halosarcia* species grow on a variety of soil types associated with saline waterways, salt flats and lake edges. Very tolerant of salinity and waterlogging. Can be grown from tubestock or cuttings or direct seeded.

Middlestorey	
Grevillea paniculata	Grows on a variety of soil types, particularly sandy soils, associated with fresh floodfringes. Not tolerant of waterlogging or salinity. Can be grown from tubestock.
Needlebush (*Hakea preissii)*	Grows on many soils types, including grey clays, duplex soils and alluvial loams, associated with floodfringes, floodways and sand rises of saline waterways. Moderately salt and waterlogging tolerant. Can be grown from tubestock.
Jam (*Acacia acuminata*)	Grows on a variety of soil types, especially red loams, associated with fresh to slightly saline floodfringes and drier floodways. Slightly waterlogging and salt-tolerant and very drought tolerant. Can be grown from tubestock or direct seeded with seeds collected from November to December.
Manna wattle (*Acacia microbotrya*)	Grows on a wide range of soil types associated with fresh to slightly saline floodways and floodfringes. Slightly waterlogging and salt-tolerant. Can be grown from tubestock or direct seeded with seed collected from early October to December.
Broombush (*Melaleuca uncinata*)	Grows on a variety of soil types. Has a variable tolerance to waterlogging and salinity.
Lesser bottle brush (*Callistemon phoeniceus*)	Grows on a variety of soil types associated with fresh to saline floodways, floodfringes and winter wet depressions. Depending on the provenance, it has a high to moderate tolerance to waterlogging, salinity and drought. Plants can be grown from tubestock or direct seeded, using seed collected throughout the year.
Swamp sheoak (*Casuarina obesa*)	Suitable for a variety of floodway soils. Very salt and waterlogging tolerant. Plant tubestock or direct seed.
Overstorey	
York gum (*Eucalyptus loxophleba*)	Grows on a variety of soils associated with floodfringes and the drier ends of floodways. Does not tolerate waterlogging but some provenances are moderately salt-tolerant. Can be grown from tubestock or direct seeded, using seed collected throughout the year.
Salmon gum (*Eucalyptus salmonophloia*)	Grows on red and brown duplex soils on the lower slopes and valley floors. Moderately tolerant of salinity.
Salt river gum (*Eucalyptus sargentii)*	Grows on a variety of soil types associated with salt lakes and saline waterways. Tolerates some waterlogging and is moderately to highly tolerant of salinity, depending on the provenance. Plants can be grown from tubestock or direct seeded. Seed can collected at any time from unopened mature fruit.
Gimlet (*Eucalyptus salubris*)	Grows on red and brown duplex soils on the lower slopes and valley floors. Moderately tolerant of salinity.
Red Morrel (*Eucalyptus longicornis*)	Grows on saline fine-textured loams and clays on valley floors.
Yorrell (*Eucalyptus yilgarnensis*)	Grows on saline fine-textured loams and clays on valley floors.

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