WETLAND INVENTORY

MOUNT LOFTY RANGES

An assessment of selected wetlands
for the Mount Lofty Ranges, encompassing the four
metropolitan Catchment Water Management Boards

Environment Australia
Department of the Environment and Heritage
Department for environment and heritage
National Parks & Wildlife South Australia
Government of South Australia

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Author

Russell Seaman
Scientific Officer, Wetlands Management.
National Parks and Wildlife SA

Cartography and design

Russell Seaman

Photographs

Russell Seaman

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Patawalonga Catchment Water Management Board

Onkaparinga Catchment Water Management Board

Northern Adelaide and Barossa Catchment Water Management Board

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Executive Summary

The Wetland Inventory for the Mount Lofty Ranges documents a representative sample of inland wetlands by recording their physical, chemical and biological attributes. Eighty-five wetlands were surveyed and included brackish water bodies, freshwater wetlands, bogs and constructed wetlands.

The aquatic invertebrate fauna generally displayed good diversity and abundance in many of the wetlands surveyed. Fourteen wetlands recorded good invertebrate trophic levels and included Woorabinda Lake at Stirling, Mount George Wetlands at Bridgewater and Onkaparinga Estuary.

Fourteen wetlands surveyed are considered to be nationally important by meeting the ANZECC criteria of being a good example of a wetland type occurring within a biogeographic region in Australia. These wetlands include Englebrook Reserve at Bridgewater, and the bogs within Cleland Conservation Park. Four wetlands are recommended for monitoring; these are Parafield Wetlands, Englebrook Reserve, Washpool Lagoon and Eurilla Bog.

Figures

Plates

Tables

MAPS

SECTION ONE WETLAND INVENTORY

1.0 INTRODUCTION

The Mount Lofty Ranges contains significant watershed areas that provide metropolitan Adelaide and peri-urban areas with domestic water supplies. Apart from the domestic use of water, surface waters sustain critical aquatic ecosystems that maintain biodiversity within the Mount Lofty Ranges. These two aspects are intrinsically linked, the quality of our domestic and agricultural water supplies depends on the health of aquatic ecosystems. This Wetland Inventory documents a representative portion of wetland habitats and records their physical, chemical and biological attributes. From this information aquatic environments that contain high biodiversity are highlighted, and threats documented. The inventory provides a snap shot of the condition and conservation value of wetlands throughout the Mount Lofty Ranges. Those wetlands that meet one or more of the Australian and New Zealand Environment and Conservation Council (ANZECC) criteria for an important wetland will be nominated through Environment Australia for inclusion into the National Directory of Important Wetlands in Australia.

The Wetland Inventory for the Mount Lofty Ranges is an initiative of the South Australian Department for Environment and Heritage, Conservation Strategies Section.

Funding support for the inventory is from the following sources:

- National Action Plan for Salinity and Water Quality
- Native Vegetation Council
- Torrens Catchment Water Management Board
- Patawalonga Catchment Water Management Board
- Onkaparinga Catchment Water Management Board
- Northern Adelaide and Barossa Catchment Water Management Board

2.0 REPORT STRUCTURE

This report is divided into three sections, namely the wetland inventory, wetland assessment and wetland monitoring.

Section 1 - Wetland Inventory. Outlines the project aims and inventory methodology.

Section 2 - Wetland Assessment. Provides an analysis of the wetland inventory, which includes the identification of wetland values and threats.

Section 3 – Wetland Monitoring. Discusses frameworks for monitoring, recommends indicator species for monitoring and specific wetlands to monitor.

3.0 PROJECT SCOPE

The project scope consists of five actions, these are to:

1. To undertake baseline wetland surveys for inland surface waters in the Mount Lofty Ranges.
2. Identify wetlands of conservation significance, according to agreed ANZECC classification.
3. Provide digital coverage of spatial boundaries of identified wetlands in ARC/INFO compatible format at appropriate scale, in consultation with Planning SA.
4. Produce a report detailing the physical, biological and chemical attributes of wetlands in the Mount Lofty Ranges.
5. Nominate wetlands of significance for inclusion in the Directory of Important Wetlands in Australia.

4.0 OVERVIEW OF PAST WETLAND INVENTORY STUDIES

The most comprehensive listing of wetlands in South Australia in terms of numbers and coverage is by Lloyd and Balla (1986). This study identified approximately 1500 wetlands and complexes state-wide.

The Lloyd and Balla listing was a desktop study that collated and recorded information within a standard format, including;

- wetland type
- name
- location
- size
- catchment
- aquatic fauna
- aquatic and fringing vegetation
- wetland condition
- water regime
- landuse
- impacts
- tenure.

The Lloyd and Balla report provides a good starting point in understanding the extent and some attributes of South Australian wetlands. However, the study falls short in providing up-to-date information on invertebrate composition, water chemistry and basic landform information. The wetlands listed for the Mount Lofty Ranges are limited, listing only three swamps.

Since Lloyd and Balla’s 1986 report, several studies have mirrored this kind of information and presentation of wetland information, but have not collected other important baseline wetland information. Good information has been generated for certain areas including the Murray River corridor, Thompson’s (1986) study of River Murray Wetlands and Jensen *et al* (1996) Wetland Atlas report of the South Australian Murray Valley Wetlands. The Wetland Atlas of the South Australian Murray Valley Wetlands made inroads into spatially capturing the locations through the use of GIS. The introduction of linking wetlands with GIS enabled the creation of a wetlands GIS database for the Murray Valley Wetlands. In 1997, Carruthers and Hille also developed a GIS database for the South East wetlands. This database recorded wetland type, name, complex, watercourses and assigned a condition score and conservation value. The benefits of collecting data and linking it to GIS became evident not only for environmental planning and for information retrieval but also for reporting to Environment Australia on the extent of wetland resources.

In 1993 the Australian Nature and Conservation Agency published the first edition of ‘*A Directory of Important Wetlands in Australia*’. A second edition was complied in 1996, which included information on 68 wetlands within South Australia. Of these only one wetland (Onkaparinga Estuary) was documented for the Mount Lofty Ranges.

De Jong and Morelli (1996) commented that in compiling the Directory of Important Wetlands it became apparent that several regions within South Australia were lacking baseline wetland information. They suggested that there is a need for systematic inventories, biological surveys and research programs in many areas of the State. Wetland information in regions such as the Great Victoria Desert, Flinders and Olary Ranges, Eyre Peninsula, Yorke Peninsula, Kangaroo Island and Nullarbor are quite inadequate.

The Wetland Inventory for the Mount Lofty Ranges combines several of these key developments and recommendations, namely continuing the development of a GIS database and providing baseline information for wetlands in the Mount Lofty Ranges.

5.0 WETLAND RISK ASSESSMENT

The wetland risk assessment is a conceptual framework to assist in predicting and assessing change in the ecological character of wetlands. The framework has been adopted by Ramsar (resolution V11.10) and is now promoted as an integral component of the management planning process for wetlands. The relevance of undertaking wetland inventories becomes apparent within this framework. A wetland inventory ultimately collects information for the wetland assessment framework. This information is also critical in order to make recommendations for monitoring.

A central component of the wetland risk assessment is the ability to record the ecological character of a wetland. The ecological character is the sum of the biological, physical, and chemical components of the wetland ecosystem and their interactions that maintain wetland functions and attributes. Recording changes to the ecological character of a wetland involves the development of a monitoring program, this is further discussed in Section Three – Wetland Monitoring.

6.0 WETLAND INVENTORY METHODOLOGY

A wetland inventory essentially collects information that assists in wetland management. It can provide information for specific assessment and monitoring activities.

6.1 Study area boundaries

The project boundary is based on the Mount Lofty Ranges Natural Heritage Trust (NHT) boundary, (refer to Map 6-1). Within this boundary, the management areas of four Catchment Water Management Boards are used, these are:

- Torrens Catchment Water Management Board.
- Patawalonga Catchment Water Management Board.
- Onkaparinga Catchment Water Management Board.
- Northern Adelaide and Barossa Catchment Water Management Board.

Waterbodies within the metropolitan boundary of the Torrens and Patawalonga Catchment Water Management Boards are not included. The Mount Lofty Ranges NHT boundary stops at the junction between the Adelaide foothills and suburban Adelaide, and natural wetlands have been substantially modified or no longer exist within the central metropolitan area.

6.2 Site selection

The aim of the wetland selection process is to sample a broad range of wetlands across the Mount Lofty Ranges. Factors such as time constraints, accessibility and the project budget were limiting factors in the number of wetlands selected. Wetlands were selected initially by studying the GIS waterbody coverage for the Southern Mount Lofty Ranges. Waterbodies within State Government lands, community lands, Council managed lands, land under management agreements and Heritage Agreements were targeted for further investigation. Stakeholders such as Friends groups, the Urban Forest Biodiversity Program, Forestry SA and National Parks and Wildlife were consulted. These stakeholders also nominated many wetlands located on private property, providing access to otherwise inaccessible information.

6.3 GIS Database

This project builds on initiatives undertaken by Planning SA and the Department for Environment and Heritage. GIS databases have been developed for the Murray River region by Carruthers and Nicolson (1992) and published in the form of an Atlas, Jensen *et al* (1996). A GIS database exists for the South East region of the state and has been published in the form of a technical report by Carruthers and Hille (1997). No other regions in South Australia have a GIS wetland database at present. One of the project objectives is to provide a digital coverage of spatial boundaries of wetlands surveyed in the Mount Lofty Ranges.

A state wide numbering system was developed for identifying wetlands which follows the system established for the Murray River wetlands. The Murray River wetlands have been assigned the numbers S0001 to S0999. The South East region (numbers S1000 to S1999), Eyre Peninsula, (numbers S3000 to S3999), Northern Agricultural Districts numbers S4000 to S4999 and Kangaroo Island S5000 to S5999. The Mount Lofty Ranges are assigned numbers S2000 to S2999. The software used to produce the wetlands data is the ESRI (Environmental Systems Research Institute) geographic information system (GIS) ARC/INFO. The GIS layer was created initially from the existing land cover layer that contained areas designated as swamps, vegetated swamps, lakes and vegetated lakes. This land cover layer was mapped from 1:40 000 colour aerial photography by the Geographical Analysis and Research Unit, Planning SA, Department for Transport, Urban Planning and the Arts.

7.0 WETLAND INVENTORY SURVEY

In developing the wetland survey, it was critical that information collected could be used for an initial assessment of wetland character. This ultimately involved the collection of physical, biological and chemical parameters. In the development of the survey template several methodologies were studied and adapted, these include:

- Butcher, R.J. (1999) *Assessing biodiversity in temporary and permanent wetlands. pp.* 50-53 in The Other 99%. *The Conservation and Biodiversity of Invertebrates*, ed by Ponder, W. and Lunney, D. (1999). Transactions of the Royal Zoological Society of New South Wales.
- Finlayson, C.M. and Spiers, A.G. (1999). *Techniques for enhanced wetland inventory and monitoring.* Supervising Scientist, Canberra
- Fairweather, P.G. and Napier (1998). *Environmental indicators for national state of the environment reporting - inland waters.* Environment Australia.
- Maher, W. and Liston, P. (1997). *Water quality for maintenance of aquatic ecosystems: Appropriate indicators and analysis. Australia: State of the Environment Technical Paper Series. (Inland waters).* Environment Australia.
- Morelli, J. and de Jong, M. (1996). *A Directory of Important Wetlands in South Australia.* South Australian Department of Environment and Natural Resources, Adelaide.
- Storey, A.W., Lane, J.A.K. and Davies, P.M. (1997). *Monitoring the ecological character of Australia's wetlands of international importance (RAMSAR Convention).* Western Australian Department of Conservation and Land Management and Biodiversity Group of Environment Australia.

7.1 Wetland survey template

For each wetland surveyed, physical, biological and chemical information was collected. A brief outline is given below. The complete wetland survey descriptions are given in Appendix 1.

Physical parameters

- Wetland Reference Number
- Wetland name
- Ramsar Site
- Description of site
- Land use
- Tenure
- Land element
- Geology

Biological parameters

- Vegetation associations
- Noteworthy flora and fauna
- Biological threats
- Aquatic vegetation classes

Chemical parameters

- Dissolved oxygen
- pH
- Conductivity
- Temperature
- Turbidity

SECTION TWO WETLAND ASSESSMENT FOR THE MOUNT LOFTY RANGES

8.0 INTRODUCTION

Wetland assessment involves the identification and status of threats to wetlands as a basis for the collection of more specific information through monitoring. In essence, Section Two of this report analyses the survey results by looking at each survey parameter individually. This comprises a background discussion and analysis.

8.1 Wetland overview

The Mount Lofty Ranges receives some of the highest rainfall in South Australia making the region one of the most substantial watershed zones in the State. Extensive drainage networks exist within the Mount Lofty Ranges. Most have been modified, resulting in altered water flow regimes. The landform of the Mount Lofty Ranges generally dictates the type of wetlands found. There are two broad categories of wetlands.

1. Wetlands found within the higher slopes of the Mount Lofty Ranges. These wetlands are typically in woodlands and comprise of bogs and swamps. The vegetation associations can be unique within the bio-region and usually contain species of high conservation significance.

2. Seasonal and permanent ponds located within the higher slopes, foothills and plains. Many of these waterbodies consist of dams that are no longer used, and now have biodiversity value.

Wetlands with high biodiversity values are mainly located within the central Mount Lofty Ranges. These wetlands are mostly in National Parks and Wildlife SA reserves, Heritage Agreements, council managed lands or under private conservation (land that is being conserved by the landowner).

The following series of maps (Maps 8-1, 8-2, 8-3, 8-4) show the location of wetlands in each Catchment Water Management Board.

9.0 WETLAND LAND USE

9.1 Background

Land use in and around wetland areas usually dictates the level of protection and the condition of the wetland. This wetland survey is biased toward lands that have a land use favouring conservation, because these lands tend to contain the remaining wetlands in the Mount Lofty Ranges. Surrounding land uses are a major contributor to the processes that threaten wetlands. Residential areas often surround land containing wetlands; threats such as invasive weeds, sediment, nutrient run - off and altered water flows through drainage are very common.

9.2 Analysis

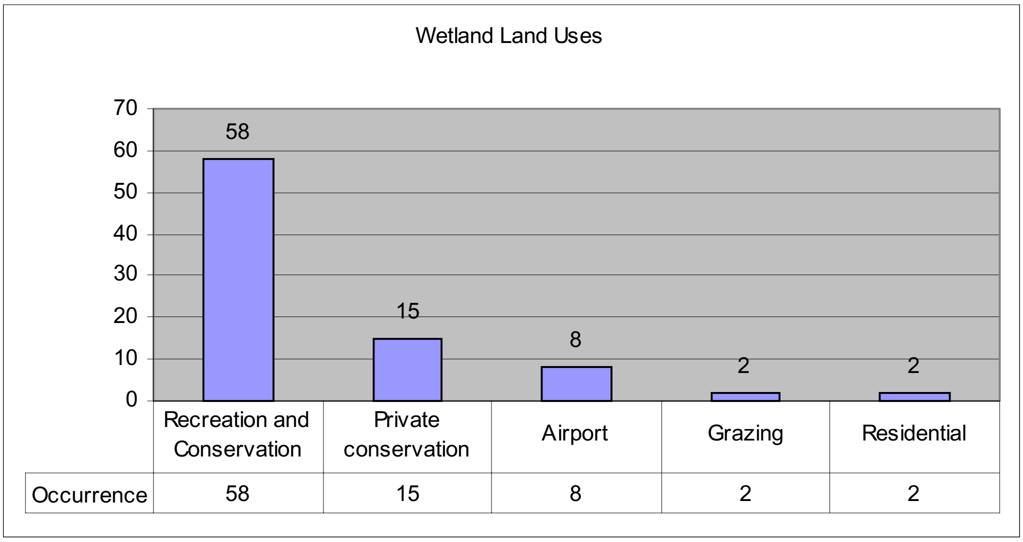


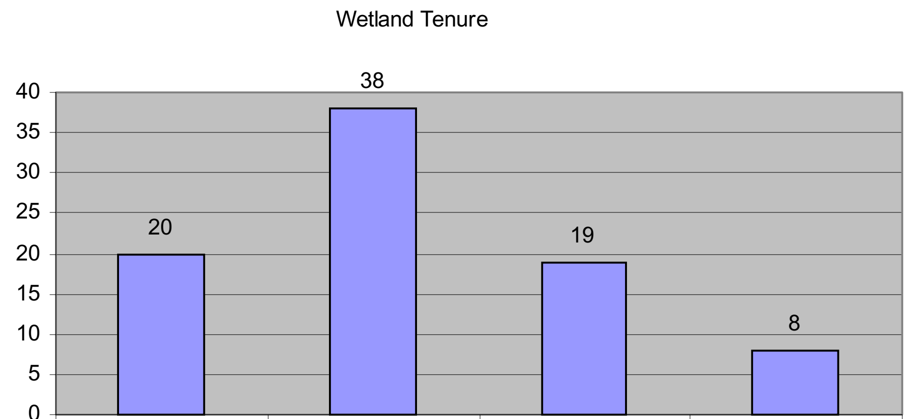
Figure 9-1. On site wetland land uses

An assessment of wetland land use revealed the importance of recreation and conservation reserves as 58 sites recorded with this land use. Wetland conservation on private lands was also high with many sites under conservation land management (Heritage Agreements, land management assistance programs). The eight wetlands located within Parafield Airport are located within the buffer south of the airport. Two water bodies were located on properties with the main land use of grazing and a further two wetlands recorded a residential land use.

10.0 TENURE AND MANAGEMENT AUTHORITY

10.1 Background

The type of management authority and tenure surrounding a wetland often dictates the type and level of protection and management for the wetland. An understanding of this also allows consideration of different legislation and approaches concerning on-site management and management planning for wetland sites.



	Local government	State government	Private	Federal government
Occurrence	20	38	19	8

Figure 10-1. Tenure and management

10.2 Analysis

Thirty-eight wetlands are located within State managed lands. The management agencies comprise the Department for Environment and Heritage (DEH), Forestry SA and SA Water. The National Trust of South Australia and DEH tended to be the most favourable land management agencies for wetland conservation because they managed land with high biodiversity value. Foresty SA lands (except the native forest reserves) tend to be highly modified often with land uses not compatible with wetland conservation. SA Water lands contain large areas of open water and excellent areas of remnant vegetation. The management of these waterbodies is not primarily for wetland conservation. Some drainage lines feeding into the reservoirs contain significant biodiversity values (eg The Barossa Reservoir Reedbeds) but this inventory has not targeted these drainage lines, primarily due to the lack of access to the sites.

Twenty sites were recorded on local government managed reserves. These reserves were primarily managed for recreation and conservation purposes. Nineteen sites were recorded on private lands with 15 of them under land management assistance programs, such as the South Para Biodiversity Project. Eight wetland sites are located on Federal government land managed by the Department for Transport and Regional Services (Parafield Wetlands).

11.0 ENVIRONMENTAL ASSOCIATIONS AND IBRA REGIONS

11.1 Background

The Interim Biogeographic Regionalisation for Australia (IBRA) is a framework for conservation planning and sustainable resource management within a bioregional context. IBRA regions represent a landscape based approach to classifying the land surface from a range of continental data on environmental attributes. In 1999-2000, IBRA version 5.0 was developed. Eighty-five bioregions have been delineated, each reflecting a unifying set of major environmental influences that shape the occurrence of flora and fauna and their interaction with the physical environment. (See: http://www.ea.gov.au/parks/nrs/ibraimcr/ibra_95/index.html)

The Wetland Inventory for the Mount Lofty Ranges is located within the Flinders Lofty Bioregion. The Flinders Lofty Block is described as temperate, with well-defined uplands of Cambrian and late Proterozoic marine sediments. The dominant vegetation type is open eucalypt forests and woodlands and heaths on mottled yellow and ironstone gravelly duplex soils in the wetter areas and red duplex soils in drier areas; now largely cleared for agriculture and urban development (Thackway and Cresswell 1995).

Environmental associations are two levels down from the IBRA regions, these associations were first described and mapped by Laut *et al* (1977). These boundaries are useful in dividing the Wetland Inventory into defined areas, which can assist in biodiversity planning.

11.2 Analysis

This Wetland Inventory covers seven Environmental Associations, each containing unique attributes. The following summary provides a brief overview of the area, catchment management agency, reserves and water resources for each association. Refer to Map 11-1 for the map of Environmental Associations within the Wetland Inventory boundary.

1 Clarendon Environmental Association

Area: 280 square kilometeres.

Township Extremities: Crafers is located near the northern extremity, Scott Creek on the eastern bounday, Clarendon on the southern boundary and Aberfoyle Park on the western boundary.

Catchment Boards: Onkaparinga and Patawalonga Catchment Water Management Boards.

NPWSA Reserves and biodiversity linkages: Seven reserves are located within this association. They include the two high profile reserves of Cleland Conservation Park and Belair National Park. The other reserves include Onkaparinga River National Park, Scott, Sturt Gorge, Mark Oliphant and The Knoll Conservation Parks. Large remnant vegetation areas and linkages encompass Mount Bold reservoir, linking north to Belair National Park and Cleland Conservation Park.

Water Resources: Mount Bold and Happy Valley reservoirs are located in the southern area of the Clarendon Environmental Association. Mount Bold reservoir not only contains significant biodiversity values, but is an important water storage area supplying the southern metropolitan area of Adelaide. Several significant drainage lines are also located in this region, namely the Onkaparinga River, Scott Creek, Sturt River and Brown Hill Creek. Twenty wetlands were surveyed in this association, many of which have biodiversity values.

2 Uraidla Environmental Association

Area: 140 square kilometeres.

Township Extremities: Gumeracha is located near the northern extremity, Balhannah to the east, Mylor on the southern boundary and Summertown on the western boundary.

Catchment Boards: Onkaparinga and Torrens Catchment Water Management Boards.

NPWSA Reserves and biodiversity linkages: Mount George and Kenneth Stirling Conservation Parks contain extensive remnants of native vegetation and form a biodiversity corridor over several kilometeres. The remaining area typically consists of scattered remnants of native vegetation.

Water Resources: Two main drainage lines are located within this region, namely the Onkaparinga River and Cox Creek. Twenty wetlands were surveyed in this association.

3 Para Environmental Association

Area: 355 square kilometeres.

Township Extremities: Angaston is located near the northern extremity, Cudlee Creek on the southern boundary and the locality of Mount Gawler on the western boundary.

Catchment Boards: Northern Adelaide and Barossa Catchment Water Management Board and the Torrens Catchment Water Management Board.

NPWSA Reserves and biodiversity linkages: There are significant remnant areas of native vegetation contained in NPWSA reserves; Hale Conservation Park, Warren Conservation Park, Para Wirra Recreation Park, Cudlee Creek Conservation Park and Kaiserstuhl Conservation Park. Open space linkages are also present within Forestry SA Lands and SA Water Land.

Water Resources: Four reservoirs (South Para, Warren, Barossa and Millbrook) are located within this association. The Little Para River, River Torrens and South Para River are the major watercourses. Twelve wetlands were surveyed in this association.

4 Aldinga Environmental Association

Area: 270 square kilometeres.

Township Extremities: Hallett Cove is located near the northern extremity, Sellicks Beach on the southern boundary and Kangarilla on the eastern boundary. Spencer Gulf forms the western boundary.

Catchment Boards: Onkaparinga Catchment Water Management Board.

NPWSA Reserves and biodiversity linkages: Overall this association contains scattered remnants with larger remnant of native vegetation areas contained within three NPWSA reserves, namely Aldinga Scrub Conservation Park, O'Halloran Hill Recreation Park and Onkaparinga River Recreation Park.

Water Resources: Drainage lines extend from the foothills to Spencer Gulf. Many of these drainage lines are extremely degraded, with the exception of Onkaparinga River which is within the NPWSA reserve system. The other watercourses are Field River and Christie, Port Willunga and Pedler Creeks. Ten wetlands were surveyed in this association.

5 Mount Terrible Environmental Association

Area: 180 square kilometeres.

Township Extremities: Lower Hermitage is located near the northern extremity, Hallett Cove on the southern boundary and Cherryville on the eastern boundary. Spencer Gulf forms the western boundary.

Catchment Boards: Northern Adelaide and Barossa, Torrens, Patawalonga and Onkaparinga Catchment Water Management Boards.

NPWSA Reserves and biodiversity linkages: This association contains 11 NPWSA reserves:

- Anstey Hill Recreation Park
- Black Hill Conservation Park
- Morialta Conservation Park
- Brownhill Creek Recreation Park
- Sturt Gorge Recreation Park
- Marino Conservation Park
- Montacute Conservation Park
- Horsnell Gully Conservation Park
- Cleland Conservation Park
- Belair National Park
- O'Halloran Hill Recreation Park

These reserves contain significant remnant areas of native vegetation. The Metropolitan Open Space Scheme (MOSS) incorporates parts of these reserves and encompasses the Adelaide Hills Face Zone.

Water Resources: The most prominent watercourse in this association is the Torrens River that runs into Kangaroo Creek Reservoir. Sections of the Sturt River are also located towards the south of this association. Smaller tributaries of Brownhill Creek, First, Second, Third, Fourth and Fifth Creeks are also included.

6 Hahndorf Environmental Association

Area: 630 square kilometeres.

Township Extremities: Mount Pleasant is located near the northern extremity, Brukunga to the east, Meadows on the southern boundary and Mylor on the western boundary.

Catchment Boards: Northern Adelaide and Barossa, Torrens and Onkaparinga Catchment Water Management Board.

NPWSA Reserves and biodiversity linkages: Cromer, Mylor and Totness Conservation Parks contain the significant remnant vegetation areas for this association. The remainder of the area has scattered remnants.

Water Resources: Onkaparinga River is the major watercourse. Three wetlands were surveyed in this association.

7 Mallala Environmental Association

Area: 1840 square kilometeres.

Township Extremities: Balaklava is located near the northern extremity, Roseworthy to the east, Paralowie on the southern boundary and Dublin on the western boundary.

Catchment Board: Northern Adelaide and Barossa Catchment Water Management Board.

NPWSA Reserves and biodiversity linkages: Clinton Conservation Park is located at the north of Spencer Gulf. Apart from this park, very little remnant vegetation remains.

Water Resources: Drainage lines in this association include Little Para River, Gawler River, Salt Creek and River Light. One constructed wetland was surveyed at Andrews Farm, near Smithfield.

12.0 KEY BIODIVERSITY AREAS

12.1 Background

Areas of high biodiversity within the landscape have been defined by developing 'key biodiversity areas'. The concept of key biodiversity areas has been adapted from the regional biodiversity plans for South Australia, developed by the Department for Environment and Heritage. Three biodiversity areas are identified within the Wetland Inventory. These are large remnant areas, threatened habitat areas and fragmented habitats. Map 12-1 shows the locations of these wetland biodiversity areas.

12.1.1 Large remnant areas

These areas have been identified on the basis that they contain large blocks of native vegetation, open space linkages, species diversity and populations of species with high conservation significance.

Two large remnant areas were identified:

1. **North – South central linkage** (marked as 1L on Map 12-1). Comprises the Mount Bold reservoir and surrounds. This land owned by SA Water contains large areas of remnant native vegetation, which extend north towards Scott Creek Conservation Park. This southern area links with the Hills Face Zone and the numerous NPWSA reserves concluding near the Anstey Hill Recreation Park. Refer to map number 1L.

2. **Mount Gawler Environs** (marked as 2L on Map 12-1). Includes the South Para and Barossa Reservoir, Kersbrook Native Forest Reserve, Para Wirra Recreation Park, and Hale and Warren Conservation Parks. Refer to map number 2L.

12.1.2 Threatened habitat areas

Threatened Habitat Areas have been identified on the basis that they:

- are selectively cleared and modified resulting in low remnancy of plant communities
- contain wetlands or vegetation that is poorly conserved within reserve system
- are wetland habitats containing regionally threatened plant communities
- contain large numbers of species of high conservation significance
- are wetlands which are subject to threatening processes (invasive weeds, surrounding land uses).

Three threatened habitat areas are identified:

1. **Aldinga environs** (marked as 1T on Map 12-1). This area contains several wetlands with high conservation value and numerous plants of high conservation significance. The boundary of this environ encompasses Aldinga Conservation Park and Washpool Lagoon. Refer to map reference number 1T.

2. **Parafield Wetlands** (marked as 2T on Map 12-1). These wetlands are located in Parafield Airport and contain species of state and regional conservation significance. This locality comprises of the southern section of the airport property. Refer to map number 2T.

3. **Central Lofty Swamps** (marked as 3T on map 12-1). Mainly located within Cleland Conservation Park, these wetland types are likely to be the last remaining in the State. The swamps are quite small, and although most are protected within National Parks and Wildlife reserves, they are still under external threats from invasive flora and introduced fauna.

12.1.3 Fragmented habitat areas

Fragmented habitats have been identified on the basis that they are:

- Highly isolated from other vegetation and drainage systems .
- Fragmented by urbanisation.

Three fragmented areas are located within the study area boundary:

1. **Willunga Basin** (marked as 1F on Map 12-1). Includes several wetlands of conservation significance that are disconnected from vegetative links within the landscape. This area adjoins the coast and extends to the slopes of the Willunga escarpment.

2. **Central Lofty Corridor** (marked as 2F on Map 12-1). This corridor follows the townships and settlements of Crafers, Stirling, Aldgate, Bridgewater and Mylor. These areas contain wetlands of conservation value, but are fragmented by housing, roads and small land holdings.

3. **Northern Adelaide Hills** (marked as 3F on Map 12-1). Encompasses the lower northern slopes of the Mount Lofty Ranges. This section encompasses Tea Tree Gully, Fairview Park and Banksia Park.

12.2 Analysis

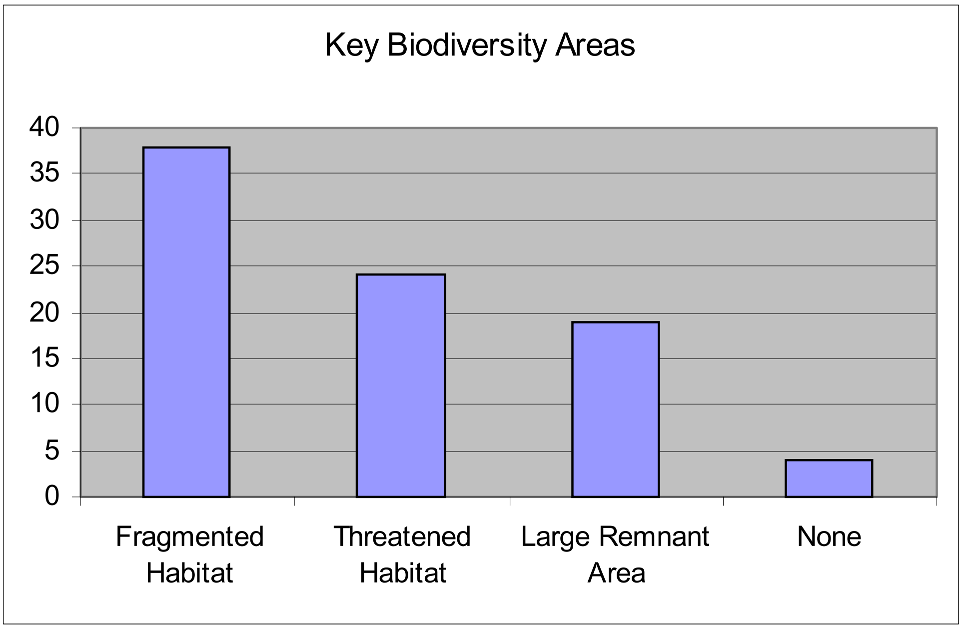


Figure 12-1. Wetlands within Key Biodiversity Areas.

Thirty-eight wetlands were surveyed in fragmented habitats, typically near townships and settlements. Twenty-four wetlands are located within threatened habitats, these areas are usually found within reserves and contain plants of high conservation significance. Nineteen sites are located within large remnant areas, these areas form substantial open space linkages.

13.0 WETLAND AREA

13.1 Background

The area of the wetlands was calculated by using ArcView GIS based on Southern Mount Lofty waterbody mapping provided by Planning SA. The total wetland area and total wetland area surveyed is provided for each Catchment Water Management Board.

13.2 Analysis

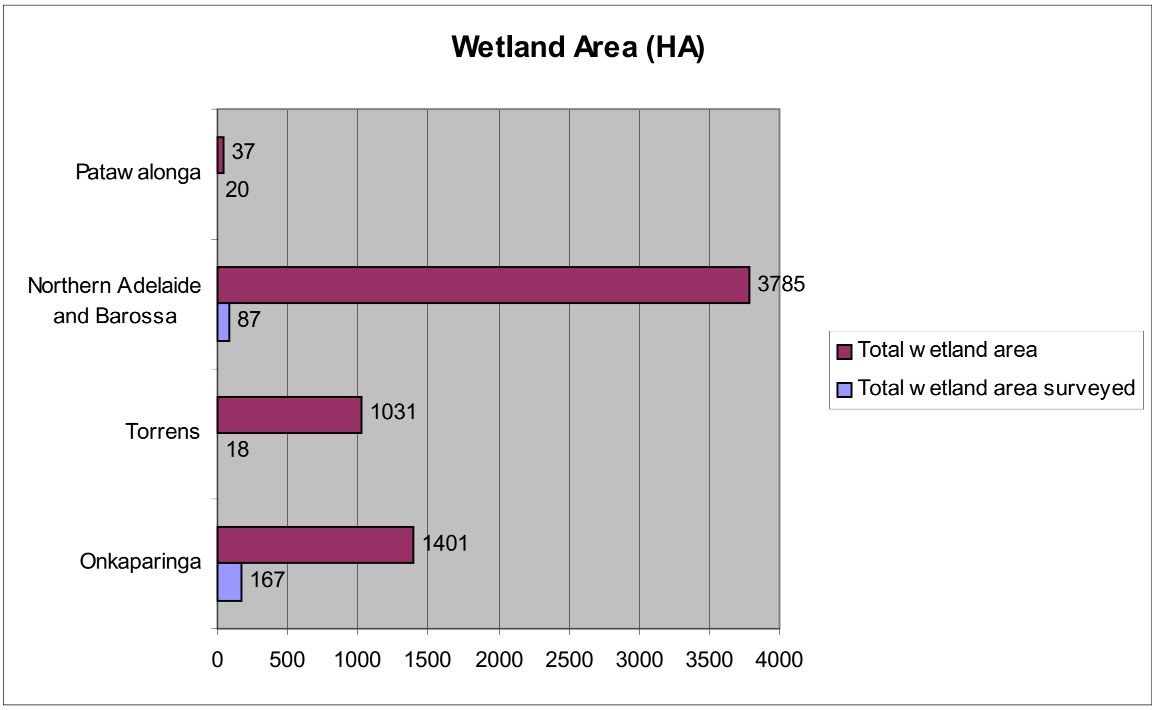


Figure 13-1. Wetland area.

The total area of waterbodies within the Wetland Inventory study area boundary is approximately 6389 ha. This coverage does not include all the watercourses (such as minor drainage lines) within the boundary and does include waterbodies, such as farm dams. The Northern Adelaide and Barossa Catchment boundary contains significant areas of coastal and intertidal waterbodies, and is the major reason for the high number of hectares for this area (3785 ha). The Catchment Water Management Boards of Onkaparinga and Torrens also includes the Torrens and Onkaparinga river systems which are not included in the wetland area.

14.0 LANDFORM ELEMENT

14.1 Background

The landform element definitions used in the wetland inventory have been adapted from Heard and Channon (1997) *Guide to a native vegetation survey using the biological survey of South Australia methodology, Section 3*. Geographic Analysis and Research Unit, Department of Housing and Urban Development. For descriptions refer to Appendix 1.

14.2 Analysis

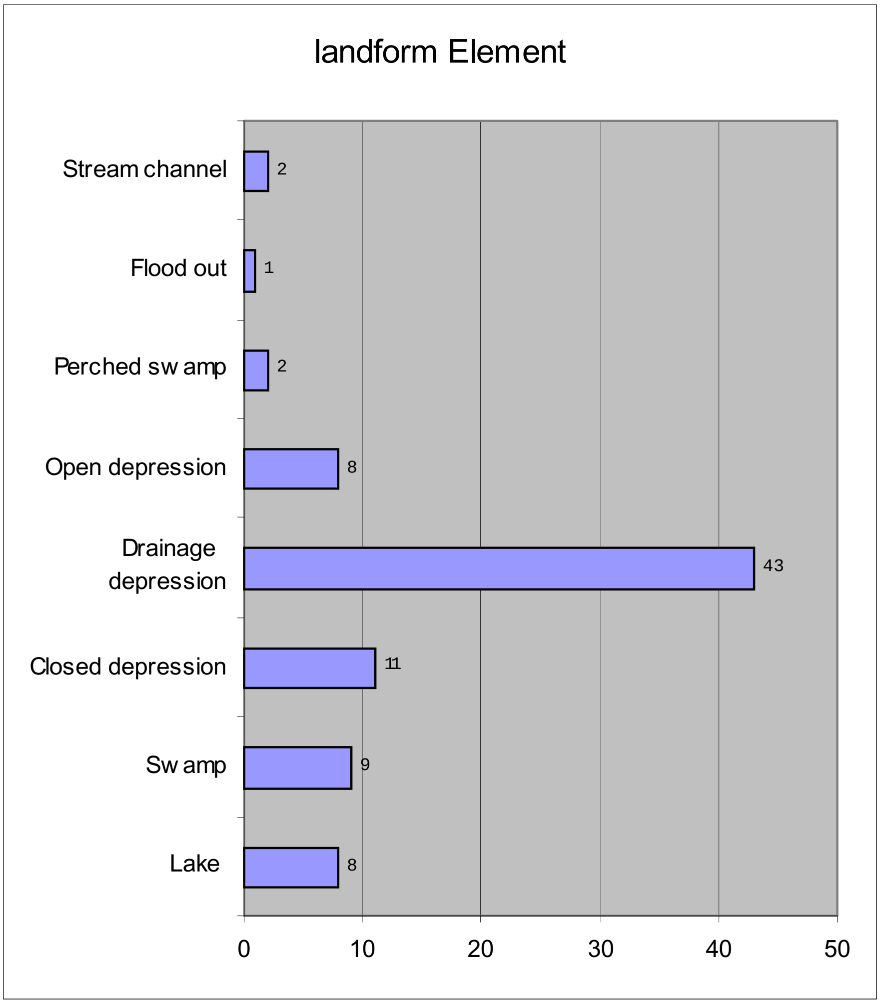


Figure 14-1. Wetland landform elements.

Wetlands are ultimately defined by the surrounding landforms. In the Mount Lofty Ranges drainage depressions were the most common landform surveyed (43 sites). These drainage depressions are commonly found in the higher slopes within the central Mount Lofty Ranges.

15.0 GEOLOGY

15.1 Background

The Adelaide Geosyncline (900-500 Ma) is the dominate province of the Mount Lofty Ranges. During this period the rocks which now form the Mount Lofty and Flinders Ranges were deposited in a long shallow crustal trough. These sediments reached a maximum thickness of 24 kilometres, the development of this sedimentary basin was a very significant event in South Australia's geological history.

15.2 Analysis

Six dominant geological formations underly the wetlands surveyed (refer to Map 15-1). Of these, the two most common geological structures are the Burra and Warrina groups. Consisting of sandstones and quartzites, the Burra group represents a time of major deposition between the Torrensian to early Sturtian time period. The Burra group forms the backdrop of the Hills for Adelaide between the Torrens Gorge and Sturt Gorge (Ludbrock, 1980). The Willyama and Barossa complex (composed of quartz, feldspar and mica) also underlie some wetlands in the Mount Lofty Ranges. Marine limestones and alluvial sediments are found under waterbodies on the plains and foothills.

16.0 HYDROLOGY

16.1 Background

The Wetland Inventory documented the average annual annual rainfall for wetlands surveyed and made observations on the main sources of water entering the wetlands. The mean annual rainfall in the Mount Lofty Ranges varies from 400 mm to 1100 mm. Approximately 50% of the rainfall falls within four months over the winter period. Mount Lofty summit is the one of the influencing factors of rainfall distribution within the ranges. The summit at 720 m receives the highest rainfall in South Australia of 1100 mm a year.

Surface water entering wetlands by drainage lines is common within the Mount Lofty Ranges. The surrounding catchments play a critical role in supplying and filtering water for the lower lying drainage lines and depressions that have formed into wetlands.

16.2 Analysis

All wetlands surveyed had rainfall ranging between 400 mm and 1100 mm. The highest frequency of wetlands surveyed were in the rainfall bracket between 1000 mm and 1100 mm (35 wetlands). The rainfall bracket of 600 mm to 800 mm recorded 32 wetlands. Those wetlands within these high rainfall zones are typically found within the higher slopes and valleys of the central Mount Lofty Ranges.

17.0 FLORA ANALYSIS BY CATCHMENT

A large proportion of wetlands surveyed within the Mount Lofty Ranges are considered to be freshwater (<1500 µs). Aquatic and semi-aquatic flora were noticeably abundant in many water bodies, especially in those below 900 µs. Members from the genera *Baumea*, *Blechnum*, *Carex*, *Gahnia* and *Juncus* are common and form the understorey component of the vegetation structure surrounding wetlands.

The vegetation types in each Catchment Water Management Board was analysed by:

- describing the general floristic distribution within the Catchment Board,
- outlining the vegetation associations that contain wetlands at a catchment scale,
- describing vegetation associations located at the site survey,
- providing descriptions of vegetation associations or plants with high conservation significance within surveyed wetlands.

This analysis was completed using ArcView GIS with data supplied by Planning SA and the Department for Environment and Heritage.

17.1 Northern Adelaide and Barossa Catchment Water Management Board

17.1.1 Remnant vegetation distribution

The distribution of remnant native vegetation is concentrated within National Parks and Wildlife reserves, namely Para Wirra Recreation Park, Warren and Hale Conservation Parks. Forestry SA lands also contain significant remnant vegetation, especially around Mount Crawford and in other native forest reserves. The steep slopes to the east and north of Tea Tree Gully contain significant areas of native remnant vegetation that form linkages to the larger remnant areas near Williamstown.

The larger remnant areas along the coast between Barker Inlet and Port Gawler contain *Avicennia marina* var. *resinifera* (Mangroves). The remnant areas north and south of Williamstown contain a mixture of eucalypt woodlands including, *E. obliqua, E. fasciculosa, E. goniocalyx, E. leucoxylon, E. camaldulensis and E. odorata.*

Refer to map 17-1 for remnant vegetation distribution.

17.1.2 Floristic vegetation within or adjacent to waterbodies

Twenty-one regional floristic associations exist within or adjacent to waterbodies. These are further broken down into 37 detailed vegetation associations. The vegetation typically consists of eucalypt woodlands on the slopes and ridgelines of the Mount Lofty Ranges, mangrove forests located at the coast and the samphire shrublands abutting the mangrove areas encompass large areas of intertidal waterbodies. For a detailed list of the vegetation associations intersecting waterbodies refer to Appendix 2.

17.1.3 Vegetation associations at survey sites

Twelve vegetation associations were recorded at the survey sites in the Northern Adelaide Barossa Catchment Water Management Board. These are listed below:

- *Juncus pallidus*, *Cyperus* sp Sedgeland
- *Eucalyptus camaldulensis* var. *camaldulensis* +/- *E. fasiculosa* +/- *E. leucoxylon*, +/- *E. goniocalyx* over *Acacia pycnantha*, *Hibbertia riparia*, *Gonocarpus elatus*, *Cheilanthes austrotenuifolia* Woodland
- *Eucalyptus fasciculosa*, *E. leucoxylon*, *E. goniocalyx* over *Acacia paradoxa*, *A. pycnantha* and *Hibbertia australis* Open Forest
- *Eucalyptus camaldulensis* var. *camaldulensis* over *Juncus kraussii*, *Cyperus gymnocaulos*, **Cynodon dactylon*, *Samolus repens* woodland
- *Eucalyptus obliqua*, *E. goniocalyx* over *Leptospermum myrsinoides*, *Xanthorrhoea semiplana* ssp. *semiplana* Open woodland
- *Typha domingensis* Grassland
- *Amphibromus nervosus* over *Eleocharis acuta*, *Rumex dumosus, Sclerolaena muricata* var. *villosa* Low grassland
- *Eucalyptus fasciculosa*, *E. leucoxylon* over *Acacia paradoxa*, *A. pycnantha* Open Forest
- *Eucalyptus obliqua*, *Acacia pycnatha* over *Typha domingensis*, *Juncus pallidus* and introduced grasses Woodland
- *Eucalyptus fasciculosa* +/- *E.leucoxylon* Open Woodland
- *Acacia melanoxylon* over *Typha domingensis*, *Phragmites australis*, *Juncus pallidus*, *Pteridium esculentum*, *Berula erecta* Open forest
- *Leptospermum myrsinoides* over introduced grasses Shrubland

*Introduced plant

17.1.4 Plants of conservation significance within survey sites

One of the most significant associations within the Northern Adelaide and Barossa Water Catchment Management Board is contained within the Parafield Wetland complex. This association comprises of *Amphibromus nervosus, Eleocharis acuta, Rumex dumosus, Sclerolaena muricata var. villosa*. This site is an important representation of flora that was once distributed throughout the Northern Adelaide plains.

The following plants of conservation significance were recorded at the Parafield wetlands.

Cressa cretica (vulnerable Southern Lofty)
Eragrostis dielsii var. *dielsii* (possible rare or vulnerable in Southern Lofty/South Australia)
Eragrostis infecunda (rare SA, vulnerable Southern Lofty)
Limosella australis (uncommon Southern Lofty)
Maireana decalvans (endangered South Australia and Southern Lofty)
Maireana enchylaenoides (uncommon Southern Lofty)
Marsilea drummondii (endangered Southern Lofty)
Marsilea hirsuta (rare Southern Lofty)
Rumex dumosus (rare South Australia, endangered Southern Lofty)
Wilsonia rotundifolia (vulnerable Southern Lofty).

Plants of conservation significance recorded at Gunda Reserve in Banksia Park:

Bolboschoenus medians (uncommon in South Australia and Southern Lofty)
Callitris gracilis (uncommon in Southern Lofty)
Carex bichenoviana (uncommon in South Australia and Southern Lofty)
Leptospermum lanigerum *planted (uncommon Southern Lofty)
Danthonia duttoniana (rare in South Australia and Southern Lofty)
Isolepis hookeriana (uncommon South Australia, rare Southern Lofty)

Plants such as *Danthonia duttoniana* (rare in South Australia and Southern Lofty), *Isolepis hookeriana* (uncommon South Australia, rare Southern Lofty) are poorly represented in National Parks and Wildlife reserves (Turner 2000).

Taworri Reserve located in Banksia Park contains 108 species. Some of these have high conservation ratings:

Acacia iteaphylla *planted (rare South Australia)
Callitris gracilis *planted (uncommon Southern Lofty)
Eucalyptus diversifolia (rare Southern Lofty)
Lomandra sororia (uncommon South Australia and Southern Lofty)
Juncus flavidus (rare South Australia and Southern Lofty)
Myriophllum integrifolium (rare in South Australia and Southern Lofty)
Isolepis hookeriana (uncommon in South Australia, rare in Southern lofty)

This list includes three plants that are poorly represented within National Parks and Wildlife reserves; *Juncus flavidus* (rare South Australia and Southern Lofty), *Myriophyllum integrifolium* (rare in South Australia and Southern Lofty) and *Isolepis hookeriana* (uncommon in South Australia, rare in Southern Lofty (Turner 2000).

Plate 1. Left: *Eleocharis acuta* over *Marsilea drummondii*. Right: *Marsilea drummondii* (Nardoo)

The plate on the left illustrates the aquatic vegetation association found at Parafield Wetland, (*Eleocharis acuta* over *Marsilea drummondii)*. The plate on the right provides a close up view of Nardoo, which is the dominant surface-floating aquatic plant on two of the wetlands at Parafield.

17.2 Torrens Catchment Water Management Board

17.2.1 Remnant vegetation distribution

The remnant native vegetation within the Torrens Catchment forms a distinct band along the spine of the Mount Lofty Ranges in a north-south direction. The National Parks and Wildlife reserves contain the majority of the remaining vegetation within the Torrens Catchment. Cleland Conservation Park, Greenhill Recreation Park, Horsnell Gully, Morialta, Black Hill and Montacute Conservation Parks form a continuous band of vegetation across the Mount Lofty Ranges. To the north vegetation extends from Montacute CP to the SA Water lands of Kangaroo Creek reservoir and Millbrook reservoir. The dominant vegetation association within this area consists of eucalypt woodlands. *Eucalyptus obliqua, E. goniocalyx, E. fasciculosa, E. camaldulensis and E. leucoxylon* are the common dominant or co-dominant overstorey species within these woodlands.

Refer to Map 17-2 for remnant vegetation distribution.

17.2.2 Floristic vegetation within or adjacent to waterbodies

Twenty-four vegetation associations are located within or adjacent to waterbodies. The vegetation of these waterbodies typically comprises eucalypt woodlands with *E. obliqua* being the dominant species. *Eucalyptus camaldulensis* is also frequently recorded within or adjacent to waterbodies in the Torrens catchment area. For a list of the vegetation associations intersecting waterbodies refer to Appendix 3.

17.2.3 Vegetation associations at survey sites

Three vegetation associations occurred within a majority of the wetlands surveyed.

1. *Eucalyptus dalrympleana* over *Gahnia sieberiana, Juncus pallidus* Open forest
2. *Eucalyptus obliqua* over *Leptospermum lanigerum, Gahnia sieberiana, Pteridium esculentum* Woodland
3. *Gleichenia microphylla, Gahnia sieberiana* Open shrubland

17.2.4 Plants of conservation significance within surveyed wetlands

<u>Carey Gully Water Reserve</u>

Eucalyptus dalrympleana (rare Southern Lofty),
Gahnia sieberiana (uncommon Southern Lofty)

<u>Chinamans Bog – Cleland Conservation Park</u>

Thirty-four indigenous plant species have been recorded by Brewer and Smith (2000) within the swamp complex of Wilsons Bog (of which Chinamans Bog is a part). Those plants with conservation significance are listed below:
Leptospermum lanigerum (uncommon Southern Lofty)
Gahnia sieberiana (uncommon Southern Lofty)
Blechnum minus (uncommon Southern Lofty)
Gleichenia microphylla (rare South Australia, rare Southern Lofty)
Sprengelia incarnata (rare South Australia, rare Southern Lofty)
Blechnum nudum (rare South Australia, rare Southern Lofty)
Todea barbara (endangered South Australia and Southern Lofty)

Plate 2 illustrates swamp vegetation located near Chinamans and Wilsons Bog in Cleland Conservation Park.

The two species pictured *Gleichenia microphylla* (the light green vegetation) and *Gahnia sieberiana* (the tan fronds protruding out of the *Gleichenia microphylla*) both have State and regional conservation ratings.

Plate 2. *Gleichenia microphylla*.

Plants of conservation significance recorded at Wilsons Bog (Cleland Conservation Park) include:

Leptospermum lanigerum (uncommon southern lofty),
Gahnia sieberiana (uncommon southern lofty)

Note: These two species were recorded at the survey site and do not represent all species of conservation value in Wilson's Bog.

Plants of conservation significance recorded at Heptinstalls Spring (Cleland Conservation Park) include:

Gahnia sieberiana (uncommon Southern Lofty),
Gleichenia microphylla (rare South Australia, rare Southern Lofty)

17.3 Patawalonga Catchment Water Management Board

17.3.1 Remnant vegetation distribution

The remnant native vegetation within the Patawalonga catchment is concentrated in the eastern section of the catchment area. There are 14 vegetation associations within the catchment. The most notable is the band of *Eucalyptus microcarpa* Woodland between Shepherds Hill Recreation Park and the South-Eastern Freeway. This woodland is distributed across the suburban foothills of Panorama and Torrens Park and links to Brownhill Creek Recreation Park and Belair National Park. The woodland terminates near the South-Eastern Freeway north from the suburb of Waite.

Eucalyptus microcarpa is rated as uncommon within the Southern Mount Lofty Ranges, and the association of *E. microcarpa* Grasy Low woodland is considered an endangered ecosystem within South Australia (DEH 2001).

Other areas of remnant vegetation are located within Belair National Park and the Brownhill Creek environs. These areas typically contain a mixture of *Eucalyptus obliqua* and *Eucalyptus leucoxylon* woodlands.

Refer to Map 17-3 for remnant vegetation distribution.

17.3.2 Floristic vegetation within or adjacent to waterbodies

Ten vegetation associations exist within or adjacent to waterbodies in the Patawalonga catchment. These associations consist of a eucalypt overstorey comprising *Eucalyptus obliqua*, *E. camaldulensis var. camaldulensis*, *E. leucoxylon*, *E. microcarpa* and *E. baxteri*. For a detailed list of the vegetation associations intersecting waterbodies refer to Appendix 4.

17.3.3 Vegetation associations at survey sites

The vegetation associations can be grouped into five categories. These are:

- *Eucalyptus obliqua, Salix sp over Typha domingensis* Open Forest.
- *Eucalyptus. camaldulensis var. camaldulensis over Phragmites australis, Carex spp. Juncus spp.* Open Forest.
- *Eucalyptus obliqua* over *Leptospermum lanigerum, Acacia retinodes, Gahnia sieberiana, Juncus pallidus, Blechnum minus, Pteridium esculentum* Woodland.
- *Eucalyptus leucoxylon ssp. leucoxylon, Acacia melanoxylon, Leptospermum lanigerum* Woodland.
- *Eucalyptus obliqua, Pultenaea daphnoides, Lepidosperma semiteres, Acrotriche fasciculiflora, Pteridium esculentum* Woodland.

Of notable importance is the association containing *Leptospermum lanigerum, Gahnia sieberiana* and *Blechnum minus. Leptospermum lanigerum* closed shrubland is considered to be endangered in the South Australian agricultural region (DEH 2001). Some of the species contained in this association have high conservation significance.

17.3.4 Plants of conservation significance within survey sites

<u>Osmond Wetland</u> Brick Kiln Road, Healthfield.
Leptospermum lanigerum (uncommon Southern Lofty), *Blechnum minus* (uncommon Southern Lofty)

<u>Copper Wetland</u> Upper Sturt Valley Road, Heathfield.
Leptospermum lanigerum (uncommon Southern Lofty)

<u>Hrmo Creek</u> Sheoak Road, Upper Sturt.
Leptospermum lanigerum (uncommon Southern Lofty), *Blechnum minus* (uncommon Southern Lofty)

<u>HK FRY Reserve</u>, Heath Road, Crafers.
Lepidosperma laterale (uncommon Southern Lofty)

Plate 3 pictures *Blechnum minus* (soft water fern) which is forming an essential understorey component within the wetland.

This site has received management assistance from the Urban Forest Biodiversity Program. Note the recently cut *Acacia longifolia* (an invasive species in the Mount Lofty Ranges) intermixed with the water fern.

Plate 3. *Blechnum minus,* located in Osmond Wetland, Heathfield.

17.4 Onkaparinga Catchment Water Management Board

17.4.1 Remnant vegetation distribution

The remnant vegetation within the Onkaparinga catchment is concentrated within the Mount Bold water catchment zone. This SA Water land contains approximately thirteen eucalypt woodland associations and the reservoir contains the largest open body of water within the catchment area. Scattered remnants of native vegetation extend north from Mount Bold, linking with Scott Creek Conservation Park. Onkaparinga River National Park contains significant linear linkages from the coast to the hills with populations *of Eucalyptus microcarpa* and *E. fasciculosa* woodlands. *Eucalyptus microcarpa* is rated as uncommon within the Southern Mount Lofty Ranges, and the association of *E. microcarpa* Grassy low woodland is considered an endangered ecosystem within South Australia (DEH 2001).

The other significant area of native vegetation is located in the Willunga Range. This area contains a mixture of *Eucalyptus obliqua* and *Eucalyptus fasciculosa* Woodlands.

Refer to Map 17-4 for remnant vegetation distribution.

17.4.2 Floristic vegetation within or adjacent to waterbodies

Nineteen vegetation associations exist within or adjacent to waterbodies. These associations are dominated by eucalypt woodlands on the slopes and higher hills. Other associations of sedgelands and shrublands are located closer to the coastal zones within the catchment. The distribution of these associations is scattered across the catchment, with Mount Bold containing the larger area of remnant vegetation. For a detailed list of the vegetation associations intersecting waterbodies refer to Appendix 5.

17.4.3 Vegetation associations at survey sites

The Onkaparinga catchment contains excellent remnant terrestrial and semi-aquatic vegetation. These associations typically consist of *Leptospermum lanigerum, Acacia retinodes* over *Gahnia sieberiana, Juncus pallidus, Blechnum minus* and *Pteridium esculentum.* Wetlands sites with these species are uncommon in the Mount Lofty Ranges. Many of the importnat sites occur within National Parks and Wildlife reserves.

17.4.4 Plants of conservation significance within survey sites

S2021 Englebrook Reserve • *Leptospermum lanigerum* (uncommon Southern Lofty), *Gahnia sieberiana* (uncommon Southern Lofty), *Blechnum minus* (uncommon Southern Lofty)	S2022 Mount George Wetland • *Leptospermum lanigerum* (planted) (uncommon in Southern Lofty)
S2032 Bushland Park Lake • The Park contains 4 vulnerable species, 13 rare species, 24 uncommon species listed in Southern Lofty region. Some wetland species with conservation significance include *Bolboschoenus medianus* (uncommon in South Australia, uncommon in Southern Lofty)	S2009 Nurutti Reserve • *Gahnia sieberiana*, (uncommon in Southern Lofty) • *Eucalyptus dalrympleana*, (uncommon in Southern Lofty). The reserve contains a total of 127 indigenous plants including 17 of State or Regional Conservation Significance.
S2025 Heron Reserve • *Leptospermum lanigerum* (uncommon Southern Lofty) • *Gahnia sieberiana* (uncommon Southern Lofty) • *Blechnum nudum* (uncommon Southern Lofty)	S2007 Heathfield Bog • *Blechnum minus* (uncommon in Southern Lofty). • *Gahnia siebreriana* (uncommon in Southern Lofty)
S2006 Rubida Grove • *Gahnia seiberiana* (uncommon Southern Lofty) • *Eucalyptus dalrympleana* (rare Southern Lofty)	S2055 Prickly Tea -Tree Swamp • *E. dalrympleana* (rare Southern Lofty)
S2001 Woorabinda Lake • *Baumea tetragona* (uncommon Southern Lofty and South Australia), *Gahnia sieberiana* (uncommon Southern Lofty), *Acrotriche fasciculiflora* (uncommon*), Baumea tetragona* (uncommon Southern Lofty), *Billarardiera bignoniacea* (uncommon Southern Lofty), *Eucalyptus dalrympleana* (rare Southern Lofty), *Logania recurva* (uncommon Southern Lofty)	S2008 Aldgate Valley Reserve *Blechnum minus* (uncommon Southern Lofty)
S2058 Aldinga Scrub Wetland • *Marsilea drummondii* (endangered Southern Lofty)	S2041 Silky Tree Swamp • *Leptospermum lanigerum* (uncommon Southern Lofty) • *Gahnia sieberiana* (uncommon Southern Lofty) • *Blechnum minus* (uncommon Southern Lofty), • *Eucalyptus dalrympleana* (rare Southern Lofty)
S2053 Kenneth Dam • *Gahnia sieberiana* (uncommon Southern Lofty)	S2085 Railway Crossing Bog • *Leptospermum lanigerum* (uncommon Southern Lofty) • *Gahnia sieberiana* (uncommon Southern Lofty) • *Blechnum minus* (uncommon Southern Lofty)
S2068 Minno Creek Railway Dam • *Leptospermum lanigerum* (uncommon Southern Lofty)	S2054 Silky Tea - Tree bog • *Leptospermum lanigerum* (uncommon Southern Lofty) • *Gahnia sieberiana* (uncommon Southern Lofty) • *Blechnum minus* (uncommon Southern Lofty)

<table>
<tr>
<td>S2084 Oak Avenue Bog
• Gahnia sieberiana (uncommon Southern Lofty),
• Gleichenia microphylla (rare South Australia, rare Southern Lofty)</td>
<td>S2076 Eurilla Bog
• Leptospermum lanigerum (uncommon Southern Lofty)
• Gahnia sieberiana (uncommon Southern Lofty)
• Blechnum minus (uncommon Southern Lofty)
• Gleichenia microphylla (rare South Australia, rare Southern Lofty)
• Gonocarpus tetragynus (rare Southern Lofty)
• Empodisma minus (uncommon Southern Lofty)
• Bauma gunnii (rare Southern Lofty)</td>
</tr>
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<td>S2077 Cleland Eastern Bog
• Leptospermum lanigerum (uncommon Southern Lofty)
• Gahnia sieberiana (uncommon Southern Lofty)
• Blechnum minus (uncommon Southern Lofty)
• Gleichenia microphylla (rare South Australia, rare Southern Lofty,)
• Lycopodium deuterodensum (endangered South Australia, endangered Southern Lofty)</td>
<td>S2046 Botanic Dam
• Leptospermum lanigerum (uncommon Southern Lofty)
• Gahnia sieberiana (uncommon Southern Lofty)
• Blechnum minus (uncommon Southern Lofty)
Geichenia microphylla (rare South Australia, rare Southern Lofty)</td>
</tr>
<tr>
<td>S2044 Radebone Road Dam 2
• Blechnum minus (uncommon Southern Lofty)</td>
<td>S2042 Ingram Swamp
• Leptospermum lanigerum (uncommon Southern Lofty)
• Gahnia sieberiana (uncommon Southern Lofty)
• Gleichenia microphylla (rare South Australia, rare Southern Lofty)</td>
</tr>
<tr>
<td colspan="2">S2060 – S2062 Onkaparinga Estuary
• Angianthus preissianus (Rare Southern Lofty)
• Apium annuum (Rare Southern Lofty)
• Austrofestuca littoralis (Rare Southern Lofty)
• Carex bichenoviana (Uncommon Southern Lofty)
• Crassula helmsii (Rare Southern Lofty)
• Diplachne parviflora (Rare South Australia)
• Gahnia filum (Rare Southern Lofty)
• Gnaphalium indutum (Rare Southern Lofty)
• Haloragis aspera (Rare Southern Lofty)
• Lavatera plebeia (Uncommon Southern Lofty)
• Lotus australis (Uncommon Southern Lofty)
• Maireana decalvans (Endangered Southern Lofty, South Australia)
• Maireana enchylaenoides (Uncommon Southern Lofty)
• Melaleuca halmaturorum (Vulnerable Southern Lofty)
• Myoporum parvifolium (Vulnerable Southern Lofty , Rare South Australia)
• Samolus repens (Uncommon Southern Lofty)
• Schoenoplectus pungens (Uncommon Southern Lofty)
• Schoenus nitens (Rare Southern Lofty)
• Selliera radicans (Rare Southern Lofty)
• Stipa eremophila (Uncommon Southern Lofty)
• Wilsonia humilis var. humilis (Uncommon Southern Lofty)</td>
</tr>
<tr>
<td colspan="2">S2057 – Washpool Lagoon

• Alternanthera denticulata (Uncommon Southern Lofty)
• Angianthus preissianus (Rare Southern Lofty)
• Carex bichenoviana (uncommon Southern Lofty)
• Geranium potentilloides var. potentilloides (unknown Southern Lofty)
• Haloragis aspera (Rare Southern Lofty)
• Hemichroa pentandra (Rare Southern Lofty)
• Imperata cylindrica (Rare Southern Lofty)
• Melaleuca halmaturorum ssp. halmaturorum (Vulnerable Southern Lofty)
• Muehlenbeckia florulenta (rare Southern Lofty)
• Samolus repens (Uncommon Southern Lofty)
• Schoenus nitens (rare Southern Lofty)
• Sclerolaena diacantha (rare Southern Lofty)
• Wilsonia humilis var. humilis (Uncommon Southern Lofty)
• Wilsonia rotundifolia (Vulnerable Southern Lofty)</td>
</tr>
</table>

Plate 4. Cleland Eastern Bog (Eurilla Conservation Park).

Cleland eastern bog (Eurilla Conservation Park) contains important swamp vegetation. In the foreground are dense stands of *Blechnum minus* (uncommon Southern Lofty) while the background contains *Leptospermum lanigerum* (uncommon Southern Lofty)

18.0 DEGRADATION AND DISTURBANCE

18.1 Background

Disturbances or threats are defined as any direct or indirect human activities at the site or in the catchment area that may have a detrimental effect on the ecological character of the wetland. The effect may be a low level disturbance (low level grazing) or a major threat such as water diversion schemes.

18.2 Analysis

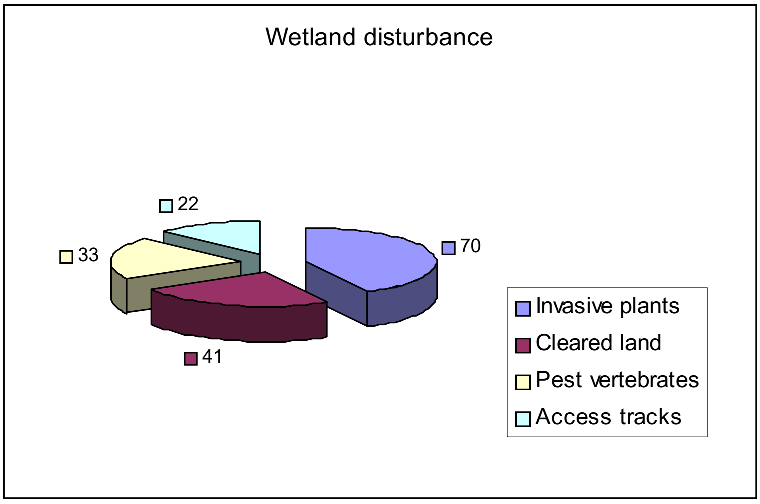


Figure 18-1. Wetland disturbance

Many wetlands contained disturbances. The two most frequent disturbances recorded were invasive plants (70 occurrences) and cleared land (41 occurrences). There were thirty-three occurrences of pest vertebrates, most commonly foxes, rabbits and cats. Several sites recorded impacts from domestic and/or native grazing on wetland vegetation. Access tracks dissecting or traversing wetlands were also common (22 sites). A concern with many of these tracks is that they are usually formed with compressed soil and during high rainfall events sediment often runs into adjacent wetlands. Other disturbances that occurred include recreational impacts (rubbish and tracks), fences and altered water flows through stormwater inputs, drainage and water extraction.

The impacts of cleared land is obvious at the California Road Wetland (center of picture), which contains *Leptospermum lanigerum*, (silky tea tree) uncommon Southern Lofty. The dominant surrounding land use is vineyards.

Plate 5. California Road wetland

19.0 AQUATIC VEGETATION CLASSES

19.1 Background

Parameters for seven classes of aquatic vegetation were included in the survey. These records can indicate the types of producers (production of oxygen and plant food) within the wetland system. The diversity of classes recorded may indicate the level of aquatic biodiversity present. The vegetation classes consist of:

Algal and aquatic moss commonly comprise Charophyta (stoneworts) and Chlorophyta (green algae) which forms macroscopic mats either attached to plants or in open water. Algae forms the photosynthetic basis for the open water food sources in many inland waters (Boulton and Brock,1999).
For images of green algae see: http://www.nmnh.si.edu/botany/projects/algae/Imag-Chl.htm.

Floating vascular/leaved plants have part or all of the leaves at the waters surface. Examples include *Azolla* species floating ferns that host bacteria that fix nitrogen, (Romanowski, 1998), *Lemna*, *Spirodela* and *Wolffia* (duckweeds) and the genus *Utricularia* (bladderworts). Members from the family Potamogetonacea (pondweeds) are also common floating plants and can be found in a variety of habitats. All these plants are able to provide habitat for invertebrates, provide shelter for fishes and produce oxygen.

Rooted vascular plants are those rooted in the sediments with either a major proportion of material above water (reeds, rushes and sedges) or totally under water (V*allisneria* spp.). Many of these plants play a key role in nutrient cycling and provide habitat for birds, insects and aquatic invertebrates. Typical genera include *Baumea*, *Bolboschoenus*, *Carex*, *Cyperus*, *Gahnia*, *Schoenus*, *Juncus*, *Triglochin* and *Myriophyllum*. *Myriophyllum* is a distinctive wetland genus that provides food, shelter and spawning or nesting sites for a variety of animals, from invertebrates to fish, frogs and birds (Romanowski, 1998).

19.2 Analysis

Rooted vascular plants are the most common form of vegetation class within the surveyed wetlands. Genera such as *Juncus*, *Carex*, *Cyprus* and *Gahnia* were frequently recorded (81 sites). The abundance and diversity of aquatic vegetation is strongly linked to the levels of disturbance. Those sites with minimal disturbance (eg Woorabinda Lake, Stirling) recorded algae, mosses and floating plants. A good diversity and abundance of reeds, rushes and sedges are also present. Those sites with high levels of disturbance (eg Simmons Hill wetlands, Mount Crawford) recorded rooted vascular plants, usually with one or two species present and with low abundance levels.

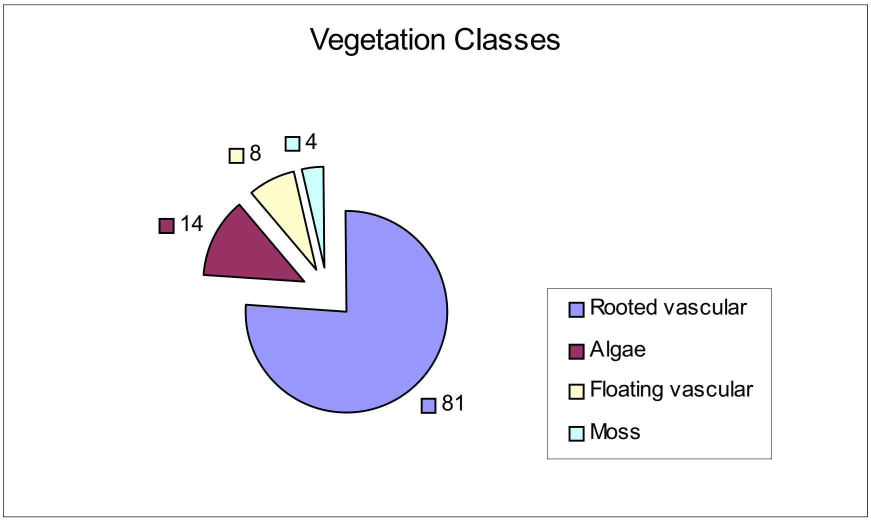


Figure 19-1. Aquatic vegetation classes.

20.0 AQUATIC INVERTEBRATE ANALYSIS

20.1 Background

Macro and micro invertebrates are an essential component of the wetland food web. They are responsible for a significant proportion of the secondary production occurring in wetlands, and form two interconnected wetland food chains, a grazing food chain and a detrital food chain. Invertebrates comprise much of the diet of waterfowl populations and the diversity and abundance of waterfowl can be a direct consequence of the invertebrate food supply.

20.1.1 Ecological benefits

Yen and Butcher (1997) provide some examples of direct ecological benefits that invertebrates contribute. These include:

Tangible direct benefits:

1. Plant pollination
2. Effects on soil; soil formation and fertility.
3. Decomposition; fragmentation and recycling of dead plant and animal material.
4. Position in the food web; invertebrates are the principle food for many vertebrates.
5. Preditation and parasitism. Invertebrates are involved in the natural regulation of populations of other species through predation and parasitism, and thus form the basis of biological control.

Indirect ecological benefits:

1. Ecosystem stability: the loss of species from highly interrelated systems is likely to cause a cascade of further losses.

2. Evolutionary time: the diversity within ecosystems over time maintains diversity.

20.1.2 Trophic dynamics

Standing water communities are dynamic systems which reflect change in many variables. The trophic state of a wetland depends on nutrient inputs from the catchment and within the wetland (Boulton and Brock, 1999). Invertebrates were collected during the Wetland Inventory and classified according to trophic levels. If samples from all trophic groups are collected, this could suggest that the aquatic ecosystem is in a reasonable state of equilibrium. The top of the food chain is occupied by vertebrate predators, including fish, water rats and water birds. These terrestrial predators can be considered to be on the top of the aquatic food chain, and provide a pathway for the export of nutrients and other material from the wetland ecosystem (Boulton and Brock 1999). These trophic levels are described below.

Primary producers

Primary producers form two groups, those that are suspended or floating and those attached to substrate or other plants. Attached macrophytes includes fringing reeds and submerged plants and periphyton (the biota attached to submerged surfaces). Suspended or floating forms generally consist of the phytoplankton and algae groups. Phytoplankton form the basic photosynthetic basis for the open water food web in most standing waters.

Consumers

There are two main types of consumers based on diet: grazers that consume plants and predators that consume other animals.

Grazers

Grazers consist of aquatic snails (Gastropoda) and some mayfly nymphs (Ephemeroptera), caddisfly larvae (Trichoptera) and beetles (Coleoptera). These groups are usually found near the edges of the water body.
Within the open water, some of the important grazers are zooplankton, including water fleas (Cladocera) and copepods (Calanoida and Cyclopoida).

Vertebrate Grazers

Vertebrate grazers generally consist of groups such as tadpoles, fish and waterbirds. Vertebrate grazers can influence the food web considerably when attracted to water bodies in times of flood or in types of drought.

Predators

Predators include dragonfly larvae (Odonata) which tend to ambush prey and invertebrates that hunt in open water, such as diving beetles (Dytiscidae, Coleoptera) (Boulton and Brock 1999). Areas such as the littoral zone tend to have high biodiversity of grazers which in turn attracts many invertebrate predators.

20.2 Temporary Wetlands

Many of the wetlands in the Mount Lofty Ranges are temporary and therefore display slightly different invertebrate fauna composition from other wetland systems such as saline lakes or permanent waters. Williams (2000) makes four general conclusions from his study of temporary wetlands. These are:

1. Faunal diversity is high and often higher than in many permanent wetlands
2. A wide range of fauna groups occurs, the particular assemblage depending largely upon time from filling. Many species are restricted to temporary wetlands, for example all notostracan, conchostracan and anostracan species are restricted to temporary wetlands
3. Local differences in hydrology, filling frequency, basin shape and other factors often result in differences between wetlands in the same area and same time
4. Considerable continental and regional endemism prevails. Most macofaunal species are endemic to Australia.

The filling or flooding of temporary water bodies releases a pulse of nutrients that, together with light and water, provide the resources for germination and growth of both micro and macro photosynthesizers. Habitat for consumers and decomposers soon follows. The invertebrate sediment egg bank with desiccation-resistant stages seems to be the initial source of colonists. The groups that tend to be first in temporary waters include rotifers, ostacods, copepods and cladocerans. When the water body starts to dry a ‘predator soup’ results, and terrestrial predators (eg birds) come to the water to feed during the drying process. This process forms a critical trophic link between aquatic and terrestrial systems (Boulton and Brock, 1999).

20.3 Analysis

Fifty-five of the sites surveyed returned invertebrate samples. These samples were identified to family level and, if possible, to genus. Limitations of resources and time constraints have not allowed samples to be collected over time and identified past the family or genus level. Therefore, the analysis of invertebrate composition is most effective by the study of trophic levels present in each wetland. Conclusions made about the ecosystem health of a wetland based on the invertebrates cannot be made due to the limited sample size, it can only provide an indication at the time of sampling.

<u>Invertebrate scoring method</u>

Invertebrate scores were assigned for each wetland. Each sample was identified to family level and the trophic level of each family recorded. An estimate was recorded of the samples diversity and abundance. The following scoring system was developed.

Score 1 = (Low) sampled one family from one trophic level, usually from a lower level trophic level (eg. detritivores and herbivores).

Score 3 = (Moderate) sampled more than one family with representatives from one or more trophic levels (eg. herbivores and carnivores).

Score 5 = (High) sampled more than two families with representatives from three or more trohic levels (eg. detritivores, herbivores, omnivores and carnivores).

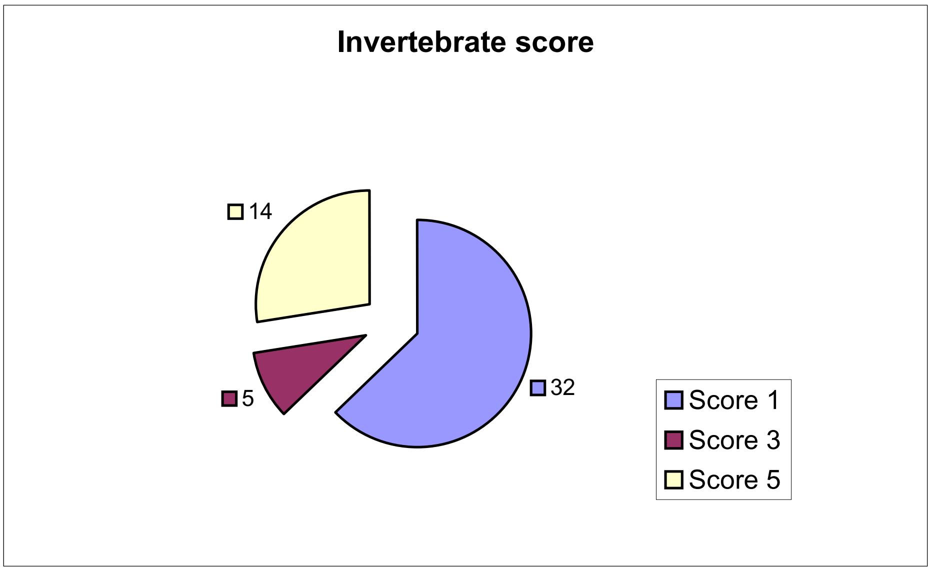


Figure 20-1. Invertebrate scores.

Thirty-two sites recorded low invertebrate trophic levels (eg Simmons Hill Wetlands), abundance and diversity. Five sites recorded an average invertebrate trophic level with low to medium abundance and diversity. Fourteen sites recorded a good trophic level with good diversity and abundance. Those sites that recorded a score of five (high) are listed below.

Wetland number	Wetland name	Catchment board
S2001	Woorabinda Lake	Onkaparinga
S2002	Stirling Park	Onkaparinga
S2022	Mount George Wetland	Onkaparinga
S2024	Mount George Wetland 2	Onkaparinga
S2027	Carey Gully Water Reserve	Torrens
S2031	Playford Lake	Patawalonga
S2034	Grasby Park	Onkaparinga
S2037	Humbug Dam 2	Northern Adelaide and Barossa
S2038	Barossa Reservoir	Northern Adelaide and Barossa
S2039	Lange Crescent	Torrens
S2061	Onkaparinga 3	Onkaparinga
S2072	Cooper Wetland	Patawalonga
S2069	Minno Creek Railway Dam	Patawalonga
S2051	Taworri Reserve	Northern Adelaide and Barossa

Table 20-1. Wetlands with high invertebrate scores.

20.4 Invertebrate Summary

Twenty-five families were recorded from the wetland survey. Four of the families identified were recorded at most wetlands surveyed. These four families consist of two classes, crustacea and insecta and are described below. Refer to Appendix 6 - Invertebrate records for wetlands surveyed.

Class: Crustacea

Family: Paramelitidae (11 records). Commonly refered to as Amphipods or scuds. Their habitat is generally stream dwellers and ponds. Trophic status is omnivores.

Family: Daphniidae (9 records). Commonly referred to as Cladocerans or water fleas. They are mostly less than 1 mm, and found in sheltered, vegetated areas of still or slow flowing freshwaters. The trophic status is detritivores and herbivores. Cladocerans are important food for zooplanktivorous fish. They have high nutritional value and are particularly rich in essential highly unsaturated fatty acids and natural antioxydants (Smirnov, 1992).

Class: Insecta

Family: Notoectidae (10 records). Often referred to as back swimmers. The most common genera recorded was *Anisops.* These insects are found in still waters and slow flowing creeks. They are active swimmers and fill the trophic level of carnivores.

Family: Chironomidae (6 records). Referred to as non-biting midges and bloodworms, Chironomids are found in the bottom debris or free in vegetation of all aquatic habitats. Their habit is a burrower and they have a trophic level of omnivores. The chironomidae family was common within the Parafield Wetlands.

Daphniopsis pusilla (*40X)*
Recorded at nine sites. Daphniidae provide an important food source for fish and other invertebrates.

Plate 6. Daphniopsis pusilla

Chironomidae, 40X (non-biting midges, bloodworms) Parafield Wetland in the Northern Adelaide and Barossa catchment recorded a high abundance of this family.

Plate 7. Chironomidae (above) and Anisops (below)

The genus *Anisops* is an active predator. This genera was recorded in 10 wetlands.

20.5 Amphibians

The most common frog recorded was the Common Froglet (*Crinia signifera*). One other frog, the Eastern Banjo Frog (*Limnodynastes dumerili*) was recorded at the Buffer Track Dam (Black Hill Conservation Park) and Lange Crescent Wetland at Birdwood.

The Eastern Banjo Frog is a common inhabitant of wetlands and rivers. The 2000 Frog Census recorded it in all habitats, with the exception of reservoirs (Walker 2001). The Buffer Track Dam provided particularly good habitat with *Typha domingensis* occupying the open water zone. This allows the Eastern Banjo Frog to lay the large foam nests that attach to emergent vegetation.

Egg foam nests located within *Typha domingensis.*

Buffer Track Dam, Black Hill Conservation Park.

Plate 8. Egg foam nests

The Common Froglet was recorded in some wetlands, generally observed as the tadpole form. This species was also the most commonly recorded frog during the 2000 Frog Census. The Froglet was recorded in every habitat type during the 2000 Frog Census except in reservoirs and most were recorded from dams and streams.

Carey Gully Water Reserve recorded a high abundance of the Common Froglets. The dense matting of *Juncus* provides excellent habitat for this frog.

Plate 9. Carey Gully Water Reserve

21.0 WATER CHEMISTRY

Chemical processes in permanent and temporary waters are extremely complex. The chemistry of the water directly influences the biological process such as photosynthesis. The physical features of the wetland also has a strong influence on both the chemical and biological processes. These three factors (chemical, physical and biological) are constantly in a state of movement and change. Changes in these parameters are most pronounced in temporary wetlands where a wetting and drying cycle occurs. The majority of wetlands within the Mount Lofty Ranges have seasonal water regimes, filling during winter and remaining dry throughout summer.

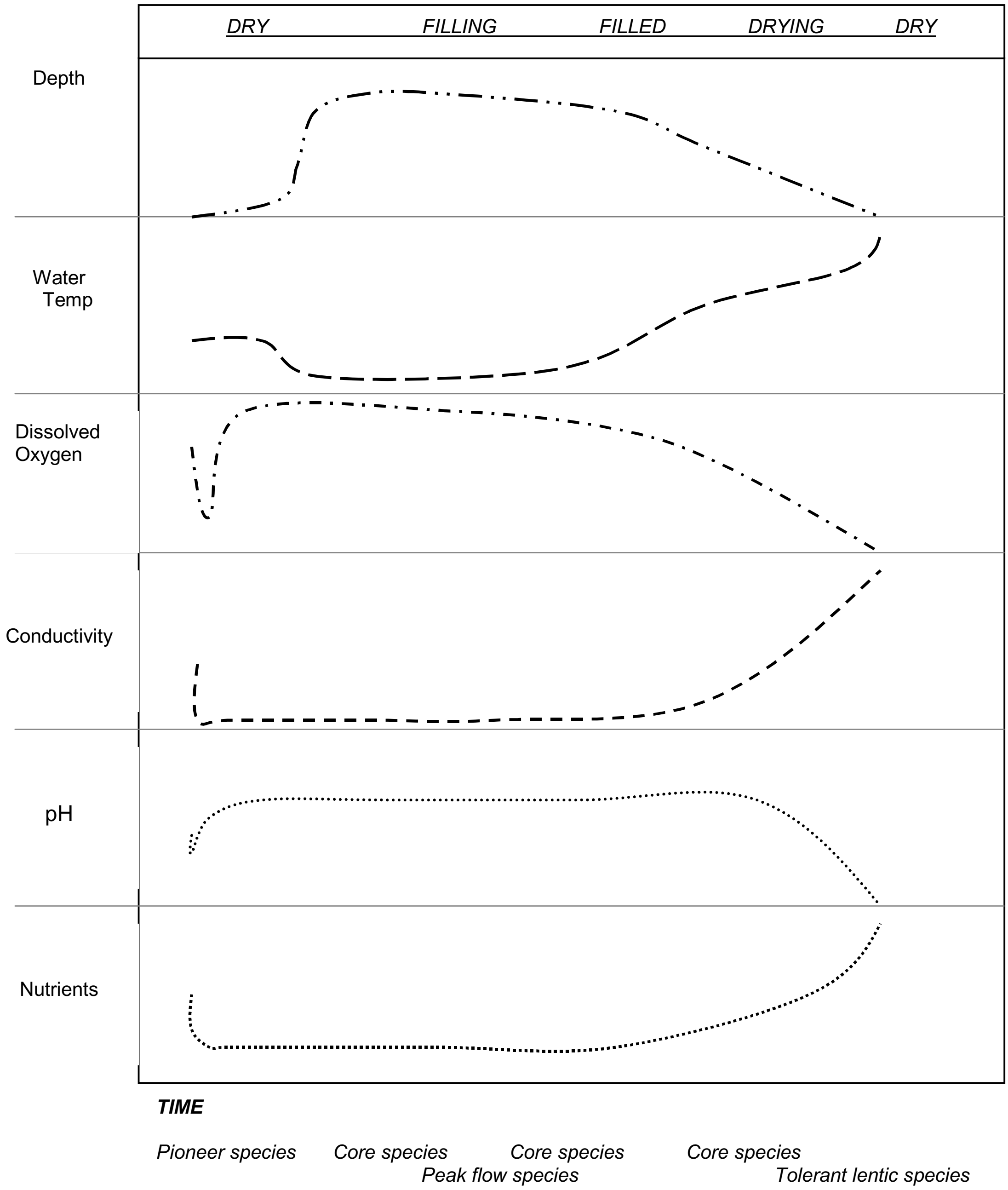


Figure 21-1. Temporary wetland cycles

Brock and Boulton (1999) states that changes in water quality during drying and filling depend on factors including:

1. sediment properties (composition, nutrients and organic content)
2. type of drawdown (gravity or evaporative)
3. severity of drying (rate of drying, temperature, weathering)
4. conditions of refilling (origin of water, degree of sediment disruption).

Figure 21-1 (Adapted from Boulton and Brock 1999) shows the changes in chemical variables over time during the phases of filling and drying in temporary wetlands. Seasonal changes in invertebrate composition is also noted.

21.1 pH

21.1.1 Background

The pH value of water indicates how acidic or alkaline it is on a scale 1-14. Acids have a low pH of about 2 for a strong acid like sulphuric acid and about 4 for a weak one like lactic acid. Alkalis have a high pH of about 12 for sodium hydroxide. Pure distilled water has a pH of 7 which is neutral. From pH 7 to 0, a liquid becomes increasing acidic and from pH 7 to 14, a liquid becomes increasingly alkaline.

Generally in South Australia, the pH of natural water ranges between 6.0 and 8.5 with most water bodies in the range 7.0-8.0. The higher pH of natural water bodies is caused by high bicarbonate levels in the water and can raise the pH during the day and lower pH at night. Chemicals entering the water can also affect the pH.

PH is an important environmental indicator. At extremely high or low pH values, the water becomes unsuitable for most organisms.

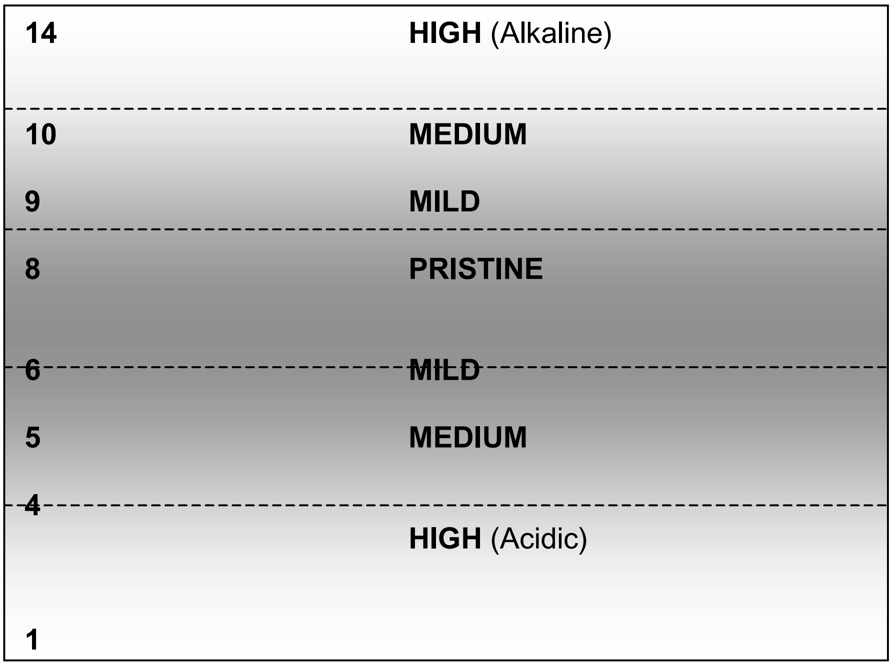


Figure 21-2. pH values

21.1.2 Analysis

The average pH of wetlands surveyed ranged between pH 7 and 8, which falls into a neutral pH value. This suggests that aquatic species within the wetlands surveyed are not severely affected by pH levels. Wetland site S2072 (Cooper Wetland) recorded the highest acidic reading with a pH of 4.34. Wetland site S2061 (Onkaparinga Wetland) recorded the highest alkaline reading (pH 9.32). These two sites interestingly had very different conductivity readings. Site S2072 (Copper Wetland) is considered to be fresh water (158 µs) and site S2061 (Onkaparinga Wetland) is marginally fresh to brackish (1060 µs).

21.2 Conductivity

21.2.1 Background

Salinity is a serious threat to aquatic ecosystems throughout Australia. The National Land and Water Resources Audit (2001) estimates that up to 41,300 kilometeres of streams could be salt affected by 2050 and that 24 of 79 river basins studies exceeded recommended salinity parameters.

Salinisation causes serious biological effects including:
- changes to the natural character of water-bodies
- loss of biodiversity
- less salt-tolerant species are replaced by more tolerant species.

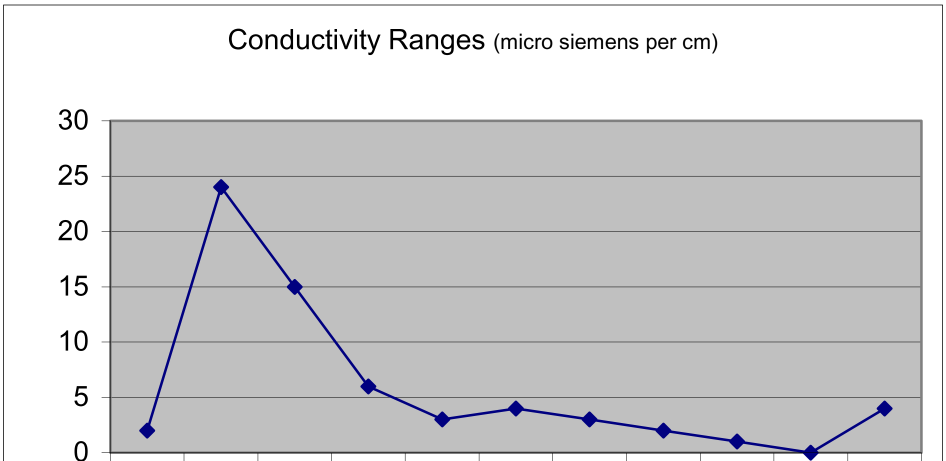
These effects can cause permanent degradation and ecosystem collapse (Williams, 2001). The loss of biodiversity is probably greater than generally realised since very little research has occurred in this area. Salinisation also leads to significant decreases in water quality for irrigation and water supply (leading to high economic costs); the loss of amenity and aesthetic values is also of concern.

Limited data are available for assessing the risk of adverse effects from salinity in different ecosystem types, particularly wetlands. The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2001) tables wetlands in South Australia with ‘no data’ related for assessing adverse effects of salinity. Guidelines developed for Western Australia state that lakes, reservoirs and wetlands should have a salinity range between 300-1500µs. Values at the lower end of the range are during rainfall events, those at the higher range are found in salt lakes and marshes.

Figure 21-3 is based on the salt measurement conversions guide from the Land Management Society Inc. (see www.space.net.au/~1msinfo). This guide indicates salinity levels and tolerance levels for different parameters. These guidelines form the basis of analysis for the Wetland Inventory.

Salinity in micro-siemens per cm µs/cm	Water definition	Guides
0	Fresh	0 = distilled water
100 - 900	Fresh	Fresh
900 - 2700	Marginal	Maximum for hot water systems, dam water starts to go clear, maximum for people.
3000 - 9100	Brackish	Maximum for milking cows and poultry, crop losses start.
9500 +	Salt	9.5 = Yabbie growth starts to slow, maximum for horses. 14.5 = Yabbie growth ceases

Table 21-1. Salinity guidelines.



No. of wetlands	0 - 99	100 - 199	200 - 299	300 - 399	400 - 499	500 - 599	600 - 699	700 - 799	800 - 899	900 - 999	1000 - 1999
	2	24	15	6	3	4	3	2	1	0	4

Figure 21-3. Conductivity ranges recorded in surveyed wetlands (µs/cm).

21.2.3 Analysis

The majority of wetlands fell within the 100 µs/cm to 199 µs/cm fresh water range (24 sites), with the remaining wetlands scattered across the fresh to brackish ranges. The lowest readings were recorded at Silky Tea Tree Swamp at Bridgewater 2µs/cm and at Rubida Grove at Aldgate 11µs/cm. The highest recording was 1480 µs/cm at Lewis Trail Wetland in Mount George Conservation Park. Other high recordings were at Parafield Wetlands (1350 µs/cm), Kangaroo Gully Wetland in Scott Creek Conservation Park (1184 µs/cm) and Para Wirra lake in Para Wirra Conservation Park recorded 1060 µs/cm. More research is required to understand the effects of salinity upon flora and fauna, in particular invertebrate fauna. Little is known regarding the range of tolerance levels that invertebrate's display. Research into these aspects would enable the development of conductivity ranges linked to biological indicators.

Plate 10. Lewis Trail Wetland

Lewis Trail Wetland in Mount George Conservation Park recorded the highest conductivity of 1480 µs/cm.

Plate 11. Silky tea-tree swamp

Silky Tea-Tree Swamp in Bridgewater recorded the lowest conductivity reading of 2.00µs/cm.

21.3 Turbidity

Turbidity is a measure of water clarity and can be affected by the amount of suspended particles of clay, silt, plankton, industrial wastes and sewage in water. Turbidity is caused by small particles suspended in water which are too small to settle out, but big enough to scatter light. At higher levels of turbidity, water loses its ability to support a diversity of aquatic organisms, and water becomes warmer as suspended particles absorb heat from the sun. Turbidity leads to less light penetrating the water, thereby decreasing photosynthesis, which in turn reduces dissolved oxygen concentrations. Suspended particles may also clog aquatic invertebrate appendages and fish gills, reduce growth rates, and prevent egg and larval development. The plant community structure and biomass in an ecosystem is determined by the light regime, in conjunction with nutrients and temperature. Changes in water clarity may produce changes in the dominant phytoplankton groups. A common result from increased clarity is a reduction in the primary productivity of systems. Changes to the primary producers will also effect the other trophic components of the ecosystem (Liston and Maher 1997).

Turbidity can have a significant effect on the microbiological quality of drinking-water. Its presence can interfere with the detection of bacteria in drinking-water. Turbid water has been shown to stimulate bacterial growth since nutrients are adsorbed on to particulate surfaces, thereby enabling the attached bacteria to grow more rapidly than those in free suspension. The major problem associated with turbidity is its effect on disinfection. High levels have been shown to protect microorganisms from the action of disinfectants and to increase the chlorine and oxygen demand. (http://www.who.int/water_sanitation_health/GDWQ/Chemicals/turbidity.htm).

Turbidity in water is measured in units called Nephelometric Turbidity Units (NTU's). It is calculated by measuring the dispersion of a light beam passed through a sample of water. Fine particles, silt, and suspended matter will cause a light beam passing through the water to be scattered. It has been found that the amount of scattering is proportionate to the amount of turbidity present. Therefore, this process gives a good indication of the relative turbidity of a water sample.

The measurement of NTU does not give the sizes of the particles, nor does it indicate the amount of particles present. It is a qualitative, rather than quantitative way of measuring turbidity.

21.3.1 Background

To understand the results fully, information about the natural levels of turbidity within all the survey wetlands at various times of the year is really required. This is important because normal levels of turbidity can vary greatly in wetlands from clear flowing zones to murky areas. Natural variations are also related to flow events such as floods, winter rains, road run-off which can increase levels dramatically.

The *Australian Water Quality Guidelines for Fresh and Marine* Waters do not set a turbididty guideline for the protection of aquatic ecosystems, but recommends that increases in suspended solids should be less than 10% of the seasonal mean NTU. This reinforces the need to ascertain the natural turbidity levels within waterbodies in the Mount lofty Ranges. Bek and Robinson (1991) also suggest that turbidity below 50 NTU is suitable for protecting aquatic animals and plants. The 2000 update of *Australian Guidelines for Water Quality Monitoring* does provide some turbidity ranges for South-Central Australia. These ranges however are so broad they cannot be used as a measure against the Wetland Inventory turbidity results for the Mount Lofty Ranges.

The New South Wales Environmental Protection Agency (EPA) has developed the following general guidelines for turbidity. These guidelines provide a useful method for comparing the turbidity values collected during the Wetland Inventory.

- good (< 5 NTU)
- fair (5-50 NTU)
- poor (> 50 NTU)

Refer to: http://www.epa.nsw.gov.au/soe/97/ch3/11.htm for more information.

The National Advisory Committee to Water on the Web has developed regional trends of fresh water fish activity against turbidity values and time (Figure 21-5).
(See: http://wow.nrri.umn.edu/wow/under/parameters/turbidity.html for more information)
These trends correspond well with those guidelines developed by the NSW EPA, mentioned above.

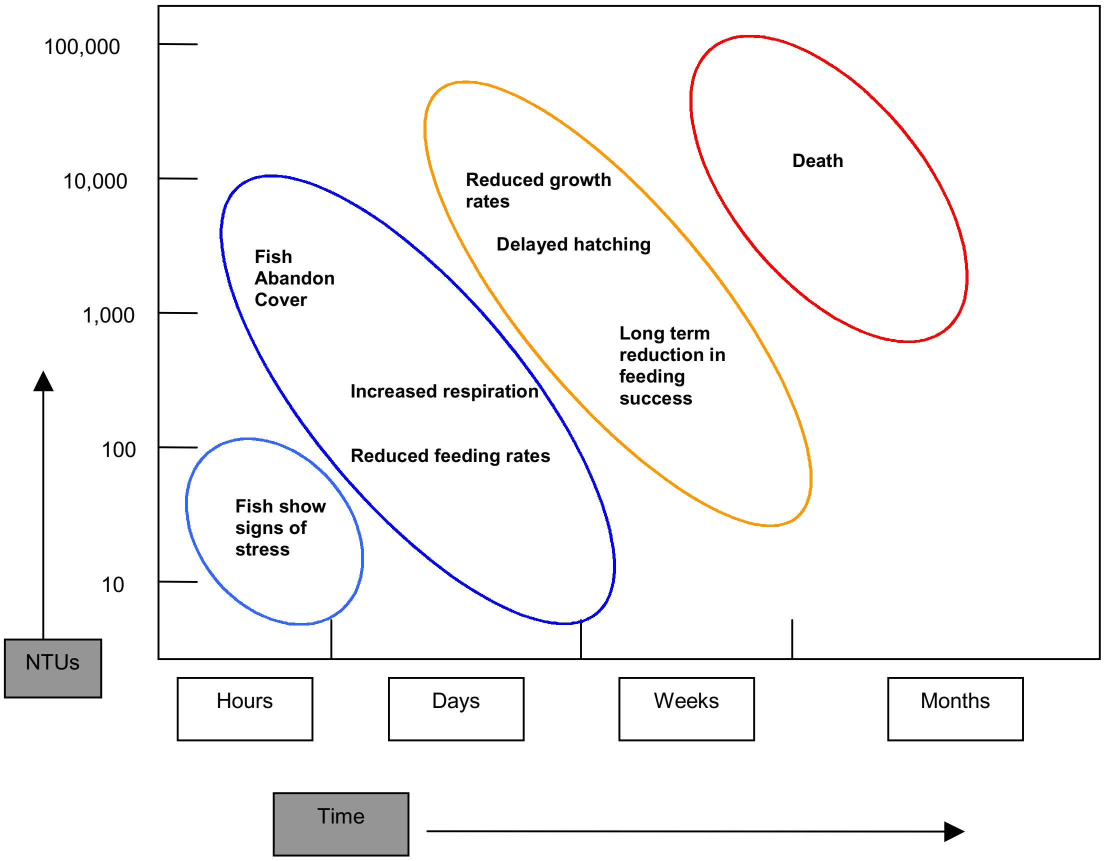


Figure 21-4. Fish activity against turbidity values and time

21.3.2 Analysis

Table 21-1 shows the number of surveyed wetlands against the turbidity guidelines developed by the NSW EPA. The majority fell within the fair range (43 sites) and 15 sites recorded good turbidity values. Eight sites recorded poor turbidity values. The highest readings were recorded from Nurrutti Reserve in Aldgate (98.00 NTU) and were due to the shallow water which was mixed with fine sediments, a natural and normal occurrence. The lowest recording (0.10 NTU) was at Radebone Dam 2, located on private property at Bridgewater.

Guideline	NTUs	Number of Wetlands
Good	<5	15
Fair	5-50	43
Poor	>50	8

Table 21-2. Turbidity guidelines.

21.4 Water Temperature

21.4.1 Background

Many of the physical, biological and chemical characteristics of a wetland are directly affected by temperature and water level. Temperature affects the solubility of oxygen in water with warmer water holding less oxygen than cooler water. These factors affect the rate of photosynthesis by algae and larger water plants, with warm water being susceptible to eutrophication and therefore algal blooms. The sensitivity of organisms to toxic waste, parasites and diseases is also related to water temperature. Organisms can become stressed as temperatures rise and become less resilient to other stresses. This results in most aquatic organisms having a narrow temperature range in which they can function effectively.

Most aquatic organisms are cold-blooded which means they are unable to internally regulate their core body temperature. Therefore, temperature exerts a major influence on the biological activity and growth of aquatic organisms. To a point, the higher the water temperature, the greater the biological activity. Fish, insects, zooplankton and other aquatic species all have preferred temperature ranges. As temperatures get too far above or below this preferred range, the number of individuals of the species decreases until finally there are few, or none.

The most obvious reason for temperature change in lakes is the change in seasonal air temperature. Daily variation also may occur, especially in the surface layers, which are warm during the day and cool at night. In deeper lakes (typically greater than 5m for small lakes and 10m for larger ones) during summer, the water separates into layers of distinctly different density caused by differences in temperature, this process is called thermal stratification.

When the surface water cools again to approximately the same temperature as the lower water, the stratification is lost and the wind can turbulently mix the two water masses together because their densities are so similar. A similar process also may occur during the spring as colder surface waters warm to the temperature of bottom waters and the lake mixes. The lake mixing associated with a turnover often corresponds with changes in many other chemical parameters and this can affect biological communities (The National Advisory Committee to Water on the Web 2001).

For aquatic systems the maximum recommended increase in the natural temperature range of any inland or marine water is 2^0C, (Waterwatch Manual 1994). Because the Wetland Inventory has recorded the first readings for many wetlands, this natural temperature range is largely unknown. As a general guide temperatures between zero and 20 degrees are acceptable limits for Mediterranean climates. Temperatures over 20 degrees can start impacting on aquatic fauna and fauna.

21.4.2 Analysis

The water temperature range for most sites is between 12 and 17 degrees centigrade. Eighteen sites recorded temperatures between 6 and 11 degrees. Nine sites recorded temperatures above 18 degrees, with 26 degrees being the highest recorded temperature at the Onkaparinga Estuary. Temperature readings are required over several time periods and during different seasons to attain a true indication of temperature regimes for wetlands in the Mount Lofty Ranges.

Plate 12. One of the wetlands in the Onkaparinga Estuary complex.
Note the absence of vegetation cover over the water and the shallow water depth indicated by the level banks. The water temperature for this wetland was 26 degrees the highest recorded in the Wetland Inventory.

21.5 Dissolved oxygen

21.5.1 Background

Adequate concentrations of dissolved oxygen are necessary for the life of fish and other aquatic organisms. Dissolved oxygen levels (DO) are considered the most important and commonly employed measurement of water quality and indicator of a water body's ability to support aquatic life. Levels above 5 milligrams per litre (mg O_2/L) are considered optimal and most fish cannot survive for prolonged periods at levels below 3 mg O_2/L.

Seasonal changes affect dissolved oxygen concentrations. For example, warmer temperatures during summer speed up the rates of photosynthesis and decomposition. Pollution can also cause a decrease in dissolved oxygen concentrations.

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000) states that there is very little data on oxygen tolerances of Australian aquatic organisms. The 1992 ANZECC guidelines recommended that dissolved oxygen should not fall below 6 mgL. The National Science Foundation in America has developed the following guidelines for tolerance levels for aquatic invertebrates. These guidelines provide a means to analyse the survey results.

No production impairment	8 mgL
Moderate production impairment	5 mgL
Limit to avoid acute mortality	4 mgL

21.5.2 Analysis

Thirteen sites recorded dissolved oxygen levels below 4 mgL (eg Parafield Wetlands). Thirty-four sites recorded dissolved oxygen levels between 5 and 7 mgL (eg Playford Lake), and 17 sites recorded dissolved oxygen levels of 8 mgL or higher, (eg Washpool Lagoon).

It appears that certain groups of invertebrates can survive with dissolved oxygen levels lower than 5 – 4 mgL. Several wetlands surveyed such as Mount George Wetland 2, had good trophic levels and low dissolved oxygen levels. This survey was however only a snapshot and further research is required to determine dissolved oxygen guidelines for wetlands in the Mount Lofty Ranges.

22.0 RAPID ASSESSMENT

The rapid assessment component of the survey provides a quick snap shot of the condition within different riparian habitats. This score is a subjective one given by the observer. It is an estimate of the percentage of intact native vegetation and the diversity and abundance of aquatic flora and fauna.

22.1 Aquatic Fauna

This is a subjective score according to the abundance and diversity of invertebrates, fish and birds located within the waterbody.

- Low (1) refers to no fish or birds with little or no invertebrate presence,
- Moderate (3) refers to some bird presence and good vertebrate abundance, fish usually are not present
- High (5) indicates good bird and invertebrate diversity and abundance with the presence of fish.

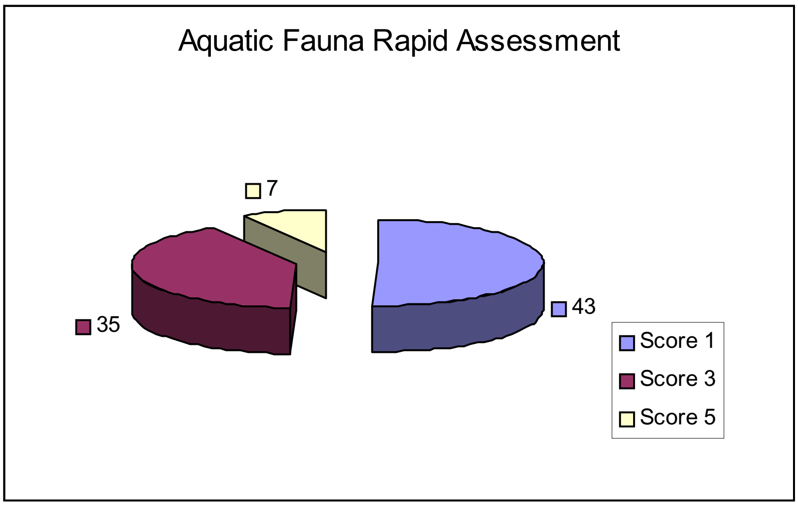


Figure 22-1. Aquatic Fauna Rapid Assessment

Forty-three sites (eg Kangaroo Gully 1 and Bushland Park Lake) recorded a score of one indicating a low observed aquatic fauna presence. Thirty-five sites (eg Centennial Drive Swamp and Radbone Road Dam) recorded moderate aquatic fauna, and seven sites recorded high aquatic fauna present. These sites are listed below:

Wetland Number	Wetland Name	Catchment Board
S2001	Woorabinda Lake	Onkaparinga
S2013	Parafield Wetland	Northern Adelaide and Barossa
S2014	Parafield Wetland	Northern Adelaide and Barossa
S2022	Mount George Wetland	Onkaparinga
S2026	HK Fry Reserve	Onkaparinga
S2038	Barossa Reservoir	Northern Adelaide and Barossa
S2057	Washpool Lagoon	Onkaparinga

Table 22-1. Wetlands with high invertebrate diversity.

22.2 Aquatic flora

The rapid assessment for aquatic flora records the abundance and diversity of aquatic vegetation. The following scoring method has been developed:

- Low (1) indicates no or very little aquatic vegetation.
- Moderate (3) indicates some aquatic vegetation cover either in the form of floating or rooted vegetation.
- High (5) indicates good diversity of aquatic vegetation with a range of rooted vegetation such as reeds and rushes and floating vegetation such as water ribbons.

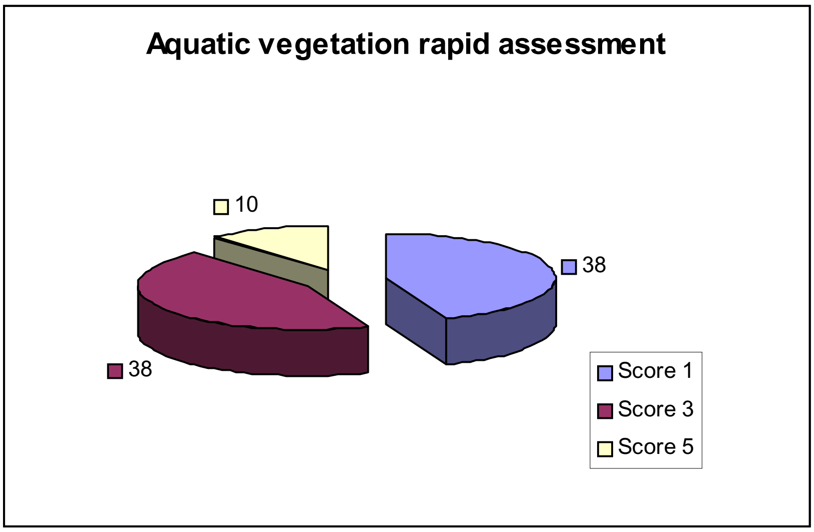


Figure 22-2. Aquatic Flora Rapid Assessment

Thirty-eight wetlands scored both low and moderate, with 10 sites scoring high abundance and diversity of aquatic vegetation classes. There is a clear connection between wetland sites with a high abundance and diversity of vegetation and wetlands with high invertebrate diversity. Woorabinda Lake, Parafield Wetland, Barossa Reservoir and Washpool Lagoon recorded a high diversity of aquatic vegetation and a high invertebrate diversity.

23.0 Riparian Vegetation Rapid Assessment

Riparian native vegetation is assessed in three zones. These are the toe of bank (low water to high water), bank (high water mark to buffer) and buffer (top of the bank to the buffer which can extend between 10 metres and 100 metres). The vegetation association for each zone consists of the dominant or co-dominant overstorey species and understorey species. The vegetation association for each zone is scored on the basis of the level of disturbance and vegetation cover within each zone.

The vegetation association scoring system consists of:

- Degraded or no vegetation (1) with less than 30% vegetation cover, and a high level of disturbance
- Natural (3) between 30 – 75% vegetation cover, with little disturbance,
- Intact (5) over 75% vegetation cover with little or no disturbance.

23.1 Analysis - Toe of bank

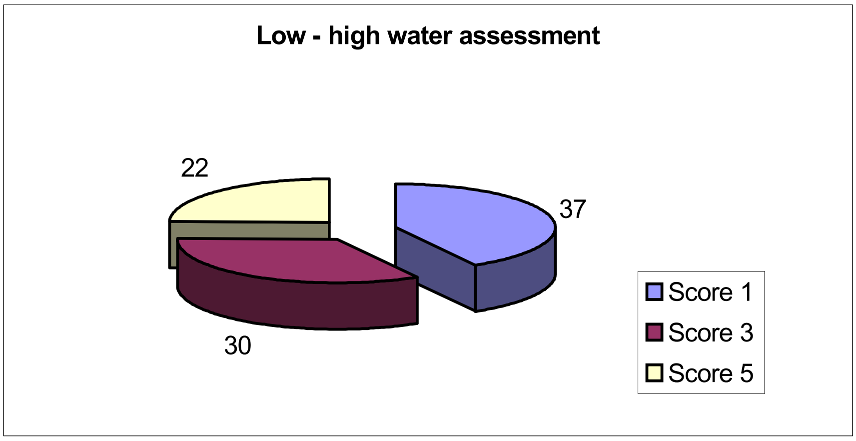


Figure 23-1. Rapid Assessment, Low – high water.

Thirty-seven sites scored as having a degraded low to high water zone, 30 sites had a natural cover and 22 sites scored an intact low to high water zone.

23.2 Bank

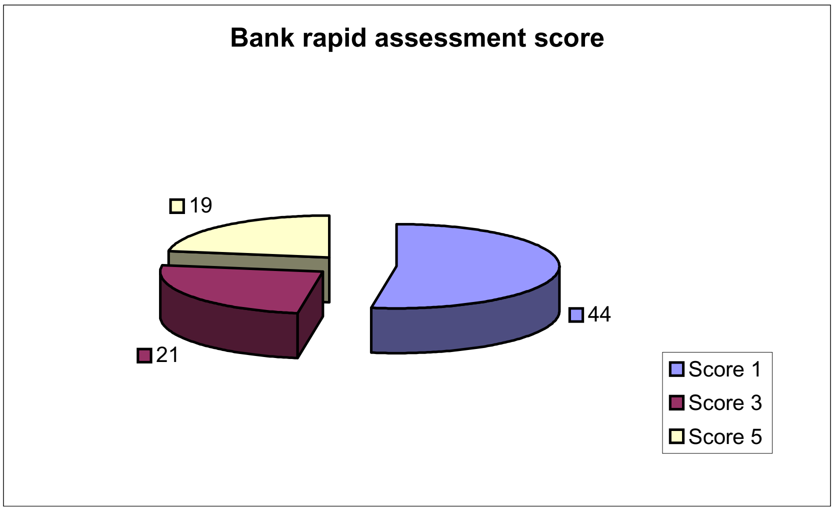


Figure 23-2. Rapid Assessment, Bank

Forty-four sites recorded as having degraded banks, 21 sites had banks in a natural condition and 19 sites had banks that are intact.

23.3 Buffer

Forty sites had a degraded buffer surrounding the wetland (eg Nicol Bog), 19 sites received a natural score and 25 sites had an intact buffer score. Many of the sites with an intact buffer are located within the National Parks reserve system (eg Wilsons Bog in Cleland Conservation Park).

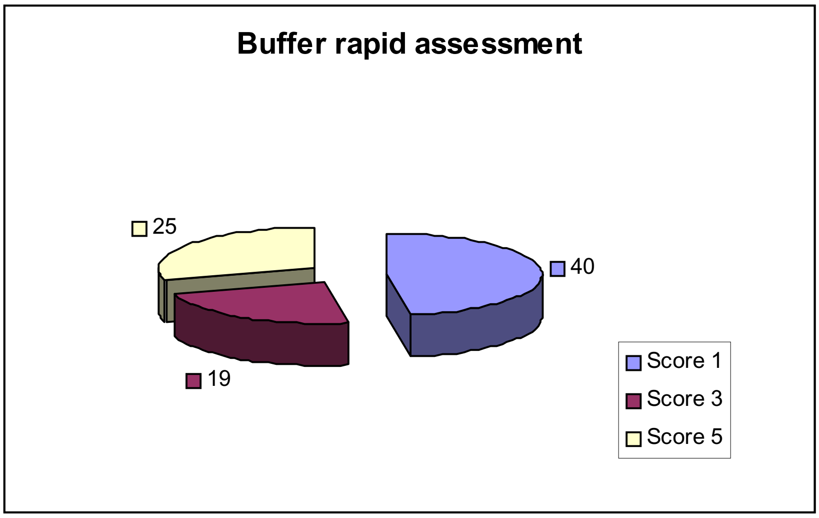


Figure 23-3. Rapid Assessment, Buffer

Plate 13. Nicol Bog.

Nicol Bog in the Northern Adelaide and Barossa Catchment area is an example of a degraded buffer surrounding a wetland area.

24.0 WETLAND CONDITION SCORE

The wetland score reflects the previous rapid assessment scores for aquatic fauna, aquatic vegetation and riparian vegetation values. The combination of these values and the interpretation of other parameters recorded during the survey (such as land degradation and water chemistry) form the basis of the wetland condition score.

The wetland score consists of:

- Degraded (1) those sites that have a high level of disturbance and received low rapid assessment scores.
- Natural (3) those sites that have little disturbance, received moderate to high rapid assessment scores and that are sites usually located within National Parks and Wildlife reserves or are managed on private lands for conservation purposes.
- Intact (5) those sites with no obvious sign of disturbance, scored very highly in the rapid assessment process and are formally conserved within National Parks and Wildlife reserves.

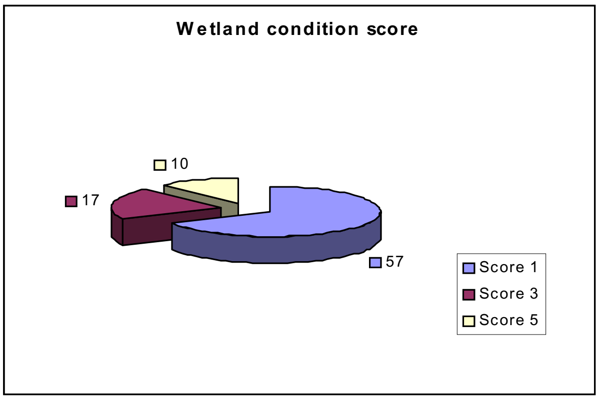


Figure 24-1. Wetland score

Ten wetland sites were scored as intact, 17 sites were scored as wetlands in a natural state and the rest of the wetlands surveyed (57) were scored as degraded, indicating high levels of disturbance. Those sites that received a score of five (intact) are listed below.

Wetland Name	Locality	Catchment
Nurutti Reserve	Aldgate	Onkaparinga Catchment Board
Wilsons Bog	Cleland CP	Torrens Catchment Board
Kangaroo Gully 2	Scott Creek Conservation Park	Onkaparinga Catchment Board
Heptinstalls Spring	Cleland CP	Torrens Catchment Board
Englebrook Reserve	Bridgewater	Onkaparinga Catchment Board
Eurilla Bog	Cleland CP	Onkaparinga Catchment Board
Chinamans Bog	Cleland CP	Torrens Catchment Board
Cleland Eastern Bog	Cleland CP	Onkaparinga Catchment Board
HK Fry Reserve	Crafers	Patawalonga Catchment Board
Oak Avenue Bog	Bridgewater	Onkaparinga Catchment Board

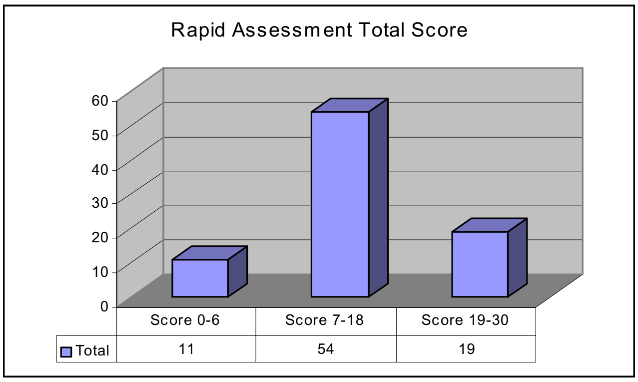
Table 24-1.Wetlands with high condition scores

25.0 Rapid assessment total score

The total score provides an indication of the environmental attributes of wetlands surveyed. These values are an interpretation of the biological, chemical and physical parameters. This score consist of a tally from all the rapid assessment scores, including the wetland condition scores.

- 0 – 6 low wetland values
- 7 – 18 moderate wetland values
- 19 – 30 high wetland values

These scores provided a quick means of assessing the environmental attributes of wetlands based on survey parameters. Those wetlands scoring high wetland scores should be more closely examined in terms of land ownership, placement within the landscape and the likely success of monitoring and protective measures.



The majority of sites surveyed recorded moderate wetland values (54 sites), 11 sites recorded none or very low wetland values. Nineteen sites recorded high wetland values.

Figure 25-1. Rapid assessment scores.

25.1 Wetlands with high rapid assessment scores

The following table lists the 19 wetlands that received high rapid assessment scores (between 19-30). Ten of these wetlands are managed by the Department for Environment and Heritage.

Wetland site number	Wetland name	Management Authority
S2001	Woorabinda Lake	Adelaide Hills Council
S2009	Nurutti Reserve	National Trust of South Australia
S2011	Kangaroo Gully 2	Department for Environment and Heritage
S2013	Parafield Wetlands	Department for Transport and Regional Services
S2021	Englebrook Reserve	National Trust of South Australia
S2025	Heron Reserve	Adelaide Hills Council
S2026	HK Fry Reserve	National Trust of South Australia
S2028	Chinamans Bog	Department for Environment and Heritage
S2029	Wilsons Bog	Department for Environment and Heritage
S2030	Heptinstalls Spring	Department for Environment and Heritage
S2038	Barossa Reservoir	Department for Environment and Heritage
S2046	Botanic Dam	Department for Environment and Heritage
S2053	Kenneth Dam	Private land adjacent to Wotton Scrub
S2055	Prickly Tea -Tree Swamp	Department for Environment and Heritage
S2058	Aldinga Scrub Wetland	Department for Environment and Heritage
S2068	California Road Wetland	Private
S2076	Eurilla Bog	Department for Environment and Heritage
S2077	Cleland Eastern Bog	Department for Environment and Heritage
S2081	Kersbrook Wetland	Private

Table 25-1. Wetland with high rapid assessment scores.

26.0 ANZECC WETLAND CRITERIA

These criteria are used for determining nationally important wetlands in Australia and forms the basis for the inclusion in the Directory for Important Wetlands. These criteria are those agreed to by the ANZECC Wetlands Network in 1994.

A wetland may be considered nationally important if it meets at least one of the following criteria:

1. *It is a good example of a wetland type occurring within a biogeographic region in Australia.*

2. *It is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.*

3. *It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail.*

4. *The wetland supports 1% or more of the national populations of any native plant or animal taxa.*

5. *The wetland supports native plant or animal taxa or communities which are considered endangered or vulnerable at the national level.*

6. *The wetland is of outstanding historical or cultural significance.*

Many of the sites in the Directory meet more than one of the criteria. Application of the criteria to individual wetland sites involves a degree of subjectivity. Aspects of a site's significance can be interpreted differently by different surveyors, and information gaps often exist which make it difficult to judge whether or not a site meets a particular criterion.

The Interim Biogeographic Regionalisation for Australia (IBRA) is used as the framework for applying Criterion 1, which identifies wetlands that are unique or representative within a biogeographic region in Australia.

26.1 Analysis

Fourteen wetland sites have recorded one or more ANZECC classifications. The most common classification is Criteria 1 (*good example of a wetland type occurring within a biogeographic region in Australia)* with all 14 sites recording this. Five sites recorded more than one criterion.

Wetland Number	Catchment Board	Wetland Name	ANZECC Criteria
S2013	Northern Adelaide and Barossa	Parafield Wetland	1
S2021	Onkaparinga	Englebrook Reserve	1
S2026	Onkaparinga	HK Fry Reserve	1
S2028	Torrens	Chinamans Bog	1,3,5
S2029	Torrens	Wilsons Bog	1,3,5
S2030	Torrens	Heptinstalls Spring	1,3,5
S2041	Onkaparinga	Silky Tea-Tree Swamp	1
S2042	Onkaparinga	Ingram Swamp	1
S2055	Onkaparinga	Prickly Tea-Tree Swamp	1
S2057	Onkaparinga	Washpool Lagoon	1
S2060	Onkaparinga	Onkaparinga 2	1,2
S2068	Onkaparinga	California Road Wetland	1
S2076	Onkaparinga	Eurilla Bog	1,3,5
S2077	Onkaparinga	Cleland Eastern Bog	1

Table 26-1. Wetlands with ANZECC Criteria.

Chinamans Bog, Wilsons Bog, Heptinstalls Spring and Cleland Eastern Bog provide habitat for populations of the Southern Brown Bandicoot (*Isodon obesulus*) which is endangered at a national level and vulnerable at a State and regional level. This conforms to ANZECC Criteria 5. Criteria 3 (*It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail*) has also been listed although it cannot be substantiated at this stage. It is assumed that these areas are of great importance during times of drought and other adverse conditions such as wildfires. Some of these bogs contain freshwater springs and stay moist throughout the year.

Criterion 1 has been recorded for all these sites because each one is located within a unique landform and contain vegetation associations which are confined in a regional setting. Sites such as Parafield Wetland, Washpool Lagoon and California Road Wetland are unique due to their location and rarity within the landform and the associated aquatic and semi-aquatic plants that occur at these sites.

27.0 WETLAND TYPES

The definition of a wetland used in the survey is one adopted by the Ramsar Convention under Article 1.1.

> *"Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent of temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres."*

Within this definition, the wetland classification system used in the Directory of Important Wetlands identifies 40 different wetland types in three categories: A-Marine and Coastal Zone wetlands, B-Inland wetlands, and C-Human-made wetlands. This wetland survey does not include Category A – Marine and Coastal Zone wetlands .
The system is based on that used by the Ramsar Convention in describing Wetlands of International Importance, but was modified slightly to suit the Australian situation.

For the purposes of this wetland inventory a category has been included which documents artificial wetlands that have conservation values. This is classified as C10.

A – Marine and Coastal Zone wetlands

1. Marine waters - permanent shallow waters less than six metres deep at low tide, includes sea bays straits
2. Subtidal aquatic beds, includes kelp beds, sea-grasses, tropical marine meadows
3. Coral reefs
4. Rocky marine shores, includes rocky offshore islands, sea cliffs
5. Sand, shingle or pebble beaches, includes sand bars, spits, sandy islets
6. Estuarine waters, permanent waters of estuaries and estuarine systems of deltas
7. Intertidal mud, sand or salt flats
8. Intertidal marshes, includes salt marshes, salt meadows, saltings, raised salt marshes, tidal brackish and freshwater marshes
9. Intertidal forested wetlands, includes mangrove swamps, nipa swamps, tidal freshwater swamps forests
10. Brackish to saline lagoons and marshes with one or more relatively narrow connections with the sea
11. Freshwater lagoons and marshes in the coastal zone
12. Non tidal freshwater forested wetlands

B – Inland wetlands

1. Permanent rivers and streams includes waterfalls
2. Seasonal and irregular rivers and streams
3. Inland deltas(permanent)
4. Riverine floodplains, includes river flats, flooded river basins, seasonally flooded grassland, savanna and palm savanna
5. Permanent freshwater lakes (8 ha) includes large oxbow lakes
6. Seasonal/intermittent freshwater lakes (>8 ha) floodplain lakes
7. Permanent saline /brackish lakes
8. Seasonal/intermittent saline lakes
9. Permanent freshwater ponds (<8 ha) marshes and swamps on inorganic sols, with emergent vegetation waterlogged for at least most of the growing season
10. Seasonal/intermittent freshwater ponds and marshes on inorganic soils includes sloughs, potholes, seasonally flooded meadows, sedge marshes
11. Permanent saline/brackish marshes
12. Seasonal saline marshes
13. Shrub swamps, shrub dominated freshwater marsh, shrub carr, alder thicket on inorganic soil
14. Freshwater swamp forest, seasonally flooded forest, wooded swamps, on inorganic soils
15. Pearlands, forest, shrubs or open bogs
16. Alpine and tundra wetlands: includes alpine meadows, tundra pools, temporary waters from snow melt
17. Freshwater springs, oasis and rock pools
18. Geothermal wetlands
19. Inland, subterranean karst wetlands

C- Human-made wetlands

1. Water storage areas; reservoirs, barrages, hydro-electric dams, impoundment's (generally over 8 ha).
2. Ponds; includes farm ponds, stock ponds, small tanks; (generally below 8 ha).
3. Aquaculture ponds; fish ponds shrimp ponds
4. Salt exploitation, salt pans, salines
5. Excavations; gravel pits; borrow pits, mining pools.
6. Wastewater treatment areas; sewage farms, settling ponds, oxidation basins.
7. Irrigated land; includes irrigation channels and rice fields, canals, ditches
8. Seasonally flooded arable land, farm land
9. Canals
10. Artificial wetlands with conservation values, Includes constructed wetlands and dams

27.1 Analysis

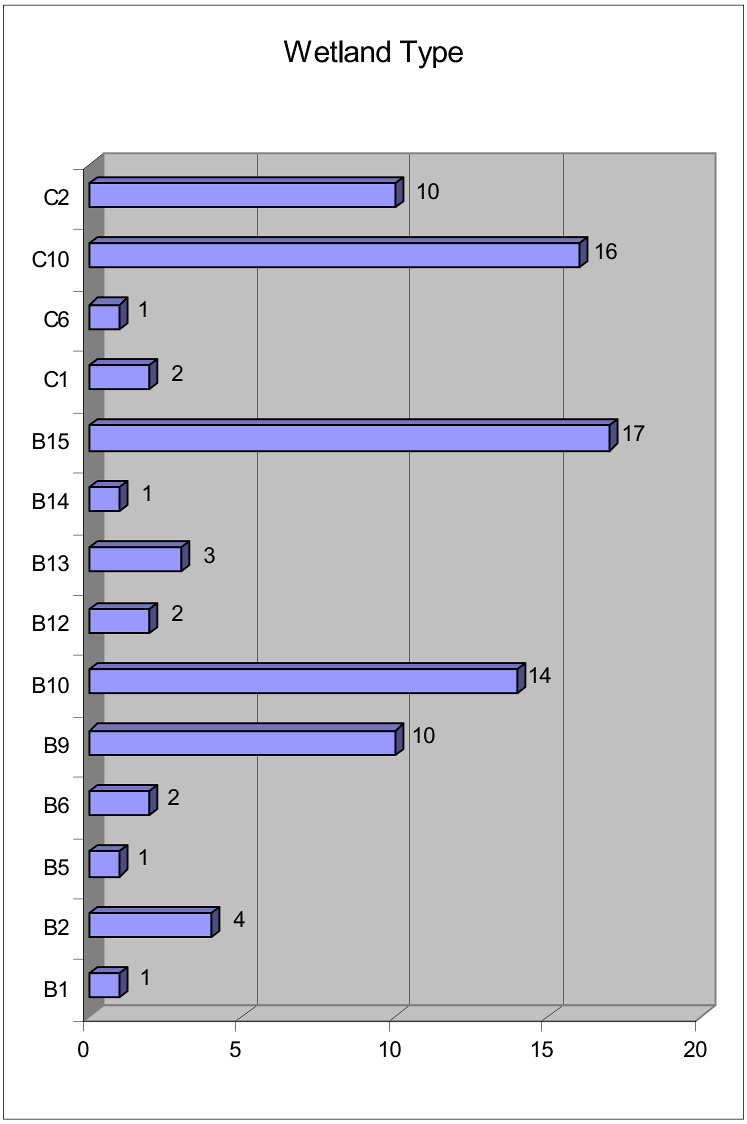


Figure 27-1. Wetland Types in the Mount Lofty Ranges

The most common wetland type was B15 'peatlands, forest, shrub or open bogs' (17 sites). The second most frequently recorded was C10 'artificial wetlands with conservation values' (16 sites). This classification includes constructed wetlands and disused dams that now have conservation values.

Woorabinda Lake, Stirling. Wetland Type C10 (constructed waterbody with conservation values).

Plate 14. Woorabinda Lake.

Englebrook Reserve, Bridgewater. Wetland Type B15 (peatland, forest, shrub or open bog)

Plate 15. Englebrook Reserve.

Kenneth Dam, Carey Gully. Wetland type C10 (Constructed waterbody with conservation value)

Plate 16. Kenneth Dam.

SECTION THREE WETLAND MONITORING

28.0 INTRODUCTION

There are three important steps in developing monitoring protocols that can be applied effectively within the South Australian wetland management context.

These consist of:

1. Identification of wetland values (collating and collecting existing information and undertaking baseline surveys)
2. Identification of wetland threats (from the analysis of wetland values)
3. Development of monitoring indicators that highlight early changes in ecological Character.

> *"Monitoring essentially means the keeping of a continual record of certain parameters, advising whether they are being maintained within prescribed limits and warning if undesirable changes occur" (Hart 1980).*

Finlayson and Eliot (2001) expand on this definition by emphasising that the information derived from monitoring provides a platform on which management actions are both based and judged.

Finlayson and Mitchell (1999) identified the following five major reasons for monitoring wetlands:

- To characterise variations in responses of wetlands to natural variability in the environment;
- To collect baseline data on wetlands as part of inventory processes;
- To record ecological changes that may be occurring as a result of specific natural or anthropogenic events;
- To measure progress toward set objectives of a management program; and
- To audit the performance of management agencies and land users.

28.1 Ecological change

The Ramsar Convention for Internationally Important Wetlands states that in order to record ecological change, the ecological character needs to be defined. Once defined it is possible to monitor for changes in ecological character.

Ecological character is the combination of the biological, physical, and chemical components of the wetland ecosystem, and their interactions, which maintain the wetland and its products, functions and attributes. The process of completing a wetland inventory assists in establishing the ecological character for wetlands surveyed.

The change in ecological character is the impairment or imbalance in any biological, physical, or chemical components of the wetland ecosystem, or in their interactions, which maintain the wetland and its products, functions and attributes. (www.ramsar.org/key_guide_list_e.html).

The Ramsar Convention provides detailed guidelines for monitoring the ecological character of wetlands. These include guidelines for initiating and conducting a risk assessment framework. The Ramsar risk assessment framework consists of six steps These are:

Step 1 - Identification of the problem. This is the process of identifying the nature of the problem and developing a plan for the remainder of the risk assessment based on this information. It defines the objectives and scope of, and provides the foundation for, the risk assessment. In the case of a chemical impact, it would include obtaining and integrating information on the characteristics (for example, properties, known toxicity) and source of the chemical, what is likely to be affected, and how is it likely to be affected, and importantly, what is to be protected.

Step 2 - Identification of the adverse effects. This step evaluates the likely extent of adverse change or impact on the wetland. Such data should preferably be derived from field studies, as field data are more appropriate for assessments of multiple impacts, such as occur on many wetlands. Depending on the extent of adverse change and available resources, such studies can range from quantitative field experiments to qualitative observational studies. For chemical impacts, on-site ecotoxicological bioassays constitute appropriate approaches, whereas for changes caused by weeds or feral animals, on-site observation and mapping may be all that is required.

Step 3 - Identification of the extent of the problem. This step estimates the likely extent of the problem on the wetland of concern by using information gathered about its behaviour and extent of occurrence elsewhere. In the case of a chemical impact, this includes information on processes such as transport, dilution, partitioning, persistence, degradation, and transformation, in addition to general chemical properties and data on rates of chemical input into the environment. In the case of an invasive weed, it might include detailed information on its entry into an ecosystem, rate of spread and habitat preferences. While field surveys most likely represent the ideal approach, use of historical records, simulation modeling, and field and/or laboratory experimental studies all represent alternative or complementary methods of characterising the extent of the problem.

Step 4 - Identification of the risk. This involves integration of the results from the assessment of the likely effects with those from the assessment of the likely extent of the problem, in order to estimate the likely level of adverse ecological change on the wetland. A range of techniques exist for estimating risks, often depending on the type and quality of the likely effects and their extent. A potentially useful technique for characterising risks in wetlands is via a GIS-based framework, whereby the results of the various assessments are overlaid onto a map of the region of interest in order to link effects to impact. In addition to estimating risks, such an approach would also serve to focus future assessments and/or monitoring on identified problem areas.

Step 5 - Risk management and reduction**.** This is the final decision-making process and uses the information obtained from the assessment processes described above, and it attempts to minimize the risks without compromising other societal, community or environmental values. In the context of the Ramsar Convention, risk management must also consider the concept of *wise use* and the potential effects of management decisions on this. The result of the risk assessment is not the only factor that risk management considers; it also takes into account political, social, economic, and engineering/ technical factors, and the respective benefits and limitations of each risk-reducing action. It is a multidisciplinary task requiring communication between site managers and experts in relevant disciplines.

Step 6 - Monitoring**.** Monitoring is the last step in the risk assessment process and should be undertaken to verify the effectiveness of the risk management decisions. It should incorporate components that function as a reliable early warning system, detecting the failure or poor performance of risk management decisions prior to serious environmental harm occurring. The risk assessment will be of little value if effective monitoring is not undertaken. The choice of endpoints to measure in the monitoring process is critical. Further, a GIS-based approach will most likely be a useful technique for wetland risk assessment, as it incorporates a spatial dimension that is useful for monitoring adverse impacts on wetlands.

29.0 MONITORING PROTOCOLS AND INDICATORS

The underlying concept of indicators is that adverse effects can be detected before actual environmental impacts occur. While such a 'early warning' may not necessarily provide firm evidence of larger scale environmental degradation, it provides an opportunity to determine whether intervention or further investigation is warranted.

Early warning indicators can be defined as:

> *"The measurable biological, physical or chemical responses to a particular stress, preceding the occurrence of potentially significant adverse effects on the system of interest".* (http://ramsar.org/key_guide_risk_e.htm)

Typically, indicators are ecological communities or assemblages of organisms, habitat or keystone-species. In selecting an indicator it is important that it reflects the ecological character of a wetland which includes the biological, chemical and physical components of the ecosystem. Therefore, it may be useful to select early warning indicators according to which of the above three components are considered more susceptible to change within the wetland (Finlayson and Spiers 1999).

The concepts of early warning and ecological relevance may conflict. As an example, biomarker responses can offer exceptional early warning of potential adverse effects. However, there exists very little evidence that observed responses result, or culminate in adverse effects at an individual level, let alone the population, community or ecosystem level Finlayson and Spiers (1999). If the primary assessment objective is that of early detection, then it is likely that it will be at the expense of ecological relevance (Finlayson and Spiers, 1999).

van Dam *et al* (*in press*) in Finlayson and Spiers (1999), suggests early warning indicators should be:

1. **anticipatory**: it should occur at levels of organisation, either biological or physical, that provide an indication of degradation, or some form of adverse effect, before serious environmental harm has occurred;

2. **sensitive**: in detecting potential significant impacts prior to them occurring, an early warning indicator should be sensitive to low levels, or early stages of the problem;

3. **diagnostic**: it should be sufficiently specific to a problem to increase confidence in identifying the cause of an effect;

4. **broadly applicable**: it should predict potential impacts from a broad range of problems;

5. **correlated to actual environmental effects/ecological relevance**: an understanding that continued exposure to the problem, and hence continued manifestation of the response, would usually or often lead to significant environmental (ecosystem-level) adverse effects;

6. **timely and cost-effective**: it should provide information quickly enough to initiate effective management action prior to significant environmental impacts occurring, and be inexpensive to measure while providing the maximum amount of information per

7. **regionally or nationally relevant**: it should be relevant to the ecosystem being assessed;

8. **socially relevant**: it should be of obvious value to, and observable by stakeholders, or predictive of a measure that is socially relevant;

9. **easy to measure**: it should be able to be measured using a standard procedure with known reliability and low measurement error;

10. **constant in space and time**: it should be capable of detecting small change and of clearly distinguishing that a response is caused by some anthropogenic source, not by natural factors as part of the natural background (that is, high signal to noise ratio);

11. **nondestructive**: measurement of the indicator should be nondestructive to the ecosystem being assessed.

Finlayson and Spiers (1999) discuss that the importance of the above attributes cannot be over-emphasized, since any assessment of actual or potential change in ecological character will only be as effective as the indicators chosen to assess it. However, an early warning indicator possessing all the ideal attributes cannot exist, as in many cases some of them will conflict, or will simply not be achievable.

29.1 Early warning indicators

Finlayson and Spiers (1999) outline a number of early warning indicators. These are placed into three broad categories:

1. rapid response toxicity tests;
2. field early warning tests; and
3. rapid assessments.

Each of the techniques may meet different objectives in water quality assessment programs. Although the majority of early warning indicators are of a biological nature, physico-chemical indicators do exist and often form the initial phase of assessing water quality (Finlayson and Spiers, 1999).

29.1.1 Toxicity tests

These represent rapid and sensitive responses to one or more chemicals. They provide an indication that there may be a risk of adverse effects occurring at higher levels of biological organization (for example, communities and ecosystems). Laboratory toxicity tests are of particular use for a chemical or chemicals yet to be released into the aquatic environment (for example, a new pesticide or pre-release waste water). They provide a basis upon which to make decisions about safe concentrations or dilution/release rates, thereby eliminating, or at least minimizing, adverse impacts on the aquatic environment. However, there are major differences in the ecological relevance of responses that can be measured (Finlayson and Spiers, 1999).

29.1.2 Field early warning indicators

These comprise of a range of techniques that are grouped together because they are used to measure responses or patterns in the field and thus provide a more realistic indication of effects in the environment. In contrast to rapid response toxicity tests, early warning field tests predict and/or assess the effects of existing chemicals. Some of the techniques can also be applied to biological and physical problems (Finlayson and Spiers 1999).

29.1.3 Rapid Assessments

Rapid assessment is essentially the method used for this wetland inventory. It has the appeal of enabling ecologically-relevant information to be gathered over wide geographical areas in a standardised fashion and at relatively low costs. The trade-off is that rapid assessment methods are usually relatively ‘coarse’ and hence are not designed to detect subtle impacts.

Finlayson and Spiers (1999) point out that the attributes of rapid assessment include:

1. measured response is widely regarded as adequately reflecting the ecological condition or integrity of a site, catchment or region (that is, ecosystem surrogate);
2. approaches to sampling and data analysis are highly standardised;
3. response is measured rapidly, cheaply and with rapid turnaround of results;
4. results are readily understood by non-specialists; and
5. response has some diagnostic value.

The most powerful impact assessment programs will generally be those that include two types of indicator, namely those associated with early warning of change and those closely associated with ecosystem-level effects. The ecosystem level indicator might include ecologically important populations (keystone species). With both types of indicators used in a monitoring program, information provided by ecosystem-level indicators may then be used to assess the ecological importance of any change observed in an early detection indicator.

30.0 RECOMMENDED INDICATORS FOR MONITORING SURVEYED WETLANDS

Monitoring **water chemistry** is recommended as an **early warning indicator** and monitoring **invertebrate composition** as an **ecosystem level indicator**.

Before these indicators can be used effectively in a monitoring program, more research and surveys are required. The wetland surveys undertaken within the Mount Lofty Ranges recorded information rapidly at one location and at one time of the year. An understanding of the natural levels of water chemistry and invertebrate composition for selected wetlands is needed before effective monitoring can occur.

30.1 Early warning indicators – Water chemistry

The collection of water chemistry parameters is suggested as the means for monitoring for early change in wetlands. Parameters essential to collect include conductivity, dissolved oxygen, temperature, turbidity and pH. Conductivity will probably play an important indicator providing the first early warning change within wetlands.

30.2 Ecosystem based indicator

Invertebrates are recommended as indicators for ecosystem monitoring. Yen and Butcher (1997) outline the important features of invertebrates which make them useful as indicators. These include:

1. Invertebrates are ecologically and functionally important.
2. Invertebrates are diverse, providing a good range from which to choose suitable taxa.
3. Many species are habitat specific.
4. Many species are abundant and are relatively simple to collect.

Indicator taxa should be selected on a regional basis and on their sensitivity to environmental change. Indicator species should also be selected that have been identified as keystone species. These species play critical ecological roles, and their loss may result (directly or indirectly) in the disappearance of several other species (Soule and Kohm, 1989 Lawton, 1991 in Yen and Butcher, 1997).

Research is required towards developing these indicators. Yen and Butcher (1997) suggest research in the following areas:

- The link between invertebrate biodiversity and ecosystem functioning.
- The value of using guilds or functional groups to monitor ecosystem processes.
- Identifying keystone taxa.
- The existence of redundant species.

The interaction between invertebrate composition and water chemistry also requires more research. Without an understanding of the dynamics between these two parameters, interpretation of ecological change will be hindered.

An example of how the invertebrate monitoring program can be applied to detect change in ecological character is to study the trophic dynamics or functional groups. The presence of both invertebrate grazers and predators indicates functional invertebrate dynamics. The loss of either group quickly indicates change in the ecological character of the wetland.

The development of keystone indicator species requires further research, however, as a starting point there are several families that can be used in developing these indicators. Representative grazers and predators are important to include as indicators due to their importance in the trophic chain.

Keystone species to monitor include:

Grazers: zooplankton, including Cladocera, Copepods, Calanoida and Cyclopoida.

Predators: dragonfly larvae (Odonata) and the families Dytiscidae and Coleoptera.

30.3 Other considerations

Monitoring is also required for many other parameters. Programs need to include whole of catchment parameters that cause change in the ecological character of wetlands. Monitoring of threats to wetlands such as land clearance and management, drainage, land ownership changes and land use changes all need to be documented and included in the monitoring program. Ideally an action plan to alleviate and manage threats should be developed for nominated wetlands in conjunction with a monitoring program.

31.0 RECOMMENDED WETLANDS TO MONITOR

Those wetlands that received a high wetland score and fulfilled the ANZECC criteria for an important wetland are priority wetlands to monitor. The second criteria used to identify prioritiy wetlands is the management authority. Those wetlands that are under public ownership are targeted as preferential sites to monitor, unless significant wetland values are identified on private lands. The reasoning behind this is that wetlands within the community land classification or under State government ownership may be easier to access and manage a monitoring program. At this early stage of developing a monitoring program the nominated sites will assist in refining techniques and developing monitoring protocols.

Once monitoring techniques have been developed and tested, the opportunity to expand monitoring to other wetlands with high conservation value on private property is feasible. Other protection measures can be developed for wetlands on private property before monitoring occurs. Actions such as buffering wetlands with revegetation, fencing, removing rubbish and the development of wise use of wetland programs for landowners are currently required to manage wetland threats. The following wetlands that are recommended for monitoring cover a broad range of wetland types, display different water regimes, vegetation structure and geographical locations.

32.0 RECOMMENDED PRIORITY WETLANDS TO MONITOR

Wetland site number	Wetland name	Catchment Board	Management Authority
S2013	Parafield Wetland	Northern Adelaide and Barossa	Department for Transport and Regional Services
S2021	Englebrook Reserve	Onkaparinga	National Trust of South Australia
S2057	Washpool Lagoon	Onkaparinga	City of Onkaparinga
S2076	Eurilla Bog	Onkaparinga	Department for Environment and Heritage

Table 31-1. Recommended wetlands to monitor

33.0 RECORDING MONITORING PARAMETERS

The wetland inventory template (refer to Section One and Appendix 1) should be used for the collection of baseline data. Once collected, analysis of the results is required to determine the values of the wetland, threats and possible key indicator groups. Routine collection of information is required in order to establish which monitoring indicators to use (early warning and ecosystem indicators). After a given time period, comparison of the data is required to identify if any ecological change has occurred. Defining acceptable limits of ecological change will be difficult and may take some time until the wetland processes are understood. The suggested wetlands to monitor will be of value in developing reference sites for other wetlands in the region.

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http://www.ea.gov.au/parks/nrs/ibraimcr/ibra_95/index.html

http://www.nmnh.si.edu/botany/projects/algae/Imag-Chl.htm

http://www.who.int/water_sanitation_health/GDWQ/Chemicals/turbidity.htm

http://www.epa.nsw.gov.au/soe/97/ch3/11.htm

http://wow.nrri.umn.edu/wow/under/parameters/turbidity.html

www.ramsar.org/key_guide_list_e.html

http://ramsar.org/key_guide_risk_e.htm

Other useful web sites

Water Watch
http://www.sa.waterwatch.org.au/

Environment Australia
http://www.ea.gov.au/water/wetlands/

Wetland Care Australia
http://www.wetlandcare.com.au/

Environmental Protection Agency
http://www.environment.sa.gov.au

AusRivas
http://ausrivas.canberra.edu.au/

Catchment Water Management Boards
http://www.catchments.net/

Invertebrates
http://www.umesci.maine.edu/ams/inverts.htm

Appendix 1 Wetland Inventory descriptions

***Wetland Reference Number**:* The wetland reference number is critical for clearly defining wetland locations within regions of the State. The wetland reference number acts as the primary key for records for each wetland, this enables data transfer between databases and GIS tables.

***Wetland Name**:* The name of the site.

***Ramsar Site*:** If the wetland is listed as a Ramsar site.

***Description of Site**:* A general description of the location features, closest roads or landmarks.

<u>Current Land use</u>

> ***On site**:* Current human use of the designated wetland area.
>
> ***Surrounding area**:* Human use on land adjacent to the wetlands, and more broadly in the surrounding catchment.

<u>Tenure/ownership</u>

> ***On site**:* Details of land ownership of the wetland site if possible.
>
> ***Surrounding**:* Details of the tenure type that is dominant in the surrounding areas if possible.

***Jurisdiction and management authority**:* The name of the body or bodies responsible for management of the wetland.

Complied by: Name of person undertaking data collection.

Organisation: Organisation that is managing the data collection

***Date/time**:* Date and time of data collection.

Region: Geographical region (eg Eyre Peninsula, Yorke Peninsula and Kangaroo Island)

Environmental Regions: This refers to broad environmental regions within South Australia as described by Laut P (1977), or regions described within the Regional Biodiversity Plans developed by the Department for Environment and Heritage (2000 – 2001).

***Key Bio diversity Areas**:* The Department for Environment and Heritage has developed key biodiversity areas within the Regional Biodiversity Plans for South Australia. The key biodiversity areas have been developed by analysis of biological assets of the area and information from community groups. There are six key biodiversity areas identified within the three wetland study regions; these are: coastal wetland habitat areas, fragmented habitat areas, grassland habitat, large remnant area, ridgeline systems, threatened habitat area.

***GPS reading**:* Taken in Latitude and Longitude or easting and northing.

***Map Sheet and Reference**:* Record of map sheet name and number with grid reference if required.

***Approximate Area**:* usually recorded after of before survey by GIS query.

Elevation: in meters above sea level. Preferably recorded from GPS and compared with map sheet elevation values.

***Landform Element**:* Landform element definitions have been adapted from Heard and Channon (1997) Guide to a native vegetation survey using the biological survey of South Australia methodology, Section 3. Geographic Analysis and Research Unit, Department of Housing and Urban Development.

Sandy Plain: Large, very gently inclined or level element composed of fine grains of weathered rocks of quartz.

Limestone plain: Large, very gently inclined or level element of hard almost horizontally bedded limestone, which contains at least 80% of the carbonates of calcium or magnesium.

Rock outcrop: Any exposed area of rock that is inferred to be continuous with underlying bedrock on a large, very gently inclined or level element.

Drainage depression: Level to gently inclined, long, narrow, shallow open depression with smoothly concave cross-section, rising to moderately inclined side slopes, eroded or aggraded by sheet wash.

Open depression: Landform element that extends at the same elevation, or lower, beyond the locality where it is observed.

Closed depression: Landform element that stands below all points in the adjacent terrain.

Flat: Planar landform element that is neither a crest nor a depression and is level or very gently inclined (<3% slope).

Swale: Linear, level-floored open or closed depression excavated by wind, or left relict between ridges built up by wind or waves, or built up to a lesser height than them. Or long, curved open or closed depression left relict between scrolls built up by channelled stream flow.

Lagoon: Closed depression filled with water that is typically salt or brackish, bounded at least in part by forms aggraded or built up by waves or reef building organisms.

Hill crest: Very gently inclined to steep crest, smoothly convex, eroded mainly by creep and sheet wash. A typical element of mountains, hills, low hills and rises.

Hill slope: Gently inclined to precipitous slope, commonly simple and maximal, eroded by sheet wash, creep, or water-aided mass movement.

Gully: Open depression with short, precipitous walls and moderately inclined to very gently inclined floor or small stream channel, eroded by channelled stream flow and consequent collapse and water-aided mass movement.

Stream channel: Linear, generally sinuous open depression, in parts eroded, excavated, built up and aggraded by channelled stream flow. This element comprises stream bed and banks.

Flood out: Flat inclined radially away from a point on the margin or at the end of a stream channel, aggraded by over bank stream flow, or by channelled stream flow associated with channels developed within the over-bank flow part of a covered plain landform pattern.

Fan-alluvial: Large gently inclined to level element with radial slope lines inclined away from a point, resulting from aggradation, or occasionally from erosion, by channelled, often braided, stream flow, or possibly by sheet flow.

Estuary: Stream channel close to its junction with a sea or lake, where the action of channelled stream flow is modified by tide and waves. The width typically increases downstream.

Lake: Large water-filled closed depression.

Salt lake: Lake, which contains a concentration of mineral salts, (predominantly sodium chloride in solution as well as magnesium and calcium sulphate).
Swamp: Almost level closed, or almost closed depression with a seasonal or permanent water table at or above the surface, commonly aggraded by over-bank stream flow and sometimes biological (peat) accumulation.

Perched swamp: A tract of land that is permanently saturated with moisture and is positioned on an elevated landform.

Playa/pan: Large, shallow, level-floored closed depression, intermittently water-filled, but mainly dry due to evaporation, bounded as a rule by flats aggraded by sheet flow and channelled stream flow.

***Geological formation name**:* Name of geological formation defined from the physical geography data sets available from http://www.atlas.sa.gov.au/

*Soil types**:*** Soil type definitions have been adapted from Heard and Channon (1997) Guide to a native vegetation survey using the biological survey of South Australia methodology, Section 3. Geographic Analysis and Research Unit, Department of Housing and Urban Development.
To determine soil texture take a small handful of soil below the crust and add water working the soil into a an elongated ball (bolus) until it just fails to stick to the fingers. The behaviour of the bolus and of the ribbon produced by shearing (pressing out) between the thumb and forefinger characterise the texture. The behaviour and feel, smoothness or graininess, during bolus formation are also indicative of its texture.

Sand: Coherence nil to very slight, cannot be moulded. Sand grains of medium size, single sand grains adhere to fingers. Commonly less than 5% clay content.

Loam: Bolus coherent and rather spongy, smooth feel when manipulated but with no obvious sandiness. May be somewhat greasy to the touch if organic matter in present. Will form a ribbon of about 25mm.

Clay Loam, Sandy: Coherent plastic bolus with medium size sand grains visible within a finer matrix, forms a ribbon between 40-50mm. Clay contents between 30% – 35%.

Medium clay: Smooth plastic bolus, can be moulded into rods without fracture. Will form a ribbon of 75 mm or more. Clay contents between 45% - 55%.
Medium heavy clay: Same properties as medium clay but with a higher clay content of 50% or more.

Loamy sand: Slight coherence, sand grains of medium size, can be sheared between thumb and forefinger to give minimal ribbon of about 5 mm. Approximate clay content of about 5%.

Silty loam: Coherent bolus, smooth, often silky when manipulated, will form a ribbon of about 25mm. Clay content between 25% with 25% or more of silt.
Silty clay loam: Coherent smooth bolus, plastic and often silky to the touch, will form a ribbon of 40-50mm. Clay contents between 30%-35% and with silt 25% or more.

Clayey sand: Slight coherence, sand grains of medium size, sticky when wet, many sand grains stick to fingers. Will form a minimal ribbon of 5-15 mm, discolours fingers with clay stain. Clay contents between 5%-10%.
Sandy clay loam: Strongly coherent bolus, sandy to touch, medium size grains visible in finer matrix, will form ribbon of 25 – 40mm. Clay contents between 20% - 30%.
Light clay: Plastic bolus, smooth to touch, slight resistance to shearing between thumb and fore finger, will form ribbon of 50 – 75 mm. Clay content between 35% - 40%.

Heavy Clay: Smooth plastic bolus, handles like stiff plasticine, can be moulded into rods without fracture, has firm resistance to ribboning shear. Will form a ribbon of 75 mm or more. Clay contents of 50% or more.

Sandy loam: Bolus coherent but very sandy to touch, will form a ribbon of 15-25 mm, dominant sand grains are of medium size and are readily visible. Clay contents between 10% - 20%.

Clay loam: Coherent plastic bolus, smooth to manipulate and will form a ribbon of 40 – 50 mm. Clay contents between 30% and 35%.

Light medium clay: Plastic bolus, smooth to touch, slight to moderate resistance to ribboning shear, will form a ribbon of about 75 mm.

Peat: Brownish or blackish fibrous substance produced by anaerobic decay of vegetation and found in boggy areas.

Comments: Any comments regarding soil structure, surface materials, rock contents or other soil attributes.

Source of water supply: The main sources of water that enter the water body, most commonly a combination of catchment run-off, ground-water and rainfall.

Rainfall estimate: Isohyet information gained from the Bureau of Meteorology for annual average rainfall. Also easily accessed by overlaying GIS isohyet information on the wetlands.

Dominant riparian vegetation association: Describes the dominant or co-dominant over storey species and understorey species.

Significance – why the wetland is important: Details any significance of the wetland within its regional setting or ecological function.

Noteworthy flora: Threatened species: threatened flora at national or State level that occur on the site (includes any threatened species identifies under national or State legislation, ANZECC lists or action plans). Composition information on the composition of any plant species or communities for which the wetland is particularly important.

Noteworthy fauna: Threatened species: list of threatened fauna at national or State level that are present at the site. (includes any threatened species identifies under national or State legislation, ANZECC lists or action plans). Composition: information regarding composition of important fauna that may inhabit the wetland permanently or seasonally including migratory species. An indication of population sizes, breeding colonies, migration stopovers is also given where available.

***Land Degradation**:* disturbances or threats are defined as any direct or indirect human activities at the site or in the site or in the catchment area that may have a detrimental effect on the ecological character of the wetland. The effect may be a low level disturbance (eg low level grazing) or a major threat (eg water diversion schemes). Examples include disturbance by stock, water extraction, river regulation, siltation, salinity, urban development, drainage, pollution, excessive human activity, and impact of invasive species. There are several typical types of land degradation that may affect wetlands; these are listed as a standard template within the survey.

- Access tracks
- Cleared land
- Fire breaks
- Off-Road vehicles
- Rubbish dumping
- Pollution
- Pest vertebrate presence
- Altered water flows
- Borrow pits/Quarry
- Drains
- Fence lines
- Power lines
- Slashing/clearance
- Watering points
- Grazing damage
- Wetland drainage

***Comments**:* Clarification of the severity of the threats and other comments.

***Potential disturbances**:* Any threats that could impact on the wetland in the future, for example, a planned change in adjoining land use.

***Conservation measures taken and measures proposed**:* Details of conservation measures being undertaken at the site (for example, fencing or revegetation) and the names of any protected areas established at or around the wetland. Details of management plans for the site and status of the site in terms of National Estate, Ramsar or World Heritage listing can also be included.

***Current scientific research**:* Outline any research activities by scientific bodies such as CSIRO or universities or other recognised research organisations.

***Current conservation education**:* Documents the existence of interpretive facilities, use of the area by school groups or other organisations.

***Recreation and tourism**:* Records recreation facilities present on the site and if there are tourism uses or values with the site.

***Social and Cultural Values**:* Documents pre-European and European historical and social values of the site.

***References**:* Lists relevant references associated with the site.

Aquatic Vegetative Classes

This parameter provides a snap shot of aquatic vegetation structure, vegetation classes recorded include:

- Algal
- Aquatic moss
- Rooted vascular
- Floating leaved
- Floating vascular
- Unknown submergent
- Unknown surface

Aquatic Flora Sample

Records any aquatic vegetation sample collected with the wetland number, wetland name, GPS location, and habitat location. Samples should be placed into a snap lock plastic bag with water and labels placed inside and outside the bag. If field trips are longer than for one day, samples should be dried and pressed that day. Pressed samples will need the paper changed every other day to avoid the specimen rotting. The Plant Biodiversity Centre can assist with plant identification and a good reference books for aquatic plant identification include *Waterplants in Australia* by G.R. Sainty (1994) and *Aquatic and wetland plants* by Nick Romanowski (1998).

Aquatic Fauna Sample

Collecting Sample Material: This is achieved by two methods.

1. **Plankton Net**. This is a small round net of approx. 200-250um pore size. Attached to the net is a length of string. One end of the string is tied to the plankton net. The other should be tied to the user of the net. The net is thrown into the water and is pulled through the water, towards the user. This procedure is done several times until sufficient sample material is collected.

If the water is too shallow then the net may be used by holding the metal rim and scooped through the water until sufficient sample material is collected in the plastic vial at the end of the net.

The sample material is then transferred from the sample vial to another vial, and 40% formalin is added to the sample to make up a mixture of approx.10% Formalin and 90% sample fluid.

2. **Hand Net**. The use of the hand net is a simple method. This is used in weedy habitats or shallow areas where the plankton net may become stuck or lost on objects. The net is used to prod at the base of vegetation and is run closely to the bottom of shallow water bodies. This is done over approx. 10-20 metres distance to obtain a representative sample from the water body.

The material in the net then is transferred to one or two sample vials.

Washing the Nets: This is done between sampling of each site in an attempt to clean the net of invertebrates to stop cross “contamination” of samples between sites. Cleaning of the net between sites is achieved by simply washing the net in the water of the site, without the sample vial attached. Ideally this should be done before and after a sample is taken.

Labelling Sample Vials: This is extremely important and should be done in a legible manner. The label should clearly and legibly be written upon and information recorded should be clearly stated.

Information recorded includes:

- Wetland number
- Name of wetland
- Date of Sample
- Grid Reference of site
- Method of collection (hand net or plankton net).

Material preservation of sample: material collected should be preserved with approximately 10% formalin as soon as possible after the sample is collected. This stops decomposition of the sample and also many of the invertebrates from eating each other. Formalin is used as many of the microinvertebrates become soft and mushy, denaturing in the 70% alcohol solution, used to preserve macroinvertebrates and vertebrates.

The formalin supplied is 40% by volume. This should be added to the sample material to make up approximately 10% formalin and 90% sample material. This is only a guide and should be used by the sampler with a degree of care.

Formalin is a dangerous chemical and is a fixative. Do not inhale it and wash your hands after use thoroughly. Read instructions on the label before use.

Water phys-chemistry

Five standard water chemistry parameters are collected; these are described below.

PH : is recorded using a Hanna HI 9025 pH meter. The meter is placed into the water body (ensuring that the probes do not touch the substrate). The reading is then given on the display. Calibration and maintenance of the pH unit is often needed, these procedures are outlined in the pH manual supplied with the unit.

Conductivity: is recorded using a Hanna HI 9635 meter. This meter can measure in the 0 to 199 µS/cm range. It can be used to measure any sample from deionised water to highly saline water. The meter is placed in the water body ensuring that the probe does not touch the substrate and the reading is given on the display when stable. Calibration and maintenance procedures required are outlined in the manual.

Turbidity: is recorded using a Hanna HI 93703 portable microprocessor turbidity meter. The unit is designed to perform measurements according to the ISO 7027 International Standard. The instrument functions by passing a beam of light through a vial containing the sample being measured. A sensor, positioned at 90º with respect to the direction of light, detects the amount of light scattered by the undissolved particles present in the sample. These readings are given in NTU units. The manual accompanying the unit outlines measurement, calibration and maintenance procedures.

Dissolved O²: is recorded using a Hanna HI 9142 dissolved oxygen meter. Dissolved oxygen is indicated in tenths of parts per million (ppm=mg/l). The dissolved oxygen probe has a membrane covering the polarographic sensors and a built in thermistor for temperature measurements and compensation. The thin permeable membrane isolates the sensor elements from the testing solution, but allows oxygen to enter. When a voltage is applied across the sensor, oxygen that has passed through the membrane reacts causing current to flow, allowing the determination of oxygen content.

Water Temperature: Water temperature is read from the pH or Dissolved Oxygen meter.

Rapid assessment (conservation values)

The rapid assessment component of the survey provides a quick snap shot of the vegetation associations and condition within different riparian habitats. Other parameters such as aquatic fauna and wetland condition is also recorded.

Aquatic Fauna*:* is a subjective score according to the abundance and diversity of invertebrates, fish and birds located within or on the water body.

- Low (1) refers to no fish or birds with little or no invertebrate presence.
- Moderate (3) refers to some bird presence and good vertebrate abundance, fish usually are not present.
- High (5) indicates good bird and invertebrate diversity and abundance with the presence of fish.

Aquatic Vegetation*:* records the abundance and diversity of aquatic vegetation.

- Low (1) indicates no or very little aquatic vegetation.
- Moderate (3) indicates some aquatic vegetation cover either in the form of floating or rooted vegetation.
- High (5) indicates good diversity of aquatic vegetation with a range of rooted vegetation such as reeds and rushes and floating vegetation such as water ribbons.

Riparian Vegetation

Riparian vegetation is assessed at three zones, these are the

- toe of bank (Low water – High water),
- bank (high water mark – buffer) and
- buffer (top of the bank to the buffer which can extend between 10 meters and 100 meters).

The vegetation association for each zone consists of the dominant or co-dominant over storey species and understorey species. The vegetation association for each zone is scored considering the level of disturbance and vegetation cover within each zone.

The vegetation association scoring system consists of:

- Degraded or no vegetation (1) with less than 30% vegetation cover, with high level of disturbance.
- Natural (3) between 30 – 75% vegetation cover, with little disturbance.
- Intact (5) over 75% vegetation cover with little or no disturbance.

Wetland Condition

The wetland score should reflect the previous rapid assessment scores for aquatic fauna, aquatic vegetation and riparian vegetation values. The combination of these values and the interpretation of others parameters recorded during the survey (such as land degradation and water chemistry) form the basis of the wetland condition score.

The wetland score consists of:
- Degraded (1) those sites that have a high level of disturbance and received low rapid assessment scores.
- Natural (3) those sites that have little disturbance, received moderate to high rapid assessment scores and that are sites usually protected within the reserve system or by private conservation.
- Pristine (5) those sites with no obvious sign of disturbance, scored very highly in the rapid assessment and are formally conserved within the reserve system.

Photographic records

Photographic records for this survey have been recorded by digital camera in JPEG and BITMAP format. The following records should be kept when using a digital camera. It is recommended that a Laptop computer be taken on surveys for ease of cataloguing photographs.

All pictures need the following information recorded:

- Picture number and wetland number
- Direction and features if relevant
- Photographer name and date.

ANZECC wetland criteria

This criteria is used for determining nationally important wetlands in Australia, and form the bases for the inclusion in the Directory. These criteria are those agreed to by the ANZECC Wetlands Network in 1994.

A wetland may be considered nationally important if it meets at least one of the following criteria:

- It is a good example of a wetland type occurring within a biogeographic region in Australia.

- It is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.

- It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail.

- The wetland supports 1% or more of the national populations of any native plant or animal taxa.

- The wetland supports native plant or animal taxa or communities which are considered endangered or vulnerable at the national level.

- The wetland is of outstanding historical or cultural significance.

Many of the sites in the Directory meet more than one of the criteria. Application of the criteria to individual wetland sites involves a degree of subjectivity. Not only may certain aspects of a site's significance be interpreted differently by different investigators, but information gaps often exist which make it difficult to judge whether or not a site meets a particular criterion.
The Interim Biogeographic Regionalisation for Australia (IBRA) is used as the framework for

applying Criterion 1, which identifies wetlands that are unique or representative within a biogeographic region in Australia.

<u>*Wetland type*</u>

The definition of a wetland used in the survey is one adopted by the Ramsar convention under Article 1.1.

> *"Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent of temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters."*

Within this definition, the wetland classification system used in the Directory of Important Wetlands identifies 40 different wetland types in three categories: A-Marine and Coastal Zone wetlands, B-Inland wetlands, and C-Human-made wetlands. This wetland survey does not include Category A – Marine and Coastal Zone wetlands .

The system is based on that used by the Ramsar Convention in describing Wetlands of International Importance, but was modified slightly to suit the Australian situation.

A – Marine and Coastal Zone wetlands

- Marine waters - permanent shallow waters less than six metres deep at low tide, includes sea bays straits
- Subtidal aquatic beds, includes kelp beds, sea-grasses, tropical marine meadows
- Coral reefs
- Rocky marine shores, includes rocky offshore islands, sea cliffs
- Sand, shingle or pebble beaches, includes sand bars, spits, sandy islets
- Estuarine waters, permanent waters of estuaries and estuarine systems of deltas
- Intertidal mud, sand or salt flats
- Intertidal marshes, includes salt marshes, salt meadows, saltings, raised salt marshes, tidal brackish and freshwater marshes
- Intertidal forested wetlands, includes mangrove swamps, nipa swamps, tidal freshwater swamps forests
- Brackish to saline lagoons and marshes with one or more relatively narrow connections with the sea
- Freshwater lagoons and marshes in the coastal zone
- Non tidal freshwater forested wetlands

B – Inland wetlands

- Permanent rivers and streams includes waterfalls
- Seasonal and irregular rivers and streams
- Inland deltas(permanent)
- Riverine floodplains, includes river flats, flooded river basins, seasonally flooded grassland, savanna and palm savanna
- Permanent freshwater lakes (8 ha) includes large oxbow lakes
- Seasonal/intermittent freshwater lakes (>8 ha) floodplain lakes
- Permanent saline /brackish lakes
- Seasonal/intermittent saline lakes
- Permanent freshwater ponds (<8 ha) marshes and swamps on inorganic sols, with emergent vegetation waterlogged for at least most of the growing season
- Seasonal/intermittent freshwater ponds and marshes on inorganic soils includes sloughs, potholes, seasonally flooded meadows, sedge marshes
- Permanent saline/brackish marshes

- Seasonal saline marshes
- Shrub swamps, shrub dominated freshwater marsh, shrub carr, alder thicket on inorganic soil
- Freshwater swamp forest, seasonally flooded forest, wooded swamps, on inorganic soils
- Pearlands, forest, shrubs or open bogs
- Alpine and tundra wetlands: includes alpine meadows, tundra pools, temporary waters from snow melt
- Freshwater springs, oasis and rock pools
- Geothermal wetlands
- Inland, subterranean karst wetlands

C- Human-made wetlands

- Water storage areas; reservoirs, barrages, hydro-electric dams, impoundment's (generally over 8 ha).
- Ponds; includes farm ponds, stock ponds, small tanks; (generally below 8 ha).
- Aquaculture ponds; fish ponds shrimp ponds
- Salt exploitation, salt pans, salines
- Excavations; gravel pits; borrow pits, mining pools.
- Wastewater treatment areas; sewage farms, settling ponds, oxidation basins.
- Irrigated land; includes irrigation channels and rice fields, canals, ditches
- Seasonally flooded arable land, farm land
- Canals

Appendix 2 Northern Adelaide and Barossa Catchment Water Management Board floristic vegetation groups intersecting waterbodies

- *Eucalyptus obliqua* Open forest
- *Avicennia marina var. resinifera* Low open forest
- *Eucalyptus obliqua, E. fasciculosa* Woodland
- *Eucalyptus leucoxylon ssp. leucoxylon* Woodland
- *Eucalyptus camaldulensis var. camaldulensis, E. viminalis ssp. cygnetensis* Woodland
- *Eucalyptus fasciculosa*, E. leucoxylon ssp. leucoxylon Open woodland
- *Eucalyptus fasciculosa* Low woodland
- *Maireana aphylla, +/- Xanthorrhoea quadrangulata, +/- Dodonaea viscosa ssp. spatula* Tall shrubland
- *Olearia axillaris, +/- Acacia longifolia var. sophorae, +/- Myoporum insulare, +/- Leucopogon parviflorus, +/- A. leiophylla, +/- Ozothamnus turbinatus* Shrubland
- *Phragmites australis &/or Typha domingensis* Sedgeland
- *Eucalyptus baxteri, E. obliqua, +/- E. cosmophylla, +/- E. fasciculosa* Open forest
- *Callitris gracilis* Low open forest
- *Eucalyptus obliqua, E. goniocalyx, +/- E. fasciculosa* Woodland
- *Eucalyptus camaldulensis var. camaldulensis, +/- E. dalrympleana ssp. dalrympleana* Woodland
- *Eucalyptus leucoxylon ssp. leucoxylon, +/- E. fasciculosa, +/- Callitris gracilis* Woodland
- *Eucalyptus odorata, +/- E. leucoxylon*
- *Eucalyptus goniocalyx, +/- E. fasciculosa* Low woodland
- *Eucalyptus fasciculosa, Callitris gracilis* Low woodland
- *Sarcocornia sp., Sclerostegia arbuscula, Suaeda australis, Halosarcia sp*. Low shrubland
- *Nitraria billardierei* Open shrubland

Appendix 3. Torrens Catchment Water Management Board floristic vegetation groups intersecting waterbodies

- *Eucalyptus obliqua over Pultenaea daphnoides, Lepidosperma semiteres, Hakea rostrata, Acrotriche fasciculiflora, Pteridium esculentum, Xanthorrhoea semiplana ssp. semiplana* Open forest
- *Eucalyptus baxteri, E. fasciculosa over Lepidosperma semiteres, Leptospermum myrsinoides, Xanthorrhoea semiplana ssp. semiplana, Hypolaena fastigiata* Low woodland
- *Eucalyptus obliqua, E. goniocalyx, E. fasciculosa over Lepidosperma semiteres, Leptospermum myrsinoides, Hibbertia exutiacies, H. sericea var. sericea, Xanthorrhoea semiplana ssp. semiplana* Woodland
- *Eucalyptus leucoxylon ssp. leucoxylon over Acacia pycnantha, *Olea europaea ssp. europaea, Hibbertia exutiacies, *Senecio pterophorus var. pterophorus, *Briza maxima, Olearia ramulosa* Woodland
- *Eucalyptus camaldulensis var. camaldulensis, E. leucoxylon ssp. leucoxylon over Acacia pycnantha, Briza maxima, Astroloma humifusum, Themeda triandra, Olearia ramulosa, *Senecio pterophorus var. pterophorus* Woodland
- *Eucalyptus camaldulensis var. camaldulensis over Acacia pycnantha, A. retinodes var. retinodes (swamp form), Callistemon sieberi, Cyperus gymnocaulos, *Briza maxima, *Senecio pterophorus var. pterophorus* Woodland
- *Eucalyptus camaldulensis var. camaldulensis, E. dalrympleana ssp. dalrympleana over *Medicago sp. *Bromus rubens, *Avena barbata, *Lolium sp.* Open woodland
- *Eucalyptus leucoxylon ssp. leucoxylon, E. viminalis ssp. cygnetensis over *Medicago sp. *Bromus rubens, *Avena barbata, Lolium sp.* (pasture weed species) Open woodland
- *Eucalyptus goniocalyx, E. fasciculosa over Acacia pycnantha, Leptospermum myrsinoides, Hakea rostrata, Calytrix tetragona, Hibbertia exutiacies* Low woodland
- *Allocasuarina verticillata, Xanthorrhoea quadrangulata over +/- Acacia rupicola, +/- A. retinodes var. retinodes hill form, +/- Dodonaea viscosa ssp. spatulata, +/- *Chrysanthemoides monilifera, +/- *Olea europaea ssp. europaea, Lomandra spp.* Very low woodland
- *Eucalyptus porosa, +/- E. leucoxylon ssp. leucoxylon, +/- E. camaldulensis var. camaldulensis over *Olea europaea ssp. europaea, Acacia pycnantha, Acacia paradoxa, Dodonaea viscosa ssp. spathulata.* Woodland
- *Sarcocornia quinqueflora, Sclerostegia arbuscula, +/-Suaeda australis, +/- Sarcocornia blackiana over Atriplex paludosa ssp., Lawrencia squamata, Distichlis distichophylla, Maireana oppositifolia, Samolus repens* Low open shrubland
- *Eucalyptus baxteri, E. obliqua over Lepidosperma semiteres, Pultenaea daphnoides, Hakea rostrata, Epacris impressa, Acrotriche serrulata, Platylobium obtusangulum* Open forest
- *Eucalyptus obliqua, E. fasciculosa over Lepidosperma semiteres, Hakea rostrata, Pultenaea daphnoides, Acrotriche serrulata, Hibbertia exutiacies* Woodland
- *Eucalyptus obliqua, E. goniocalyx over Xanthorrhoea semiplana ssp. semiplana, Lepidosperma semiteres, Hibbertia exutiacies, Acacia myrtifolia var. myrtifolia, Pultenaea daphnoides, Lomandra fibrata* Woodland
- *Eucalyptus leucoxylon ssp. leucoxylon over *Medicago sp. *Bromus rubens, *Avena barbata, *Lolium sp. (pasture weeds)* Open woodland
- *Eucalyptus camaldulensis var. camaldulensis, E. leucoxylon ssp. leucoxylon over *Medicago sp. *Bromus rubens, *Avena barbata, *Lolium sp. (pasture weed species)* Open woodland
- *Eucalyptus camaldulensis var. camaldulensis over *Phalaris sp., *Spartium juncea, *Bromus sp. Danthonia sp., *Avena barbata* Open woodland
- *Eucalyptus leucoxylon ssp. leucoxylon, E. viminalis ssp. cygnetensis, over Pteridium esculentum, Acacia pycnantha, *Briza maxima, Xanthorrhoea semiplana ssp. semiplana, *Senecio pterophorus var. pterophorus* Woodland
- *Eucalyptus goniocalyx over Acacia pycnantha, Xanthorrhoea semiplana ssp. semiplana, A. myrtifolia var. myrtifolia, Gonocarpus tetragynus, Hibbertia exutiacies* Low woodland
- *Eucalyptus fasciculosa, E. leucoxylon ssp. leucoxylon over Acacia pycnantha, *Briza maxima, Hibbertia exutiacies, Lepidosperma semiteres, Astroloma humifusum* Woodland
- *Eucalyptus fasciculosa over Acacia pycnantha, Astroloma conostephioides, A. humifusum, *Briza maxima, Leptospermum myrsinoides* Woodland
- *Halosarcia halocnemoides ssp. halocnemoides, Sclerostegia arbuscula over Disphyma crassifolium ssp. clavellatum, Maireana oppositifolia* Low shrubland
- *+/- Themeda triandra, +/- Danthonia sp., +/- Lomandra sp., +/- Poa sp., +/- Stipa sp.* Closed tussock grassland

*Introduced weeds

Appendix 4. Patawalonga Catchment Water Management Board floristic vegetation groups intersecting waterbodies

- *Eucalyptus obliqua* over *Pultenaea daphnoides, Lepidosperma semiteres, Hakea rostrata, Acrotriche fasciculiflora, Pteridium esculentum, Xanthorrhoea semiplana* ssp. *semiplana* Open forest
- *Eucalyptus obliqua, E. fasciculosa* over *Lepidosperma semiteres, Hakea rostrata, Pultenaea daphnoides, Acrotriche serrulata, Hibbertia exutiacies* Woodland
- *Eucalyptus camaldulensis* var. *camaldulensis, E. leucoxylon* ssp. *leucoxylon* over *Acacia pycnantha, *Briza maxima, Astroloma humifusum, Themeda triandra, Olearia ramulosa, *Senecio pterophorus* var. *pterophorus* Woodland
- *Eucalyptus leucoxylon* ssp. *leucoxylon, E. viminalis* ssp. *cygnetensis* over *Pteridium esculentum, Acacia pycnantha, *Briza maxima, Xanthorrhoea semiplana* ssp. *semiplana, *Senecio pterophorus* var. *pterophorus* Woodland
- *Eucalyptus microcarpa* over *Acacia pycnantha, Olearia ramulosa, Acacia paradoxa, *Olea europaea* ssp. *europaea, Lomandra densiflora, *Briza maxima* Low woodland
- *Eucalyptus baxteri, E. obliqua* over *Lepidosperma semiteres, Pultenaea daphnoides, Hakea rostrata, Epacris impressa, Acrotriche serrulata, Platylobium obtusangulum* Open forest
- *Eucalyptus leucoxylon* ssp. *leucoxylon* over *Acacia pycnantha, *Olea europaea* ssp. *europaea, Hibbertia exutiacies, *Senecio pterophorus* var. *pterophorus, *Briza maxima, Olearia ramulosa* Woodland
- *Eucalyptus camaldulensis* var. *camaldulensis* over *Acacia pycnantha, A. retinodes* var. *retinodes* (swamp form), *Callistemon sieberi, Cyperus gymnocaulos, *Briza maxima, *Senecio pterophorus* var. *pterophorus* Woodland
- *Eucalyptus camaldulensis* var. *camaldulensis, E. viminalis* ssp. *cygnetensis* over *Acacia pycnantha, Banksia marginata, Neurachne alopecuroidea, Hibbertia sericea* var. *sericea, Leptospermum myrsinoides* Woodland
- *Eucalyptus obliqua, E. fasciculosa, E. cosmophylla,* over *Hakea rostrata, Pultenaea daphnoides, Hibbertia exutiacies, Lepidosperma semiteres* Low open forest

Appendix 5. Onkaparinga Catchment Water Management Board floristic vegetation groups intersecting waterbodies

- *Eucalyptus obliqua* over *Pultenaea daphnoides, Lepidosperma semiteres, Hakea rostrata, Acrotriche fasciculiflora, Pteridium esculentum, Xanthorrhoea semiplana* ssp. *semiplana* Open forest
- *Eucalyptus obliqua, E. fasciculosa* over *Lepidosperma semiteres, Hakea rostrata, Pultenaea daphnoides, Acrotriche serrulata, Hibbertia exutiacies* Woodland
- *Eucalyptus camaldulensis* var. *camaldulensis, E. leucoxylon* ssp. *leucoxylon* over *Acacia pycnantha, Briza maxima, Astroloma humifusum, Themeda triandra, Olearia ramulosa, *Senecio pterophorus* var. *pterophorus* Woodland
- *Eucalyptus leucoxylon* ssp. *leucoxylon, E. viminalis* ssp. *cygnetensis,* over *Pteridium esculentum, Acacia pycnantha, *Briza maxima, Xanthorrhoea semiplana* ssp. *semiplana, *Senecio pterophorus* var. *pterophorus* Woodland
- *Eucalyptus fasciculosa, E. viminalis* ssp. *cygnetensis* over *Acacia pycnantha, Xanthorrhoea semiplana* ssp.*, Acacia paradoxa, Olearia ramulosa, Acrotriche serrulata* Woodland
- *Eucalyptus viminalis* ssp. *viminalis, +/- E. viminalis* ssp. *cygnetensis, +/- E. dalrympleana* over *Acacia retinodes var. retinodes (swamp form), Pteridium esculentum, Leptospermum continentale, Leptospermum lanigerum, Melaleuca decussata, *Rubus ulmifolius* var. *ulmifolius* Woodland
- *Eucalyptus fasciculosa* over *Acacia pycnantha, Astroloma conostephioides, A. humifusum, *Briza maxima, Leptospermum myrsinoides* Woodland
- *Eucalyptus obliqua, E. fasciculosa, E. cosmophylla,* over *Hakea rostrata, Pultenaea daphnoides, Hibbertia exutiacies, Lepidosperma semiteres* Low open forest
- *Sarcocornia quinqueflora, Sclerostegia arbuscula, +/-Suaeda australis, +/- Sarcocornia blackiana* over *Atriplex paludosa* ssp.*, Lawrencia squamata, Distichlis distichophylla, Maireana oppositifolia, Samolus repens* Low open shrubland
- *Pteridium esculentum* Fernland
- *Eucalyptus baxteri, E. obliqua* over *Lepidosperma semiteres, Pultenaea daphnoides, Hakea rostrata, Epacris impressa, Acrotriche serrulata, Platylobium obtusangulum* Open forest
- *Eucalyptus leucoxylon* ssp. *leucoxylon* over *Acacia pycnantha, *Olea europaea* ssp. *europaea, Hibbertia exutiacies, *Senecio pterophorus* var. *pterophorus, *Briza maxima, Olearia ramulosa* Woodland
- *Eucalyptus camaldulensis* var. *camaldulensis* over *Acacia pycnantha, A. retinodes* var. *retinodes* (swamp form), *Callistemon sieberi, Cyperus gymnocaulos, *Briza maxima, *Senecio pterophorus* var. *pterophorus* Woodland
- *Eucalyptus camaldulensis* var. *camaldulensis, E. viminalis* ssp. *cygnetensis* over *Acacia pycnantha, Banksia marginata, Neurachne alopecuroidea, Hibbertia sericea* var. *sericea, Leptospermum myrsinoides* Woodland
- *Eucalyptus viminalis* ssp. *cygnetensis, +/- E. obliqua* over *Pteridium esculentum, *Briza maxima, Acacia pycnantha, *Rubus ulmifolius* var. *ulmifolius, Acrotriche fasciculiflora* Woodland
- *Eucalyptus microcarpa* over *Acacia pycnantha, Olearia ramulosa, Acacia paradoxa, *Olea europaea* ssp. *europaea, Lomandra densiflora, *Briza maxima* Low woodland
- *Eucalyptus cosmophylla, +/- Allocasuarina muelleriana* ssp. *muelleriana* over *Leptospermum myrsinoides, Hakea rostrata, Astroloma humifusum, Hibbertia riparia* Very low woodland
- *Muehlenbeckia florulenta, +/- Gahnia filum* over *Samolus repens, Isolepis nodosa, Sarcocornia quinqueflora, *Cynodon dactylon* Tall shrubland
- *Beyeria lechenaultii, +/- Allocasuarina verticillata* over *Acrotriche patula, Eutaxia microphylla* var. *microphylla, Pomaderris paniculosa* ssp. *paniculosa, Gahnia lanigera* Low shrubland

Appendix 6. Invertebrate records for surveyed wetlands

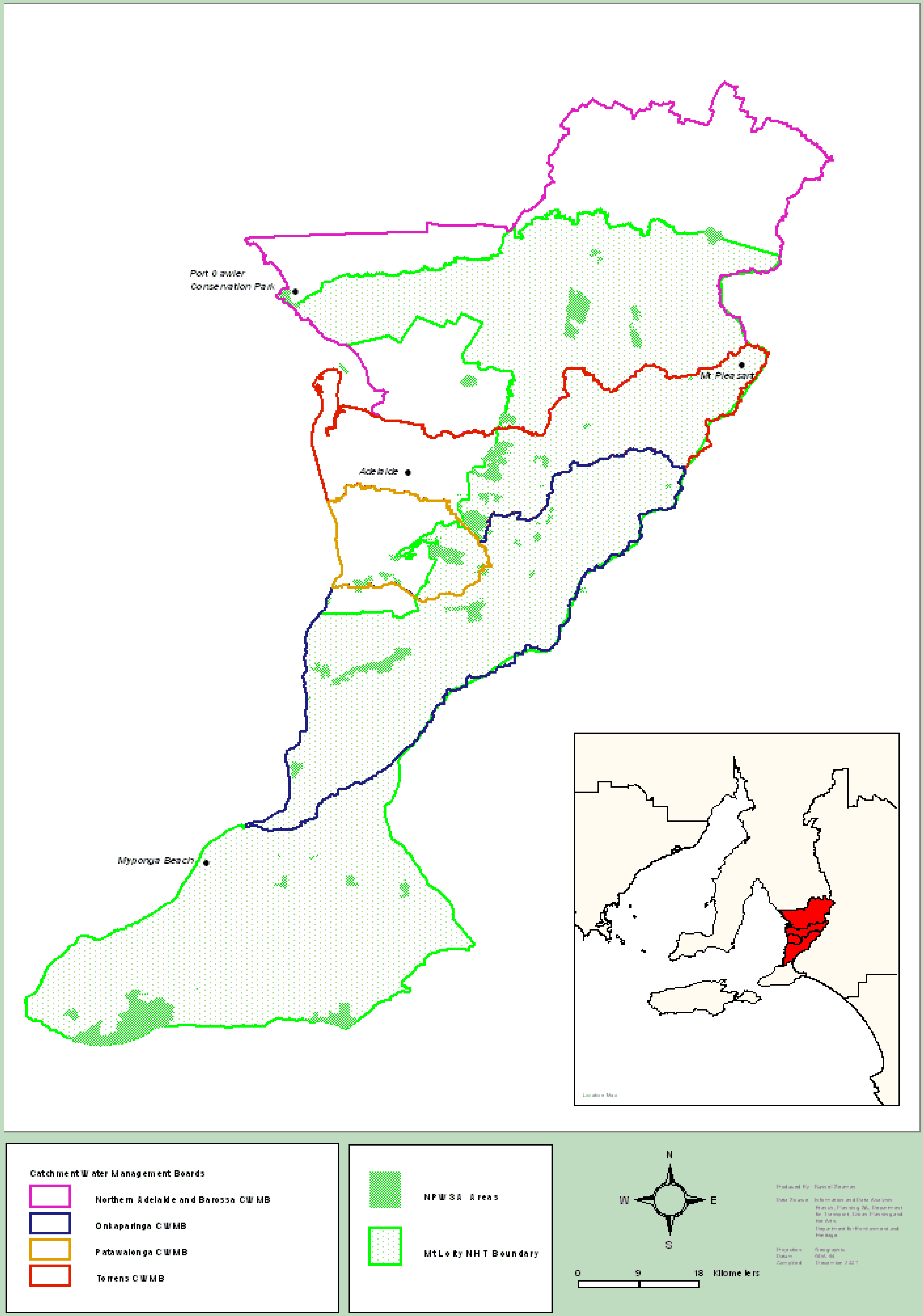
WETLAND NUMBER	FAMILY	GENUS	SPECIES	COMMON_NAME
S2073	Lymnaeidae	*Austropeplea*		Snails
Osmond Wetland	Notodromadidae	*Newnhamia*		Seed shrimps
S2081	Hylidae	*Crinia*	*signifera*	Juvenile form Common froglet
Kersbrook Wetland		*Newnhamia*		Seed shrimp
	Notonectidae	*Anisops*		Backswimmer
	Libellulidae			Dragon fly
	Ceinidae			Scuds
S2061	Notonectidae	*Anisops*		Backswimmers
Onkaparinga 3		*Newnhamia*		Seed shrimp
	Hydrobiidae	*Potamopyrgus*		Introduced snail
S2057	Daphniidae			Water fleas
Washpool Lagoon	Paramelitidae			Scuds
S2062 Onkaparinga 4	Paramelitidae			Scuds
S2067 Frank Smith Dam	Paramelitidae			Scuds
S2075	Lymnaeidae	*Austropeplea*		Pond snail
Centennial Drive Swamp				
	Notonectidae	*Anisops*		Backswimmer
	Paramelitidae			Scuds
S2058	Notonectidae	*Anisops*		Backswimmers
Aldinga scrub wetland	Daphniidae			Water fleas
S2053 Kenneth Dam				Beetle
S2051	Hylidae	*Crinia*	*signifera*	Juvenile form Common froglet
Taworri Reserve				
	Daphniidae			Water fleas
		Newnhamia		Seed shrimp
S2066 Frank Smith wetland		*Newnhamia*		Seed shrimp
S2049 Fox Creek Dam				
	Paramelitidae			Scuds
S2071				
Hrmo creek	Ceinidae			Scuds
	Chironomidae			Non-biting midge larve
S2048 Simmonds Hill 2	Daphniidae			Water fleas

WETLAND NUMBER	FAMILY	GENUS	SPECIES	COMMON_NAME
S2055 Prickly Tea - Tree Swamp	Culicidae			Mosquitoes
S2049	Paramelitidae			Scuds
Fox Creek Dam		*Newnhamia*		Seed shrimp
S2047 Simmons Hill 1	Daphniidae			Water fleas
S2052 Gunda Reserve	Notonectidae	*Anisops*		Backswimmers
S2041 Silky Tree Swamp	Notonectidae	*Anisops*		Backswimmers
S2021 Englebrook Reserve	Chironomidae			Non-biting midge larve
S2033 Bushland Park Lake 2	Paramelitidae			Scuds
S2007 Heathfield Bog	Paramelitidae			Scuds
S2026 HK Fry	Notonemouridae			Stoneflys
	Hydrobiosidae	*Apsilochorema*		Caddis Fly
S2040	Daphniidae			Water fleas
Radbone Road Dam	Chaoboridae			Phantom midges
S2004 Stirling Park Wetland 3		*Newnhamia*		Seed shrimp
S2046	Daphniidae			Water fleas
Botanic Dam		*Newnhamia*		Seed shrimp
S2011 Kangaroo Gully 2	Chaoboridae			Phantom midges
S2013	Chironomidae			Bloodworms
Parafield wetlands		*Newnhamia*		Seed shrimp
	Daphniidae			Water fleas
S2022	Hydrachnidae			Mite
Mount George wetland	Viviparidae	*Notopala*		Snails
		Newnhamia		Seed shrimp
S2037		*Newnhamia*		Seed shrimp
Humbug dam 2	Notonectidae	*Anisops*		Backswimmers
	Daphniidae			Water fleas
S2028 Chinamans bog	Notonemouridae			Stonefly

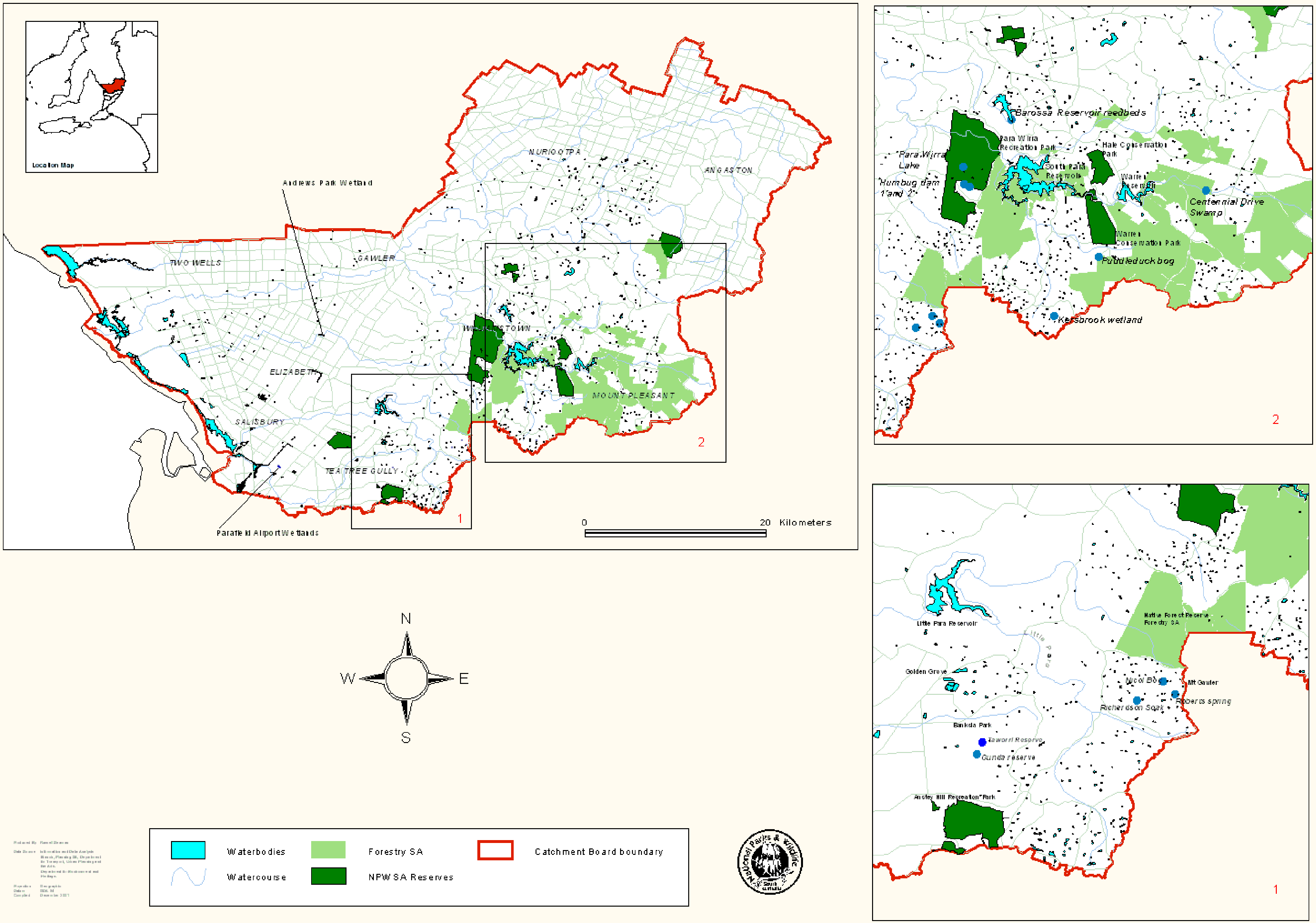
WETLAND NUMBER	FAMILY	GENUS	SPECIES	COMMON_NAME
S2003 Stirling Park Wetland 2		*Newnhamia*		Seed shrimp
S2023 Lewis trail Wetland	Janiridae	*Newnhamia*		Seed shrimp
S2038	Coenagrionidae			Damselflies
Barossa Reservoir		*Newnhamia*		Seed shrimp
	Atyidae	*Paratya*		Freshwater shrimp
S2002				Caddis flies
Stirling Park Wetland 1	Chironomidae			Non-biting midges
	Hydrachnidae			mites
S2031	Hydrachnidae			mites
Playford Lake	Daphniidae			Water fleas
S2024	Janiridae			
Mount George wetland 2		*Newnhamia*		Seed shrimp
	Culicidae			Mosquitoes
	Paramelitidae			Scuds
S2034	Janiridae			
Grasby Park	Chaoboridae			Phantom midges
		Newnhamia		Seed shrimp
S2008	Chydoridae			Water fleas
Aldgate Valley Reserve		*Newnhamia*		Seed shrimp
S2005 Para Wirra Lake	Hydrachnidae			mites
S2006 Rubida Grove		*Newnhamia*		Seed shrimp
S2027		*Newnhamia*		Seed shrimp
Carey Gully Water Reserve	Notonemouridae			Stoneflies
	Hydrophilidae			Water beetles
S2001	Hydrachnidae			mites
Woorabinda Lake		*Newnhamia*		Seed shrimp
	Chydoridae			Water fleas
	Janiridae			
	Paramelitidae			Scuds
S2029 Wilsons Bog		*Newnhamia*		Seed shrimp
S2035	Caenidae			Mayfly
Buffer Track				Seed shrimp
S2012	Paramelitidae			Mayfly
Kangaroo Gully		*Newnhamia*		Seed shrimp
S2032 Bushland Park Lake	Caenidae			Mayfly
S2036 Humbug Dam 1	Chydoridae			Water fleas

WETLAND NUMBER	FAMILY	GENUS	SPECIES	COMMON_NAME
S2010 Kangaroo Gully 1	Chydoridae			Water fleas
S2039				Proboscis worm
Lange Crecent	Ceinidae			Common froglet (Tadepole)
	Chydoridae			Water fleas
S2009 Nurutti Reserve	Chydoridae			Water fleas
S2083		*Newnhamia*		Seed shrimp
Puddleduck Bog	Chironomidae			Non-biting midges
	Notonectidae	Anisops		Backswimmers
S2069	Notodromadidae	Newnhamia		Seed shrimps
Minno Creek Railway Dam	Notonectidae	Anisops		Backswimmers
S2072	Philorheithridae			Caddis fly
Cooper Wetland	Notodromadidae			Seed shrimps
S2074	Ceinidae			Scuds
Andrews Park Wetland	Notonemouridae			Stoneflys

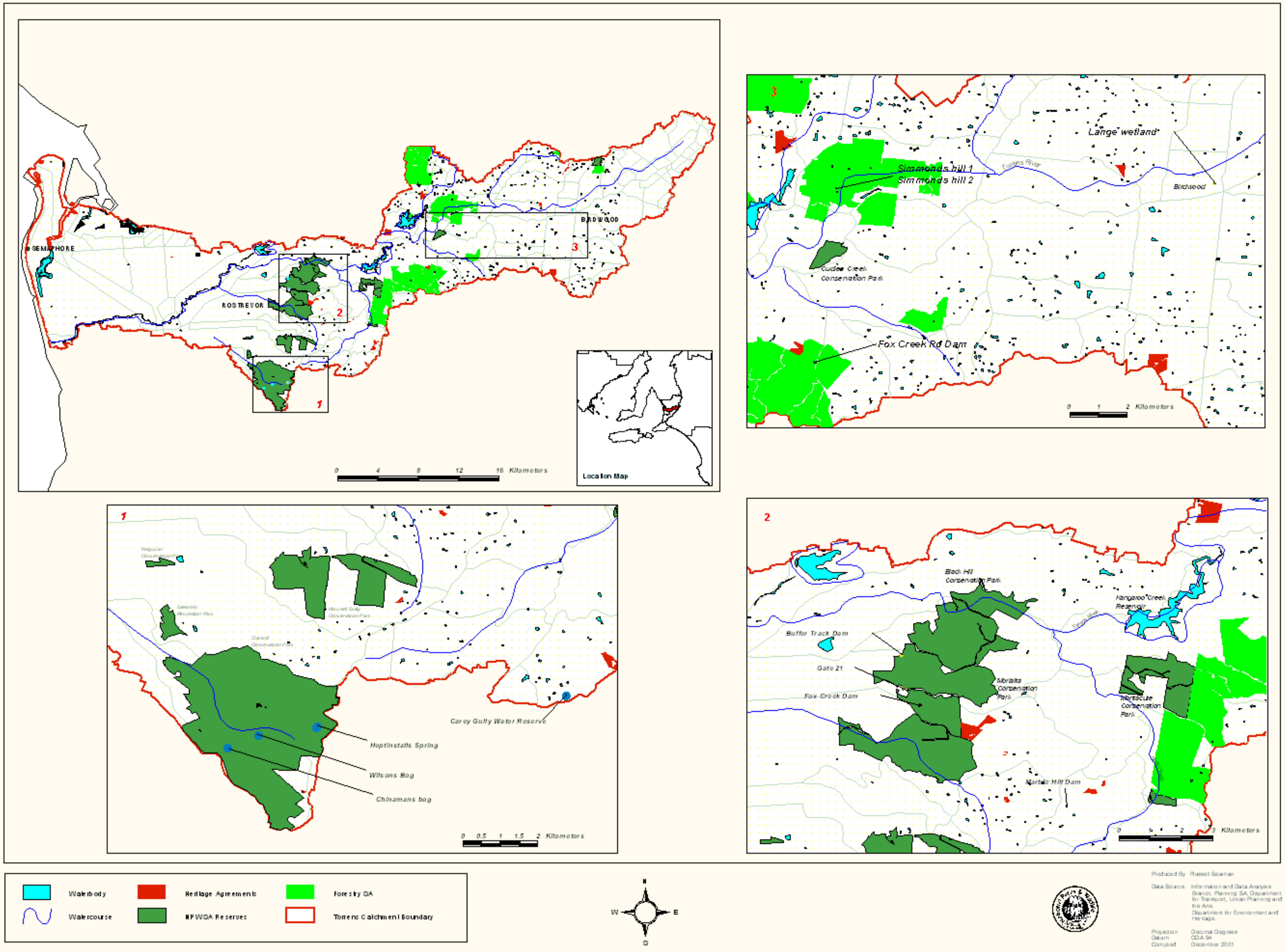
Map 6-1 Wetland inventory boundaries



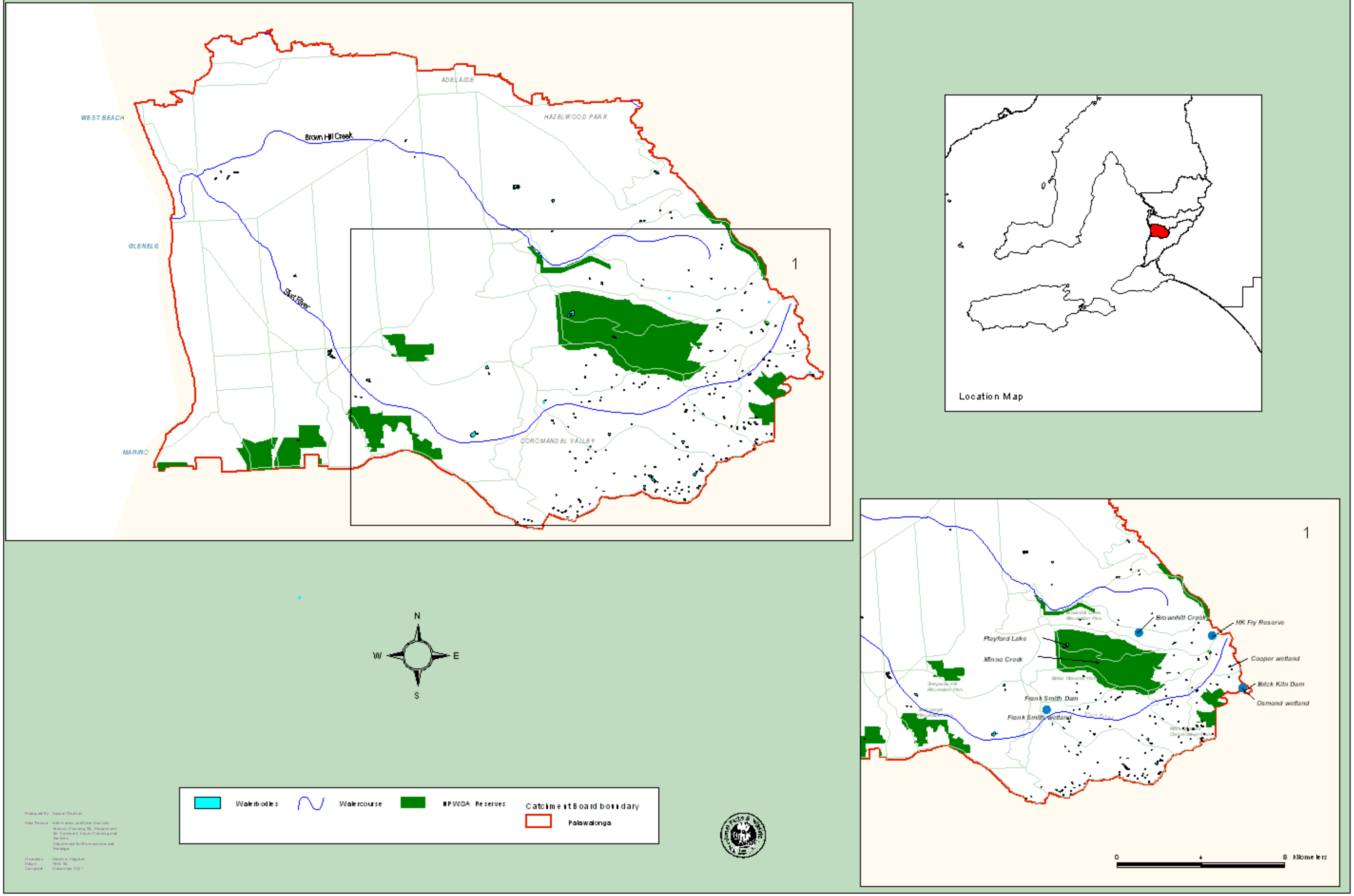
Map 8-1 Wetland localities in the Northern Adelaide and Barossa Catchment Water Management Board



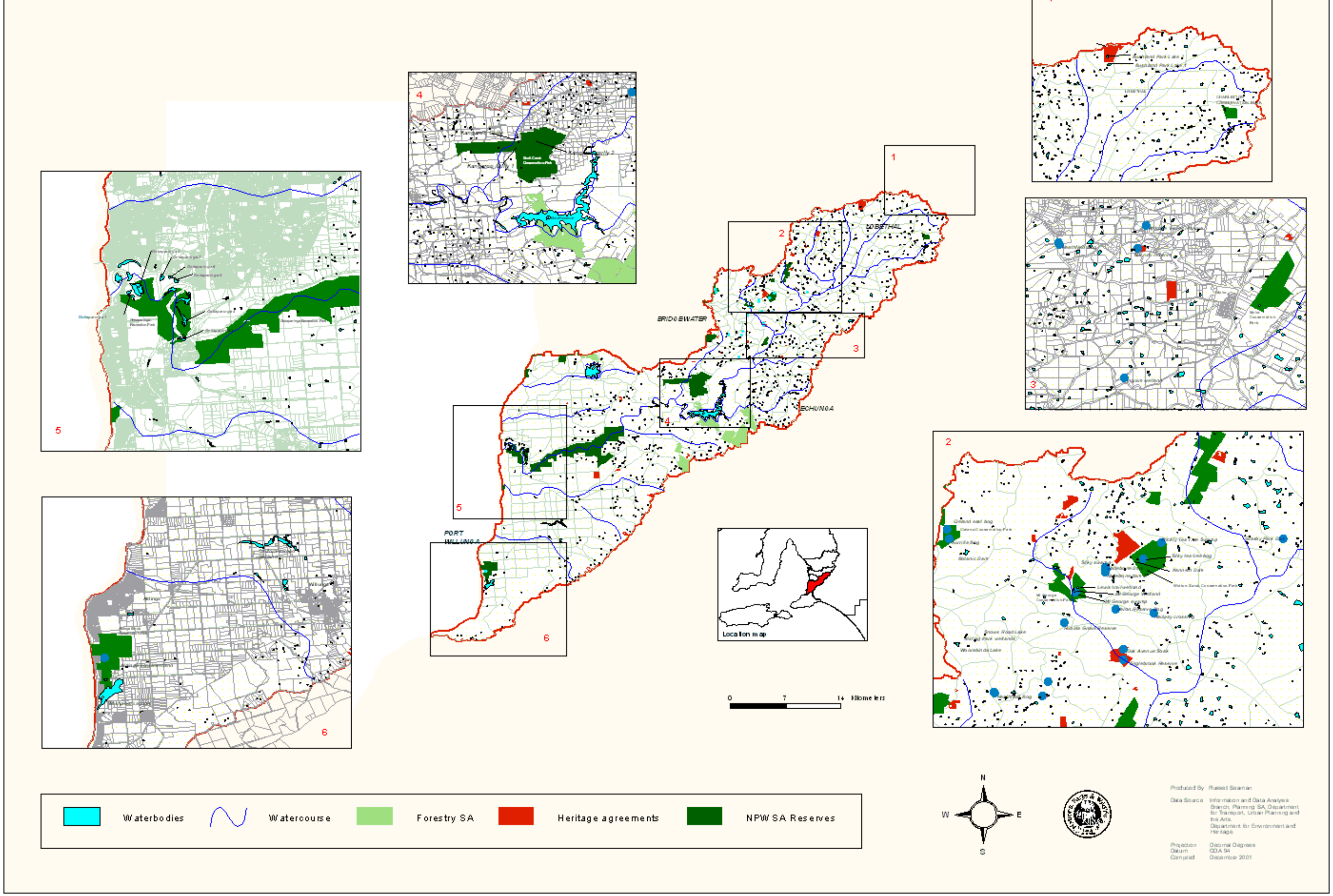
Map 8-2 Wetland localities in the Torrens Catchment Water Management Board



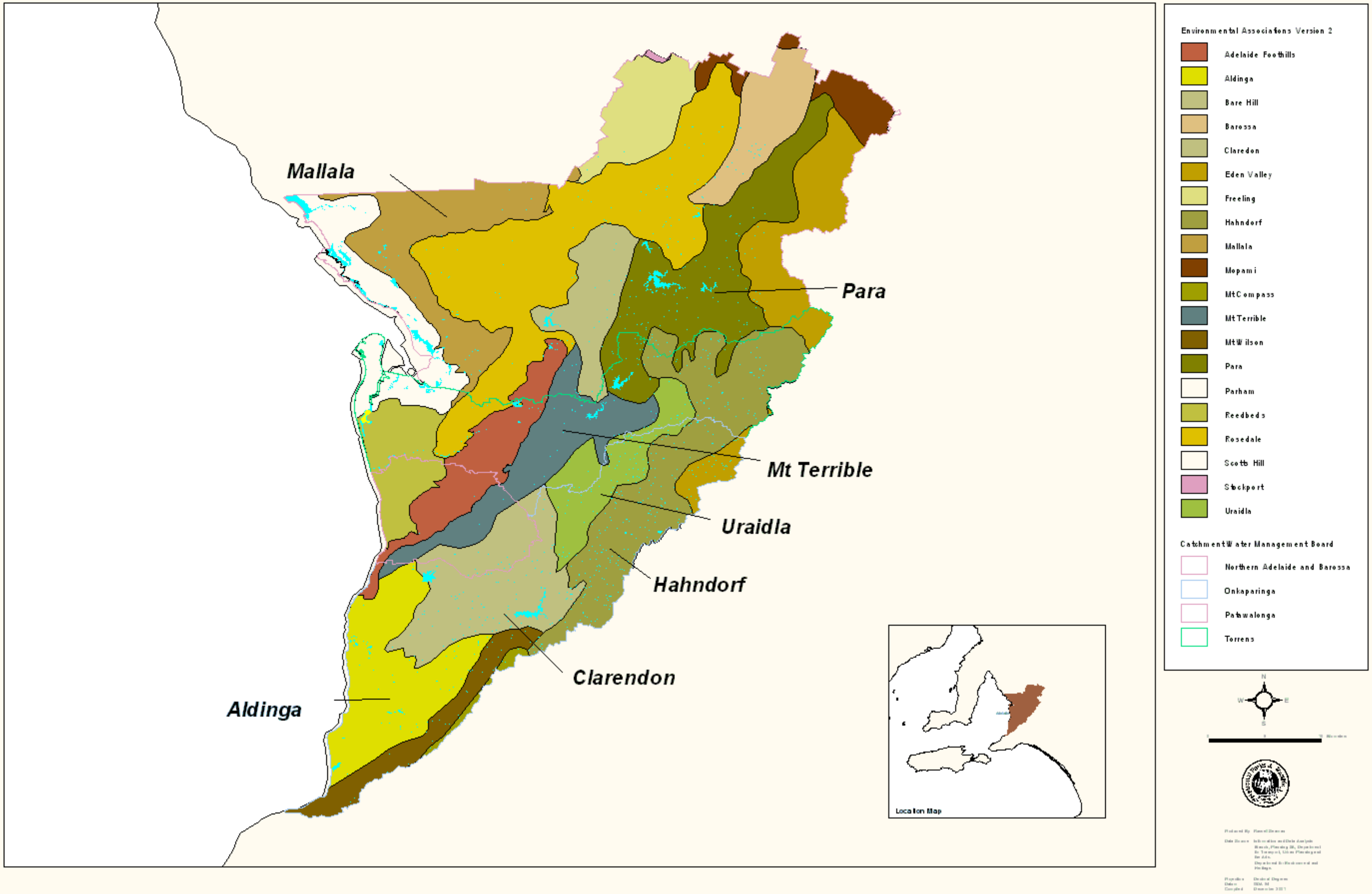
Map 8-3 Wetland localities in the Patawalonga Catchment Water Management Board



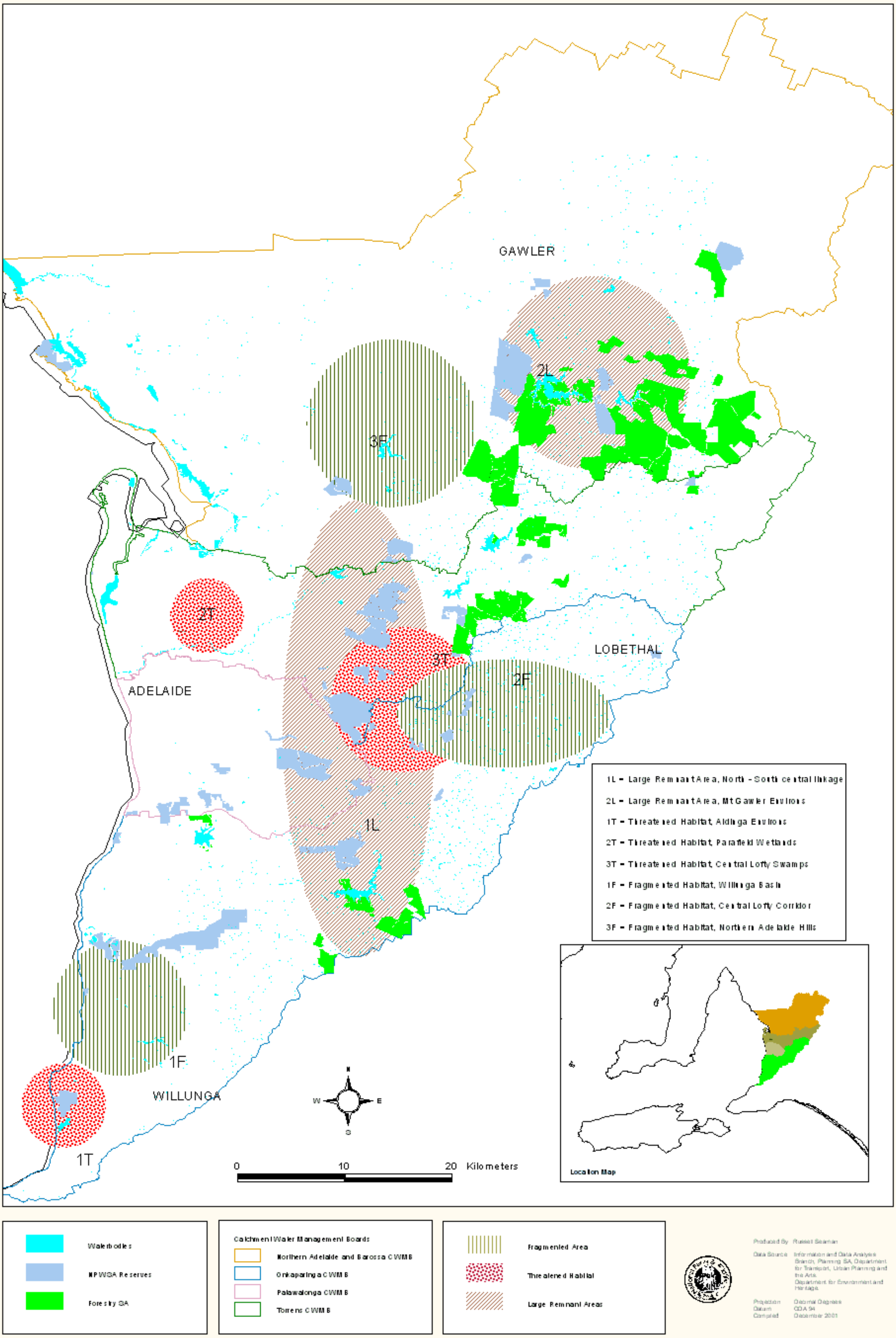
Map 8-4 Wetland localities in the Onkaparinga Water Catchment Management Board



Map 11-1 Environmental Assocations



Map 12-1 Wetland Key Biodiversity Areas

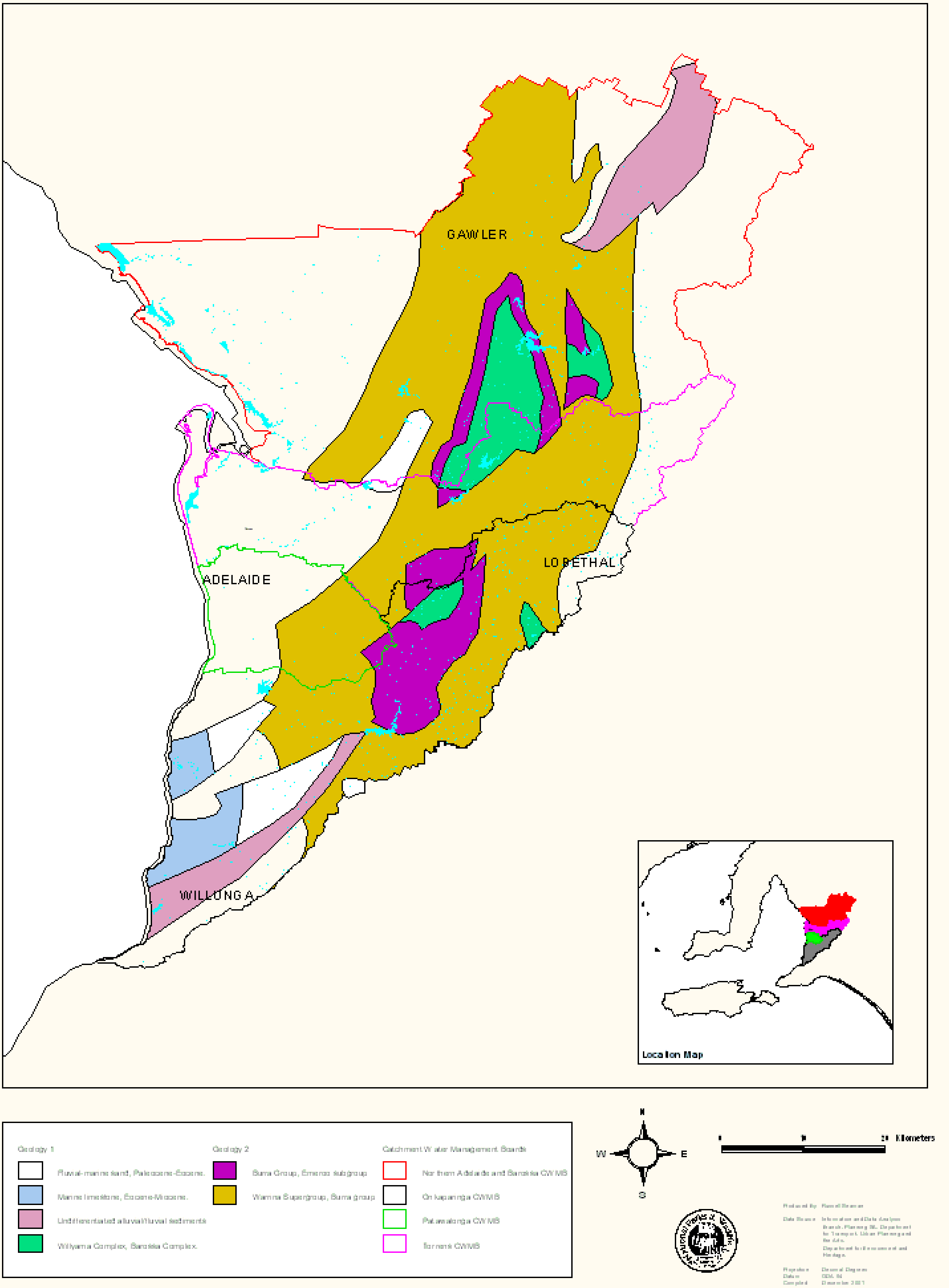


Produced By Russell Seaman

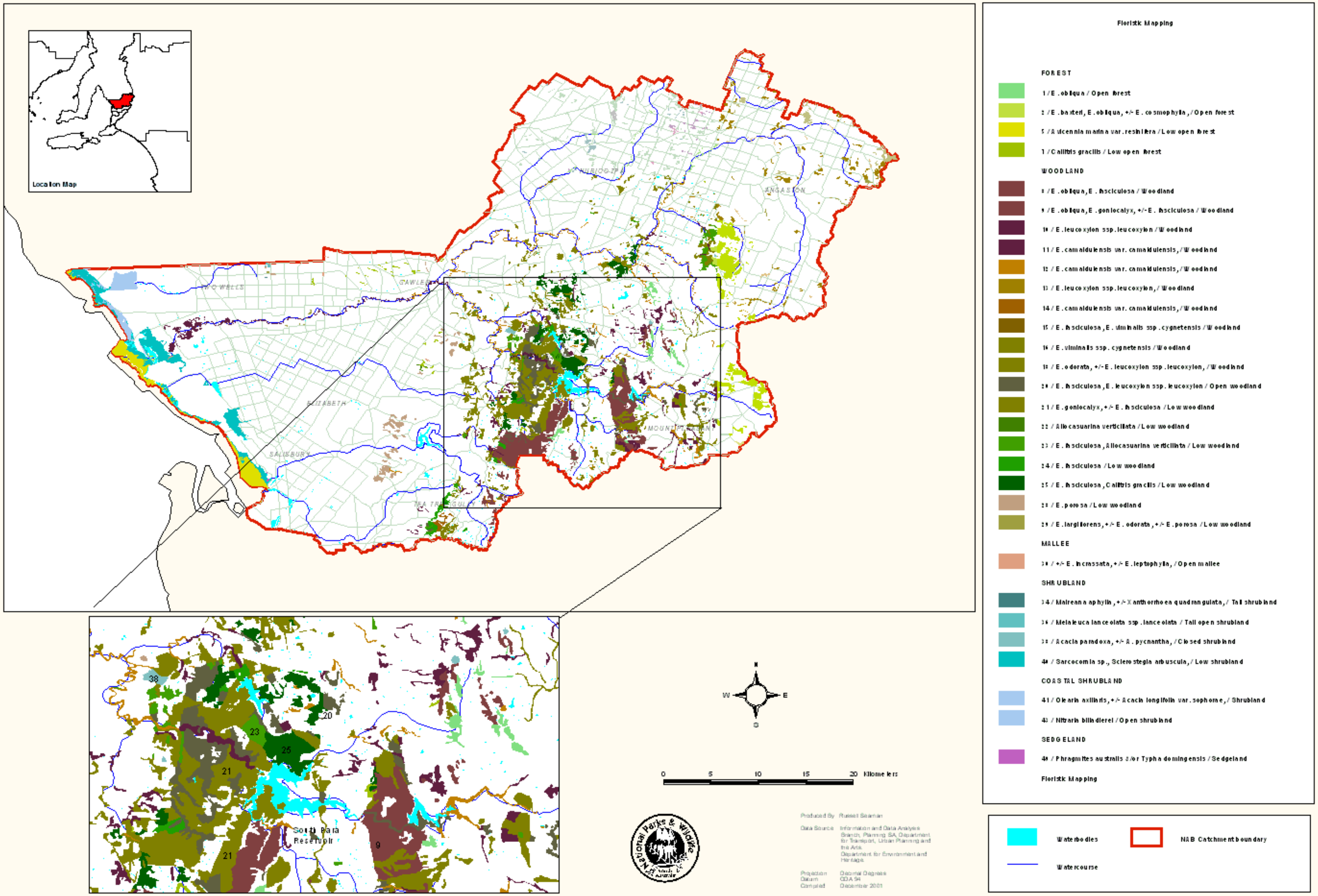
Data Source Information and Data Analysis Branch, Planning SA, Department for Transport, Urban Planning and the Arts. Department for Environment and Heritage.

Projection Decimal Degrees
Datum GDA 94
Compiled December 2001

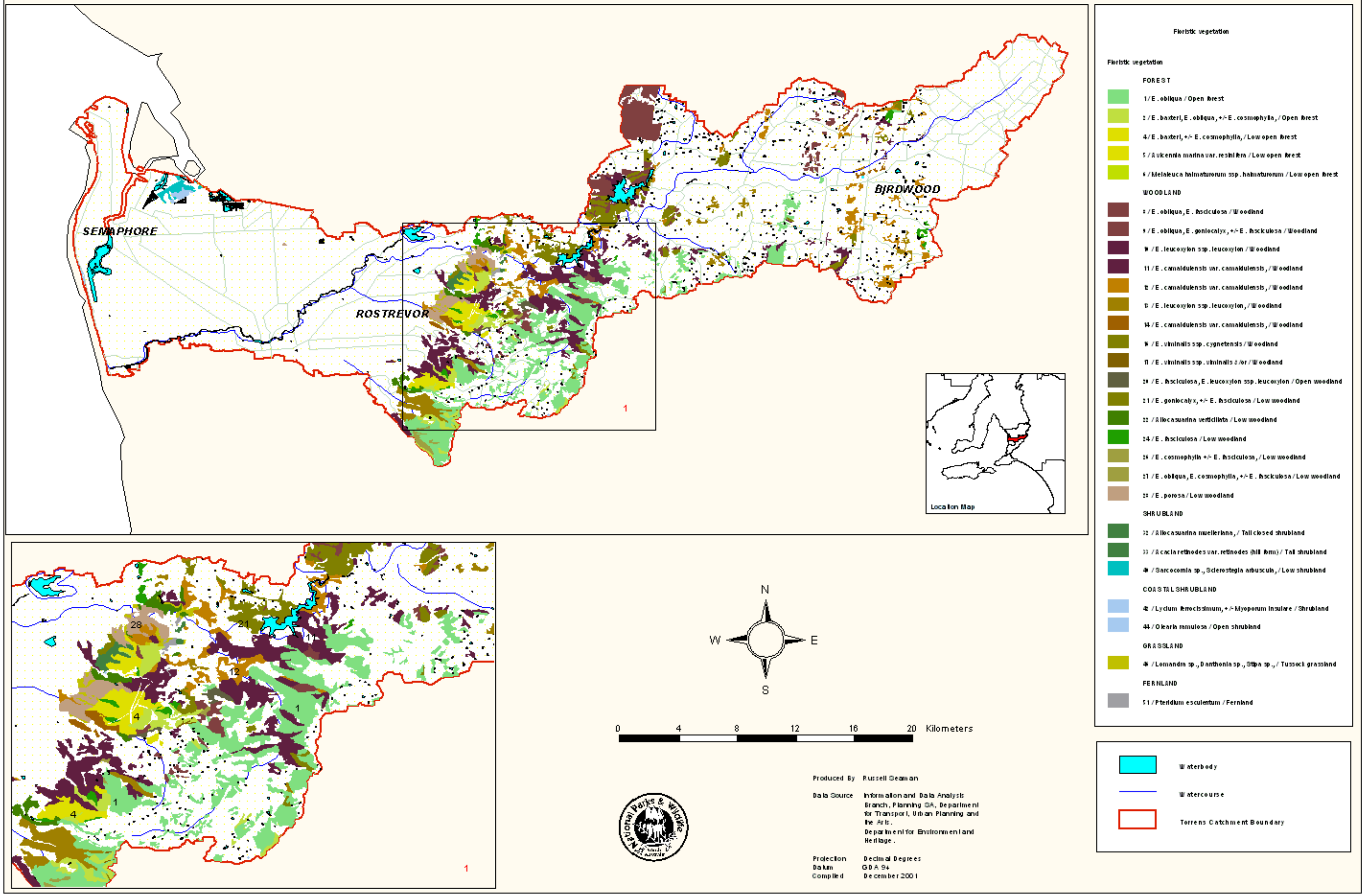
Map 15-1 Geological groups within wetlands surveyed



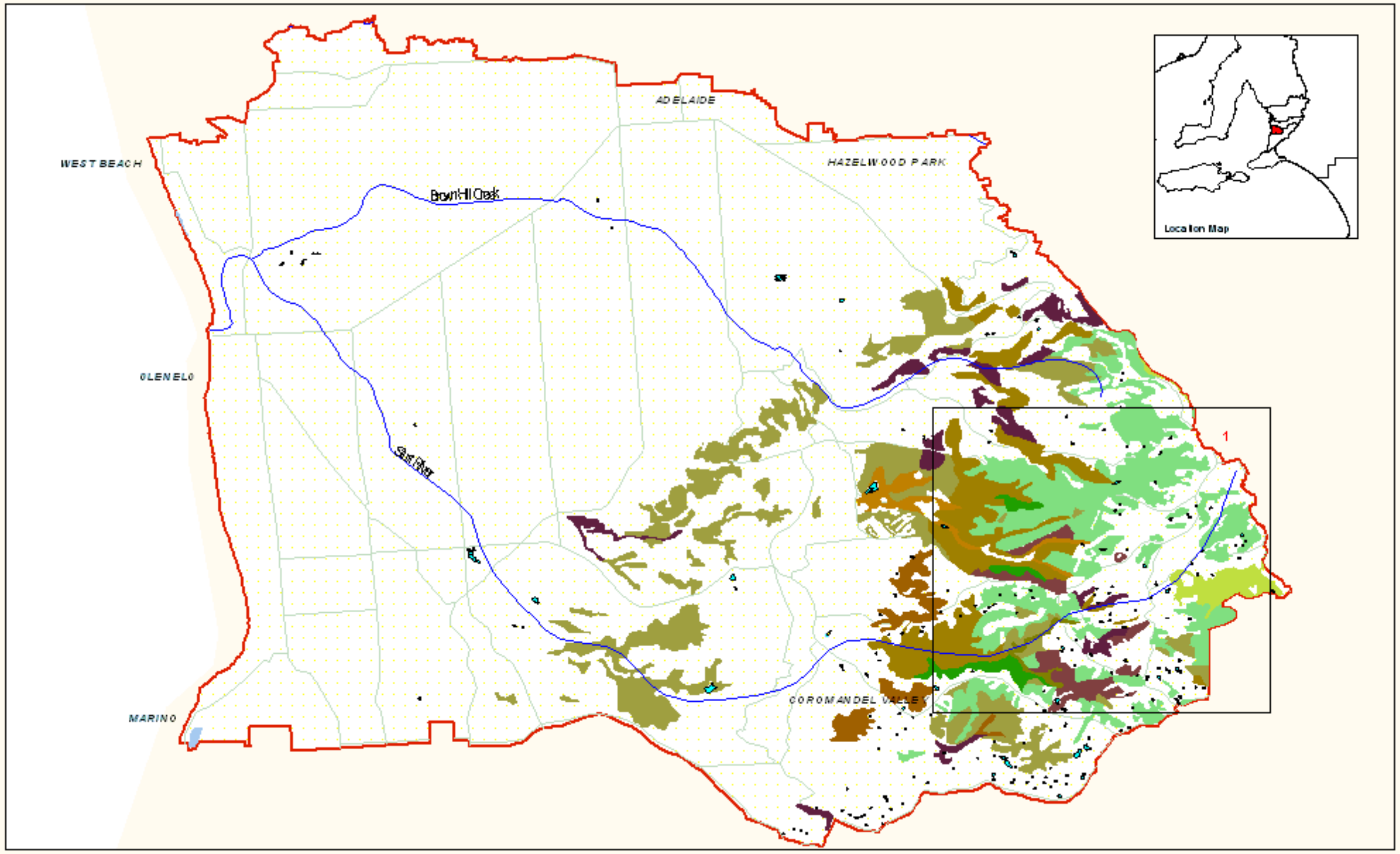
Map 17-1 Remnant vegetation distribution within the Northern Adelaide and Barossa Water Catchment Board

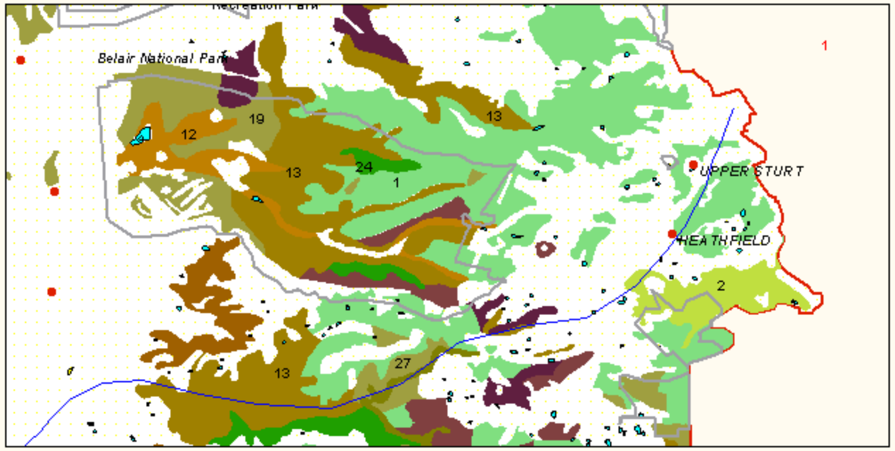


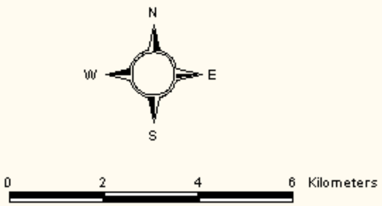
Map 17-2 Remnant vegetation distribution within the Torrens Catchment Water Management Board



Map 17-3 Remnant vegetation distribution within the Patawalonga Catchment Water Management Board







Florisfic vegetation

FOREST

1 / E. obliqua / Open forest

2 / E. baxteri, E. obliqua, +/- E. cosmophylla, / Open forest

WOODLAND

8 / E. obliqua, E. fasciculosa / Woodland

10 / E. leucoxylon ssp. leucoxylon / Woodland

11 / E. camaldulensis var. camaldulensis, / Woodland

12 / E. camaldulensis var. camaldulensis, / Woodland

13 / E. leucoxylon ssp. leucoxylon, / Woodland

14 / E. camaldulensis var. camaldulensis, / Woodland

16 / E. viminalis ssp. cygnetensis / Woodland

19 / E. microcarpa, +/- E. fasciculosa, / Woodland

24 / E. fasciculosa / Low woodland

26 / E. cosmophylla +/- E. fasciculosa, / Low woodland

27 / E. obliqua, E. cosmophylla, +/- E. fasciculosa / Low woodland

COASTAL SHRUBLAND

41 / Olearia axillaris, +/- Acacia longifolia var. sophorae, / Shrubland

Waterbodies

Watercourse

Catchment boundary

Patawalonga

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Department for Environment and Heritage.

Projection Decimal Degrees
Datum GDA 94
Compiled December 2001

Map 17-4 Remnant vegetation distribution within the Onkaparinga Catchment Water Management Board