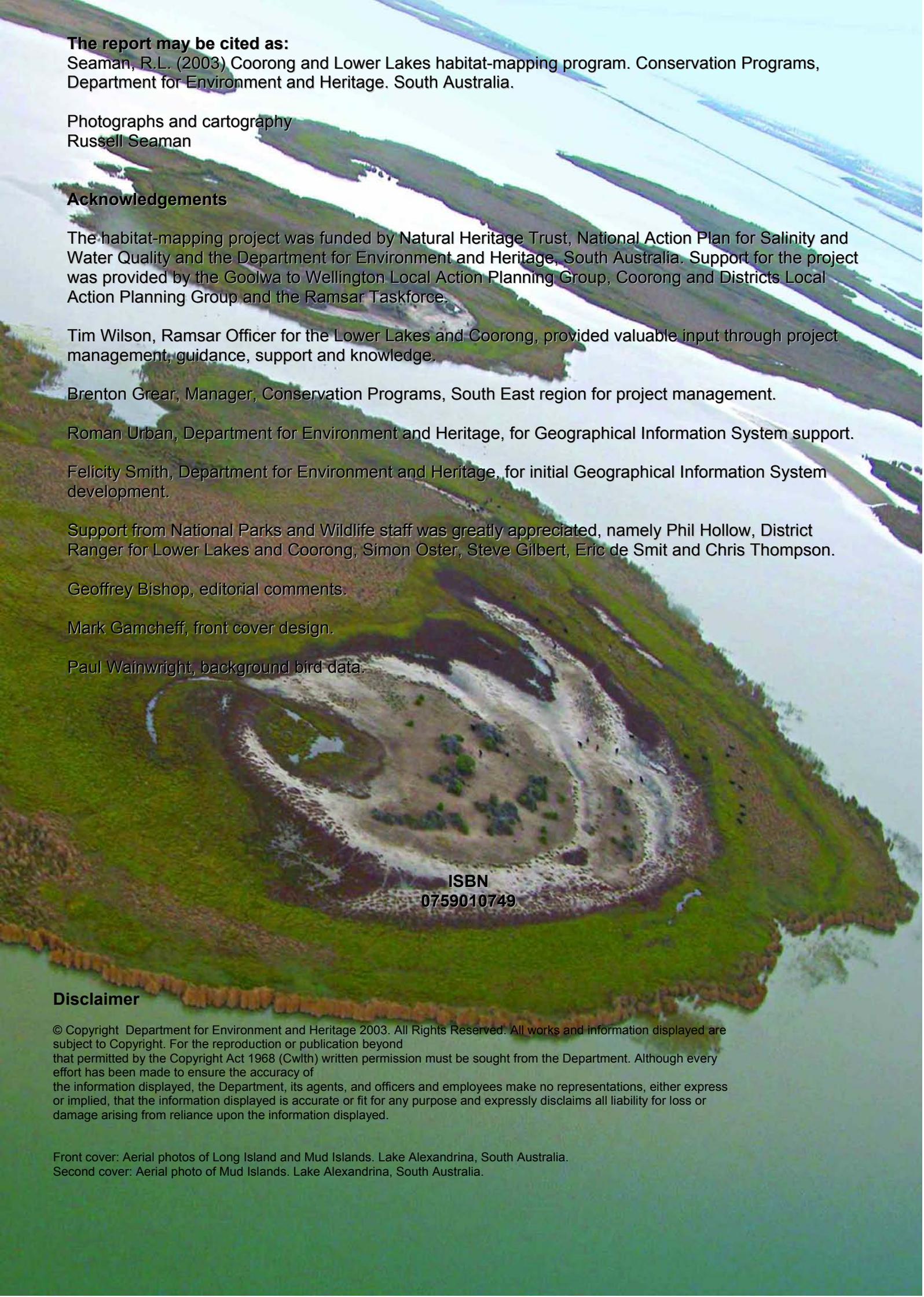


Coorong and Lower Lakes Ramsar Habitat Mapping Program



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Front cover: Aerial photos of Long Island and Mud Islands. Lake Alexandrina, South Australia.
Second cover: Aerial photo of Mud Islands. Lake Alexandrina, South Australia.

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Abstract

The Coorong and Lower Lakes encompasses one of Australia's most significant wetlands. Owing to its significant waterbird habitats, the Coorong, Lake Alexandrina and Lake Albert has been designated a Wetland of International Importance under the Ramsar Convention in 1985. A Ramsar Management Plan was produced in 2000 to guide government agencies and the community groups in the management of this area.

One of the key strategies of the Ramsar Management Plan (Strategy 4.1) is the development of a detailed mapping program and database for the Ramsar site. The aim of habitat mapping database is to provide a planning tool to inform government, the community and private enterprise of the nature, distribution and value of the natural resources and critical habitat areas within and the Ramsar site.

The Habitat mapping database project was completed between July 1st 2002 and July 1st 2003. The study area is divided into two stages. Stage one covers the localities of Lake Alexandrina, Lake Albert, Currency Creek, Finniss River, Hindmarsh Island and Goolwa Channel. Stage one classified 518 habitats covering an area of 24,400 hectares. Stage two encompasses the Coorong National Park covering an area between the Murray Mouth and the southern Coorong National Park boundary near Kingston. Stage two classified 195 habitats covering an area of 25,980 hectares.

The habitat mapping project identifies and maps the types of habitats within the Ramsar area, for example, mud flats, rocky shorelines, sandy beaches, cliffs and all vegetation associations. These habitats are mapped using Geographical Information Software (GIS) and information about the habitat is recorded by entering information into a GIS database, which allows for 50 habitat classification categories. From this information habitats can be classified, habitat condition and threats documented. The habitat mapping database can also be queried and can show habitat types, extent, condition and species use.

The database is also a prediction tool enabling the user to input habitat requirements for a particular species and then produce maps showing the distribution of the selected parameters. Habitat predictions for the Southern Pygmy Perch *Nannoperca australis*, Murray Hardyhead *Craterocephalus fluviatilis* and the Yarra Pygmy Perch *Nannoperca obscura* is provided. Predicted habitats are also given for bird species, including, five vulnerable species and one critically endangered species listed under the *National Parks and Wildlife Act 1972*. Habitat distribution is also displayed for five migratory waders and five water birds with rare or vulnerable ratings listed under the *National Parks and Wildlife Act*.

An example of how the habitat mapping database is used as a planning tool is also provided by, analysing potential conflicts with habitats and development plan zoning provisions. Habitats that have been classified with an excellent condition rating have been extracted and overlaid with the development planning zones for the district councils of Murray Bridge, Coorong and Alexandrina.

This project represents the first stage of a long term strategy to improve the knowledge and information base for the Coorong and Lower Lakes Ramsar site. This first stage has established a GIS habitat database and will be updated regularly as more information is collected.

Section one Coorong and Lower Lakes habitat mapping program

1.0 Introduction

The Coorong and Lower Lakes encompasses one of Australia's most significant wetlands. Owing to its significant waterbird habitats, it was designated as a Wetland of International Importance under the Ramsar Convention in 1985. This wetland provides habitat for many local species as well as for migratory wading birds, many flying in from as far away as Alaska. The Australian Federal Government has obligations to manage habitat for these species, due to migratory bird agreements, such as the China and Australia Migratory Bird Agreement (CAMBA), signed in 1986, and the Japan and Australia Migratory Bird Agreement (JAMBA), signed in 1981. Together the lakes cover approximately 648 square kilometres which makes them the largest freshwater body in South Australia.

The Coorong and Lower Lakes (Lakes Alexandrina and Albert) are the ancestral home for the Ngarrindjeri people who have a living cultural connection with this region. Since the late 1800s, the Coorong and Lower Lakes have been altered by river regulation, agriculture, introduced exotic plants and animals, river traffic and recreation. The Ramsar area includes a variety of habitat types, which can vary seasonally. The area is extensively utilised by the community, has economic significance and is a popular recreation area.

Habitats around the edge of the lakes are influenced by, and change in response to, water regulation procedures at the barrages which maintain the lakes at a nominal level of 0.75 metres Australian Height Datum (AHD). However, there is a cyclical change in levels from about 0.85 metres AHD in late spring to a low of 0.6 metres AHD in autumn and lower in drought years. As a result, variations in water levels around the lake edges resulting in mud flats being exposed seasonally, providing habitat for migratory waders. This slight rise and fall in lake water levels results in seasonal variation to habitats. Wind has an important influence on lake levels. Wind can push water higher up one side of the lakes or the other, and up and down the river resulting in daily and weekly variations in local lake levels of nearly a metre during periods of prolonged, strong winds.

The Coorong, which is the water body confined by the coastal dune barrier of the Younghusband and Sir Richard Peninsulas, is some 140 kilometres long. Coorong habitats range from seasonally fresh near the barrages when large quantities of water are being released, to brackish in the Murray Mouth area, grading to hypersaline in the southern lagoon. The Coorong experiences seasonal changes in water level which are as much as a metre in the southern lagoon from late spring highs to late autumn lows. As water levels fall from early summer, extensive tidal mud flats are exposed along the southern shores of the Coorong. These are habitat for a number of species of wading birds, many of which are seasonal migrants to Australia and breed in Alaska, northern China and Siberia. On the peninsula side, there are freshwater soaks, which provide further variety of habitat types. Wind and tide also cause short-term variations in water levels locally. Storm tide events can force seawater back through open barrage gates into the lakes and across causeways on Ewe and Tauwichee islands into the lakes. The seaward side of the coastal dune barrier is a high energy coast with a continuous sand beach broken only by the Murray Mouth, stretching from Lacepede Bay to Encounter Bay, a distance of nearly 200 kilometres. About 150 kilometres of this beach is within the Ramsar area (Department for Environment and Heritage 2000).

The habitat mapping project identified and mapped the types of habitats within the Ramsar area, for example, mud flats, rocky shorelines, sandy beaches, cliffs and all vegetation associations. These habitats were mapped using Geographical Information Software (GIS) and information about the habitat was recorded by entering information into a GIS database. From this information habitats were classified and habitat condition and threats documented. The habitat mapping database can be queried and can show habitat types, extent, condition and species use.

The database is also a predictive tool enabling the user to input habitat requirements for a particular species and then produce maps showing the distribution of the selected parameters. The habitat mapping database is an evolving process and the primary application is for assisting management decisions by providing information about habitats. Undertaking habitat analysis in a report format is not the aim of the project. This report however, provides a 'snap shot' of the habitat mapping database at the current stage of development.

2.0 Report Structure

This report is divided into four sections:

Section 1 - habitat mapping program. This section outlines the project aims and methodology.

Section 2 – habitat assessment. This section provides an analysis of the habitat mapping database and includes the identification of habitat values and threats.

Section 3 – habitat mapping database applications. This section explores the applications available for the habitat mapping database. Habitat requirements for migratory birds, native fish and other selected fauna are discussed and habitat distribution is predicted for these species. Threat analysis is undertaken with respect to regional planning and the concepts of defining ecological character are investigated.

Section 4 – provides descriptions for the habitat classification table.

3.0 Ramsar Management Plan

One of the key strategies of the Ramsar Management Plan (Strategy 4.1) is the development of a detailed mapping program and database for the Ramsar site. The aim of habitat mapping database is to provide a planning tool to inform government, the community and private enterprise of the nature, distribution and value of the natural resources and critical habitat areas within and surrounding the Ramsar site.

The habitat mapping database will assist in achieving the following objectives of the Ramsar Management Plan (Department for Environment and Heritage 2000):

Objective 1: Integrated environmental management of the Coorong and Lower Lakes Ramsar Wetlands with monitoring of biotic indicators to ensure the sustainable, multiple use of the region; and monitoring of management performance against the plan objectives.

Objective 3: Improved awareness among all key stakeholders and the wider community of the natural values of the Coorong and Lower Lakes Wetlands and Ramsar principles expressed in the Management Plan.

Objective 4: Protection of the full range of wetland habitats and restoration of degraded habitats in the Ramsar area and their conservation for future generations.

Objective 5: Increased environmental benefits from the improved management of existing water entitlements and improved water quality and flows.

4.0 Project Actions

In assisting to achieve the objectives listed above, the project consists of five actions:

- Establish a detailed mapping program and database linked to a Geographical Information System (GIS)
- Map and document areas of significant environmental importance
- Include all habitat types, including reed beds, managed and natural riparian vegetation and salt marsh
- Include habitat for key species identified as rare, vulnerable or endangered in the area, including the habitats for migratory species protected under CAMBA or JAMBA
- Identify degraded and degrading habitats.

5.0 Study boundaries and time frame

The habitat mapping database project boundaries include the Coorong National Park and Lakes Alexandrina and Albert. The perimeter of the study boundary extends to include those wetlands that are within the 1956 flood level of the River Murray. Refer to [Figure 1](#).

The study area was divided into two areas to assist in efficient data collection, data storage and analysis. Stage one covers the localities of Lake Alexandrina, Lake Albert, Currency Creek, Finnis River, Hindmarsh Island and Goolwa Channel. Stage two encompasses the Coorong National Park covering an area between the Murray Mouth and the southern Coorong National Park boundary near Kingston, refer to [Figure 1](#). The two areas also reflect broad ecological differences, the lower lakes being a freshwater environment and the Coorong is a saline coastal environment.

Dataset development and fieldwork was undertaken for stage one between July 2002 and February 2003 with the majority of the fieldwork undertaken between October 2002 and February 2002. Fieldwork for stage two was undertaken between March 2003 and June 2003.

6.0 Project Milestones

One: Selection of habitat classification methodology and a database design.

The classification methodology has been developed through a review of literature and methodologies relevant to the classification of habitats. Some of these include the South Australian Biological Survey landform classification criteria developed by the Department for Environment and Heritage (DEH) and the ANZECC wetland criteria for determining important wetlands.

A review of literature and databases was undertaken to gain an understanding of ecological requirements for key flora and fauna and habitat types within the Ramsar site. Threats and threatening processes for species and communities were also documented.

Two: Collate existing spatial data sets

The analysis of existing data is concentrated at the 1:50,000 scale, which is the standard used by the State Biological Mapping Program. The collation of existing GIS data sets provided an overview of current resources and highlight data gaps.

The data sets analysed included:

- Vegetation mapping
- Topographic mapping
- Mangrove and salt marsh mapping classification as developed by DEH
- GIS point data of marine mammal and seabird distributions
- GIS map of land tenure
- Mapped distributions of known major spawning, feeding, shelter, nursery areas for fish
- Distributions of commercially and recreational significant fish and mollusc species and other spatial fisheries information (in progress)
- GIS data relevant to vulnerability/threats analysis (drainage and discharge points, aquaculture lease boundaries and descriptions; position of coastal national parks as buffers against some coastal threats)
- Migratory bird data set
- Soil data

In collating information consideration was given to the currency of information, the source of data and information, and the reliability of the data.

Outcome: the identification of those GIS data sets that can be used to develop a habitat mapping data set.

Three: Data set development

Those data sets that can be used to develop a habitat mapping data set are combined into a single data set through a process of editing, merging and joining using ArcGIS.

Outcome: creation of a GIS habitat mapping data set

Four: Gap analysis and fieldwork preparation

As there is either an absence of critical datasets for some areas or there are sites within the study area for which little or no habitat information is available, a gap analysis was carried out.

In order to fill these gaps in the spatial coverage of existing datasets, two methods of analysis are used prior to field investigations, these are:

1. Aerial Photography

Aerial photography interpretation (1:40,000) to identify habitats areas that are not included in the habitat mapping coverage.

2. Expert knowledge

Local knowledge of habitats is gained through consultation with local experts. Habitats are included which could not be identified through the use of aerial photography or existing data sets.

The absence of datasets was filled during the data collection stage. The amount of additional data to collect is determined by the temporal and financial constraints placed on the project. In consultation with experts and appropriate major stakeholders decisions were made as to whether effort should go into gathering more information for a smaller area or less information for a larger area.

Outcome: Additional habitat sites and datasets are identified.

Five: Field Investigation, verification, data collection and storage

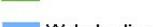
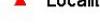
The purpose of this stage was to verify, map and assign attributes to the habitat mapping data set. The information is collected using the habitat classification template and entered into the GIS database.

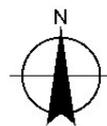
Outcome: A GIS coverage for each habitat identified and environmental information linked to the habitat.

Figure 1. Habitat Mapping Project Study Boundaries



Legend

-  Stage one
-  Stage two
-  1956 Flood level
-  National Parks SA Reserves
-  Waterbodies
-  Localities
-  Roads



1:942,200

0 10 20 40 Kilometres



Produced by: Russell Seaman
 Conservation Strategies Program,
 Department for Environment and Heritage.
 Data source: DEH
 Projection/Datum: MGA, GDA 94.
 Compiled: August 2003, ESRI ArcGIS.

Six: Report and database inclusion

This stage produced a report detailing the methods undertaken in developing the habitat mapping database and discusses the results giving examples of practical applications.

It also reviewed the collection and storage methods used for biological information so it can be included in South Australia's biological information databases. From this review, a database was developed and data was processed for inclusion in the database.

Outcome: A habitat mapping database that can identify at the local level:

- Areas of significant environmental importance
- All habitat types within the Ramsar site
- The habitat types of key species
- Degraded and degrading habitats.

Seven: Distribution

The Habitat Mapping data set will be incorporated into the State biological information databases so it can be accessed through the Internet. Until the habitat mapping database is available on-line, hard copy and electronic data will be distributed to local government and other parties for its use as a planning tool.

Outcome: Distribution of the data collected in this study.

7.0 Project limitations

The timeline for the project was essentially one year, covering the period between July 1st 2002 and July 1st 2003. The scope and scale of work reflects the funding allocated for this time period.

Mapping and documenting habitats within the Lower lakes and Coorong has not been undertaken in this scale and time frame before. Gaining an understanding of the methods suitable for documenting habitats in this region was required and mapping techniques had to be developed. The initial stage of the project involved preliminary literature research, GIS dataset review, software and hardware purchases. Field-testing of this software and hardware in developing a methodology comprised a substantial portion of the project time.

The actual collection of data in the field took approximately six months. This allowed for a 90% coverage of the study area, but there are limitations regarding the complexity of the data from some localities. This project is in effect, work in progress; gaps in the data and mapping will be completed throughout Stage two of the project (2003 – 2004). Stage two will focus on Ramsar planning and the development of an ecological character description for the Ramsar site. The habitat mapping database provides the primary tool for investigating these topics.

8.0 Habitat classification

8.1 Overview of past habitat classification studies

A habitat can be defined as 'The natural abode, locality or region of an animal or plant' (Webster 1998). The task of this project is to classify as many of these areas as possible whilst making the classification method relevant for the study area.

There are a number of relevant publications regarding habitat classification, generally originating from overseas. The Ramsar Bureau has established a guide to the classification of habitats titled *Mediterranean wetland inventory: Habitat Description System*; this is based on the United States methodology for the classification of wetlands and deepwater habitats. These publications provide methodologies for habitat classification, however the classification methods are aimed at a national and landscape scale (over 1:100,000).

This generally meant that habitat classification was too broad and not at a scale useful for classifying habitats with the Lower Lakes and Coorong Ramsar site, eg between 1:5,000 and 1:25,000.

A method for assessing and mapping habitats within South Australia at this scale needed to be developed. Several reports provided useful ideas and methods for the classification of different habitat components. These included vegetation survey methodologies, wetland survey methodology, landform surveys and fauna surveys. The habitat classification survey template was developed from this information and is used as the basis for classifying habitats.

Several reports provided direction for the classification of habitats; these are listed in [Table 1](#).

Table 1. Habitat classification references

REPORT REFERENCE	HABITAT CLASSIFICATION USE
Canty & Hille (2002) Draft technical report, Coastal Saltmarsh and mangrove mapping. Department for Environment and Heritage, South Australia.	South Australian methodology with 69 habitat codes with flexibility for the addition of codes. A five tiered classification system comprising landform category, estuarine influence, tidal influence and degree of inundation, vegetation cover and integrity. Only covers coastal systems, and does not provide detailed descriptions for each habitat type.
Caboolture Shire Habitat mapping http://www.caboolture.qld.gov.au/Community/Environment/Environment/Vegetation/default.htm Accessed 28/06/02	Concentrates on vegetation as habitat and classifies habitat as endangered, vulnerable and rare, special concern, CAMBA and JAMBA migratory birds, habitat specialist, locally significant and culturally significant areas. These descriptions are useful in describing the value of habitat to species.

REPORT REFERENCE	HABITAT CLASSIFICATION USE
<p>Farinha, Costa <i>et al.</i> (1996) <i>Mediterranean wetland inventory: Habitat Description System</i>. MedWet/Instituto da Conservacao Natureza (ICN)/Wetlands International/Greek Biotope/Wetland Centre (EKBY) Publication, Volume III.</p>	<p>Method supported by Ramsar and Australian classification systems. The classification is designed at varying levels, for example, systems, classes, subclasses, and dominance types. Water regimes, water salinity and artificial modifiers are also included.</p> <p>Very broad classes and system levels and the classification keys do not go down to sub-systems. This level is required for the habitat mapping in the Lower Lakes and Coorong.</p>
<p>New South Wales Government (1992) WRL Technical Report 00/11. Categories of estuarine habitats.</p>	<p>Provides useful habitat categories such as: open water reefs and rocky shores, un-vegetated bed sediments, seagrass beds, inter-tidal sand and mud flats, beaches, dunes and sand spits, mangrove forests, salt marshes, swamp forest, ephemeral floodplain wetland and dune lake, fresh water aquatic vegetation.</p>
<p>Seaman (2002) Wetland Inventories for the Mount Lofty Ranges, Northern Agricultural Districts, Eyre Peninsula and Kangaroo Island. Report series 2001-2002, for the Department for Environment and Heritage South Australia.</p>	<p>Classification methods for wetlands include: habitat condition, landform, vegetation and survey template structure.</p>
<p>Heard & Channon (1997) <i>Guide to a native vegetation survey using the biological survey of South Australia methodology, Section 3</i>. Geographic Analysis and Research Unit, Department of Housing and Urban Development.</p>	<p>Provides useful definitions for landform pattern, landform elements, lithology, surface strew size, outcrop cover, disturbance, and soils, Muir classification for life forms.</p>
<p>Classification of wetlands and deepwater habitats of the USA. http://www.nwi.fws.gov/classifman/contents.html Accessed 30/07/02</p>	<p>Provides detailed descriptions of wetland habitats by using a classification key.</p>
<p>Classification of habitats in the Kuban Delta, Russia. http://www.wetlands.org/programs/RussiaCD/eng/KUBAN-4.HTM Accessed 02/07/2002</p>	<p>Identifies habitat classification classes with correlation to water regimes.</p>
<p>Interactive Biodiversity Information System, Wildlife-habitat type definitions. http://198.88.146.70/ibis/wildhabs/WHDEFS.asp Accessed 28/06/02</p>	<p>Outlines wildlife habitat classifications for the Oregon and Washington region.</p>
<p>Mapping breeding habitat for lack-necked Cranes in Tibet Autonomous Region, People's Republic of China: An Integration of Crane Ecology and Physiography using ArcView GIS. http://www.utexas.edu/depts/grg/hudson/grg394k/studentprojects/gao/gao.html Accessed 12/04/02.</p>	<p>Outlines methods used in collecting and storing habitat information. Discuss types of analysis that can be generated by using AcrView.</p>

REPORT REFERENCE	HABITAT CLASSIFICATION USE
World Wildlife Fund Philippines: Training on species and habitat mapping using GPS/GIS. Conservation science research and extension program. http://www.wwfphil.com.ph/train2.htm . Accessed 12/04/02.	Briefly describes goals and objectives of the habitat mapping program in the Philippines.
Lower Columbia River Estuary Partnership: Habitat Mapping USA. http://www.lcrep.org/habitat_mapping.htm . Accessed 12/04/02	Outlines methodology used in the habitat mapping program for the Lower Columbia River.
Jordan, Lawler & Halley (1998) Estuarine Habitat Mapping in the Derwent-Integrating Science and Management. Final Report, NHT project. Tasmanian Derwent Estuary Program.	Provides an overview of habitat classification methodologies, analysis methods and report layout concepts.
U.S. NOAA Coastal Services Centre. (2001) Guidance for Benthic Habitat Mapping: An Aerial photographic approach. Prepared by Mark Finkbeiner, Bill Stevenson and Renee Seaman. Technology Planning and Management Corporation, Charleston, SC.	Provides excellent ideas for habitat mapping methodologies and use of GIS topology.
Blackman, Spain & Whiteley (1992) Provisional Handbook for the Classification and Field Assessment of Queensland Wetlands and Deep Water Habitats. Wetland Inventory Team, Conservation Strategy Branch, Department of Environment and Heritage, Northern Regional Centre, QLD, Australia.	Comprehensive report detailing classification methods. Methods based on the <i>Mediterranean wetland inventory: Habitat Description System</i> .
Davis <i>et al.</i> (2001) Environmental water requirements to maintain wetlands of national and international importance. Environment Australia.	Discusses habitat analysis methodologies in respect to environmental flow regimes. Relationships between biota and the water are also discussed.
Thompson (1986) River Murray Wetlands, their characteristics, significance and management. Department of Environment and Planning, SA.	Provides methods of classifying wetlands in the River Murray.

From these reports, distinct habitat classification groupings became apparent. These components consist of location and site description, physical features, geology and soils, hydrological features, vegetation descriptions, land degradation, water chemistry and habitat condition. These groupings formed the bases for the habitat classification survey template ([Appendix 1](#)).

8.2 Classification survey

For each habitat mapped information was recorded detailing the habitat chemical, biological and physical attributes. This information was recorded directly through a laptop computer into the habitat classification table located within the GIS software.

The habitat classification table consists of 38 parameters. These parameters are outlined in [Table 2](#).

Table 2. Habitat classification parameters

Location Information		
Habitat Number	Date	GPS readings
Elevation	General description	
Physical description		
Wetland system	Landform	Landuse
Micro relief	Surface type	Strew
Sediment size	Substrate surface	Water origin
Tidal class	Water depth	Water regime
Biological description		
Vegetation association	Cover and abundance	Life form
Surface fauna	Opportunistic sightings	Reliability of sighting
Aquatic class	Aquatic density	Habitat condition
Wetland type	Degradation	Micro habitats
Chemical description		
PH	Conductivity	Turbidity
Temperature	Dissolved oxygen	
Social descriptions		
Recreation	Cultural	Comments
Photo record		

Definitions and explanations for these parameters are given in [Section four](#).

9.0 GIS Database methodology

The essential component of this project was to identifying the location of habitats in the landscape and to map these locations using ArcGIS 8.2. In order to achieve this, habitats located within the landscape require a spatial reference; this reference can be a point, line or polygon. Once the habitat has a spatial reference, attribute information about the habitat is recorded.

To develop this spatial reference a mapping review was undertaken to identify existing GIS coverage's contained within South Australia's geographical information system databases. Several GIS coverage's were identified and formed the basis for the habitat map. These coverage's include vegetation mapping, wetland mapping and topographic coverage's such as vegetation and water. The following describes the GIS coverage's chosen to form the basis of the habitat mapping coverage.

9.1 GIS Dataset, landscape wetlands (after Thompson and Pressey)

File format: Shapefile. Projection: mga54. Datum: gda94.

Provides coverage of wetlands identified within the Lower Lakes by Thompson and Pressey in 1986.

The wetland units that Thompson (1986) described have a numbering system that relate to the GIS coverage and correspond to a description of the wetland in the report. The use of the numbering system allows for a more detailed investigation of the wetlands identified by Thompson, if required, by matching the wetland number in the GIS coverage with the number in Thompson's 1986 report.

9.2 GIS Dataset, landscape wetlands

File format: Shapefile. Projection: mga54. Datum: gda94.

Provides coverage of wetlands identified using the Australian wetland number system.

This wetland coverage is also used in Jensen *et al* (1996) Wetland Atlas of the South Australian Murray Valley. The numbering system provided in this report can be matched with numbers provided in the GIS coverage allowing for extraction of detailed information for each wetland unit. This is useful because the Wetland Atlas summarises conclusions made by Thompson's study in 1996 the Wetlands Working Party comments in 1996, the River Murray Wetlands Management Committee in 1994 and several other reports. Comments are also made regarding future management, water regimes, key species and level of conservation importance.

9.3 GIS Dataset, topographic sand

File format: Shapefile. Projection: mga54. Datum: gda94.

Identifies topographic sand areas in the northern Coorong National Park Murray Mouth region.

GIS Dataset, topographic vegetation

File format: Shapefile. Projection: mga54. Datum: gda94.

Identifies vegetation from Murray Mallee, South East, Western Murray Flats and Southern Mount Lofty Ranges datasets. Also includes extra vegetation data from topographic data that provides coverage for reedbeds. Excellent coverage based on sound data collection using the biological survey methodology for South Australia (areas <1 ha are not included).

9.4 GIS Dataset, topographic water

File format: Shapefile. Projection: mga54. Datum: gda94.

Contains waterbody data from topographic data. Includes small depressions such as saline flats and samphire shrublands.

9.5 GIS Dataset, PIRSA land and soil

File format: Shapefile. Projection: mga54. Datum: gda94.

Supplied by PIRSA Land Information 2001. Includes an inventory of the land and soil resources of South Australia's agricultural districts. Includes information on a range of soil and landscape attributes. Extensive coverage; very useful for locating rocky outcrops and cliff lines.

9.6 GIS Dataset, Saltmarsh mapping

Generated in 2002 by the Department for Environment and Heritage. Provides information on coastal and marine habitats along the Coorong, Sir Richard Peninsula, southern Hindmarsh Island and Murray Mouth.

10.0 Integrating GIS datasets

Each of these coverage's was analysed by using aerial photography to verify their accuracy and extent. The coverage's that overlap were edited through a process of merging, joining and unions, functions contained within the ArcGIS software. This process transferred selected information from one coverage to another, resulting in a single coverage containing the attributes of many coverage's. The vegetation coverage was chosen as the primary GIS coverage to use because it identifies habitats at a suitable scale and has uniform coverage for the area. In those cases where vegetation coverage is not adequate, analysis of other coverage's (such as topographic vegetation or water) was required to identify the best representation of habitat.

11.0 Gaps in GIS coverage's

11.1 Existing gaps

Substantial gaps in the GIS coverage existed. Cliff lines, rocky outcrops, sand banks, beaches, reedbeds, freshwater soaks and mud flats have either not previously been mapped or have been mapped at large scales, eg 1,000,000 which is too extensive for the identification of habitats for this project. It is important to include these habitats because of their high habitat values for example, mud flats provide feeding areas for migratory birds, cliffs provide nesting sites for birds, and rocky shorelines provide habitats for fish and invertebrates.

11.2 Inaccuracies

Several GIS datasets were combined into one dataset and this resulted in inconsistencies. These arose due to differing levels of accuracy through dataset creation, scale differences in coverage and overlaps where several datasets overlap within one location.

A process of merging datasets, joining and deleting coverage's was undertaken to overcome these inaccuracies. Topological consistency checks are still required to detect flaws in the data structure, and this will ensure that all polygons are closed, nodes are formed at intersections of lines and polygons are not overlapping. Owing to these inconsistencies, the habitat mapping dataset should be considered as interim only.

12.0 Mapping on the fly

Habitats not included in the primary GIS coverage database, for example mud flats, were included in the GIS habitat map by creating polygons based on digital aerial photography or capturing streaming GPS points into ESRI ArcPad software which creates a polygon of the habitat as the surveyor walks around the habitat boundary. The newly created habitat map is then transferred to the primary GIS habitat coverage.

Ortho-rectified digital photography was used to identify habitat boundaries while in the field. When new habitats need to be created, or existing polygons modified this was carried out through the ArcGIS editing functions, using the digital aerial photography as a background to assist in defining habitat boundaries. On-screen digitising was used to define a habitat and to generate the new habitat boundary.

13.0 Assigning attributes

The habitat GIS coverage provides a spatial reference for habitat, and linked to this coverage is an underlying table allowing attributes to be recorded. These attributes consist of the information contained in the habitat classification survey. The habitat classification survey provides the template for documenting and classifying habitat.

14.0 Field application

Once the habitat classification methodology and the GIS coverage was created, the method of collecting data in the field was developed. This method can be broken down into several steps, as outlined below.

1. The area of study is selected and a desktop analysis of the GIS coverage with aerial photography is undertaken. The GIS coverage is edited if the boundaries of habitat do not correspond with habitat boundaries interpreted from aerial photography. This problem occurs quite often because of scale differences in data collected in various coverage's.
2. The second step involves visiting the locality and undertaking the habitat classification survey. The locality is divided into as many habitats as can be observed, and then mapped on site using a laptop. The division of habitat is landform and vegetation based, for example stream channels, reed beds and cliffs. New polygons are created in the database that define the habitat, or if there are existing polygons, these are modified if required. The GIS layer is instantly updated with the new habitat boundaries.
3. Each new habitat on the GIS layer has an underlying table where information about the habitat is recorded; this information is gained through observations and entered directly into the table. The habitat classification survey template is used as a guide for the collection of information.
4. Once the locality had been divided into habitats and attribute information entered, a photograph is taken as a record of the site. This photograph is transferred directly onto the hard drive of the Laptop and a 'hotlink' set up, this links the photograph to the habitat on the GIS layer.
5. This final stage involves checking that the GIS coverage edits have been successful and attribute information has been recorded and saved.

Section two – Habitat assessment

This section discusses the results of the habitat classification survey and provides an overview of the number of different habitat classifications. Not every classification category is discussed; a selection of the most descriptive are included. This discussion does not include the following categories: wetland system, micro-relief, surface types, sediment size, strew, water origin, tidal class, water depth, vegetation type, recreation and water regime. Background descriptions of the habitat classifications are listed in Section Four.

Throughout this section, reference is made to stage one and stage two. Stage one encompasses the lower lakes (Lakes Alexandrina and Albert) and stage two encompasses the Coorong National Park (refer to [Figure 1](#)).

15.0 Landform

Landforms are described and interpreted as the dominant pattern of the land surface. A total of 26 landform types are recorded within stage one, and analysis of the categories is provided in Table 3. The most frequently recorded landforms are floodplains which comprised of 31% of habitat recorded that covers an area just less than 15,000 hectares. The floodplains are evenly distributed around Lake Alexandrina and Lake Albert. Vegetated bed sediment (reedbeds) account for 18% of habitat recorded and covered 3,126 hectares. The reedbeds dominate freshwater areas especially in shallow waters and in areas of sediment build up, for example in the upper reaches of the Finniss and Currency creeks. Refer to [Figure 2](#) for distribution of floodplains and vegetated bed sediments recorded in stage one.

Table 4 lists 27 landforms recorded during stage two (Coorong National Park). Common landforms recorded in stage two are the consolidated dunes located parallel to the coastline; these comprise approximately 9,825 hectares. Other dune systems, typically those without vegetation, covered 7,980 hectares. A series of salt lakes stretching from north of Kingston to Salt Creek covered 2,296 hectares. Mud flats providing specialized habitat for migratory waders covered 831 hectares. This figure is only an indication at one point in time, as seasonal variations in wind and water depth alter the extent of mud flat exposed. Refer to [Figure 3](#) for distribution of salt lakes and mud flat recorded in stage two.



Plate 1. Mud flat, Coorong National Park

Table 3. Landform categories, stage one

Landform	Number	Percent	Hectares
Beach	11	2	79
Channel	29	6	139
Cliff	5	1	5
Closed depression	45	9	856
Consolidated dune	7	1	81
Cove	27	5	2,745
Drainage depression	17	3	279
Dune	6	1	536
Floodplain	161	31	14,099
Inter-dune corridor	1	0	40
Island	5	1	52
Lagoon	11	2	851
Lake	7	1	131
Mud flat	13	3	456
Open depression	11	2	168
Ridge	1	0	1
Rocky outcrop	12	2	13
Rocky shore	5	1	63
Sand bar	2	0	36
Sandy beach	2	0	10
Shoreline	19	4	350
Stream bank	4	1	13
Stream channel	11	2	186
Unvegetated bed sediment	4	1	1
Vegetated bed sediment	95	18	3,126
Vegetated island	6	1	89
Total	517	100	24,405



Plate 2. Reed beds, Finniss River

Table 4. Landform categories, stage two.

Landform	Number	Percent	Hectares
Beach	11	5.8	726
Channel	1	0.5	2
Cliff	2	1.0	28
Closed depression	20	10.5	340
Consolidated dune	10	5.2	9,825
Cove	3	1.6	442
Dune	3	1.6	7,980
Flat	3	1.6	240
Floodplain	34	17.8	1,804
Hill foot slope	1	0.5	79
Lagoon	1	0.5	112
Mud flat	18	9.4	831
Open depression	13	6.8	337
Reef	3	1.6	184
Rocky cliff	2	1.0	1
Rocky outcrop	3	1.6	7
Rocky reef	3	1.6	125
Rocky ridge	2	1.0	1
Rocky shore	14	7.3	416
Salt lake	14	7.3	2,296
Sand bar	2	1.0	2
Sandy beach	4	2.1	159
Shoreline	3	1.6	273
Stream channel	1	0.5	5
Undulating plain	1	0.5	26
Vegetated bed sediments	11	5.8	56
Vegetated island	8	4.2	174
Total	191	100.0	26,471



Plate 3. Samphire shrub land, Loveday Bay

16.0 Land use

Land uses were recorded only if an obvious indication of use was apparent within the defined habitat. Nineteen land uses were recorded in stage one, with the land use of grazing recording the highest percentage of 57% or 254 habitat sites (Table 5).

Stage two of the habitat map is contained within the Coorong National Park, with the exception of some habitats adjacent to the southern park boundary and scattered habitats on the eastern and northern park boundaries. Land use is not recorded in the same context as in stage one; land use has been documented in stage two as National Park. Fifty-six habitat sites recorded additional land uses within the National Park or in habitats adjacent to the sites. These are documented in Table 6. Grazing as a formal land use was recorded four times; these records reflect land uses adjacent to the park's southern boundary and within Aboriginal Lands Trust land north of Long Point.

Table 5. Land uses, stage one

LAND USE	NUMBER	PERCENTAGE
Access tracks	1	0.23
Boat launch area	2	0.46
Boat mooring	6	1.37
Boating	5	1.14
Conservation	54	12.30
Council reserve	31	7.07
Cropping	3	0.68
Fishing	1	0.23
Game reserve	21	4.78
Grazing	254	57.86
Horticulture	1	0.23
Jetties	1	0.23
Mining	1	0.23
National park	7	1.59
Reserve	29	6.61
Residential	4	0.91
Unknown	25	5.69
Water extraction	20	4.56
Total	439	100.00



Plate 4. Water extraction, Bremer River.

Table 6. Land uses, stage two

LAND USE	NUMBER	PERCENTAGE
Access tracks	42	75.00
Boat launch area	3	5.36
Grazing	4	7.14
Shacks	3	5.36
Walking trail	4	7.14
Total	56	100.00



Plate 5. Access track, Coorong National Park



Plate 6. Grazing, Hindmarsh Island

17.0 Substrate

Substrate form is described where its aerial coverage comprises at least 25% or greater of the habitat surface, and where the aerial extent of vegetation is less than 30%. Twelve substrate forms were recorded in stage one with open water recorded in 30 (42.9%) habitats; rocky shore was the next most common substrate form with 12 records (17%) (Table 7). Stage two recorded nine substrate forms with rocky shores recorded in 21 habitats and muddy shorelines were recorded in 14 habitats (Table 8). These two substrate types are largely distributed along the eastern edges within the northern Coorong lagoon.

Table 7. Substrate form, stage one

Substrate	Number	Percentage
Calcrete	1	1.4
Clay loam	4	5.7
Mud	3	4.3
Muddy sand	3	4.3
Open water	30	42.9
Rock bottom	2	2.9
Rocky shore	12	17.1
Sand	6	8.6
Sandy beach	1	1.4
Sandy shore	2	2.9
Stream bed	1	1.4
Unconsolidated bottom	5	7.1
Total	70	100.0

Table 8. Substrate form, stage two

Substrate	Number	Percentage
Consolidated bottom	1	1.7
Muddy clays	3	5.2
Muddy sand	8	13.8
Muddy shoreline	14	24.1
Open water	1	1.7
Rock bottom	7	12.1
Rocky reef	2	3.4
Rocky shore	21	36.2
Sandy shore	1	1.7
Total	58	100.0



Plate 7. Rocky shoreline, Coorong National Park

18.0 Cover abundance

Cover abundance records an estimate of the percentage of native plant cover within the landscape. This information when viewed with life form and vegetation types assists in building a picture of the habitat structure. Four classifications were used to estimate cover abundance, namely habitats with over 75%, 50% - 75%, 25% - 50%, and 5% - 25% coverage. In stage one, coverage abundance greater than 75% was recorded for 258 habitats (56%) (see [Table 9](#)). Table 10 documents cover abundance for stage two; 51 (49.5%) habitats recorded a cover abundance of more than 75%.

Table 9. Cover abundance, stage one

COVER ABUNDANCE	NUMBER	PERCENTAGE
<5%	2	0
5 - 25%	46	10
25 - 50%	77	17
50 - 75%	79	17
>75%	258	56
Total	462	100

Table 10. Cover abundance, stage two

COVER ABUNDANCE	NUMBER	PERCENTAGE
<5%	9	8.7
5 - 25%	20	19.4
25 - 50%	15	14.6
50 - 75%	17	16.5
>75%	51	49.5
Total	103	100.0

92 habitats do not have cover abundance records



Plate 8. Samphire cover abundance >75%, Pelican Point

19.0 Life form

Life form records the structural height of vegetation present within the habitat. Stage one recorded 16 categories of life form with grasses over half a metre being the most frequently recorded at 36.9% of sites (Table 11). This life form generally comprises reeds *Phragmites australis* and *Typha domingensis*. Areas such as Currency Creek, Finniss River, Dog Lake, Pondala Point, Mud Islands and Narrung Narrows are core areas for this habitat type. The life form of grass <0.5m typically included introduced grasses such as *Paspalum distichum*, Kikuyu *Pennisetum clandestinum* and Couch *Cynodon dactylon*. The distribution of this life form is wide spread with dense areas commonly found along shorelines and within grazed areas.

Shrubs between zero and half a metre high were the next highest recorded in stage one with 106 records (23%) of total life form records. This life form is represented by samphire shrublands, typically *Sarcocornia* spp. and *Halosarcia* spp. The distribution of this life form is wide spread around Lakes Alexandrina and Albert, with some of the denser areas located along the shoreline between Pt Sturt and Milang. Lignum *Muehlenbeckia florulenta* is categorised as a shrub, usually growing to over two metres high, and is typically confined to scattered isolated patches within stage one. It is usually found in association with *Sarcocornia* spp. and *Halosarcia* spp.

Swamp Paperbark *Melaleuca halmaturorm* is classified as a tree life form. The distribution of Swamp Paperbark in stage one is restricted to several areas around Lakes Alexandrina and Albert. These areas include an isolated patch along the northern edge of Goolwa Channel and near the mouth of Currency Creek. Goose Island, opposite the township of Clayton, has significance stands and the Salt Lagoon Island Complex in Loveday Bay also has dense paperbark woodlands. Several areas on Hindmarsh Island contain paperbark woodlands, including a patch on the northern shoreline and dense areas along Eastick Creek and Hunters Creek mouth leading into Mundoo Channel. Two islands in Mundoo Channel also contain individual trees.

The life form of sedge typically includes species such as *Gahnia filum* and *Juncus kraussii*. Sedges are commonly found scattered along shorelines and inland usually adjacent to samphire shrublands. Freshwater creeks such as Finniss and Currency creeks have several areas along them where sedges are the dominant life form. The shorelines adjacent to Goolwa channel (Sir Richard Peninsula and Hindmarsh Island) also contain scattered remnants of sedges. The life form of aquatic and algae are discussed in 19.0.



Plate 9. *Phragmites australis*, Currency Creek.

Table 11. Life form, stage one

LIFE FORM	NUMBER	PERCENTAGE
Algae	5	1.09
Aquatic	28	6.09
Grass <0.5m	47	10.22
Grass >0.5m	170	36.96
Sedges 0.5 - 1m	2	0.43
Sedges <0.5m	24	5.22
Shrub >2m	1	0.22
Shrubs 0.5 - 1m	28	6.09
Shrubs <0.5m	11	2.39
Shrubs >2m	9	1.96
Shrubs 0 -0 .5m	106	23.04
Shrubs 1 - 1.5m	2	0.43
Shrubs 1.5 - 2.0m	7	1.52
Trees <5m	6	1.30
Trees 15 - 30m	1	0.22
Trees 5 - 15m	13	2.83
Total	460	100.00

Stage two recorded shrubs between zero and half a metre high were the dominate form in 59 records (49.2%) reflecting samphire shrublands (*Sarcocornia* spp. and *Halosarcia* spp.) and coastal dune vegetation associations (*Olearia axillaris*, *Acacia longifolia* var. *sophorae* and *Leucopogon parviflorus*). Grasses over half a metre high occurred in 20 records (15.4%). The grasses were generally reed species (*Phragmites australis* and *Typha domingensis*) and the sites were mainly distributed along the western inland dune shoreline of the Coorong where there are expressions of freshwater (Table 12).

Swamp paperbark distribution within stage two is more extensive than stage one. Many of the inland salt lakes in the Coorong have a dense buffer of swamp paperbark woodland surrounding them. Several habitats recorded trees between 5 – 15m, the majority of these records being *Eucalyptus diversifolia*.



Plate 10. *Melaleuca halmaturorm*, Southern Lagoon Coorong National Park

Table 12. Life form, stage two

LIFE FORM	NUMBER	PERCENTAGE
Algae	5	3.8
Aquatic	1	0.8
Grass .>5m	20	15.4
Grass .<5m	10	7.7
Sedge <.5m	1	0.8
Shrubs .5 - 1m	5	3.8
Shrubs >2m	1	0.8
Shrubs 0 - .5m	59	45.4
Shrubs 1 - 1.5m	10	7.7
Shrubs 1.5 - 2.0m	6	4.6
Trees <5m	4	3.1
Trees 5 - 15m	8	6.2
Total	130	100.0



Plate 11. *Gahnia filum*, Coorong National Park

20.0 Aquatic classes

This parameter provided a 'snap shot' of aquatic vegetation structure; vegetation classes recorded include algae, floating leaved (eg *Azolla* spp.), rooted floating leaved (eg *Myriophyllum* spp.) and rooted vascular plants (eg *Triglochin* spp.).

In stage one there were 96 (56%) habitats with rooted floating leaved vegetation and 49 sites with floating leaved vegetation (Table 13). These aquatic vegetation classes are distributed within shallow calm waters such as drainage channels and coves. Areas containing dense cover of aquatic vegetation provide habitat for invertebrates (Seaman *in* Brandle 2002) and when located in sheltered channels they provide habitat for native fish (Wedderburn & Hammer 2003). The coves adjacent to Clayton township have a high cover of aquatic vegetation as do the freshwater drainage channels on the eastern end of Hindmarsh Island. The upper reaches of Finniss and Currency creeks also contain dense areas of aquatic vegetation. Refer to [figure 4](#) for distribution of rooted floating leaved aquatic class recorded during stage one.

Table 13. Aquatic classes, stage one

AQUATIC CLASS	NUMBER	PERCENTAGE
Algae	23	13.5
Floating leaved	49	28.8
Rooted floating leaved	96	56.5
Rooted vascular	2	1.2
Total	170	100.0



Plate 12. Floating leaved vegetation, Lake Alexandrina

Stage two recorded very little aquatic vegetation with only moss and algae being observed (Table 14). The absence of rooted floating leaved vegetation in the northern and southern Coorong lagoons such as *Ruppia* spp. is of concern, indicating an important component of the food chain in decline. Refer to figure 5 for distribution of algae aquatic class during stage two.

Table 14. Aquatic classes, stage two

AQUATIC CLASS	NUMBER	PERCENTAGE
Algae	32	97.0
Aquatic moss	1	3.0
Total	33	100.0



Plate 13. Algae, Coorong National Park



Plate 14. Rooted floating leaved vegetation, Narrung Narrows

21.0 Degradation

Any degrading processes that are impacting on the integrity of the habitat were recorded. The scale of the impact was not directly recorded although an indication can be gained from habitat condition, which is discussed later. Generally habitats that record livestock grazing also record low habitat condition ratings. The most common degrading processes for stage one recorded included 255 habitats with vegetation clearance (27%), 204 habitats with grazing (22%), and 210 habitats with introduced grasses (23%) (Table 15).

Table 15. Degradation, stage one

DEGRADATION	NUMBER	PERCENTAGE
Access roads	47	5.15
Altered flows	6	0.66
Clearance	255	27.93
Degraded banks	2	0.22
Degraded buffer	2	0.22
Erosion	8	0.88
Excavated	5	0.55
Fence line	21	2.30
Grazing	204	22.34
Introduced grasses	210	23.00
Introduced plants	31	3.40
Introduced trees	5	0.55
Jetty	6	0.66
Mowing of aquatics	1	0.11
Pest plants	55	6.02
Pest vertebrate presence	8	0.88
Rubbish	9	0.99
Salt intrusion	1	0.11
Sand extraction	1	0.11
Walking tracks	7	0.77
Water extraction	28	3.07
Fire scars	1	0.11
Total	913	100.00



Plate 15. Degraded banks and buffers, Hindmarsh Island

Stage two recorded substantially fewer degrading processes; this reflects the protection available to habitats contained within a National Park. A total of 178 degradation records were documented for stage two, compared with 913 records in stage one. Access roads accounted for 25.3% of recorded disturbances in stage two, introduced grasses (21.3%), vegetation clearance (2.2%) and degraded buffers of habitats were also recorded (16.9%) (Table 16).

Table 16. Degradation, stage two

DEGRADATION	NUMBER	PERCENTAGE
Altered flows	2	1.1
Access road	45	25.3
Boat launch area	3	1.7
Camping sites	3	1.7
Clearance	4	2.2
Cleared buffer	27	15.2
Degraded buffer	30	16.9
Fence lines	9	5.1
Grazing	7	3.9
Introduced grasses	38	21.3
Rubbish	1	0.6
Pest vertebrate pests	1	0.6
Walking tracks	2	1.1
Woody weeds	6	3.4
Total	178	100.0

22.0 Microhabitats

Within each defined habitat there generally exists several smaller habitat types these are defined as microhabitats. An example of a defined habitat type would be a samphire shrubland located on a floodplain, but within this habitat there are also mud flats and hummocks. Both mud flats and hummocks may provide a niche for habitat specialist such as migratory waders. The most frequent microhabitats recorded in stage one were sheltered areas (31.9%), mud flat (20.5%), snags and structural diversity both comprised 6.5% of recorded microhabitats ([Table 17](#)).

Table 17. Microhabitat, stage one

MICROHABITAT	NUMBER	PERCENTAGE
Banks with hollows	14	3.0
Hollows	11	2.4
Hummocks	16	3.4
Lignum	6	1.3
Detritus	18	3.9
Mounds	19	4.1
Mud flat	95	20.5
Nesting areas	7	1.5
Open water	1	0.2
Perches	9	1.9
Pooling	11	2.4
Rock areas	22	4.7
Roosting area	3	0.6
Sand	15	3.2
Sheltered areas	148	31.9
Snags	30	6.5
Structural diversity	30	6.5
Surface aquatics	3	0.6
Undulations	5	1.1
Worm reefs	1	0.2
Total	464	100.0



Plate 16. Pooling, Coorong National Park

Stage two recorded 98 mud flats being 29.9% of total recorded microhabitats. Other microhabitats such as sheltered areas (47 sites), detritus (46 sites) and rocky areas (35 sites) are well-distributed in stage two (Table 18).

Table 18. Microhabitats, stage two

MICROHABITAT	NUMBER	PERCENTAGE
Burrows	7	2.1
Algae mat	5	1.5
Detritus	46	14.0
Freshwater soak	4	1.2
Hollows	9	2.7
Hummocks	11	3.4
Mud flat	98	29.9
Molluscs	3	0.9
Nesting areas	5	1.5
Pooling	20	6.1
Rocky areas	35	10.7
Sandy areas	8	2.4
Sheltered areas	47	14.3
Structural diversity	30	9.1
Total	328	100.0



Plate 17. Mud flat area within a rocky shore, Coorong National Park

23.0 Habitat condition

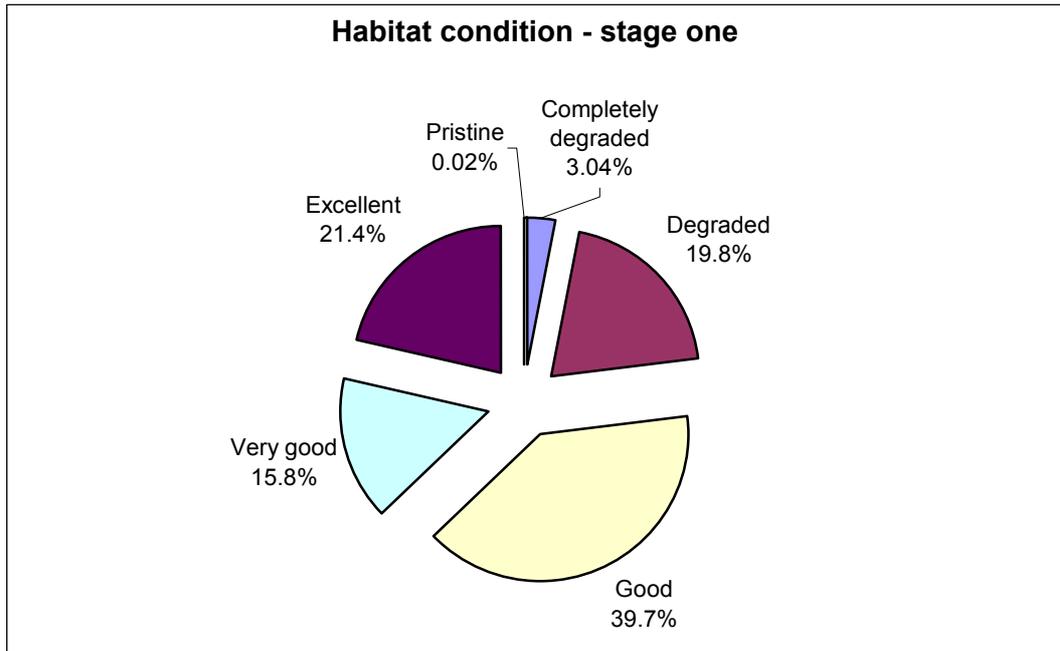
Habitat condition is a subjective assessment based on field observations. The assessment considered ecological values such as connectivity, pest plants, human impacts, integrity of vegetation associations and condition of core habitat areas. Habitat condition descriptions were based on previous landscape and ecosystem scale assessments made within South Australia (Adelaide Hills Council 2000; Bechervaise & Seaman 2002; Caves, Seaman & Taylor 1999; Lloyd & Balla 1986; Seaman 2002).

Table 19. Habitat Condition Descriptions

Condition scale	Description
Pristine	Pristine, or nearly so, no obvious signs of disturbance. Indigenous flora dominant and abundant, 100 % ground cover, if applicable. Structural diversity present, if applicable, and microhabitats present. Surrounding ecosystems intact with high connectivity. Habitat integrity is high. Reflects pre-European vegetation or natural landscape feature.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non- aggressive species limited to 5 - 20% coverage. Diverse species and stable fauna habitat. Habitat buffered by and linked to remnant vegetation with ecosystem stability. Microhabitats present.
Very Good	Vegetation structure altered, Indigenous and exotics together, 20-50% weed invasion, obvious signs of disturbance (eg disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback and grazing). Core habitat areas exist buffered by remnant vegetation. Obvious signs of use by fauna, areas of structural diversity might exist with some microhabitats.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it (eg disturbance to vegetation structure caused by very frequent grazing). Presence of aggressive weeds at high density (50 - 70%). Core habitat areas exist that are buffered by scattered remnants. Species use of habitats is likely to be opportunistic. Structural diversity limited to isolated patches if at all, micro-habitats presence low.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. Disturbance to vegetation structure caused by cropping, grazing or clearance, presence of very aggressive weeds, partial clearing, dieback and livestock grazing. Weed presence greater than 70%. Habitats are impacted by disturbances and are not connected with remnant buffers.
Completely degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. Habitats do not exist, although areas might be used as opportunistic habitats or 'stepping stones' to desirable habitat areas. Weed presence aggressive and greater than 80%, monoculture may exist, eg pasture.

Stage one recorded habitat condition of very good in 180 habitats, with 155 habitats classified as good and 154 habitats as degraded (Table 20).

Figure 6 illustrates the distribution of habitat condition recorded for stage one. Some localities around the lower lakes contain excellent habitat, but are quite isolated on a regional scale, examples include Finniss river, Currency Creek Game Reserve and Narrung Narrows reedbeds. Other areas such as Sir Richard Peninsula show excellent connectivity that is reflected with a high habitat condition rating. Degraded sites occur along the western and south-eastern shoreline of Lake Alexandrina.



Graph 1. Percentage of habitat condition, stage one

Table 20. Habitat condition, stage one

HABITAT CONDITION		PERCENTAGE	HECTARES
Completely degraded	19	3.2	742
Degraded	154	26.2	4850
Good	155	26.4	9689
Very good	180	30.7	3862
Excellent	78	13.3	5242
Pristine	1	0.2	4
Total	587	100.0	24,389

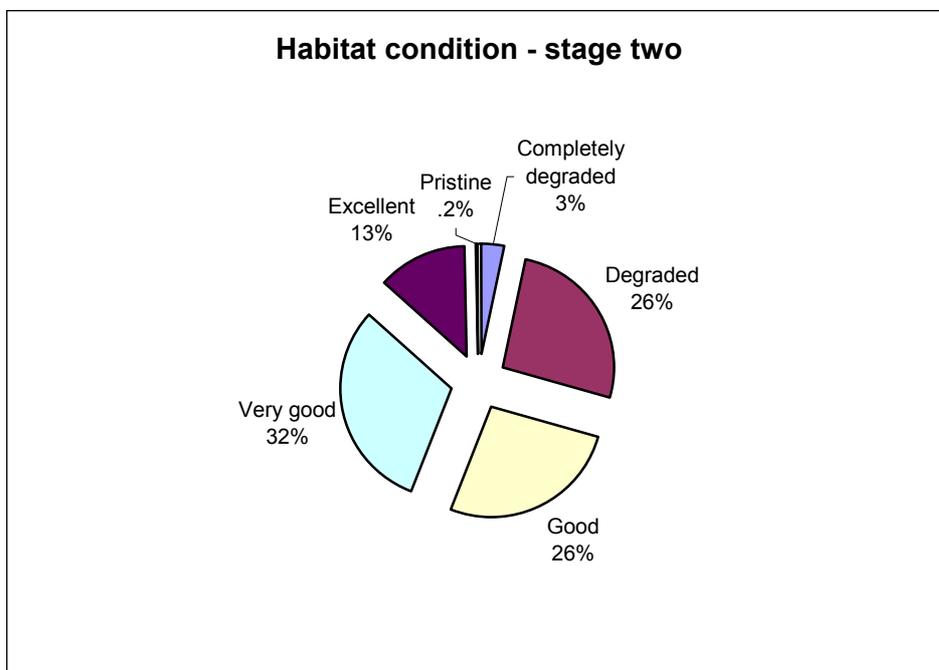


Plate 18. Completely degraded habitat, Point Sturt

Over half of the habitats recorded in stage two had a habitat condition rating of excellent, namely 98 sites covering approximately 21,000 hectares. Twenty-four sites had habitats in pristine condition comprising 12.8% of the habitats. No sites had habitats that are completely degraded and only 10 sites (5.3%) had degraded habitats (Table 21). Refer to figure 7 for habitat condition recorded in stage two.

Table 21. Habitat condition, stage two

HABITAT CONDITION	NUMBER	PERCENTAGE	HECTARES
Degraded	10	5.3	479
Good	20	10.7	671
Very good	35	18.7	1,962
Excellent	98	52.4	21,606
Pristine	24	12.8	1,234
Total	187	100.0	25,952

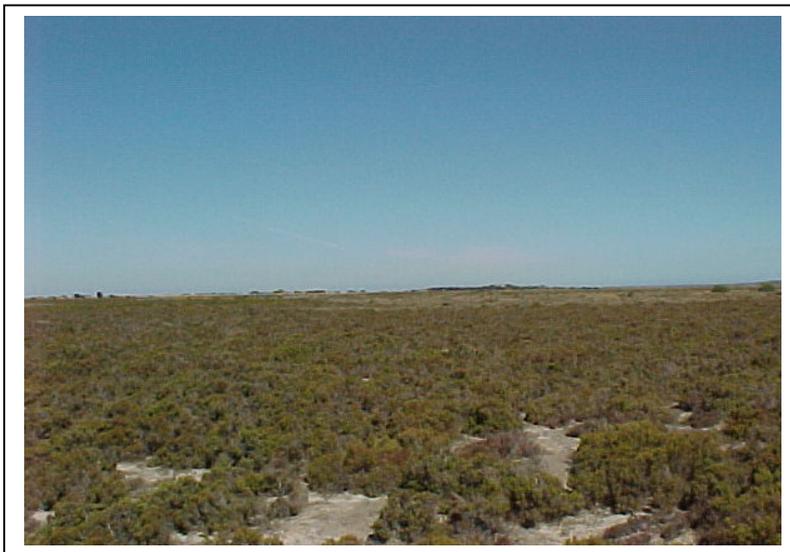


Graph 2. Percentage of habitat condition, stage two



- Samphire vegetation impacted by clearance.
- Scope for regeneration but not to a state approaching good condition without intensive management.
- Disturbance to vegetation structure caused by clearance, presence weeds with presence greater than 70%

Plate 19. Degraded habitat, Coorong National Park



- Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species limited to 5 - 20% coverage.
- Habitat buffered by and linked to remnant vegetation with ecosystem stability.
- Microhabitats present.

Plate 20. Excellent habitat, Hindmarsh Island



- No obvious signs of disturbance. Indigenous flora dominant and abundant.
- Microhabitats present.
- Surrounding ecosystems intact with high connectivity.
- Habitat integrity is high.
- Reflects pre-European vegetation or natural landscape feature.

Plate 21. Pristine habitat, Southern Lagoon, Coorong

24.0 Wetland type

The definition of a wetland as used in this survey is that adopted by the Ramsar convention under Article 1.1:

Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or 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 (2001) identifies 40 different wetland types in three categories: A-Marine and Coastal Zone wetlands, B-Inland wetlands, and C-Human-made wetlands. This classification system is based on that used by the Ramsar Convention in describing Wetlands of International Importance.

Several of the wetland descriptions were expanded to suit the habitats contained within the Lower Lakes. Additions included descriptions for reedbeds (vegetated bed sediments) and freshwater/brackish mud or sand flats. Three new classifications for the marine and coastal zones were developed and include coastal dune shrublands (A13), freshwater soaks (A14), and estuarine stream channels (A15).

The most frequently recorded wetland types in stage one were permanent freshwater ponds and coves with emergent vegetation such as reeds (27%), seasonal saline marshes, generally including samphire shrublands (27%) and freshwater ponds, marshes and reed shorelines (10%) (Table 22).

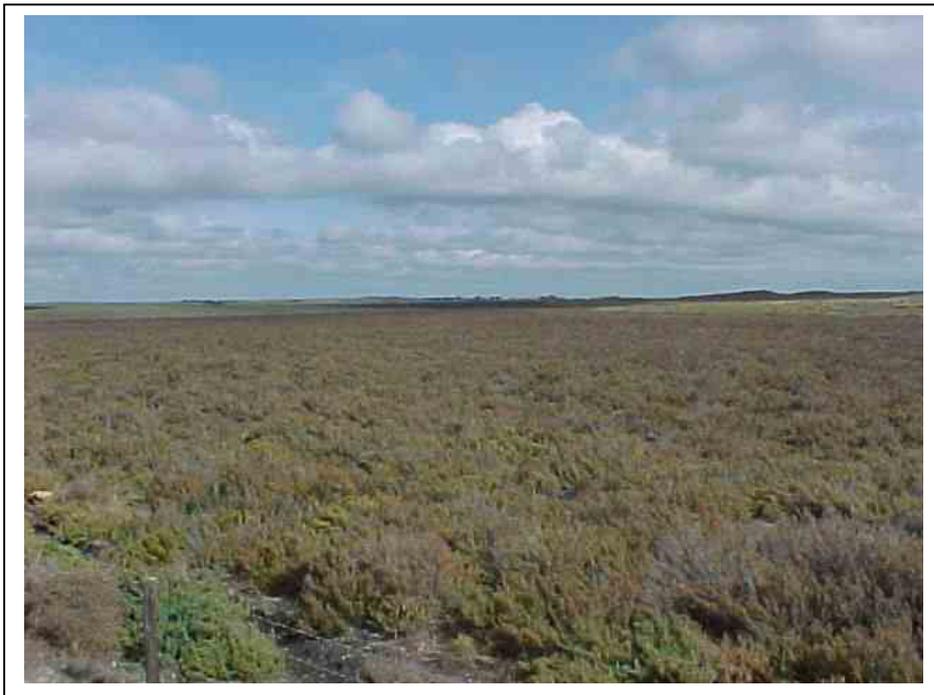


Plate 22. Wetland type B12, samphire swamp between Wellington and Meningie

Table 22. Stage one wetland type

WET CODE	NUM.	HA	%	DESCRIPTION
A1	2	13	0.4%	Marine waters-permanent shallow waters less than six metres deep at low tide, includes sea bays and straits.
A5	12	137	2.5%	Sand, shingle or pebble beaches, includes sand bars, spits, sandy islets.
A6	1	37	0.2%	Estuarine waters, permanent waters of estuaries and estuarine systems of deltas.
A7	6	350	1.3%	Intertidal mud, sand or salt flats and <i>algae</i> .
A8	12	308	2.5%	Intertidal marches, including saltmarshes, salt meadows, saltings, raised salt marshes, tidal brackish and freshwater marshes and vegetated shorelines.
A9	2	14	0.4%	Intertidal forested wetlands, includes mangrove swamps, nipa swamps, tidal freshwater swamp forest.
A11	2	6	0.4%	Freshwater lagoons and marshes in the coastal zone. <i>Reedbeds and vegetated bed sediments</i> .
A13	5	476	1.1%	Coastal dune shrubland.
B1	16	230	3.4%	Permanent rivers and streams + waterfalls.
B2	7	33	1.5%	Seasonal irregular river and streams.
B5	23	2,905	4.9%	Permanent freshwater lakes (<8ha) includes oxbow lakes.
B8	2	98	0.4%	Seasonal/intermittent saline lakes.
B9	129	4,548	27.3%	Permanent freshwater ponds (<8 ha), marshes and swamps on inorganic soils, with emergent vegetation. Waterlogged for at least most of the growing season. <i>Includes coves and open water enclosed with reeds</i> .
B10	49	1,052	10.4%	Seasonal/ intermittent freshwater ponds and marshes on inorganic soils includes potholes, seasonally flooded meadows, sedge marshes. <i>Includes reed shorelines</i> .
B11	2	74	0.4%	Permanent saline/brackish marshes.
B12	130	11,767	27.5%	Seasonal saline marshes.
B13	17	246	3.6%	Shrub swamps, shrub dominated freshwater marsh, sedges and <i>Gahnia sedgeland</i> .
B14	12	181	2.5%	Freshwater swamp forest, seasonally flooded forest, wooded swamps.
B20	11	57	2.3%	<i>Freshwater/brackish mud or sand flats</i> .
C7	14	66	3.0%	Irrigated land, canals, ditches.
C8	18	1,423	3.8%	Seasonally flooded arable land, farmland.
Total	472	24,021	100.0%	



Plate 23. Wetland type B9, Hindmarsh Island

Coastal dune shrublands were a dominant feature in stage two covering more than 17,000 hectares ([Table 23](#)). Although coastal dune shrublands are not technically a wetland by definition, this new category was added for ease of habitat classification within the marine and coastal zone and reflects the interdependence of wetland systems and dune systems. Characteristic wetland types in the Coorong National Park such as mud and sand flats cover over 1,000 hectares with 26 individual habitats recording these attributes.

Several freshwater soaks within the Coorong National Park have been documented and mapped with new soak locations being investigated. The total number of soaks is not reflected within [Table 21](#) under wetland type of A14; the inclusion of all freshwater soaks within the habitat map will occur in the next stage of the habitat mapping project.



Plate 24. Wetland type A7, mud flat, Coorong National Park

Table 23. Stage two wetland types

WETLAND CODE	NUM.	HA	%	DESCRIPTION
A11	7	45	3.8%	Freshwater lagoons and marshes in the coastal zone. <i>Reedbeds and vegetated bed sediments.</i>
A13	16	17,408	8.6%	Coastal dune shrubland.
A14	1	1	0.5%	Freshwater soaks <8ha within the coastal zone.
A15	1	2	0.5%	Estuarine stream channel.
A4	11	387	5.9%	Rocky marine shores, includes rocky offshore islands, sea cliffs. Rocky estuarine shores.
A5	36	1,434	19.5%	Sand, shingle or pebble beaches, includes sand bars, spits, sandy islets.
A7	26	1,365	14.1%	Intertidal mud, sand or salt flats and <i>algae</i> .
B1	1	5	0.5%	Permanent rivers and streams + waterfalls.
B12	56	2,348	30.3%	Seasonal saline marshes.
B13	8	406	4.3%	Shrub swamps, shrub dominated freshwater marsh, sedges and <i>Gahnia</i> sedgeland.
B14	7	390	3.8%	Freshwater swamp forest, seasonally flooded forest, wooded swamps.
B6	1	278	0.5%	Seasonal/intermittent freshwater lakes (>8ha), floodplain lakes.
B8	14	1,275	7.6%	Seasonal/intermittent saline lakes.
Total	185	25,344	100.0%	



Plate 25. Wetland type B8, saline lake, Coorong National Park

Section three – Habitat Mapping Database Applications

25.0 Database functionality

Information for each habitat is recorded in a GIS attribute table, which includes existing information from GIS datasets used to create the habitat mapping database as well as new fields that record information outlined in the survey template ([Appendix 1](#)). Displaying and extracting information from this table is achieved by selecting attributes, selecting by location and the use of symbology and exporting tables to spreadsheets.

Selecting by attributes involves querying the database through building SQL (structured query language), which is used through the select by attributes menu. This function allows the user to create habitat models; for example, a query can be written to display records showing samphire shrublands in excellent condition, containing mud flats and with grazing. With the select by location feature, features are selected based on their location relative to other features. This can be useful when doing analysis of the habitat map in relation to other information, for example intersecting habitat with bird survey locations.

A simple method of displaying habitat information is carried out using symbology. Symbology allows the user to display features, categories, quantities, charts and multiple attributes. Exporting the habitat attribute table from ArcMap to Microsoft Excel is another method that allows the user to manipulate data easily.

26.0 Predicting habitat distributions

Displaying habitat preferences for species provides information on the location of habitat suitable for species within the Lower Lakes and Coorong Ramsar site. Outcomes include a map of suitable habitats that displays possible species distribution, approximate area of available habitat, analysis of threats to habitats and condition of habitats. To undertake this analysis research into the habitat preferences for the chosen species is required. This can be gained from relevant references and expert knowledge. A list of habitat requirements is documented and matched against the habitat mapping database fields (listed in [Section 4](#)). The matching habitat classifications are then entered into ArcMap SQL as a query and results are displayed as a selection on the map, these selected records can be exported from the ArcMap table and analysed.

Davis *et al* (2001) describes this approach to predicting habitats as ecology-driven because habitats can be assessed as interlinked systems if examined in terms of the needs of particular fauna. The advantage of this approach is that the current ecological values and issues facing the habitat, for example use by waterbirds, presence of endangered species or communities, can be directly addressed. This means that conceptual models can be developed which indicate consequences of various management actions. Obligations associated with Ramsar can be directly addressed, as the ecological character is developed and management can be adapted to maintain this character (Davis *et al* 2001).

Two examples of habitat prediction functionality using the habitat mapping database are provided. Firstly, native fish habitats are predicted and secondly, predicted habitats for avifauna (water fowl and waders) are discussed. One further example provides an analysis of local government planning zones and habitats with high conservation value. These are analysed to assess conflict areas in terms of zoning and land uses. This is an example of one of the first tasks that will be undertaken in the next stage of the habitat mapping database project. One of the aims of the next project is to compare a habitat-zoning plan with the State Development Plan to identify areas of compatibility and conflict and make recommendations as to how the needs of Ramsar habitat can be better recognised in the State Planning System.

27.0 Predicted habitats for native fish

Habitat predictions for the Southern Pygmy Perch *Nannoperca australis*, Murray Hardyhead *Craterocephalus fluviatilis* and the Yarra Pygmy Perch *Nannoperca obscura* have been chosen because of their conservation significance at a National and regional level. The habitat preferences for these native fish are developed from information in Wedderburn & Hammer (2003) and Hammer (2002). All three species have similar habitat requirements; these are grouped together to form one query in the habitat mapping database.

27.1 Native fish background information

Southern Pygmy Perch *Nannoperca australis*

The Southern pygmy perch was historically widespread throughout the Lower River Murray and its tributaries, wetlands and backwaters. Populations now only occur in four Mount Lofty Ranges tributaries and small areas around Lake Alexandrina (Wedderburn & Hammer 2003). A recovery outline has been prepared for the Southern Pygmy Perch in the Mount Lofty Ranges by (Hammer 2002).

This species is soon to be listed as endangered in South Australia under the *National Parks and Wildlife Act 1972*, Threatened Species Schedule and protected under the *Fishery Act 1982*, (Wedderburn & Hammer 2003).

Habitat preferences

- Sheltered habitat
- Permanently connected drains
- Drains with artificial water regimes
- Dense submerged or emergent vegetation
- Overhanging edge vegetation
- Freshwater
- Intact banks with vegetation.



Plate 26. Southern Pygmy Perch.

Murray Hardyhead *Craterocephalus fluviatilis*

Nationally vulnerable, State regionally endangered.

Wedderburn & Hammer (2003) discuss the need for more research of this species to understand its habitat requirements. The Murray Hardyhead prefer habitats similar to the Southern Pygmy Perch, although Wedderburn & Hammer (2003) note that localised flow driven disturbance and areas with dense aquatic vegetation can attract this species.

Habitat preferences

Same as Southern Pygmy Perch, with an emphasis on:

- Dense aquatic vegetation
- Drains with artificial water regimes



Plate 27. Murray Hardyhead

Yarra Pygmy Perch *Nannoperca obscura*

Nationally vulnerable, State regionally endangered.

The Yarra Pygmy Perch seems to have a restricted range with records collected in discrete areas on Hindmarsh Island and the Finniss River (Wedderburn & Hammer 2003). Wedderburn and Hammer (2003) observed that an important feature of habitat quality for the Yarra Pygmy Perch appears to be flow related. The natural population dynamics of the species is likely to involve expansion and contraction in range according to local conditions, with refuges at wetlands at the lower region of streams (Wedderburn and Hammer 2003). Habitat preferences are based on the previous two species.

27.2 Habitat database query

The habitat mapping database has been queried for the following information to match up the habitat requirements for the native fish.

Habitat mapping database fields queried

Landform element: Channel, stream channel.

Aquatic class: Floating leaved, rooted floating leaved.

Cover abundance: greater than 75%.

Life form: Aquatic, algae.

Microhabitats: Snags, sheltered areas, sheltered channels.

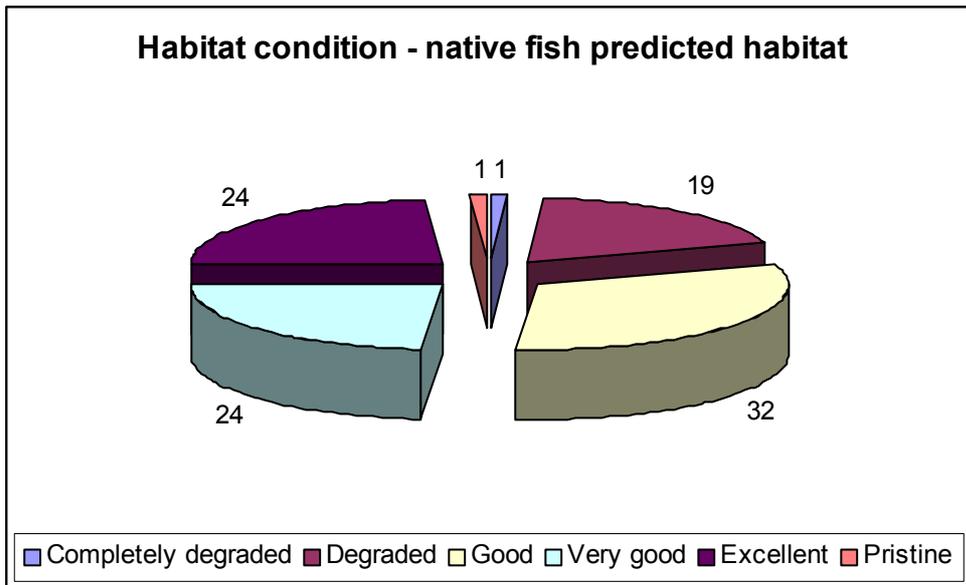
Results

One hundred and one habitats located in stage one returned a suitable match for the habitat requirements for the three native fish chosen. These habitats cover an area of 2,802 hectares; with the majority of suitable habitats are located in the western sector of Lake Alexandrina, southeastern areas of Hindmarsh Island, Currency Creek and Finniss River, refer to [Figure 8](#). Habitats with formal protection, for example within National Parks and Wildlife Reserves, cover approximately 650 hectares leaving 2,152 hectares excluded from formal conservation protection. Refer to [Figure 8](#), for stage one predicted habitat for Southern Pygmy Perch, Murray Hardyhead and Yarra Pygmy Perch.

Habitat condition

The majority of habitats are in very good condition or are in excellent condition (24 sites each) totalling 48 sites, nearly half of the total records. One habitat, located in the upper reaches of Currency Creek, is recorded as being pristine and one habitat, located on the shoreline of Goolwa Channel, is recorded as being completely degraded. Nineteen habitats recorded degraded habitats with thirty-two habitats recording a good habitat condition.

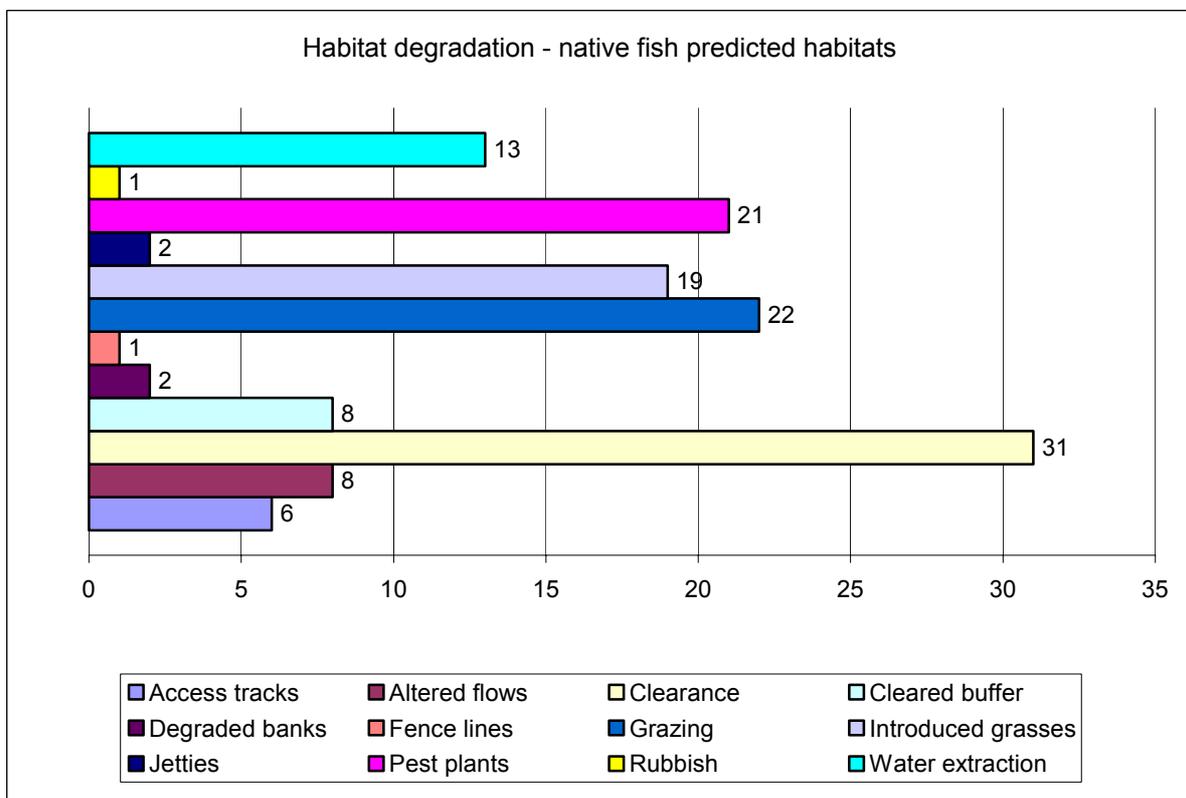
Possible future management actions could include an investigation of those habitats with a good, very good, excellent and pristine habitat condition rating and conducting fish surveys in conjunction with implementing protection measures for these habitats.



Graph 3. Habitat condition – native fish predicted habitat.

Habitat degradation

Clearance of native vegetation is recorded as the highest degrading process with thirty-one habitats being impacted. Grazing (22 records), introduced grasses (19 records) and pest plants (21 records) are the next most common degrading processes. Degrading processes such as clearance, grazing and degraded banks (8 records) are perhaps the most threatening processes to fish habitats because they remove protective vegetation cover from the water body and increase turbidity through erosion of banks. Hammer (2002) also states that the main threat to the Southern Pygmy Perch is habitat loss through stock damage to stream edge vegetation and banks.



Graph 4. Habitat degradation – native fish predicted habitats.

28.0 Predicted habitats for native birds

Habitat preferences for 18 bird species that have been recorded in the Lower Lakes and Coorong Ramsar area were analysed on the basis of habitat preferences; these species include migratory waders, waterfowl and terrestrial birds. Predicted habitats are given for five vulnerable species and one critically endangered species listed under the *National Parks and Wildlife Act 1972*. Habitat distribution is also displayed for five migratory waders and five waterbirds with rare or vulnerable ratings listed under the *National Parks and Wildlife Act 1972*. This selection was gathered from a list of bird species recorded in the Lower Lakes and Coorong Ramsar area that have conservation status under the *National Parks and Wildlife Act*, the International Union for Conservation of Nature and Natural Resources (IUCN) red list classifications, the Australian migratory bird agreements and Watkins' 1993 ratings for significant areas for shorebirds.

Provided below are the definitions for each rating classification, description habitat requirements for selected birds, fields used for information retrieval from the database and a brief analysis of the results. Different reporting criteria are used for each to reflect the scope of data interpretation available.

28.1 Background information

NPWSA ratings

The *National Parks and Wildlife Act 1972*, lists the conservation status of threatened plants and animals in schedules 7, 8 and 9. Species are divided into three categories: *Endangered*, *Vulnerable* and *Rare*. The NPW Act 1972 is South Australian legislation and is concerned only with the status of a species within state boundaries.

Definition of a Rare Species

- a. Reduced area of occupancy and/or extent of occurrence: Taxa that have disappeared from >50% of their former area of occupancy and/or extent of occurrence and it is observed, estimated, inferred or suspected that further decline is continuing.
- b. Declined in abundance: Taxa that have experienced a significant decline in abundance in >50% of their former area of occupancy and/or extent of occurrence and it is observed, estimated, inferred or suspected that further decline is continuing.
- c. Small populations: Taxa where it is observed, estimated, inferred or suspected that the total population size numbers <3000 mature individuals and specifying any of the following:
 - i) Resident population
 - ii) Regular visitors to the state (eg migratory taxa)
 - iii) Irregular visitors to the state (eg in response to episodic rainfall events)
 - iv) Taxa that are experiencing range extensions into SA, with data for other areas showing that they are increasing in range and abundance.
- d. Restricted extent of occurrence or area of occupancy: Taxa with either i) or ii)
 - i) extent of occurrence <20,000 km²
 - ii) area of occupancy <2,000 km² that is highly fragmented.

IUCN criteria

IUCN International Union for Conservation of Nature and Natural Resources (The World Conservation Union) classifications.

IUCN criteria have been adopted for identifying Extinct, Critically Endangered, Endangered and Vulnerable species under the National Parks and Wildlife Act. The 2000 IUCN Red List for threatened species is a global inventory of threatened plants and animals. There are nine categories of threat: *Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern, Data Deficient, and Not Evaluated.*

The overall aim of the IUCN Red List is to convey the urgency and scale of conservation problems to the public and policy-makers, and to motivate the global community to try to reduce species extinctions.

Bird species found within the Ramsar area with a listed IUCN status have been listed in [Table 24](#). Of most concern are the two critically endangered species, the Mount Lofty Ranges Southern Emu Wren *Stipiturus malachurus intermedius* and the Orange Bellied Parrot *Neophema chrysogaster*.

Watkins Ratings

Watkins (1993) has identified 180 internationally important areas for shorebirds in Australia based on the estimated population of each species along the Asian-Australasian flyway. The Coorong and Lower Murray Lakes provide habitat for nine internationally and 10 nationally significant species.

An internationally significant site is defined as one that regularly supports 20,000 or more shorebirds or supports 1% or more of the individuals in the Asian-Australasian flyway. A nationally significant site is an area where 10,000 or more shorebirds have been recorded, and/or 1% or more of the individuals of the Australian population of a species or sub-species of a shorebird.

JAMBA/CAMBA (Japan/China) - Australia Migratory Bird Agreement)

The JAMBA and CAMBA agreements are concerned with birds for which there is reliable evidence of migration between the two countries from the recovery of bands or other markers.

The aim of the migratory bird agreement is to:

- establish sanctuaries and other facilities for the management and protection of migratory birds and their environment.
- take appropriate measures to preserve and enhance the environment of migratory birds
- seek means to prevent damage to migratory birds and their environment.
- endeavor to take such measures as may be necessary to restrict or prevent the importation and introduction of animals and plants, which are hazardous to the preservation of migratory birds and their environment.

Bird species listed on these migratory bird agreements include all those that are common to both countries except for species that are considered to be:

- i) resident species in either country (that is, they are found in both countries but expert opinion is that they do not migrate between them), or
- ii) extinct by either country (there were no species identified in this list), or
- iii) vagrants to either country (typically species which have been recorded in either country less than 10 times).

Table 24 Significant bird species recorded in the Ramsar Area.

Bird Species	Species Name	National Parks and Wildlife Act 1972	IUCN (1994)	JAMBA/CAMBA Dedicated species	Watkins 1993
Musk Duck	<i>Biziura lobata</i>	Rare			
Australasian Shoveler	<i>Anas rhynchos</i>	Rare			
Freckled Duck	<i>Stictonetta naevosa</i>	Vulnerable	Least Concern		
Blue-billed Duck	<i>Oxyura australis</i>	Rare	Least Concern		
Cape Barren Goose	<i>Cereopsis novaehollandiae</i>	Rare			
Great-crested Grebe	<i>Podiceps cristatus</i>	Rare			
Intermediate Egret	<i>Ardea intermedia</i>	Rare			
Glossy Ibis	<i>Plegadis falcinellus</i>	Rare		CAMBA	
Baillon's Crake	<i>Porzana pusilla</i>	Rare			
Golden-headed Cisticola	<i>Cisticola exilis</i>	Rare			
Australasian Bittern	<i>Botaurus poiciloptilus</i>	Vulnerable	Vulnerable (C2a)		
Lewin's Rail	<i>Rallus pectoralis</i>	Vulnerable	Near Threatened: c		
Latham's Snipe	<i>Gallinago hardwickii</i>	Vulnerable	Least Concern	CAMBA	
Painted Snipe	<i>Rostratula benghalensis</i>	Vulnerable	Vulnerable (A1b)	CAMBA	
Hooded Plover	<i>Charadrius rubricollis</i>	Vulnerable	Least Concern		
Little Tern	<i>Sterna albifrons</i>	Vulnerable	Least Concern	CAMBA, JAMBA	
Fairy Tern	<i>Sterna nereis</i>	Vulnerable	Least Concern		
Blue-winged Parrot	<i>Neophema chrysostoma</i>	Vulnerable			
Rufous Bristlebird	<i>Dasyornis broadbenti</i>	Vulnerable	Least Concern		
Orange-bellied Parrot	<i>Neophema chrysogaster</i>	Endangered	Critically Endangered (C2b)		
Southern Emu Wren (Mount Lofty Ranges)	<i>Stipiturus malachurus intermedius</i>	Endangered	Critically Endangered (B1+ 2 abcde)		
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>			CAMBA, JAMBA	Coorong Int. significant
Red-necked Stint	<i>Calidris ruficollis</i>			CAMBA, JAMBA	Coorong Int. significant
Pied Oystercatcher	<i>Haematopus longirostris</i>				Coorong Int. significant
Banded Stilt	<i>Cladorhynchus leucocephalus</i>				Coorong Int. significant
Sanderling	<i>Crocethia alba</i>			CAMBA, JAMBA	Coorong Int. significant
Curlew Sandpiper	<i>Calidris ferruginea</i>			CAMBA, JAMBA	Coorong Int. significant
Common Greenshank	<i>Tringa nebularia</i>			CAMBA, JAMBA	Coorong Int. significant
Red-necked Avocet	<i>Recurvirostra novaehollandiae</i>				Coorong Int. significant
Red-capped Plover	<i>Charadrius ruficapillus</i>				Coorong Int. significant
Pacific Golden Plover	<i>Pluvialis fulva</i>				Coorong Nat. significant

28.2 Habitat requirements for Painted Snipe, Australasian Bittern, Lewins Rail, Little Tern and Fairy Tern.

Painted Snipe *Rostratula benghalensis*

(IUCN; Vulnerable A1b, NPWSA Act: Vulnerable, CAMBA)

Painted Snipe use modified habitats, such as low lying woodlands converted to grazing pasture, sewerage farms, dams and bores (Favaloro 1943; Hindwood & Hoskin 1954; Beste 1970; Lowe 1970). McGilp (1934) has discussed observations of cattle destroying suitable tussock habitat by trampling and grazing. The decline in Painted Snipe numbers is estimated at 20-50% every three generations (estimated at 15 years), and has continued over the last decade (Garnett & Crowley 2000).

Habitat:

- terrestrial shallow freshwater (occasionally brackish) wetlands.
- ephemeral and permanent lakes, swamps, claypans.
- inundated or waterlogged grassland and marshland.
- drains with emergent tussocks of grass, sedges, rushes, reeds or samphire.
- clumps of lignum or tea-tree (Beste 1970; Thomas 1975).
- samphire swamps (Paton in EarthTech 2003).

Habitat mapping database fields queried

Water depth: damp, film, 3-10cm, 10cm -5m

Landforms: closed depressions, vegetated bed sediments and drainage depression

Life form: shrubs 0 - 0.5m, grass >5m

Microhabitats: lignum

Results

A total of 362 habitats in stage one and 125 habitats in stage two returned a positive result from the query. Stage one habitat covers an area of 17,486 hectares and stage two covers an area of 4,630 hectares. Habitats protected under the National Parks and Wildlife reserve system totaled 84, covering an area of 2,960 hectares. Refer to [Figures 9 and 10](#) for the distribution of predicted habitats.

The habitat condition of the 362 habitats identified in stage one comprised of:

- 10 Completely degraded
- 108 Degraded
- 119 Good
- 71 Very good
- 53 Excellent
- 1 Pristine

Six habitats in stage two are classified as degraded with the remaining being classified as very good to pristine reflecting the status of the area as a National Park.

Australasian Bittern *Botaurus poiciloptilus*
(IUCN: Vulnerable C2a, NPWSA Act: Vulnerable)

The Australasian Bittern breeds in deep densely vegetated freshwater swamps and pools, building nests in deep cover over shallow water (Bright 1935, Soper 1958. Populations contain approximately 2,500 mature individuals with no subpopulations thought to contain more than 1000 individuals, and numbers are probably still decreasing (Garnett & Crowley 2000).

Habitat:

- terrestrial wetlands and occasionally estuarine habitats.
- favor wetlands with tall dense vegetation, where they forage in still shallow water up to 0.3m deep, often at edges of pools or waterways. (Bright 1935; Whiteside 1989).
- favors permanent fresh-waters, particularly those dominated by sedges, rushes, reeds or cutting grass. (eg *Phragmites*, *Eleocharis*, *Juncus*, *Typha*, *Baumea* and *Gahnia*) growing over muddy or peaty substrate. (Corrick & Norman 1980).
- occasionally ventures into areas of open water or onto banks and tolerate brackish water in estuaries and tidal flats, where birds inhabit beds of rushes or reeds in saltmarsh, especially near mouths of creeks or freshwater seepage (Owen & Sell 1985).

Habitat mapping database fields queried

Water depth: damp, film, 3-10cm.

Landforms: closed depressions, vegetated bed sediments .

Life form: shrubs 0 -.5m, Grass >0.5m, Sedges >0.5m, Sedges <0.5m.

Microhabitats: sheltered areas.

Water regime: permanent.

Results

Predicted habitats for stage one totalled 402 habitats covering an area of 19,733 hectares. Stage two totalled 97 habitats covering 3,508 hectares. The known habitat preferences for the Australasian Bittern needs to be defined more accurately in order for highly preferred habitats to be located. The current prediction indicates there is suitable habitat covering the majority of the Lower Lakes, although Australasian Bittern survey records do not reflect the use of all available habitat (Dadd 2003; Eckert 2003). The classification method used in the habitat mapping database may also need amending to reflect the habitat requirements for the Australasian Bittern.

Refer to [Figure 11](#) for predicted habitat distribution in the Lower Lakes and Coorong.

Lewin's Rail *Rallus pectoralis*
(IUCN: Near Threatened c, NPWSA Act: Vulnerable)

This species has undergone a decline in abundance in Australia over at least half of the subspecies range, caused primarily by the contraction of wetlands (Garnett and Crowley 2000). The habitat description is broad and poses the same problems as the Australasian Bittern. Analysis of bird survey data is required to investigate key habitat preference in the Lower Lakes and Coorong.

Habitat:

- densely vegetated, fresh, brackish or saline wetlands usually with areas of standing water; favor permanent wetlands, but often on ephemeral ones (Gilbert 1936; Leicester 1960; Morris 1975; Czechura 1983).
- swamps, marshes, lakes, small pools, inundated depressions, swampy or tidal creeks and streams, saltmarshes, coastal lagoons, estuaries and farm dams are all used when they have fringing or emergent, long or tussocky grass, reeds, rushes, sedges or bracken. (Parker 1985; Jaensch 1987; Skemp 1955).
- forage in soft mud or shallow water (<5cm) at edges of wetlands usually remaining close to dense vegetation, such as samphire, but occasionally in the open (Gilbert 1936; Watson 1955; Leicester 1960; Jaensch 1987)
- Shrubland, reedbeds, tussocks and grass and weeds (Paton in EarthTech 2003).

Habitat mapping database fields queried

Water depth: damp, film

Landforms: closed depressions, vegetated bed sediments, drainage depressions

Life form: shrubs 0 - 0.5m, Grass > 0.5m, Sedges > 0.5m, Sedges < 0.5m

Water regime: permanent

Substrate form: mud, muddy sand

Results

Predicted habitats for stage one totalled 411 habitats covering an area of 20,838 hectares. Stage two totalled 110 habitats covering 4,087 hectares. These results indicate that habitat preferences for the Lewin's Rail need to be defined more accurately. Habitats recording degraded or completely degraded condition are not extensive, in stage one these habitats accounted for 110 habitats covering an area of 2,440 hectares from a total of 20,838 hectares, suggesting that the remaining habitat available is in good condition. Refer to [Figure 12](#) for habitat distribution for the Lewin's Rail.

Little Tern *Sterna albifrons* and Fairy Tern *Sterna nereis*

Little Tern (NPW Act: Vulnerable, CAMBA and JAMBA), Fairy Tern (NPW Act: Vulnerable)

Habitat:

- Sheltered coastal environments, including lagoons, estuaries, river mouths.
- Prefers exposed sandbanks or sand-spits and ocean beaches.
- Rarely on rocky or muddy shores, (Cox & Close 1977)

Habitat mapping database fields queried

Landform: beach, sandy beach, unvegetated bed sediments

Micro habitats: sand flats

Substrate: muddy sand, sand, sandy beach, sandy shore

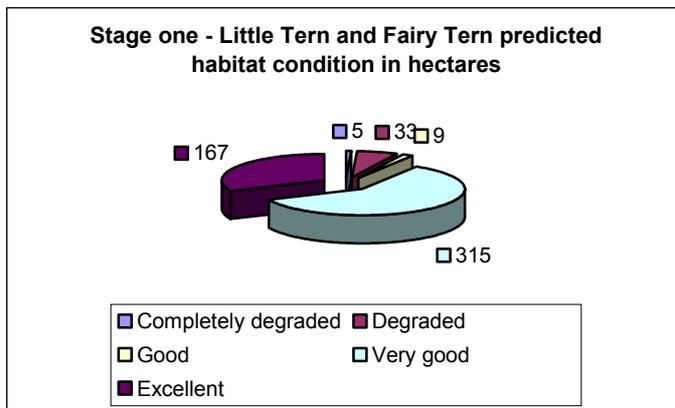
Wetland type: A5 and A7



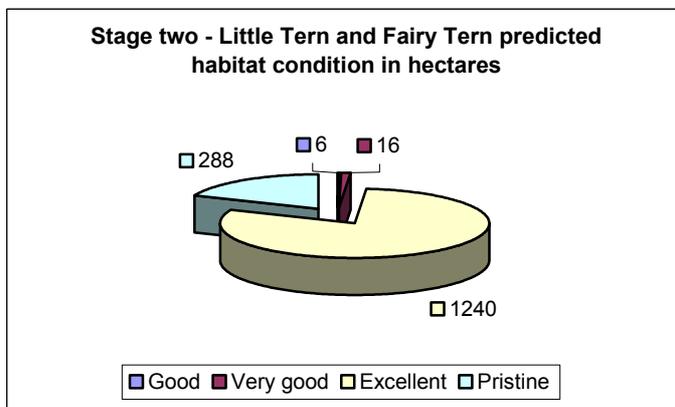
Plate 28. Fairy Terns

Results

Stage one recorded 31 habitats covering 529 hectares with habitat distribution concentrated around the southern shorelines of Hindmarsh Island. Habitats with a very good condition assessment comprised 315 hectares; 167 hectares were degraded, refer to [Graph 5](#). In stage two recorded 25 habitats covering 1,550 hectares with habitat evenly distributed throughout the Coorong National Park. The majority of habitats (1,240 hectares) were in excellent habitat condition, refer to [Graph 6](#). Refer to [Figure 13](#) for habitat distribution.



Graph 5. Stage one, Little Tern and Fairy Tern predicted habitat condition (HA)



Graph 6. Stage two, Little Tern and Fairy Tern predicted habitat condition (HA)

28.3 Habitat preferences for the Orange-Bellied Parrot

Orange-Bellied Parrot *Neophema chrysogaster*

(IUCN: Critically Endangered: C2b, NPW Act: endangered)

There are about 180 mature individuals of this species in a single sub-population, with numbers continuing to decline (Garnett and Crowley 2000). Their breeding range includes Birch's Inlet to Louisa Bay and south-west Tasmania (OBPRT 1998); the non-breeding range includes: King Island on migration then south-east South Australia principally the Coorong, east and south of Gippsland, Lake Connewarre, Swan Bay and The Spit Nature Reserve (OBPRT 1998).

Habitat:

- mainland, mostly within three kilometres of the coast, bays, lagoons, estuaries.
- low samphire herbland dominated by Beaded glasswort *Sarcocornia quinqueflora*, Sea heath *Frankenia pauciflora* or Sea-blite *Suaeda australis*. Also in taller shrubland dominated by Shrubby glasswort *Sclerostegia arbuscula*; sometimes in low samphire shrubland dominated by Grey Glasswort *Halosarcia halonemoides*, or in Chenopodium herbfields. (Belcher 1914; Watson 1955; Yugovic 1984; Hewish & Starks 1988; Stephenson 1991).
- beaches, amongst patches of colonising plants (Watson 1955).
- heath vegetation (Loyn & Kinhill Planners 1979b) rarely in cultivated sunflower crops (Eckert 1990).
- When migrating in South Australia, and in western Victoria, they also use beaches, dune frontages and adjacent dune systems and sheltered areas along rocky foreshores where they feed on the seeds of strandline plants, e.g. sea rocket *Cakile maritima* (OBPRT 1998).

Habitat mapping database fields queried

Life form: shrubs 0 - 0.5m

Landforms: Closed depressions, floodplain, beach

Microhabitat: Rocky areas, sheltered areas

Results

Stage one habitats conforming to the query totalled 250 habitats, covering an area of 15,916 hectares, and stage two comprised of 94 habitats covering an area of 18,877 hectares. These results indicate extensive habitat available for the Orange-bellied Parrot, however it is known that all these habitats are not used (OBPRT 1998). To define the habitat preferences further, only beaches and rocky shores have been queried because they have been identified as unique feeding areas (OBPRT 1998). From this query, only 16 habitats in stage one were identified covering an area of 142 hectares and 25 habitats in stage two covering an area of 1,142 hectares. Refer to [Figure 14](#) for habitat distribution.

28.4 Migratory Waders

Within South Australia, 31 sites of international importance and seven areas of national importance have been identified (Watkins 1993). The Coorong and Lower Lakes are included as one of these areas. Watkins ranks each site to indicate the importance of a wetland site for a specific water bird species; Table 25 lists migratory waders recorded in the Ramsar site that are included in this ranking. Four species are selected from this list and habitat requirements are discussed and suitable habitat predicted by using the habitat mapping database. These species are also listed under the CAMBA and JAMBA migratory bird agreements.

Table 25. Watkins rankings for migratory waders

Species	Significance	Ranking
Sharp-tailed Sandpiper	Internationally Significant	Ranked most important wetland area in SA
Red-necked Stint	Internationally Significant	Ranked most important wetland area in SA
Pied Oystercatcher	Internationally Significant	Ranked 2nd in SA
Red-capped Plover	Internationally Significant	Ranked 2nd in SA
Banded Stilt	Internationally Significant	Ranked 2nd in SA
Sanderling	Internationally Significant	Ranked 3rd in SA
Curlew Sandpiper	Internationally Significant	Ranked 3rd in SA
Greenshank	Internationally Significant	Ranked 4th in SA
Red-necked Avocet	Internationally Significant	Ranked 7th in SA
Pacific Golden Plover	Nationally Significant	Ranked 9th in SA
Murray mouth area Sharp-tailed Sandpiper	Internationally Significant	Ranked 25th in SA

Migratory wader predicted habitats

Four species of migratory waders (Sharp-tailed Sandpiper, Curlew Sandpiper, Red-necked Stint and Common Greenshank) are grouped together because they have similar habitat requirements. Habitat descriptions have been sourced from Favaloro (1943), Badman (1979), Roberts (1981), Lane (1986), Boehm (1960), Thomas (1968), Thomas and Dartnell (1971) and Loyn (1975,1978).

Selected migratory waders

Sharp-tailed Sandpiper *Calidris acuminata*, Curlew Sandpiper *Calidris ferruginea*
Red-necked Stint *Calidris ruficollis*, Common Greenshank *Tringa nebularia*

Habitat:

Forage on mudflats, muddy edges and nearby shallow water with fine sediments. In non-tidal wetlands, usually wade, mostly in water 15-30mm, but up to 60mm deep. Also forage farther out or on mud and sand covered by a film of water.

Habitat mapping database fields queried

Landform: mud flat

Surface type: mud

Sediment size: fine

Substrate: mud

Water depth: film <3cm

Microhabitat: mud flat

Results

Stage one had 34 habitats covering an area of 2,040 hectares, the distribution of habitat concentrated on the north eastern shoreline of Lake Alexandrina and the southern shorelines of Hindmarsh Island. Stage two had of 92 habitats covering an area of 5,330 hectares with habitat widely distributed throughout the Coorong National Park. Refer to [Figure 15](#) for habitat distribution.

28.5 Predicted habitat for waterbirds

Five waterbirds are grouped together that contain similar habitat characteristics:

Freckled Duck *Stictonetta naevosa* (Vulnerable)
Musk Duck *Biziura lobata* (Rare)
Baillon's Crake *Porzana pusilla* (Rare)
Golden Headed Cisticola *Cisticola exilllis* (Rare)
Great-crested Grebe *Podiceps cristatus* (Rare)

These birds are listed in schedules 8 and 9 of the *National Parks and Wildlife Act 1972*.

Habitat:

- found in rivers, river pools, farm-dams, shallow fresh swamps with emergent vegetation, prefer shallow productive waters (Frith 1965).
- feeding limited to top 0.7m of water reached by upending (Morton *et al.* 1989).
- also found on shores and shallow margins of large lakes or deeper swamps, in open water or amongst tall emergent vegetation (Recher *et al* 1983).
- Often found in wetlands with dense vegetation, often with abundant floating plants, but also occur on open waters (Barlow & Sutton 1975).
- Uses reedbeds, tussocks and floating vegetation (Paton in EarthTech 2003).

Habitat mapping database fields queried

Water depth: open water, 10cm - 0.5m

Landforms: stream channel, vegetated bed sediments, drainage depressions

Life form: grass > 0.5m

Water regime: permanent

Aquatic class: rooted floating leaved, floating leaved

Results

Predicted waterfowl habitat in stage two comprised of 13 habitats covering an area of 63 hectares. These habitats are located in small isolated areas on the landward dune shoreline in the Coorong. Habitats suitable for selected waterfowl in stage one comprise of 177 habitats covering an area of 5,537 hectares. These habitats are widely distributed with concentration of habitats around the southeastern end of Hindmarsh Island, Currency and Finniss Creeks, Narrung Narrows and the southern shorelines of Lake Albert. Refer to [Figure 16](#) for the distribution of predicted habitat.

28.6 Habitat mapping and the State planning system

Another application for the habitat mapping database is for land use planning purposes. Analysis of the habitat mapping database and planning information is done by using GIS software (geographical information systems). This enables information to be displayed and scenarios explored which assists in making management decisions. Information about land ownership, planning zones, council strategic planning and State government planning initiatives can be analysed against the habitat mapping database. This allows for a detailed study of land use planning and potential conflicts with the Ramsar principles of wise use of wetlands.

The following is an example of how the habitat mapping database can be used to analyse potential conflicts between habitats and development plan zoning provisions. Habitats that have been classified with an excellent condition rating have been extracted and overlaid with the development planning zones for the district councils of Murray Bridge, Coorong and Alexandrina (refer to [Figure 17](#)). The zones that contain excellent habitats are described in [Table 26](#), in terms of their objectives and comment is given regarding the compatibility with ecosystem and habitat management. [Figure 17](#) illustrates current planning zones and habitats with an excellent condition rating. [Figure 18](#) illustrates potential conflict areas with current development plan zones and habitats assessed with excellent condition. Three conflict areas are highlighted, these include the northern shoreline of Lake Alexandrina (Boggy and Dog Lake localities), upper reaches of the Finniss River and the south-western area near Goolwa township and Sir Richard Peninsula.

28.6.1 Development Plans

Development Plans outline the desired character for different parts of a region, the types of development preferred and the criteria against which development applications will be assessed. These policies cover a range of social, environmental and economic matters (www.planning.gov.sa.au).

In short a Development Plan has two roles:

- It provides a 'desired direction' and a local policy framework for development
- It provides the detail for assessment of individual development applications

28.6.2 Zone Provisions

Zone provisions provide a framework for development envisaged within a particular geographic area and provide specific policies for assessing development within that zone. Zone provisions also generally list the kinds of development that are 'complying' within the zone (either outright or subject to specific conditions) and those developments which are "non-complying" within that zone. Any form of development which is not included in either list is required to be assessed on its 'merits' by the relevant authority in accordance with the desired character and specific policies for development listed within that zone, and against the broader policies contained within the Development Plan (Council-wide provisions) (www.planning.gov.sa.au).

Table 26. Development plans zones.

Development Plan Zone	Number of habitats Contained in zone	Compatibility
<p><u>Alexandrina Council</u> Source: Alexandrina Council (2003) Development Plan. Planning SA.</p> <p>Zone: Coastal Objective: The retention of the natural open character and scenic amenity of land adjacent to the coast.</p>	2	Compatible
<p>Zone: Conservation Zone Objective:</p> <ol style="list-style-type: none"> 1. Preservation of areas of natural vegetation, wildlife habitat and wilderness and other features of major conservation significance to the earth or social sciences. 2. Land subject to inundation kept free of development which could be damaged by, or impede, the natural flow of flood waters. 3. The conservation of the natural character of the zone. 4. The maintenance of the water quality of Lake Alexandrina and the River Murray. 	104	Compatible
<p>Zone: Conservation (Hindmarsh Island) Objectives:</p> <ol style="list-style-type: none"> 1. Preservation of areas of natural vegetation, wildlife habitat and wilderness and other features of major conservation value. 2. The maintenance of the water quality of Lake Alexandrina and the waterways. 3. The retention of farming land in large allotments for commercial rural uses, with the land being managed in such a way that it protects the conservation value of the zone. 4. The provision of appropriate environmental and heritage interpretive facilities. 	157	Compatible
<p>Zone: Flood zone Objectives:</p> <ol style="list-style-type: none"> 1. Maintenance of the open rural character and productive use of land. 2. Preservation of the natural land contours and significant natural features including the mature remnant vegetation lining the Bremer River and Angas River. 3. Restricted development in recognition of the hazards associated with flood events, minimising structures and changes to existing natural ground levels. 4. Maintenance of existing flood flow-paths through the Langhorne Creek township such that flood conditions are not worsened. 	1	Compatible

Development Plan Zone	Number of habitats Contained in zone	Compatibility
<p><i>Alexandrina Council Continued.</i> Zone: Residential Objective: 1. A zone primarily accommodating a range of dwellings, together with appropriate community uses complementing the permanent and the holiday accommodation requirements of the urban coastal area.</p>	9	Not compatible. Statement regarding the protection of important habitat maybe appropriate.
<p>Zone: Water front Objectives: 1. A zone containing land developed for low intensity primary production purposes or managed for conservation. 2. Protection of the natural open character and features of the zone. 3. Maintenance of the water quality of Lake Alexandrina and associated watercourses. 4. Prevention of development on land inundated by the 1956 flood where that development could be damaged by flooding or which may impede the natural drainage of surface flow of waters.</p>	50	Compatible
<p>Zone: rural water front (Hindmarsh Island) Objective: 1. The retention of land within the zone in large allotments for farming uses with buildings and structures located and designed in such a way that they will not detract from the views obtainable from the mainland, the waterways or designated tourist routes/scenic lookouts. 2. The conservation of the natural character and the environment of the shoreline, wetlands and bird habitat areas.</p>	4	Compatible.
<p>Zone: Rural Living (Strathalbyn District) Objectives: 1. A zone primary accommodating detached dwellings in association with hobby farming, grazing and other activities of a minor and non-intensive nature on various sized allotments. 2. Development within this zone maintaining the rural character and amenity of the zone. 3. Land within the zone enhanced by extensive screening, clustering of buildings and landscaping. 4. Development of policy areas rural living (3), rural living (6) and rural living (7) with appropriate forms of small-scale industry associated with rural activities. 5. The protection of the Angas River, particularly its banks, from excavation and development.</p>	1	Compatible. Although the identified habitat is located on the banks of the Finnis River which is not clearly stated as in objective 5.

Development Plan Zone	Number of habitats Contained in zone	Compatibility
<p><u>Alexandrina Council</u> Cont.</p> <p>Zone: Rural Fringe. Objectives 1. A zone accommodating a restricted range of rural uses which are not prejudicial to future urban development of land within or adjacent to the zone, and which do not detract from the appearance and open character of the zone.</p>	6	Compatible. Clear statement for the protection of remnant vegetation maybe appropriate.
<p>Zone: Holiday House (Hindmarsh Island) Objectives 1. The location of single storey small-scale holiday homes on existing leased allotments with extensive landscaping so as to minimise the visual impact of such development when viewed from the Murray Mouth area and the Conservation (Hindmarsh Island Zone). 2. The maintenance of the water quality of the waterways. 3. The provision for public access along the foreshore. 4. The protection and enhancement of amenity of the foreshore and frontal sand dune system. 5. The protection of dwellings from inundation and the maintenance of access during times of extreme tide and anticipated sea level rise.</p>	1	Compatible.
<p>Zone: Grazing Objectives 1. Retention of land in primary production. 2. Preservation of the open rural character and natural beauty of the land within the zone. 3. Conservation of the remaining items of heritage value associated with former mining activities in the vicinity of the "Highland Valley" Homestead. 4. Preservation of significant areas of natural vegetation and the mature Eucalypts lining the Bremer River and Angas River.</p>	1	Compatible. Statement for the protection of remnant vegetation maybe appropriate.
<p>Zone: General Farming (Port Elliot and Goolwa) Objective 1. The retention of land within the zone for a wide range of farming uses.</p>	1	Not compatible. Does not reflect the ecological importance of the Finnis River.

Development Plan Zone	Number of habitats Contained in zone	Compatibility
<p><u>Rural City of Murray Bridge</u> Source: Rural City of Murray Bridge (2003) Development Plan. Planning SA.</p> <p>Zone: Floodzone Objectives:</p> <ol style="list-style-type: none"> 1. The preservation of the quality of the river water. 2. The conservation of the natural character of the river valley. 3. Land liable to flooding free of buildings and structures likely to impede or be damaged by floodwaters. 4. Land division enabling security of tenure for existing dwellings. 5. The upgrading of existing dwellings to assist environmental improvements. 	63	Compatible. Although objective 2 is open to vague interpretations. Statement regarding the protection of remnant vegetation maybe appropriate.
<p>Note: No conservation zone stated in Rural City of Murray Bridge (2003) Development Plan.</p>		
<p><u>The Coorong District Council</u> Source: The Coorong District Council (2003) Development Plan. Planning SA.</p> <p>Zone: Conservation Zone Objectives:</p> <ol style="list-style-type: none"> 1. A zone in which land and features of major conservation significance, including areas of native vegetation, wetlands, wildlife habitat and sites containing features of significance to the earth sciences and cultural heritage, are conserved in their natural state. 2. Protection of surface and underground water resources. 3. Provision of appropriate environmental and heritage interpretive facilities. 	169	Compatible.
<p>Zone: River Murray and Lakes (Primary Production) Objectives:</p> <ol style="list-style-type: none"> 1. Long term operation and sustainability of rural production and primary industries. 2. Maintenance of natural hydrological systems and environmental flows. 3. Surface run-off designed to protect property, life and environmental quality. 4. Retention and maintenance of wetlands and existing native vegetation for its conservation, biodiversity, habitat value and environmental management function. 5. Maintenance and enhancement of landscape character. 6. Protection and maintenance of soil characteristics. 7. Other objectives for horticulture, dairying, aquaculture, air quality, noise pollution, hazard minimisation, waste, built form and design, infrastructure and land division. 	6	Compatible.

Section four habitat classification table descriptions

29.0 GIS Habitat classification table descriptions

29.1 Existing GIS datasets

The following is a list of GIS datasets that formed the habitat mapping database, and includes descriptions of the original fields retained within the database.

Native vegetation

Native vegetation datasets were extracted from South East 2000, Murray Mallee 2002, Southern Mount Lofty Ranges 2002 and Western Murray 2000.

Fields used:

MU_50: Vegetation grouping codes.

DESCRIPTION: Vegetation association description.

FORM DESCRIPTION: Structural formation description.

DATALAYER: Lists which vegetation mapping dataset is used.

Landscape wetlands

Provides coverage of wetlands identified by Thompson between 1983 – 1986 and Pressey (1986).

Fields used:

THOMPSON: Thompson's wetland numbering system as stated in Thompson (1986).

PRESSEY: Pressey wetland reference number as stated in Pressey (1986).

GEOMORPHIC: Geomorphic categories as used in Pressey (1986).

HYDROLOGY: Hydrological unit categories as used in Pressey (1986).

DATALAYER: Identifies GIS dataset used.

Landscape wetlands

A State-wide numbering system has been developed for identifying wetlands. It follows the system established for the Murray River wetlands by Carruthers & Nicolson in 1992 and published in the form of a Wetland Atlas (Jensen *et al.* 1996). This atlas also developed a GIS layer for the Murray River wetlands. A GIS database also exists for the South East region of South Australia and has been published in the form of a technical report by Carruthers & Hille (1997). The Upper South East has been updated by Wilson (1999) as part of the Wetlands Waterlink project. Seaman (2002) started the wetland reference numbering system and GIS coverage for Eyre Peninsula, Northern Agricultural Districts, Kangaroo Island and Mount Lofty Ranges as part of a series of regional wetland inventories.

The Murray River wetlands have been assigned the numbers S0001 to S0999. Numbers for the other regions are as follows: South East S1000 to S1999. Eyre Peninsula S3000 to S3999, Northern Agricultural Districts S4000 to S4999, Kangaroo Island S5000 to S5999 and Mount Lofty Ranges S2000 to S2999.

Fields used:

AS2482: Australian landform definition codes.

AUSTRALIAN WETLAND NUMBER: Unique wetland numbering system for each region in South Australia.

COMPLEX: Wetland complex identified.

DATALAYER: Describes which GIS dataset is used.

Topographic features

Topographic features including water, sand and vegetation and are included in this dataset.

Fields used:

TOPOGRAPHIC WATER: Topographic water features extracted from Department for Environment and Heritage (DEH) GIS data layer 2002.

TOPOGRAPHIC SAND: Topographic sand features extracted from DEH GIS data layer 2002.

TOPOGRAPHIC VEGETATION: Topographic vegetation extracted from DEH GIS data layer 2002.

AS2482: Australian landform definition codes.

DATALAYER: Describes which GIS dataset used.

PIRSA Land Information

Includes an inventory of the land and soil resources of South Australia's agricultural districts.

The inventory includes a look-up table in which categorical values for a range of soil and landscape attributes are linked to the mapping units. Each attribute includes several classes or categories that provide a simple picture of the degree of land-affecting agricultural use across the State. Four of these categories have been extracted from the original dataset and incorporated in the habitat mapping database.

Fields used:

SOIL GROUP: Provides codes for 15 soil groups.

COMMON SOIL GROUP: Provides codes for 61 common soil groupings.

ROCK SURFACE: Classified according to the overall amount of surface stone and outcropping rock. Where rockiness is not uniformly distributed across the map unit (eg a complex of sandhills and stony flats), a weighted average estimate is made.

TEXTURE SURFACE: Map units are classified according to their most common surface texture category, eg sandy loams, clays.

Coastal Saltmarsh and Mangrove Mapping

Coastal Saltmarsh and Mangrove Mapping undertaken by the Department for Environment and Heritage; described in a draft technical report by Canty & Hille (2002).

Fields used:

LANDFORM: Describes dominant coastal landform.

ESTUARINE: Identifies if the map unit is estuarine or non-estuarine.

TIDAL CLASS: Identifies tidal class of map unit.

COVER: Defines the cover type of the mapped habitat polygon.

INTEGRITY: Defines the condition of the cover type.

DESCRIPTION: Provides a brief description of map unit.

29.2 New GIS habitat descriptions

The following provides descriptions for the habitat classification survey that is located within the habitat mapping GIS database.

29.2.1 *Habitat Number*

The habitat number is a unique identifier for each habitat; the number consists of four digits, eg 0001.

29.2.2 *Date*

Date and time of data collection.

29.2.3 *GPS reading*

Easting and northing, if required.

29.2.4 *Approximate Area*

Usually recorded before or after survey by GIS query.

29.2.5 *Wetland system*

Wetland system descriptions are based on the Mediterranean Wetland Inventory, Habitat Description System developed by Farinha, Costa *et al.* (1996).

Marine: A marine system consists of permanent shallow waters less than six metres deep at low tide and associated exposed coastlines. The salinity generally exceeds 64 mS/cm (milli-siemens) or 35,200 ppm (part per million) with little or no dilution except outside the mouths of estuarine systems.

The boundaries of the marine system extends from a depth of six metres at low tide shoreward to one of the following:

1. The non-wetland limit of the wetland (in coastlines with weal tides). Includes the associated splash zone
2. The landward limit of tidal inundation (extreme high water of spring tides or annual storm surge), including the splash zone from breaking waves
3. The seaward limit of wetland emergents, trees or shrubs
4. The seaward limit of the estuarine system where this limit is determined by other factors other than vegetation.

Estuarine: The estuarine system consists of habitats with low energy and variable salinity influences, and is often semi-enclosed, by land but with open, partly obstructed or sporadic access to the marine system. The salinity may be periodically increased above that of the sea by evaporation. Estuarine habitats include lagoons and salt marshes bordering estuaries in areas with evident intertidal zone.

Riverine: The riverine system is contained in natural or artificial channels where water is usually, but not always, flowing, with the exception of all wetlands within an open channel. Mosses, lichens, persistent emergents, shrubs and trees usually dominate a riverine system.

The riverine system is bounded by:

1. The landward side and channel bank including natural and artificial levees or wetlands dominated by trees, shrubs, persistent emergent, emergent mosses or lichens.
2. The downstream end where the flow concentration of marine-derived salts occur during the period of annual flow, or where the channel enters a natural or artificial lake.
3. The upstream end where tributary streams originate or where the channel leaves a lake.

Lacustrine: The lacustrine system includes wetland habitats situated in a topographic depression or a dammed river channel. The total area exceeds 8 ha and the associated exposed or shallow shore vegetation comprises aquatic beds or non-persistent emergents. Excluded in this system are persistent emergents, shrubs and trees with greater than 30% aerial coverage.

Similar wetland habitats totalling less than 8 ha are also included in the lacustrine system if they have at least one of the following characteristics:

1. The water depth in the deepest part of the depression exceeds two (2) metres at low water
2. A wave formed or bedrock feature makes up all or part of the shoreline boundary.

Lacustrine habitats include permanently flooded lakes, reservoirs and intermittent lakes. Typically they are extensive areas of deep water and there is considerable wave action.

The lacustrine system is bounded by:

1. The landward side by a non-wetland
2. A wetland dominated by lichens, emergent mosses, persistent emergent vegetation, shrubs or trees on the shoreward side.

Palustrine: The palustrine system includes all non-tidal wetlands dominated by emergent mosses or lichens, persistent emergents, shrubs or trees. Wetland habitats lacking such vegetation, and those dominated by aquatic bed or by non-persistent emergent vegetation, are also included in the palustrine system if they exhibit all of the following characteristics:

1. The total area is less than 8 ha
2. There is not active wave formation or a bed rock shoreline feature
3. The water depth in the deepest part of the depression is less than two (2) metres at low water.

Palustrine wetland habitats may also be situated shoreward of lakes, adjacent to river channels, inland or estuaries, on river floodplains, in isolated catchments, on slopes, or as islands in lakes or rivers.

The palustrine system is bounded by a non-wetland and by any of the other four systems.

29.2.6 Landform element

Landform element definitions have been adapted from:

- Heard, L. & Channon, B. (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.
- Farinha, J.C., Costa, L.T., Zalidis, G., Mantzavelas, A., Fitoka, E., Hecker, N. & Tomas Vives, P. (1996) Mediterranean Wetland Inventory: Habitat description System. MedWet/ Instituto ds Conservacao da Natureza (ICN)/ Wetlands International/ Greek Biotope/ Wetland Centre (EKBY) Publication, Volume III.
- Canty, D. & Hille, B. (2002) Coastal Saltmarsh and Mangrove Mapping, Draft technical report. Department for Environment and Heritage, South Australia.

Landform elements are smaller mosaics within landform patterns and have a characteristic dimension of about 40 metres across, although within the context of the habitat mapping classification this can extend to distances greater than 40 metres, for example along rocky shorelines.

Descriptions of landform classifications are provided below.

Beach: Short, low, very wide slope, gently or moderately inclined, built up or eroded by waves, forming the shore of a lake or sea.

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.

Cliff: Very wide cliffed (>72 degrees) maximal slope usually eroded by gravitational fall as a result of erosion of the base, sometimes built up by marine organisms.

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

Consolidated dune/dune: Moderately inclined to very steep ridge or hillock built up by the wind. This element may comprise dunecrest and duneslope. May also be consolidated due to the stabilising effects of vegetation.

Cove: Body of water, depth six metres or less bounded by land on three sides. Water is connected permanently by a narrow or wide opening to a larger water body.

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.

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

Floodplain: Alluvial plain characterised by frequent active erosion and aggradation by channelled or over-bank stream flow. Unless otherwise specified, frequently active is to mean that flow has an average recurrence interval of 50 years or less.

Hill footslope: Moderately to very gently inclined waning lower slope of a hill resulting from aggradation of erosion by sheet flow, earth flow or creep.

Interdune corridor: Wide, linear level floored open depression between parallel dunes.

Island: Sediments built up over time through water movement forming a landform with low relief.

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.

Lake: Large water-filled closed depression.

Mud flat: Unconsolidated substrates where particles are smaller than stones are predominantly clay and silt size, and have an a real coverage of 25% or greater. Vegetation cover is less than 30%.

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

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

Reef/rocky reef: Area built up by marine organisms; limestone substrate.

Ridge: Compound landform, with narrow crest and short adjoining slopes, the crest length being greater than the width of the landform element.

Rocky cliff: Very wide cliffed (>72 degrees) maximal slope comprising of bedrock, boulders or rocky material covering more than 75% of the cliff.

Rocky outcrop: An exposed area of rock that is inferred to be continuous with underlying bedrock and is on a mountain, hill or rise.

Rocky shore: Shorelines adjacent to a waterbody having an aerial cover of bedrock, stones and boulders alone or in combination with 75% or more of the surface cover. The vegetative cover is less than 30%.

Salt lake: Lake containing a concentration of mineral salts, predominantly sodium chloride in solution as well as magnesium and calcium sulphate.

Sand bar: Elongated, gently to moderately inclined low ridge containing coarse grains, built up by water movement.

Sandy beach: Short, low, very wide slope, gently or moderately inclined, built up or eroded by waves, forming the shore of a lake or sea. Composed of coarse grains.

Shoreline: Extensive, low, very wide slope, gently or moderately inclined, built up or eroded by waves, forming the shore of a lake or sea. Composed of a combination of one or more of the following: coarse grain sands, mud flat, rocky reef and rocky shore.

Stream bank: Very short, wide slope, moderately inclined to precipitous, forming the marginal upper parts of a stream channel and resulting from erosion or aggradation by channeled stream flow.

Stream channel: Linear, generally sinuous open depression, in parts eroded, excavated, built up and aggraded by channel stream flow.

Undulating plain: Large very gently inclined or level landform of unspecified geomorphological agent or mode of activity.

Un-vegetated bed sediments: Sediments that are covered with water for most of the year that have no vegetation present.

Vegetated bed sediments: Sediments permanently inundated with water supporting dense aquatic/semi-aquatic vegetation.

Vegetated island: Sediments built up over time through water movement forming landform with low relief consolidated by stabilising effects of vegetation.

29.2.7 *Micro relief*

Micro relief refers to relief no more than a few metres surrounding the land surface. Definitions have been adapted from Mc Donald *et al.* (1990) in Blackman, Spain & Whiteley (1992). The classification of structural relief was developed during fieldwork by Seaman (2003).

Structural relief: Unique areas within a characteristically flat landscape containing defined vegetation structure of several lifeforms.

Crabhole: Holes with or without mounds formed by the activity of crabs.

Undulating surface: Undifferentiated, irregularly distributed or isolated mounds and/or depressions set in a flat surface.

Hummock: Usually steep sided earth rising above a flat surface. Frequently occupied by trees or shrubs while the lower surface may be vegetation free or occupied by sedges or reeds. Areas where hummocks occur are usually subject to prolonged seasonal flooding.

Mounds: Convex, long axis not more than three times the shorter axis.

Depressions: Concave, occurs as a closed or elongated landform.

Terrace: Low level surfaced rise.

Slopes: Gently inclined to precipitous slope.

Banks: Short, wide slope, moderately inclined.

28.2.8 *Substrate surface type*

The substrate surface type identifies the most common substrate surface type within the survey site. Definitions have been adapted from Heard & Channon (1997) and from Mc Donald *et al.* (1990) in Blackman, Spain & Whiteley (1992).

For surface types with coherence such as clay, soil texture may need to be determined by taking a small handful of soil below the crust, add water and work the soil into 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 is also indicative of its texture.

Mud: (silt and clay) <0.02 mm. Includes unconsolidated substrates where the particles smaller than stones are predominantly clay and silt size, have an aerial coverage of 25% or greater and vegetation cover less than 30%.

Sandy mud: 0.02 – 2.00 mm. Includes unconsolidated substrates where the particles smaller than stones are predominantly sand and mud size, have an aerial coverage of 25% or greater and vegetation cover less than 30%.

Shelly mud 0.02 – 2.00 mm. Includes unconsolidated substrates where the particles smaller than stones are predominantly shell and silt size, have an aerial coverage of 25% or greater and vegetation cover less than 30%.

Shelly sand 0.02 – 2.00 mm. Includes unconsolidated substrates where the particles smaller than stones are predominantly shell and sand size, have an aerial coverage of 25% or greater and vegetation cover less than 30%.

Shells 0.02 – 2.00 mm. Includes unconsolidated substrates where the particles smaller than stones are predominantly shell size, have an aerial coverage of 25% or greater and vegetation cover less than 30%.

Sand 0.02 – 2.00 mm. Includes unconsolidated substrates where the particles smaller than stones are predominantly sand size, have an aerial coverage of 25% or greater and vegetation cover less than 30%.

Gravel 2.00 – 60.00, Cobbles 60.00 – 200.00 mm. At least 25% of the substrate is covered by unconsolidated particles smaller than stones are characterised by cobbles and gravel (size range of particles: 2.00 – 2000 – mm). The vegetative cover is less than 30%. Sand, silt and shell fragments often fill the spaces between the larger particles. Where unconsolidated shores are subject to strong wave and currents, gravel and cobble may take the form of beaches and flats.

Stones 200.00 – 600.00 mm, Boulders 600.00 – 2000.00 mm and Bedrock. Includes substrates having an aerial cover of bedrock, stones and boulders alone or in combination with 75% or more of the surface. The vegetative cover is less than 30%.

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 long.

Clay Loam, Sandy: Coherent plastic bolus with medium size sand grains visible within a finer matrix, forms a ribbon between 40-50mm. Clay content 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 content between 45% - 55%.

Medium heavy clay: Same properties as medium clay but with a 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. Clay content of about 5%.

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

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 content between 5% -10%.

Sandy clay loam: Strongly coherent bolus, sandy to touch, medium size grains visible in finer matrix, will form a ribbon of 25 – 40mm. Clay content between 20% - 30%.

Light clay: Plastic bolus, smooth to touch, slight resistance to shearing between thumb and fore finger, will form a 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 content 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 content between 10% - 20%.

Clay loam: Coherent plastic bolus, smooth to manipulate and will form a ribbon of 40 – 50 mm. Clay content 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.

29.2.9 Surface Strew cover

Surface strew cover is adapted from Mc Donald *et al.* (1990) in Blackman, Spain & Whiteley (1992) and from Heard & Channon (1997). Surface strew cover is an estimate of rock fragments covering the habitat or mapping unit. This estimate is divided into five increments: 2%, 10%, 20%, 50% and 90%.

29.2.10 Sediment Size

Sediment size is a quick indication of sand content of the soil within the habitat. It is based on grain sizes in which are determined by substrate surface type and is divided into coarse or fine sediments.

Coarse sediment: 80% or more sand content (0.002 – 2.00 mm).

Fine sediment: 80% or more silt and mud (<0.02mm).

29.2.11 Substrate Form

Substrate form is described where its aerial coverage comprises at least 25% or greater of the wetland surface, and where the aerial extent of vegetation is less than 30%. Definitions are adapted from Blackman, Spain & Whiteley (1992).

Rock bottom: Includes habitats with substrates having aerial cover of stones, boulders or bedrock of 75% or greater and vegetative cover of less than 30%. Rock bottoms are usually high energy habitats, the rock substrate is important in determining the abundance, variety and distribution of animals.

Unconsolidated bottom: Includes habitats with 25% or greater cover of particles smaller than stones and vegetative cover less than 30%. Unconsolidated bottoms are characterised by the lack of large stable surfaces for plant and animal attachment. They are usually lower energy habitats than rock bottoms.

Rocky shore: Includes habitats where bedrock, boulders or stones which singly or in combination have a aerial cover of greater than 75% and have aerial cover of vegetation less than 30%. Rocky shores are usually high energy habitats which lie exposed as a result of continuous erosion by wind driven waves or strong currents. Rocky shores usually contain vertical zonation that is a function of tidal range, wave action and expose to sun.

Unconsolidated shore: Includes habitats with unconsolidated substrates comprising 75% or less of bedrock, boulders or stones and 30% or less aerial cover of vegetation other than pioneering

plants. Unconsolidated shores are characterised by substrates lacking vegetation except for pioneering plants that become established during brief periods when growing conditions are favourable.

Streambed: Streambeds vary greatly in substrate and form depending on the gradient of the channel, velocity of the water and sediment load. Generally streambeds are not vegetated.

Rocky reef: Includes habitats with ridge or mound like structures and adjacent flats formed by the colonisation and growth of sedentary invertebrates. Reefs are characterised by their elevation above the surrounding substrate and their interference with normal wave flow. Reefs are primarily subtidal, with corals, oysters, molluscs and worms mainly responsible for reef formation.

Open water/unknown bottom: Includes water habitats with aerial extent of vegetation less than 30%.

Muddy shoreline: Includes habitats with muddy substrates comprising of sand and silt and 30% or less aerial cover of vegetation. Muddy shorelines are characterised by substrates lacking vegetation except for algae that become established during brief periods when growing conditions are favourable.

Clay loam: Clay contents between 30% and 35%.

Mud: (silt and clay) <0.02 mm. Includes unconsolidated substrates where the particles are smaller than stones and are predominantly clay and silt size.

Muddy clay: Clay contents between 30% and 35%. Includes unconsolidated substrates where the particles smaller than stones are predominantly clay and silt size.

Muddy sand: Includes unconsolidated substrates where the particles are smaller than stones and are predominantly clay and silt size. Sand grains visible in finer matrix.

Sand: 0.02 – 2.00 mm. Includes unconsolidated substrates where the particles are smaller than stones and are predominantly sand size.

Sandy beach: Short, low, very wide slope, gently or moderately inclined, built up or eroded by waves, forming the shore of a lake or sea. Composed of coarse grains.

Sandy shore: Extensive, more so than sandy beach. Widely sloped, gently or moderately inclined, built up or eroded by waves, forming the shore of a lake or sea. Composed of coarse grains.

Consolidated bottom: Characterised by stable surfaces for plant and animal attachment. Usually of lower energy and supports algae growth or microbial crusts.

Calcrete: Characterised by almost level or very gently inclined element of bedded limestone or containing at least 80% of carbonates of calcium or magnesium. Calcrete expressions are common within coastal and marine areas.

29.2.12 Source of water supply

This category records the main sources of water that enter the habitat; most commonly a combination of catchment runoff, ground water and rainfall is recorded. If the origin of water is from a named creek, river system or basin this is documented.

29.2.13 *Water regime*

The hydrological characteristics of habitats in part determine the occurrence of plant and animal communities. Definitions are adapted from Blackman, Spain & Whiteley (1992).

Permanently flooded: Water covers the land surface throughout the year. Vegetation is composed of obligate hydrophytes.

Semi-permanently flooded: Surface water persists throughout the year, except in years of extensive drought.

Seasonally flooded: Surface water is present for extended periods, especially early in the growing season, but is absent by the end of the season in most years. When surface water is absent, the watertable is often very near the land surface.

Temporarily flooded: Surface water is present for brief periods during the growing season. The watertable usually lies well below the land surface for most of the season.

Intermittently flooded: The substrate is usually exposed, but surface water is present for variable periods without detectable seasonal periodicity. Inundation is not predictable to a given season and may be intervened by long periods.

Saturated: Surface water is seldom present, but the substrate is saturated to the surface for extended periods during the growing season.

Artificially flooded: The amount and duration of flooding is controlled by means of pumps or siphons, in combination with dykes or dams.

29.2.14 *Tidal Class*

Tidal classes record the tidal influence upon the habitat. Definitions are adapted from Blackman, Spain & Whiteley (1992).

Intertidal: Includes habitats in the marine and estuarine zones where water regimes are largely influenced by oceanic tides.

Non tidal: Includes habitats commonly within the riverine, lacustrine and palustrine zones. Water regimes are not influenced by oceanic tides.

Intermittent tidal: Includes habitats in the marine and estuarine zones where water regimes are largely influenced by oceanic tides although terrestrial systems such as rivers and streams can dominate the water regime for most or part of the year.

29.2.15 *Water Depth*

Water depth is an estimate of surface water present in the habitat. Six categories are used, namely: damp, film, less than 3 cm, 3 -10 cm, 10cm - 0.5 m and open water.

29.2.16 Dominant vegetation association

Describes the dominant or co-dominant over- storey species and understorey species. Based on descriptions developed by Environmental Analysis Research Unit, DEH. The last four descriptions were added for this project.

MU_50	FORM DESCRIPTION	LEGEND
1.05	Forest	<i>Eucalyptus obliqua</i> / Open forest
2.03	Forest	<i>Eucalyptus baxteri</i> , <i>E. obliqua</i> , +/- <i>E. cosmophylla</i> / Open forest
3.03	Forest	<i>Eucalyptus ovata</i> +/- <i>E. leucoxylon</i> ssp. <i>leucoxylon</i> / Open forest
4.05	Forest	<i>Eucalyptus baxteri</i> +/- <i>E. cosmophylla</i> / Low open forest
5.01	Forest	<i>Avicennia marina</i> var. <i>resinifera</i> / Low open forest
6.01	Forest	<i>Melaleuca halmaturorum</i> ssp. <i>halmaturorum</i> / Low open forest
7.01	Forest	<i>Callitris gracilis</i> / Low open forest
9.01	Woodland	<i>Eucalyptus obliqua</i> , <i>E. goniocalyx</i> +/- <i>E. fasciculosa</i> / Woodland
10.01	Woodland	<i>Eucalyptus leucoxylon</i> ssp. <i>leucoxylon</i> / Woodland
11.01	Woodland	<i>Eucalyptus camaldulensis</i> var. <i>camaldulensis</i> / Woodland
20.01	Woodland	<i>Eucalyptus fasciculosa</i> <i>E. leucoxylon</i> ssp. <i>leucoxylon</i> / Open woodland
21.01	Woodland	<i>Eucalyptus goniocalyx</i> +/- <i>E. fasciculosa</i> / Low woodland
22.01	Woodland	<i>Allocasuarina verticillata</i> / Low woodland
23.01	Woodland	<i>Eucalyptus fasciculosa</i> , <i>Allocasuarina verticillata</i> / Low woodland
24.01	Woodland	<i>Eucalyptus fasciculosa</i> / Low woodland
25.01	Woodland	<i>Eucalyptus fasciculosa</i> , <i>Callitris gracilis</i> / Low woodland
26.01	Woodland	<i>Eucalyptus cosmophylla</i> +/- <i>E. fasciculosa</i> / Low woodland
27.01	Woodland	<i>Eucalyptus obliqua</i> , <i>E. cosmophylla</i> +/- <i>E. fasciculosa</i> / Low woodland
28.01	Woodland	<i>Eucalyptus porosa</i> / Low woodland
31.01	Mallee	<i>Eucalyptus diversifolia</i> +/- <i>E. cosmophylla</i> / Low mallee
32.01	Shrubland	<i>Allocasuarina muelleriana</i> / Tall closed shrubland
33.01	Shrubland	<i>Acacia retinodes</i> var. <i>retinodes</i> (hill form) / Tall shrubland
34.01	Shrubland	<i>Maireana aphylla</i> +/- <i>Xanthorrhoea quadrangulata</i> / Tall shrubland
35.01	Shrubland	<i>Muehlenbeckia florulenta</i> +/- <i>Gahnia filum</i> / Tall shrubland
37.01	Shrubland	<i>Melaleuca uncinata</i> / Tall open shrubland
38.01	Shrubland	<i>Acacia paradoxa</i> +/- <i>A. pycnantha</i> / Closed shrubland
39.01	Shrubland	<i>Leptospermum continentale</i> &/or <i>L. lanigerum</i> / Shrubland
40.01	Shrubland	<i>Halosarcia pergranulata</i> , <i>Sarcocornia</i> sp., <i>Sclerostegia arbuscula</i> / Low shrubland
41.01	Coastal Shrubland	<i>Olearia axillaris</i> , +/- <i>Acacia longifolia</i> var. <i>sophorae</i> , / Shrubland
42.01	Coastal Shrubland	<i>Lycium ferrocissimum</i> , +/- <i>Myoporum insulare</i> / Shrubland
43.01	Coastal Shrubland	<i>Nitraria billadierei</i> / Open shrubland
45.01	Coastal Shrubland	<i>Beyeria lechenaultii</i> , +/- <i>Allocasuarina verticillata</i> / Low shrubland
47.01	Grassland	<i>Spinifex sericeus</i> / Open (tussock) grassland
49.01	Sedgeland	<i>Phragmites australis</i> &/or <i>Typha domingensis</i> / Sedgeland
50.01	Sedgeland	<i>Gahnia</i> sp. &/or <i>Juncus</i> sp. / Open sedgeland
51.01	Fernland	<i>Pteridium esculentum</i> / Fernland
	Freshwater wetland	Open water aquatics (<i>Myriophyllum</i> spp).
	Freshwater wetland	<i>Triglochin procerum</i> herbland
	Sea grasses	<i>Posidonia</i> sp, <i>Zostera</i> sp, <i>Heterozostera</i> sp, <i>Amphibolis</i> sp.
	Grassland	Introduced grasses/pasture species.

29.2.17 Cover/abundance

Cover abundance provides an indication of the amount of vegetative cover within the habitat. The following scale is adapted from Heard & Channon (1997).

- Not many, 1-10 individuals
- Sparsely present, cover very small <5%
- Plentiful, but of small cover <5%
- Any number of individuals covering 5 – 25% of the area
- Any number of individuals covering 25 – 50% of the area
- Any number of individuals covering 50 – 75% of the area
- Covering more than 75% of the area.

29.2.18 Life form

Life form classifications are adapted from Heard & Channon (1997). Twenty-four categories have been used and these are listed below. The categories of aquatic/algae were added by Seaman (2003).

Trees >30m	Trees 15 – 30 m	Trees 5 – 15 m
Trees <5m	Mallee (>3m)	Low mallee (<3m)
Shrubs >2 m	Shrubs 1.5 – 2.0 m	Shrubs 1 – 1.5 m
Shrubs .5 – 1.0 m	Shrubs 0 – 0.5 m	Mat plants (single plant)
Hummock grass	Grass >.5m	Grass <.5m
Herbaceous spp	Sedges >0.5m	Sedges <0.5m
Vines	Mistletoes	Ferns
Mosses, liverwort	Lichens	Aquatic/algae

Trees are defined as woody perennial plants, generally erect with a canopy raised well above the ground.

Shrubs are defined as woody; generally erect but may have a weeping habit. They are commonly broadly conical in form with the foliage occupying all or part of the total height of the plant. Multiple stems and branches arise from a rootstock or a common short trunk. Shrubs are generally less than 5 metres tall.

Mat plants are herbaceous or woody plants of prostrate habit, with major stems growing along the ground. Rarely exceed 10 cm in height.

Hummock grasses are herbaceous perennial grasses of the genera *Triodia* or *Plectrachne*. They have atypical mound like form due to trapping of debris and soil within the stem bases, building up into a hummock.

Grasses are herbaceous plants of the family Poaceae; they are perennial or annual, generally erect or spreading.

Herbs are herbaceous or slightly woody, annual or sometimes perennial plants. Foliage usually covers the majority of the branches in shrubby or creeping forms. Rarely exceed 0.5 metres in height.

Sedges are herbaceous, usually perennial, erect plants. Generally have a tufted habit. Arise from tubers, bulbs, rhizomes, stolons or seeds.

Vines are climbing, twining, winding or scrambling plants usually with a woody stem.

Ferns include fern allies, ie non-vascular cryptogams (plants that do not produce seeds).

Mistletoes are aerial stem parasitic shrubs belonging to the families Loranthaceae or Viscaceae.

Lichens are non-vascular cryptogams that comprise a symbiotic association between a fungus and an alga.

Mosses are small leafy non-vascular cryptogams.

Aquatics include plants completing lifecycles while permanently inundated. Plants can include freely floating vegetation or vegetation rooted to a substrate. Algae are included in this life form.

29.2.19 *Substrate surface fauna*

This category records any surface fauna observed occupying the substrate within the habitat, examples include, but are not limited to:

- Molluscs
- Crabs
- Worms
- Ants
- Other insects.

29.2.20 *Opportunistic records*

Opportunistic records for fauna are recorded within the habitat mapping attribute table. Reliability of observation is also noted, with seven distances to choose from, namely:

0-5m	>250-500m
0-50m	>500-1km
>50-100m	>1km-10km
>100-250m	

29.2.21 *Aquatic vegetative classes*

This parameter provides a 'snap shot' of aquatic vegetation structure. Definitions have been adapted from Blackman, Spain & Whiteley (1992). Vegetation classes recorded are:

Algal: vegetation dominated by macrophytic algae growing in water or on an associated splash zone. Occupy substrates with a wide range of sediments, depths and textures.

Floating vascular: vegetation dominated by vascular species, which float freely either in the water, or on its surface. Predominantly occur in shelter waters. Wind or currents may move beds of floating vascular species.

Aquatic moss: Primarily found in the riverine systems and in permanently flooded and intermittently exposed parts of some lacustrine systems.

Rooted floating leaved: dominated by submergent vascular species rooted to the substrate.

Floating leaved: dominated by submergent vascular species with floating leaves. Predominantly occurs in shallow waters; some species may adopt a floating leaved habit or stand erect above the water surface or substrate.

Moss/Lichen: Vegetation dominated by mosses or lichens.

29.2.22 *Aquatic vegetation score*

This parameter records the abundance and diversity of aquatic vegetation. Three scales have been adapted from Lloyd & Balla (1986). These described below:

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.

29.2.22 *Microhabitats*

Microhabitat classifications were developed during habitat mapping fieldwork during 2002 and 2003. Generally, microhabitats provide niche environments for organisms, for example mud flats and rocky shores. The area of microhabitats are included if habitats do not occupy more than 10% of the habitat mapping unit. The habitat attribute table allows for three microhabitats to be recorded for each habitat mapping unit. Descriptions of microhabitats are listed below.

Algae mat: Mats are formed by sediments trapped by algae and they can form a dense layered capping on the surface of muddy substrates. Algal mats are usually found within intertidal and supratidal zones.

Banks with hollows: Hollows within banks provide habitat for reptiles, insects and some birds. Wombat burrows have also been observed in banks with a sandy substrate.

Burrows: Obvious burrowing activity within the habitat.

Detritus: Accumulated material often trapping nutrients and seeds.

Freshwater soak: Areas of freshwater within the coastal zone with the water supply generally from a freshwater lens. Water regime is seasonal.

Hollows: Found in trees, generally of ages greater than 10 years. Hollows provide habitats for birds and reptiles.

Hummocks: Mounds, tussocks or sedges rising above flat surfaces and trap debris and nutrients.

Lignum: A native shrub (*Muehlenbeckia florulenta*) that provides excellent habitat for small birds and other fauna.

Molluscs: substrate composed of molluscs, found in wetlands and deep-water habitats.

Mounds: Soil raised above a flat surface, occasionally providing habitat for specialised vegetation types.

Mud flat: Unconsolidated substrates covering extensive areas often within landforms such as coves and bays.

Nesting areas: Observed habitats that provide nesting areas for birds, eg dense reed beds, tall shrubs and trees.

Open water: Habitats that contain areas of open water. These areas provide freshwater, food sources and provide connectivity with the surrounding habitat.

Perches: Dead or living wood that is clearly being used by birds for perching. These provide habitats for birds (especially birds of prey) as part of their feeding and hunting regime.

Pooling: Areas of shallow water, usually found along rocky shores. These pools provide habitat for micro-algae, invertebrates and other flora and fauna.

Rocky areas: Areas of rock within the habitat providing shelter or habitat niche for fauna or flora.

Roosting area: Observed areas within the habitat providing resting places for birds.

Sandy areas: Areas within the habitat containing sand.

Sheltered areas: Areas within the habitat that provide shelter. These may be a landform feature, for example, a small cove or structural formation such as a woodland.

Snags: Habitats that have areas of dead or living wood or shrub material located in the water zone.

Structural diversity: Unique areas within a characteristically flat landscape containing defined vegetation structure of several life forms.

Surface aquatics: Comprise floating or rooted floating vegetation.

Undulations: Areas within the habitat that contain topographic variations providing niché habitats for flora and fauna.

29.2.23 *Land Degradation*

Disturbances or threats are defined as any direct or indirect human activities within the habitat or adjacent to the habitat that may have a detrimental effect on the ecological character of the habitat. These activities may be low level disturbance (eg fence lines) or a major threat (eg water diversion schemes). Examples include disturbance caused by livestock, water extraction and invasive plants. The types of land degradation are recorded by using the habitat classification survey: the categories are listed below.

Biological threats

Introduced grasses
Introduced plants
Introduced trees
Mowing of aquatics
Pest plants
Pest vertebrate presence
Salt intrusion
Fire scars
Woody weeds

Recreation threats

Boat launch area
Camping sites
Rubbish
Walking tracks

Land use threats

Access tracks
Altered flows
Clearance
Degraded banks
Degraded buffer
Erosion
Excavated
Fence line,
Grazing
Jetty
Sand extraction
Water extraction
Altered flows
Access road

The following section a brief description of recorded degrading processes.

29.2.24 *Land degradation definitions*

Access road: Sealed or unsealed vehicular roads/tracks within the habitat.

Altered flows/ Water extraction: Water either being diverted or extracted from the habitat.

Boat launch area: Sealed or unsealed boat launch areas dissecting habitats, usually along shorelines.

Camping sites: Camping sites within habitats, some vegetation clearance, roads and foot traffic present.

Clearance: Removal of vegetation within the habitat.

Cleared buffer: Removal of vegetation around the boundaries of the habitat.

Degraded banks: Presence of degrading processes such as introduced/pest plants (ie non-native) and grazing along banks adjacent to a watercourse.

Degraded buffer: Presence of degrading processes such as pest plants and grazing pressure adjacent to the habitat, generally within 100 – 200 metres.

Erosion: Areas of soil degradation caused by wind, water and vegetation removal impacting on the integrity of the habitat.

Excavated: Areas within the habitat that have undergone earth-works resulting in the removal of soil or rock.

Fence lines: Presence of fence lines within the habitat, usually resulting in vegetation clearance, access tracks and possibly limiting fauna movement.

Fire scars: Areas within the habitat that have been burnt.

Grazing: Habitats that have grazing (by livestock) occurring within them, generally resulting in pugging of soil, vegetation removal and the introduction of non-native grasses (and other pasture species, eg clovers and medics).

Introduced grasses: Grasses not native to the region that compete aggressively with native vegetation resulting in habitat degradation.

Introduced plants: Shrubs not native to the region often competing with native vegetation and resulting in habitat degradation.

Introduced trees: Trees not native to the region often competing with native vegetation and resulting in habitat degradation, eg Willows (*Salix* spp.).

Jetty: Built structures impacting on shoreline habitat.

Mowing of aquatics: Mechanical removal of native aquatic vegetation.

Pest plants/woody weeds: Unidentified pest plants not native to the region often competing with native vegetation and resulting in habitat degradation.

Pest vertebrate presence: Observed presence of vertebrate pests such as rabbits and foxes.

Rubbish: Hard rubbish disposed within the habitat, this can include plastics and used chemical containers.

Salt intrusion: Salt expression within the habitat that is clearly affecting vegetation health through dieback.

Sand extraction: See *excavation*; sand is the targeted resource for removal from the habitat. This can affect soil structure leading to vegetation and habitat alteration.

Walking tracks: The formation of walking tracks/trails may result in the clearance of native vegetation or other surface material and may lead to soil compaction and altered water flows.

29.2.25 Comments

These categories allow for additional comments to be noted by the recorder regarding the habitat or surrounding features.

29.2.26 Recreation

Records of recreation facilities present on the site and if there are tourism uses or recreation values associated with the habitat.

29.2.27 Cultural Values

Documents indigenous cultural significance and European historical and social values.

29.2.28 Hyper-link

Records the path for photographic record retrieval.

29.2.29 Description

Allows for a description of the habitat in terms of landscape location, special features or points of interest.

29.2.30 Water phys-chemistry

The habitat classification attribute table provides for the recording of the water chemistry of the habitat. 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 $\mu\text{S}/\text{cm}$ 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 once stable, the reading is given on the display. Calibration and maintenance procedures 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 90° 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 O_2 : is recorded using a Hanna HI 9142 dissolved oxygen meter. Dissolved oxygen is indicated in tenths of parts per million ($\text{ppm}=\text{mg}/\text{l}$). 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.

29.2.31 Habitat condition

Habitat condition is a subjective assessment based on observations; the assessment considers ecological values such as habitat connectivity, pest plants, human impacts, integrity of vegetation associations and condition of core habitat areas.

Habitat condition descriptions were based on previous landscape and ecosystem scale assessments made within South Australia (Adelaide Hills Council 2000; Bechervaise & Seaman 2002; Caves, Seaman & Taylor 1999; Lloyd & Balla 1986; Seaman 2002).

Condition scale	Description
Pristine	Pristine, or nearly so; no obvious signs of disturbance. Indigenous flora dominant and abundant, 100 % ground cover. Structural diversity present if applicable and microhabitats present. Surrounding ecosystems intact with high connectivity. Habitat integrity is high. Reflects pre-European vegetation or natural landscape feature.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species limited to 5 - 20% coverage. Diverse species, stable fauna habitat, structural diversity present, if applicable. Habitat buffered by and linked to remnant vegetation with ecosystem stability. Microhabitats present.
Very Good	Vegetation structure altered, Indigenous and exotics together, 20-50% weed invasion, obvious signs of disturbance (eg disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback and grazing). Core habitat areas exist buffered by remnant vegetation. Obvious signs of use by fauna, areas of structural diversity might exist with some microhabitats.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it (eg disturbance to vegetation structure caused by very frequent grazing). Presence of aggressive weeds at high density (50 - 70%). Core habitat areas exist that are buffered by scattered remnants. Species use of habitats is likely to be opportunistic. Structural diversity limited to isolated patches if at all, micro-habitats presence low.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management (eg disturbance to vegetation structure caused by cropping, grazing or clearance; the presence of very aggressive weeds, partial clearing, dieback and livestock grazing). Weed presence greater than 70%. Habitats are impacted by disturbances and are not connected with remnant buffers.
Completely degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. Habitats do not exist, although areas might be used as opportunistic habitats or 'stepping stones' to desirable habitat areas. Weed presence aggressive and greater than 80%, monoculture can exist such as pasture.

29.2.32 Wetland type

The definition of a wetland used in this survey is that adopted by the Ramsar convention under Article 1.1:

Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or 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 (2001) identifies 40 different wetland types in three categories: A-Marine and Coastal Zone wetlands, B-Inland wetlands, and C-Human-made wetlands. This classification system is based on that used by the Ramsar Convention in describing Wetlands of International Importance. Several of the wetland descriptions have been expanded to suit the habitats contained within the Lower Lakes. Additions include descriptions for reedbeds (vegetated bed sediments) and freshwater/brackish mud or sand flats. Three new classifications for the marine and coastal zones were developed and include coastal dune shrublands (A13), freshwater soaks (A14), and estuarine stream channels (A15). Although coastal dune shrublands are not technically a wetland by definition, this new category was added for ease of habitat classification within the marine and coastal zone and reflects the interdependence of wetland systems and dune systems.

Inland	Human Made
B1 permanent rivers and streams + waterfalls	C1 Water storage areas, reservoirs, barrages, impoundment (>8ha)
B2 Seasonal irregular river and streams	C2 Ponds , farm, stock, tanks (<8ha)
B3 Inland deltas (permanent)	C3 Aquaculture
B4 Riverine floodplains	C4 Salt pans
B5 Permanent freshwater lakes (8ha) includes oxbow lakes)	C5 Excavations, gravel pits, borrow pits, mining
B6 Seasonal/intermittent freshwater lakes (>8ha), floodplain lakes	C6 Waste water treatment, settling ponds (Constructed/Artificial Wetlands?)
B7 Permanent saline/brackish lakes	C7 Irrigated land, canals, ditches
B8 seasonal/intermittent saline lakes	C8 Seasonally flooded arable land, farm land
B9 Permanent freshwater ponds (<8 ha), marshes and swamps on inorganic soils, with emergent veg. Waterlogged for at least most of the growing season. Includes coves and open water enclosed with reeds	C9 Canals
B10 Seasonal/ intermittent freshwater ponds and marshes on inorganic soils includes potholes, seasonally flooded meadows, sedge marshes. Includes reed shorelines.	Marine and Coastal Zone Wetlands
B11 Permanent saline/brackish marshes	A1 Marine waters-permanent shallow waters less than six metres deep at low tide, includes sea bays and straits
B12 seasonal saline marshes	A2 Sub tidal aquatic beds, includes kelp beds, seagrasses, tropical marine meadows
B13 Shrub swamps, shrub dominated freshwater marsh, sedges and Gahnia sedgeland	A3 Coral reefs
B14 Freshwater swamp forest, seasonally flooded forest, wooded swamps	A4 Rocky marine shores, includes rocky offshore islands, sea cliffs. Rocky estuarine shores.
B15 Peatlands, forest, shrub or open bogs	A5 Sand, shingle or pebble beaches, includes sand bars, spits, sandy islets
B16 Alpine	A6 Estuarine waters, permanent waters of estuaries and estuarine systems of deltas
B17 Freshwater springs, rock pools	A7 Intertidal mud, sand or salt flats and algae.
B18 Geothermal wetlands	A8 Intertidal marches, including saltmarshes, salt meadows, saltings, raised salt marshes, tidal brackish and freshwater marshes and vegetated shorelines.
B19 Inland Karst.	A9 Intertidal forested wetlands, includes mangrove swamps, nipa swamps, tidal freshwater swamp forest
B20 freshwater/brackish mud or sand flats.	A10 Brackish to saline lagoons and marshes with one or more relatively narrow connections to the sea
	A11 Freshwater lagoons and marshes in the coastal zone. Reedbeds and vegetated bed sediments.
	A12 Non tidal freshwater forested wetlands
	A13 Coastal dune shrubland
	A14 Freshwater soaks <.8ha within the coastal zone
	A15 Estuarine stream channel

Appendix 1 Habitat Classification Survey Template

Wetland system

Marine	Estuarine	Riverine	Lacustrine	Palustrine
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Landform element

Beach	Channel	Cliff
Closed depression	Consolidated dune	Cove
Drainage depression	Dune	Flat
Floodplain	Hill footslope	Interdune corridor
Island	Lagoon	Lake
Mud flat	Open depression	Reef
Ridge	Rocky cliff	Rocky outcrop
Rocky reef	Rocky ridge	Rocky shore
Salt lake	Sand bar	Sandy beach
Shoreline	Stream bank	Stream channel
Undulating plain	Un-vegetated bed sediments	Vegetated bed sediments
Vegetated island	Other	

Micro relief

Structural relief	Crabhole	Undulating surface
Hummock	Mounds	Depressions
Terrace	Slopes	Banks

Substrate surface type

Moud (silt and clay)	Sandy mud	Shelly mud
Shelly sand	Shells	Muddy sand
Sand	Loams	Gravel
Cobbles	Stones	Boulders
Bedrock	Reef	Sand
Sandy loam	Light clay	Heavy clay

Surface strew cover

2%	10%	20%	50%	90%
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Sediment size

Coarse sediment (high sand content 0.02 – 2.00mm)
Fine sediment (low sand content, <0.02mm)

Substrate form

Substrate form is described where its aerial coverage comprises at least 25% or greater of the wetland surface, and where the aerial extent of vegetation is less than 30%.

Calcrete	Clay loam
Consolidated bottom	Mud
Muddy clays	Muddy sand
Muddy shoreline	Open water
Rock bottom	Rocky reef
Rocky shore	Sand
Sandy beach	Sandy shore
Stream bed	Unconsolidated bottom

Water regime

Permanent	Intermittent	Temporarily	Seasonal	Artificially flooded
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Tidal class

Intertidal	Supratidal	Non tidal
Stranded tidal	Intermittent tidal	

Water depth

Damp	Film	Not present
3 -10 cm	10cm - .5 m	Open water

Dominant vegetation association

*MU_50	GENFORMDES	LEGEND DESCRIPTIONS
1.05	Forest	<i>Eucalyptus obliqua</i> / Open forest
2.03	Forest	<i>Eucalyptus baxteri</i> , <i>E. obliqua</i> , +/- <i>E. cosmophylla</i> / Open forest
3.03	Forest	<i>Eucalyptus ovata</i> , +/- <i>E. leucoxylon</i> ssp. <i>leucoxylon</i> / Open forest
4.05	Forest	<i>Eucalyptus baxteri</i> , +/- <i>E. cosmophylla</i> / Low open forest
5.01	Forest	<i>Avicennia marina</i> var. <i>resinifera</i> / Low open forest
6.01	Forest	<i>Melaleuca halmaturorum</i> ssp. <i>halmaturorum</i> / Low open forest
7.01	Forest	<i>Callitris gracilis</i> / Low open forest
9.01	Woodland	<i>Eucalyptus obliqua</i> , <i>E. goniocalyx</i> +/- <i>E. fasciculosa</i> / Woodland
10.01	Woodland	<i>Eucalyptus leucoxylon</i> ssp. <i>leucoxylon</i> / Woodland
11.01	Woodland	<i>Eucalyptus camaldulensis</i> var. <i>camaldulensis</i> / Woodland
13.01	Woodland	<i>Eucalyptus leucoxylon</i> ssp. <i>leucoxylon</i> / Woodland
15.01	Woodland	<i>Eucalyptus fasciculosa</i> , <i>E. viminalis</i> ssp. <i>cygnetensis</i> / Woodland
16.01	Woodland	<i>Eucalyptus viminalis</i> ssp. <i>cygnetensis</i> / Woodland
20.01	Woodland	<i>Eucalyptus fasciculosa</i> , <i>E. leucoxylon</i> ssp. <i>leucoxylon</i> / Open woodland
21.01	Woodland	<i>Eucalyptus goniocalyx</i> , +/- <i>E. fasciculosa</i> / Low woodland
22.01	Woodland	<i>Allocasuarina verticillata</i> / Low woodland
23.01	Woodland	<i>Eucalyptus fasciculosa</i> , <i>Allocasuarina verticillata</i> / Low woodland
24.01	Woodland	<i>Eucalyptus fasciculosa</i> / Low woodland
25.01	Woodland	<i>Eucalyptus fasciculosa</i> , <i>Callitris gracilis</i> / Low woodland
26.01	Woodland	<i>Eucalyptus cosmophylla</i> +/- <i>E. fasciculosa</i> / Low woodland
27.01	Woodland	<i>Eucalyptus obliqua</i> , <i>E. cosmophylla</i> , +/- <i>E. fasciculosa</i> / Low woodland
28.01	Woodland	<i>Eucalyptus porosa</i> / Low woodland
31.01	Mallee	<i>Eucalyptus diversifolia</i> , +/- <i>E. cosmophylla</i> / Low mallee
32.01	Shrubland	<i>Allocasuarina muelleriana</i> / Tall closed shrubland
33.01	Shrubland	<i>Acacia retinodes</i> var. <i>retinodes</i> (hill form) / Tall shrubland
34.01	Shrubland	<i>Maireana aphylla</i> +/- <i>Xanthorrhoea quadrangulata</i> / Tall shrubland
35.01	Shrubland	<i>Muehlenbeckia florulenta</i> +/- <i>Gahnia filum</i> / Tall shrubland
37.01	Shrubland	<i>Melaleuca uncinata</i> / Tall open shrubland
38.01	Shrubland	<i>Acacia paradoxa</i> +/- <i>A. pycnantha</i> / Closed shrubland
39.01	Shrubland	<i>Leptospermum continentale</i> &/or <i>L. lanigerum</i> / Shrubland
40.01	Shrubland	<i>Halosarcia pergranulata</i> , <i>Sarcocornia</i> sp., <i>Sclerostegia arbuscula</i> / Low shrubland
41.01	Coastal Shrubland	<i>Olearia axillaris</i> +/- <i>Acacia longifolia</i> var. <i>sophorae</i> / Shrubland
42.01	Coastal Shrubland	<i>Lycium ferrocissimum</i> +/- <i>Myoporum insulare</i> / Shrubland
43.01	Coastal Shrubland	<i>Nitraria billadierei</i> / Open shrubland
45.01	Coastal Shrubland	<i>Beyeria lechenaultii</i> +/- <i>Allocasuarina verticillata</i> / Low shrubland
47.01	Grassland	<i>Spinifex sericeus</i> / Open (tussock) grassland
49.01	Sedgeland	<i>Phragmites australis</i> &/or <i>Typha domingensis</i> / Sedgeland
50.01	Sedgeland	<i>Gahnia</i> sp. &/or <i>Juncus</i> sp. / Open sedgeland
51.01	Fernland	<i>Pteridium esculentum</i> / Fernland
	Freshwater wetland	Open water aquatics (<i>Myriophyllum</i> spp).
	Freshwater wetland	<i>Triglochin procerum</i> herbland
	Sea grasses	<i>Posidonia</i> sp, <i>Zostera</i> sp, <i>Heterozostera</i> sp, <i>Amphibolis</i> sp.
	Grassland	Introduced grasses/pasture species.

*MU 50 codes taken from Southern Mount Lofty Vegetation Mapping

Cover/abundance

- Not many, 1-10 individuals
- Sparsely present, cover very small <5%
- Plentiful, but of small cover <5%
- Any number of individuals covering 5 – 25% of the area
- Any number of individuals covering 25 – 50% of the area
- Any number of individuals covering 50 – 75% of the area
- Covering more than 75% of the area

Life form

Trees >30m	Trees 15 – 30 m	Trees 5 – 15 m
Trees <5m	Mallee (>3m)	Low mallee (<3m)
Shrubs >2 m	Shrubs 1.5 – 2.0 m	Shrubs 1 – 1.5 m
Shrubs 0.5 – 1.0 m	Shrubs 0 – 0.5 m	Mat plants (single plant)
Hummock grass	Grass >0.5m	Grass <0.5m
Herbaceous spp.	Sedges >0.5m	Sedges <0.5m
Vines	Mistletoes	Ferns
Mosses, liverworts	Lichens	Aquatic/algae

Substrate surface fauna

Molluscs	Crabs
Worms	Ants
Other insects	Other crustaceans

Reliability for opportunistic sightings

0-5m	>250-500m
0-50m	>500-1km
>50-100m	>1km-10km
>100-250m	

Land degradation

Access tracks	Altered flows	Clearance
Degraded banks	Degraded buffer	Erosion
Excavated	Fence line	Grazing
Introduced grasses	Introduced plants	Introduced trees
Jetty	Mowing of aquatics	Pest plants
Pest vertebrate presence	Rubbish	Salt intrusion
Sand extraction	Walking tracks	Water extraction
Fire scars	Altered flows	Access road
Boat launch area	Camping sites	Clearance
Cleared buffer	Degraded buffer	Fence lines
Grazing	Introduced grasses	Rubbish
Vertebrate pests	Walking trail	Woody weeds

Aquatic vegetative classes

Algal	Aquatic Moss	Unknown submergent
Floating leaved	Rooted floating leaved	Other
Unknown surface	Moss/Lichen	

Aquatic vegetation

Low – None (1)	Moderate (3)	High (5)
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Water phys-chemistry

pH	-
Conductivity	us
Turbidity (Tn)	ntu
Dissolved O2	ppm
Water Temperature	Oc

Habitat condition

Condition scale	Description
Pristine	Pristine, or nearly so, no obvious signs of disturbance. Indigenous flora dominant and abundant, 100 % ground cover. Structural diversity present, if applicable, and microhabitats present. Surrounding ecosystems intact with high connectivity. Habitat integrity is high. Reflects pre-European vegetation.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non- aggressive species limited to 5 - 20% coverage. Diverse species, stable fauna habitat. Structural diversity present, if applicable. Habitat buffered by and linked to remnant vegetation with ecosystem stability.
Very Good	Vegetation structure altered, Indigenous and exotics together, 20-50% weed invasion, obvious signs of disturbance (eg disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback and grazing). Core habitat areas exist buffered by remnant vegetation. Obvious signs of use by fauna, areas of structural diversity might exist with some microhabitats.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances (as above). Retains basic vegetation structure or ability to regenerate it (eg disturbance to vegetation structure caused by very frequent grazing). Presence of aggressive weeds at high density (50 - 70%). Core habitat areas exist that are buffered by scattered remnants. Species use of habitats is likely to be opportunistic. Structural diversity limited to isolated patches if at all, micro-habitats presence low.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. Disturbance to vegetation structure caused by cropping, grazing or clearance, presence of very aggressive weeds, partial clearing, dieback and grazing damage. Weed presence greater than 70%. Habitats are impacted by disturbances and are not connected with remnant buffers.
Completely degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. Habitats do not exist, although areas might be used as opportunistic habitats or 'stepping stones' to desirable habitat areas. Weed presence aggressive and greater than 80%; monoculture may exist, eg pasture.

Micro habitats

Algae mat	Banks with hollows	Burrows
Detritus	Freshwater soak	Hollows (trees)
Hummocks	Lignum	Molluscs
Mounds	Mud flat	Nesting areas
Open water	Perches	Pooling
Rocky areas	Roosting area	Sandy areas
Sheltered areas	Snags	Structural diversity
Surface aquatics	Undulations	Worm reefs

Wetland type

Inland	Human Made
B	C1 Water storage areas, reservoirs, barrages, impoundment (>8ha)
B1 permanent rivers and streams + waterfalls. <i>Includes natural channels</i>	C2 Ponds , farm, stock, tanks (<8ha)
B2 Seasonal irregular river and streams	C3 Aquaculture
B3 Inland deltas (permanent)	C4 Salt pans
B4 Riverine floodplains	C5 Excavations, gravel pits, borrow pits, mining
B5 Permanent freshwater lakes (8ha) includes oxbow lakes)	C6 Waste water treatment, settling ponds <i>Constructed/Artificial Wetlands</i>
B6 Seasonal/intermittent freshwater lakes (>8ha), floodplain lakes	C7 Irrigated land, canals, ditches
B7 Permanent saline/brackish lakes	C8 Seasonally flooded arable land, farm land
B8 seasonal/intermittent saline lakes	C9 Canals
B9 Permanent freshwater ponds (<8 ha), marshes and swamps on inorganic soils, with emergent vegetation. Waterlogged for at least most of the growing season. <i>Includes coves and open water enclosed with reeds.</i>	Marine and Coastal Zone Wetlands
B10 Seasonal/ intermittent freshwater ponds and marshes on inorganic soils includes potholes, seasonally flooded meadows, sedge marshes. <i>Includes reed shorelines.</i>	A1 Marine waters-permanent shallow waters less than six metres deep at low tide, includes sea bays and straits
B11 Permanent saline/brackish marshes	A2 Sub tidal aquatic beds, includes kelp beds, seagrasses, tropical marine meadows
B12 seasonal saline marshes	A3 Coral reefs
B13 Shrub swamps, shrub dominated freshwater marsh, <i>sedges and Gahnia grassland</i>	A4 Rocky marine shores, includes rocky offshore islands, sea cliffs. <i>Rocky estuarine shores</i>
B14 Freshwater swamp forest, seasonally flooded forest, wooded swamps	A5 Sand, shingle or pebble beaches, includes sand bars, spits, sandy islets
B15 Peatlands, forest, shrub or open bogs	A6 Estuarine waters, permanent waters of estuaries and estuarine systems of deltas
B16 Alpine	A7 Intertidal mud, sand or salt flats <i>and algae</i>
B17 Freshwater springs, rock pools	A8 Intertidal marches, including saltmarshes, salt meadows, saltings, raised salt marshes, tidal brackish and freshwater marshes <i>and vegetated shorelines.</i>
B18 Geothermal wetlands	A9 Intertidal forested wetlands, includes mangrove swamps, nipa swamps, tidal freshwater swamp forest
B19 Inland Karst.	A10 Brackish to saline lagoons and marshes with one or more relatively narrow connections to the sea
B20 freshwater/brackish mud or sand flats	A11 Freshwater lagoons and marshes in the coastal zone. <i>Reedbeds and vegetated bed sediments</i>
	A12 Non tidal freshwater forested wetlands
	A13 Coastal dune shrubland
	A14 Freshwater soaks <8ha within the coastal zone
	A15 Estuarine stream channel

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