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Corangamite Wetland Inventory

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CORANGAMITE WETLAND INVENTORY

Prepared for:

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EXECUTIVE SUMMARY

Background

Wetlands within the Corangamite region have been identified as highly valuable elements of the region's natural ecosystems. Significant loss of wetlands within this region has occurred since European settlement, and threatening processes resulting in further loss of wetlands currently remain.

The Corangamite Catchment Management Authority (CCMA) covers an area totalling 1, 334, 000 ha. It comprises the Barwon River, Moorabool River, Lake Corangamite and Otway Coast basins. A total of 56 sub-catchments have been identified within these basins. The greater part of the study area is freehold land (70%) used almost entirely for agriculture.

The majority of wetlands occur on the volcanic plain, which covers 46% of the study area. Lakes and wetlands have formed in volcanic craters, depressions due to lava collapse and where drainage patterns have been interrupted, usually by lava flows. Seasonal variation in hydrology, the type of basalt substrate, and the great variety of catchment-to-surface area ratios and throughflows, combine to produce lakes and wetlands with an unusually wide range of salinities.

The region contains wetlands of national and international significance. A total of 1, 457 wetlands greater than 1 ha in size, covering approximately 65, 000 ha have been identified. Of these, 24 wetland complexes have been listed as nationally important in the Directory of Important Wetlands (Environment Australia 2001). Two sites of international significance also exist within the Corangamite region: Western District Lakes Ramsar site and a large proportion of Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site.

Knowing the location, distribution and character of wetlands, their values, uses and threats, is essential for developing and implementing management strategies for their wise use. This is required at geographical scales ranging from local site management, to development of national policies and global priority setting.

Wetland conservation needs and priorities in the Corangamite region are currently determined primarily through reference to anecdotal knowledge of condition, values and threatening processes. Consequently it is not possible to adequately or objectively determine management and rehabilitation needs or to quantify resource requirements in meeting these needs.

The Wetland Inventory for the Corangamite region was a CCMA initiative. The Centre for Environmental Management (CEM), University of Ballarat was contracted to design and complete the wetland inventory for the region.

Review of wetland inventory and research

A review was undertaken of the extent and adequacy of wetland inventory information and associated past research on the character, condition, known threats, trends and management issues relevant to wetlands within the Corangamite region.

Wetland inventories on regional, national and international scales were reviewed including classification systems used and the ability of the data to provide information on wetland condition. A total of nine inventories and databases with relevance to wetlands of the Corangamite region were analysed. A large proportion of research papers focused on saline lakes, biological values, and management of wetlands within the Corangamite region. A total of 40 research papers of various formats containing information directly relating to wetlands and lakes of the Corangamite region were reviewed.

The most complete wetland inventory data existing for the Corangamite region is the Wetlands Database (DCNR 1995), originating from mapping work undertaken in the 1970's

by Corrick (1982). The Directory of Important Wetlands in Victoria and wetlands listed under the Ramsar Convention provided detailed information on a total of 93 significant wetland areas throughout the Corangamite region. Most wetlands identified as nationally or internationally significant are large, permanent and publicly owned.

Present wetland inventory data within the Corangamite region was found to be limited in scope and classification accuracy. It also lacked information on values and threats for the majority of wetlands. This lack of detailed biological data for 98% of the wetlands reflects a number of factors. Firstly, many of the wetlands are small and non-permanent or drained, and have often been extensively modified so that they are now little more than flooded pasture. Many others are artificial (farm dams) and both professional biologists and amateur naturalists tend not to study such areas. This is compounded by the lack of public access to many of these wetlands, especially those on private land.

Wetland Inventory – wetland mapping

Wetland inventory is the process for determining and recording the location, number and specific characteristics of wetlands within a given area. Existing wetland geographic data for the Corangamite region was found to be lacking for wetland areas under 1 ha in size. The use of remote sensing data on a regional scale was considered the most cost-effective and efficient method for mapping the extent of inundated areas.

Wetland mapping for the Corangamite region consisted of identifying, delineating and broadly classifying wetlands from remotely sensed images. A combination of supervised and unsupervised classification techniques were used. Aerial photographs, ancillary data, the Wetlands Database (DCNR 1995), and field data were used to identify training sites and label spectral clusters. Post-classification modelling was performed using ancillary data (Wetland_1994, Wetland_1788 and hydrology data) to further refine the classification of wetlands.

Fine scale wetland mapping was completed for sample sub-catchments and comparisons with previous wetland mapping enabled changes in wetland areas to be assessed and wetland boundaries updated to reflect the current situation. Wetland areas were found to have significantly decreased across all sub-catchments, when compared with pre-settlement wetland mapping (Wetland_1788 layer). An increase in the total number of wetlands identified was achieved, largely through the identification of smaller wetlands (<1 ha).

Wetland Inventory – field survey

A total of 96 wetland field surveys were completed within the five sub-catchments sampled. The number and types of wetlands surveyed within each sub-catchment was distributed with respect to both the number and the area of wetlands within each sub-catchment.

The Corangamite Wetland Inventory documents a representative portion of wetland habitats within selected sub-catchments and records their spatial, physical, chemical and biological attributes. Human activities and impacts, and wetland function and values for the Corangamite region were also recorded. From this information, wetlands containing high biodiversity and ecosystem values were highlighted, and threats documented.

Data from the Wetland Inventory were entered into a Microsoft Access 2000® format database. This allows the Wetland Inventory data to be easily accessible and updated as further wetland inventories are undertaken.

The mechanism for the wetland inventory outlined in this report provides an effective tool for collecting and storing information on wetlands within the CCMA. The mechanism uses a strategic approach to collect information and utilises technological advances in mapping, data storage and dissemination. The Corangamite Wetland Inventory provides

an improvement on past inventory effort within the sample areas, notably that undertaken in the 1980's, and later developed into the Wetland Database (DCNR 1995).

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1. INTRODUCTION

Wetlands within the Corangamite region have been identified as highly valuable elements of the region's natural ecosystems. Significant losses of wetlands within this region have occurred since European settlement (Corrick 1982), and threatening processes resulting in the loss of further wetlands currently remain. The majority of the regions most threatened wetland types (including shallow freshwater meadows and marshes) occur within, or bounded by privately owned land.

In recognition of the value of wetland ecosystems and current threatening processes, Parks Victoria and the Corangamite Catchment Management Authority (CCMA) in partnership with Greening Australia, landholders, Landcare coordinators and Department of Sustainability and Environment (DSE) staff have implemented a protection and rehabilitation project in the Western Districts Lakes (Ramsar site) region. A similar project including Department of Primary Industry (DPI), City of Greater Geelong, Landcare and local community groups has been implemented in the Coonewarre and Bellarine areas of the Port Philip Bay and Bellarine Peninsula Ramsar sites. Individuals and community groups also actively pursue numerous smaller projects with assistance from government and agency programs. Conservation needs and priorities for wetlands within the Corangamite region have been previously determined through reference to anecdotal knowledge of condition, values and threatening processes (C. Allen pers. comm.).

Knowing the location, distribution and character of wetlands, their values, uses, and the threats to them is essential for developing and implementing management strategies for their wise use (Dugan 1990; Finlayson & van der Valk 1995). This is required at geographical scales ranging from local site management to development of national policies and global priority setting (Finlayson & Spiers 1999).

Identification of the distribution and extent of wetland area and types can be used to develop strategic priority areas for management of wetlands in the Corangamite region, including the identification of potential reserve areas. A process for identifying, mapping, data collection and data storage for wetlands within the Corangamite region was therefore designed to aid in the allocation of resources to improve wetland conservation throughout the region. Within this context, it is considered that the wetland inventory will provide a basis for collecting reliable knowledge and providing information for making decisions concerning the conservation and wise use of wetland resources (Finlayson et al. 2002). Wetland inventory will also assist government agencies to identify wetlands of national and international importance and prioritise actions.

The mechanism for the wetland inventory outlined in this report provides an effective tool for collecting and storing information on wetlands within the CCMA region. The mechanism uses a strategic approach to collect information and utilises technological advances in mapping, data storage and dissemination. The Corangamite Wetland Inventory provides an improvement on past inventory effort within the sample areas, notably that undertaken in the 1980's (Corrick 1982), and later developed into the Wetland Database (DCNR 1995).

The Corangamite Wetland Inventory documents a representative portion of wetland habitats within selected sub-catchments and records their spatial, physical, chemical and biological attributes. From this information wetlands containing high biodiversity and ecosystem values were highlighted, and threats documented. Fine scale wetland mapping was completed for sample sub-catchments and comparisons with previous wetland mapping (DCNR 1995) enabled changes in wetland areas to be assessed and wetland boundaries updated to reflect the current situation.

The Wetland Inventory for the Corangamite region was an initiative of the CCMA. The Centre for Environmental Management (CEM) was contracted to design and complete the wetland inventory for the region.

1.1 Project scope

Wetlands were defined as areas where water is the primary factor controlling the environment and the associated plant and animal life. They occur where the water table is at or near the surface of the land, or where the land is covered by shallow water (Ramsar Convention Bureau 2001).

Wetlands, as defined by The Ramsar Convention Bureau (2001) include:

> "*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*".

The very broad definition of wetlands adopted by The Ramsar Convention Bureau has been used within this wetlands inventory. As a result, the coverage of the inventory extends to a wide variety of habitat types, including freshwater marshes and meadows, lakes (both fresh and saline), estuaries, floodplains, and artificial impoundments. Rivers and streams and marine waters are not included within the inventory except to the extent that they directly impact on wetlands.

In the context of this wetland inventory, condition refers to ecosystem health. Spencer *et al.* (1998) define wetland condition as the capacity of the ecosystem to support a diverse community of organisms and perform functions comparable to undisturbed wetland ecosystems. This includes the ability of the system to withstand environmental stress (Spencer *et al.* 1998).

Wetland character refers to the ecological classification of wetlands resulting in classes that were ecologically homogeneous and ecologically distinct from other classes (Beilharz 1996).

Wetlands within the Corangamite region have a highly dynamic character and support a regionally important biodiversity. Variability in flooding regimes result in seasonal differences in water salinity and can lead to different characteristics and life forms in the same wetland throughout the year (Costa *et al.* 1996). This inventory therefore provides a "snap shot" of the current situation and has limited ability to account for past characteristics.

The scope of the inventory was limited to selected sub-catchment boundaries due to the large size of the study area. A minimum of 100 physical wetland surveys were allowed for within the project budget (refer to Section 3.1.2). Mapping encompassed all identifiable wetlands within selected sub-catchment boundaries.

Existing data and literature relevant to the wetlands and lakes of the Corangamite region was reviewed. Literature reviewed within this report has focused on research and data with specific reference to the study area (Corangamite region). However, additional documents with relevance to issues concerning wetlands within the Corangamite region have also been reviewed. It is acknowledged that this review was not exhaustive and was limited by the allocated time and funding.

This report analysed the extent and adequacy of wetland inventory information and associated past research on the character, condition, known threats, trends and management issues relevant to wetlands within the Corangamite region.

1.2 Aims and Objectives

The aims of the literature review (Section 2) were to:

- Provide a summary of the scope and findings of past reports and inventories that have focused on or otherwise addressed the character and condition of wetlands in the Corangamite region;

- Analyse known values, threats, and trends relevant to wetlands and lakes of the Corangamite region;
- Identify potential implications of known values, threats, and trends related to wetlands for the management and conservation of the region's wetlands;
- Provide an evaluation of the implications of known trends in changes to wetland condition within the Corangamite region; and
- Analyse the nature and extent of gaps in current knowledge and how these gaps compromise the capacity of land managers and funding bodies to make decisions about priorities for the allocation of resources to wetland management and conservation.

The aims and objectives for the Corangamite Wetland Inventory (Section 3) included:

- Design a rapid assessment protocol for wetland survey within the Corangamite region;
- Develop a sampling procedure for determining the character and condition of wetlands within the Corangamite region;
- Provide digital coverage of spatial boundaries of all wetlands and lakes within sampling areas;
- Provide a database of all wetland survey results;
- Provide a summary of the character, condition and threats of wetlands surveyed;
- Identify significant wetlands within the sampling areas; and
- Identify gaps in the current wetland information and provide recommendations for further research.

1.3 Report structure

Due to the very large area covered by the Corangamite CMA boundary, survey and assessment of wetlands was carried out in selected sub-catchments. Results for each sub-catchment included in the inventory are presented separately within this report. This allows for easy inclusion of additional sub-catchment analyses in the future.

This report includes:

Section 1 – General introduction.

Section 2 – Literature review: examines past reports within the Corangamite region, and existing wetland inventory data. Wetland character and condition is reviewed with regard to known values of, and threats to Corangamite wetlands. Trends and management implications are discussed.

Section 3 – Corangamite Wetland Inventory:

a. Development of inventory protocol, mapping and database: this section provides a detailed outline of the methods involved in the development of this inventory.

b. Analysis of results and assessment of wetlands: the analysis is divided into separate sub-sections for each sub-catchment included within the inventory. A summary section of all results for the Corangamite CMA region has also been included. The sections are designed to be a stand-alone analysis for each sub-catchment.

Section 4 – Discussion of results and conclusions: inventory data is summarised, and discussed with relation to previous findings and reports within the Corangamite region.

1.4 Study area

The study area is the region bounded by the Corangamite Catchment Management Authority, an area totalling 1, 334, 000 ha (Map1, Figure 1.1). It comprises the Barwon River,

Moorabool River, Lake Corangamite and Otway Coast basins. A total of 56 sub-catchments have been identified within these basins.

The majority of wetlands occur on the volcanic plain, which covers 46% of the study area (Figure 1.1). Lakes and wetlands have formed in volcanic craters, depressions due to lava collapse and where drainage patterns have been interrupted, usually by lava flows (LCC 1976; Australian Biological Research Group 1989). As a result of these geologically recent lava flows, the volcanic plain bioregion generally has low relief and poorly developed drainage systems. Many shallow permanent and ephemeral waterbodies of varying salinity levels occur at the lowest level of the plain (Coram 1996), where drainage is mostly internal to lakes, wetlands or to ground water (Corrick 1982). Many wetlands have been modified or lost to drainage works for agricultural purposes (Corrick 1982; Australian Biological Research Group 1988; Corrick 1995).

Seasonal variation in hydrology, the type of basalt substrate and the great variety of catchment-to-surface area ratios and through flows combine to produce lakes and wetlands with an unusually wide range of salinities (Australian Biological Research Group 1989).

The majority of the study area is freehold land (70%) used almost entirely for agriculture (Corangamite CALP Board 1997). The region contains wetlands of national and international significance. A total of 1, 681 wetlands covering approximately 65, 000 ha have been identified (DCNR 1995). Of these, 340 have been listed as significant in an inventory undertaken by the Australian Biological Research Group (1988), 24 have been listed as nationally important (Environment Australia 2001) and 11 have been classified as internationally important under the Ramsar Convention (Ramsar Convention Bureau 2001). Ramsar wetlands within the study area include:

- Western District Lakes (comprising eight lakes: Lakes Beeac, Colongulac, Corangamite, Cundare, Gnarpurt, Milangil, Murdeduke and Terangpom);
- Port Phillip Bay (Western Shoreline) and Bellarine Peninsula (Figure 1.1).

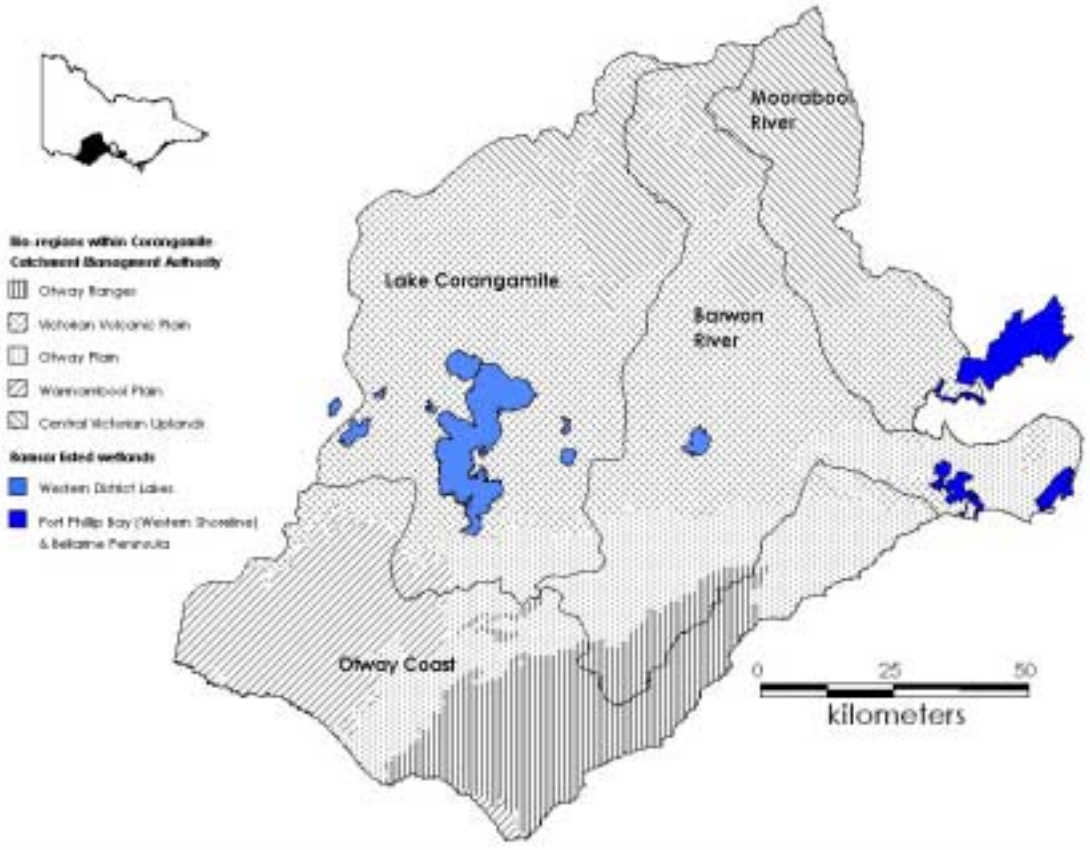


Figure 1.1 Study area – Corangamite Catchment Management Authority.

2. REVIEW OF INVENTORY DATA AND RESEARCH ON WETLANDS IN THE CORANGAMITE REGION

The review of literature examines the scope of past reports within the Corangamite region, and the extent of existing wetland inventory data. Wetland character and condition is reviewed with regard to known values of, and threats to Corangamite wetlands. Trends and management implications are discussed for each wetland value and threats identified. The overall adequacy of the information base on wetlands was analysed and gaps and flaws in data identified. Figure 2.1 illustrates the structure of topics to be addressed within this review.

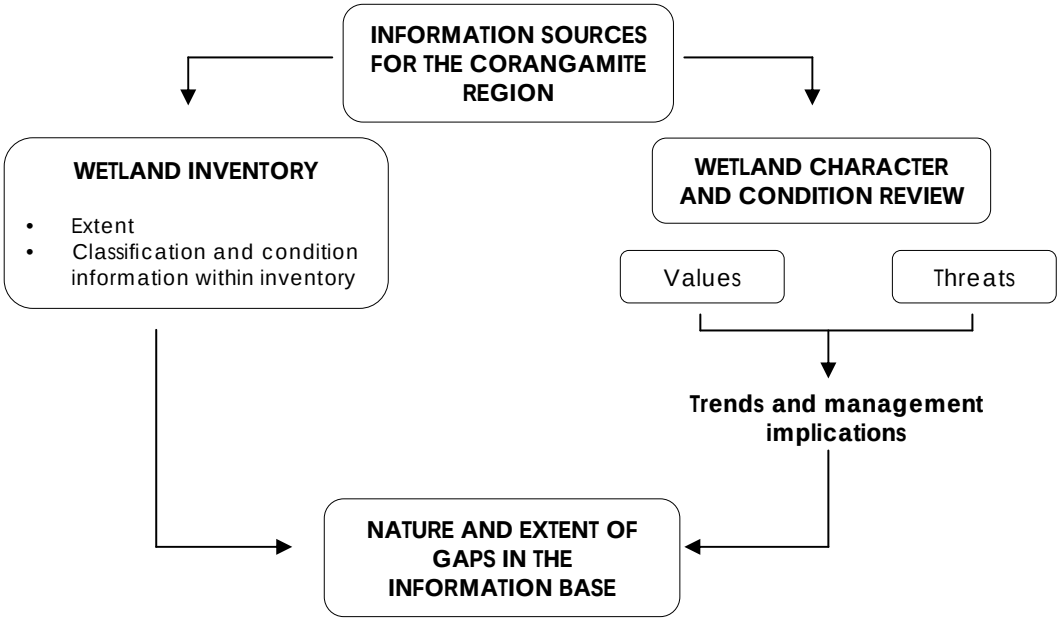


Figure 2.1 Review process and structure.

2.1 Information sources

2.1.1 Methods used to obtain wetland information

Existing wetland inventory data and reference material was examined.

Approaches used to identify wetland inventories and other materials included:

- Review of materials held by regional Department of Sustainability and Environment – Colac and Ballarat offices;
- Review of materials held by Corangamite Catchment Management Authority, Colac;
- Computerised library search;
- Internet search;
- Consultation with wetland experts in the region; and
- Review of digital data in Geographic Information System (GIS) format.

The analysis of existing data and literature was based on readily available, published inventories and the additional information obtained through searches during the short period of the review. The review focused on material relating directly to wetlands and

lakes of the Corangamite region. Studies and reports that were conducted elsewhere but contained information relevant to Corangamite wetlands were also included.

Analysis of available spatial data was conducted using MapInfo® Version 6.0 Geographic Information Systems.

2.1.2 Summary of information sources reviewed

Wetland inventory data at all scales (regional, national and international) was found to be limited, often incomplete and structured for a variety of purposes. Inventories of wetlands and inventories relevant to wetlands within the Corangamite region that were reviewed are listed in Table 2.1. The analysis of information on wetland inventory shows the diversity of materials and approaches that have been used (Appendix 1).

Table 2.1 Existing inventories and databases of wetlands within the Corangamite region.

Title	Description	Source
Regional Inventories		
Victoria: Wetland_1788 & Wetland_1994	Digital wetland data from Corrick (1982). Identifies 1, 457 wetlands within the Corangamite region over 1 ha in size.	DCNR (1995)
Atlas of Victorian Wildlife	Contains fauna records for Victoria including those of breeding and non-breeding waterbirds on 134 wetlands within the Corangamite region.	DNRE (2001a)
Victorian Brolga Survey Database	Contains location data and wetland descriptions of Brolga nest sites in south-western Victoria, including 124 wetlands within the Corangamite region.	Harding (2000)
Wetlands Resource Assessment Package (WRAP)	Database containing data for conservation value assessment (CVA) of wetlands. Incomplete data on 1, 500 wetlands within the Corangamite region is included (uses wetlands identified by Corrick (1982)).	Australian Biological Research Group (1988).
Water Status of Wetlands in the Western District – 1982-83 Drought Survey.	Contains data on the water status (water surface area) of wetlands during 1982-1983 drought. Contains information on 323 permanent wetlands classified by Corrick (1982).	Dale & Myers (1984)
Wetland Management and Consultation Summary (Swampcare - Field and Game Australia)	Provides a summary of wetland characteristics relevant to Field and Game Australia. Includes management objectives, assessment of character, threats and location details. Only one wetland detailed for CCMA – Ross Creek Swamps.	Field and Game Australia (2000)
Flora Information System	Contains flora records for Victoria. 71 wetlands within the Corangamite region contain flora records.	DNRE (2001b)
National Inventories		
A Directory of Important Wetlands in Australia	Lists nationally important wetlands and summarises wetland values for each. A total of 24 wetland complexes have been identified as nationally important within the Corangamite region (available as an online searchable database).	Environment Australia (2001)
International Inventories		
Wetlands of international importance (Ramsar sites)	Inventories of wetlands listed as internationally important under the Ramsar Convention. Contains information sheets on Western District Lakes and Port Phillip Bay (Western Shoreline) and Bellarine Peninsula.	Ramsar Convention Bureau (2002)

Forty research papers of various formats containing information directly relating to wetlands and lakes of the Corangamite region were reviewed. Appendix 1 provides an analysis of past research concerning wetlands. Key points from the analysis are summarised in Table 2.2 below. The majority of the material analysed was of recent origin (since 1990) from published sources funded by both government and non-government organisations.

Table 2.2 Key attributes of wetland research reviewed for the Corangamite region.

Attribute	Summary
Type of source material	Material was available from a variety of sources. 32.5% of materials reviewed were internal departmental reports. Peer review journals and formal government reports were also common.
Publication format	Most of the information reviewed was from published sources (65%), however many unpublished interdepartmental reports existed (32.5%).
Funding	The large majority of research was funded by the Department of Natural Resources and Environment (52.5%). Academic institutions also contributed substantially (12.5%).
Main objective	22.5% of reports were management recommendations for particular wetlands. Wetland inventory and hydrochemistry analysis were also well represented.
Wetland Classification	Corrick's wetland classification system was used to define wetlands in the majority of reports where relevant.
Extent of coverage	A significant proportion of research focused on Ramsar lakes (40%) and other large lakes and wetlands (30%). Smaller wetlands, temporary wetlands and estuaries received far less coverage.
Status description	Most sources stated threatening processes and overall status description of wetlands.
Publication date	67.5% of reports reviewed have been published since 1990.

Figure 2.2 illustrates the distribution of wetland research focus within the Corangamite region. A large proportion (27.5%) of research papers focused on salinity and hydrochemistry analysis and were specific to saline lakes of the Corangamite region. Research concerning the biological values and condition of wetlands within the Corangamite region contributed 20% of papers reviewed. Management plans have been written for most of the larger lakes and wetlands including those listed under the Ramsar Convention and most listed on the Directory of Important Wetlands. Research focusing on waterbirds and macroinvertebrates were also well represented, however research on wetlands flora within the region was lacking. See Appendix 1 for analysis of source material reviewed for the purposes of this report.

The very broad scope of wetland information existing for the Corangamite region as indicated in Table 2.2 and Figure 2.2 is summarised within this report (Section 2.2). Gaps and limitations of the existing data are also identified (Section 2.4).

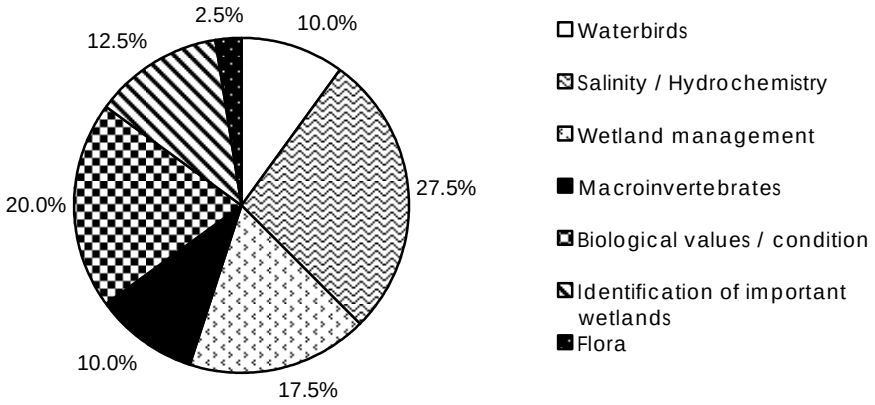


Figure 2.2 Focus of wetland research for the Corangamite region.

2.2 Extent and adequacy of wetland inventory information

2.2.1 Wetland inventory

Regional inventories

Corrick (1982) completed a wetland inventory within the Corangamite incorporating all wetlands over 1 ha in area. Wetlands surveyed and mapped by Corrick (1982) represent the most complete wetland inventory data available for the Corangamite region. The Corrick inventory also forms the basis for several other inventories (e.g. Dale & Myers 1984; Australian Biological Research Group 1988; DCNR 1995).

Corrick and Norman (1980) devised a system for classification of wetlands into categories and sub-categories based on salinity, depth, and vegetation characteristics (Corrick 1981; 1982). This classification is summarised in Table 2.3. Wetlands greater than 1 ha were located using aerial photographs and additional field surveys (Corrick & Norman 1980). The classification system was specific to the project and orientated toward use by waterbirds (Pressey & Adam 1995).

The Corrick data contains information on:

- Wetland location, comprising both Australian Map Grid (AMG) references and latitude/longitude;
- Wetland category and sub-categories;
- Area in hectares of each wetland;
- Previous category and previous area;
- Whether the wetland is artificial or not;
- Land status (e.g. private, game reserve, state park); and
- Corrick's study area number.

Detailed data on threats, landuse, flora, fauna, geomorphology and limnology are lacking within the Corrick data.

A GIS-based inventory of wetlands in Victoria was completed in 1994 (DCNR 1995), having originated from mapping work undertaken in the 1970s (Corrick 1982). There were two layers in the GIS: the first indicating pre-settlement wetland areas (>1 ha), divided into categories based on salinity and water regime; and the second detailing current wetland distribution, divided into categories and sub-categories based largely on subjective description of vegetation types recognisable from aerial photographs.

Table 2.3 Corrick (1982) classification of wetland categories and sub-categories.

Category/sub-category of wetland	Depth (m)	Duration of inundation
FRESHWATER		
1. Flooded River Flats	<2	
2. Freshwater meadows	<0.3	<4 months/year
2.1 herb-dominated		
2.2 sedge-dominated		
2.3 red gum-dominated		
lignum-dominated		
3. Shallow freshwater marshes	<0.5	<8 months/year
3.1 herb-dominated		
3.2 sedge-dominated		
3.3 cane grass-dominated		
3.4 lignum-dominated		
red gum-dominated		
4. Deep freshwater marsh	<2	Permanent
4.1 shrub-dominated		
4.2 reed-dominated		
4.3 sedge-dominated		
4.4 rush-dominated		
4.5 open water		
4.6 cane grass-dominated		
4.7 lignum-dominated		
red gum-dominated		
5. Permanent open freshwater		Permanent
5.1 shallow	<2	
5.2 deep	>2	
impoundments		
SALINE		
6. Semipermanent saline wetlands	<2	<8 months/year
6.1 salt pan		
6.2 salt meadow		
6.3 salt flats		
6.4 sea rush-dominated		
hypersaline lakes		
7. Permanent saline wetlands		Permanent
7.1 shallow	<2	
7.2 deep	>2	
intertidal flats		
20. Sewage ponds		
21. Salt works		

Other regional wetland inventories have been specific to the purpose of a particular study and therefore contain limited wetland data that was not easily incorporated and analysed with other wetland inventory data. For example, Harding (2000) provides locations of Brolga nest sites including the location of the wetland, dominant vegetation (as related to nesting material), area and surrounding landuse; Sheldon (2003) provides similar information for Brolga flocking sites and Dale and Myers (1984) identify wetlands containing water during a drought in 1982-1983. None of these inventories were complete or encompassed significant proportions of the Corangamite region.

The former Wetlands Unit, established within the Department of Conservation and Natural Resources, initiated an inventory of wetlands in the Colac region. Field investigation for the inventory was completed from late 1980's to 1991 (Appleby 1989; 1991). Wetlands in the Colac region were divided into zones based on geology and related hydrology by Appleby (1991) for the purposes of the inventory. Table 2.4 lists zones identified by Appleby (1991) and significant wetlands included within each zone. The original data sheets collected throughout these regions were unable to be located and it is understood that no comprehensive analysis of the data has been undertaken.

Table 2.4 Wetland zones identified in the Colac region.

Zone	Area Description	Notable Wetlands
1. Dissected sedimentary plains	Port Campbell, Cobden, Birregurra, Bambra, Leslie Manor.	Leslie Manor area, Kooraweera lakes, Terangpom catchment, Lake Terangpom.
2. Folded sedimentary	Otway hills.	Otway reservoirs, Lake Elizabeth, North Otway hills, Carlisle heathlands.
3. Floodplains	Barwon, Gellibrand and Aire Rivers.	Princetown area, Lower Gellibrand, Lower Aire system, Barham River Lagoon, lower Curdies system, East Winchelsea.
4. Volcanic craters	Camperdown area, Red Rock.	Camperdown volcanic crater, Red Rock lakes area.
5. Volcanic plains	Winchelsea, Cloven Hills, Vite Vite.	Lake Dubban area, Lake Gherang area, Lake Murdeduke, East Winchelsea, Weering area, Cundare Pool/Lake Martin, Mt. Hesse-Mingawalla plains, Winchelsea Irrewarra plains, Upper Lough Calvert, Middle Lough Calvert, Lower Lough Calvert, Lake Beeac, Lake Cundare, Lake Colac area, Beeac-Cundare lakes, Barpinba, Cressy plains, East Murdeduke, Camperdown plains, Lake Colongulac, Lake Milangil, Lake Round area, Terangpom catchment, Skipton Lismore plains, Vite Vite-Darlington plains.
6. Volcanic stony rises	Warrion Hill, Mt. Porndon, Mt. Widderin.	Warrion Hill stony rises (Wool Wool area, South Dreeite swamps, Duck Holes, Cundare-Dreeite stony rises, East Eurack, North Colac rises); Mount Porndon stony rises (Porndon east rises, Purrumbete south stony rises, Crater's Road swamps, Stonyford, Bungador); Selkirk stony rises (Banongill network).

(Source: Appleby 1991)

National and International inventories

The Directory of Important Wetlands (Environment Australia 2001) identifies nationally important wetlands across Australia and provides information on each, including their

classification and the dependent flora and fauna. The Directory is a cooperative project between the Commonwealth, State and Territory Governments of Australia and is available as an online searchable database. Appendix 2 lists wetlands identified as nationally important within the Corangamite area. A total of 24 wetland complexes were identified within the Corangamite region incorporating a total of 93 individual wetlands (Appendix 2). Wetlands within the database were classified into 40 different wetland types in three categories: A – Marine and coastal zone; B – Inland waters; and C- Human-made wetlands. The system was based on that used by the Ramsar Convention in describing Wetlands of International Importance, however it was modified slightly to suit Australian conditions. The following data fields were provided for each wetland:

- Location
- Area
- Elevation
- Other listed wetlands in the same aggregation
- Wetland type
- Criteria for inclusion
- Site description
- Physical features
- Hydrological features
- Ecological features
- Significance
- Notable flora
- Notable fauna
- Social and cultural values
- Land tenure
- Current landuse
- Disturbance or threat
- Conservation measures taken
- Management authority and jurisdiction
- Compiler and date

Most wetlands from the Corangamite region included in the Directory of Important Wetlands are large permanent lakes.

The Ramsar Convention Bureau (2002) listed Wetlands of International Importance. The Corangamite region encompasses the Western District Lakes Ramsar site and a large proportion of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site (Appendix 2). Information on these Ramsar listed wetlands is extensive and Draft Strategic Management Plans have been written for both sites (Parks Victoria 2001; 2002).

Standardising of inventory approaches

Future wetland inventory projects for the Corangamite region require a standardised approach compatible with existing inventories. This will allow comparative studies and the ability to build on existing data.

Standardisation of inventory procedures could be derived from existing models, notably the Mediterranean Wetland Inventory (Costa *et al.* 1996; Costa *et al.* 2001), and the United States Fish and Wildlife Service National Wetland Inventory (Gebhard 1988). The remote sensing techniques and the classification systems used in these approaches have been successfully adapted for use in other countries and could provide a basis for a standardised framework and/or generic wetland inventory database (Finlayson & Spiers 1999).

National frameworks for wetland inventory are currently being investigated for Australia with the implementation of a National Wetland Inventory Taskforce (M. Finlayson, pers com. 2004). The taskforce aims to agree upon and implement a set list of essential parameters and protocols to be used for all future wetland inventory initiatives in Australia.

Furthermore, a framework for the development of an index of wetland condition in Victoria is currently being investigated by the Department of Sustainability & Environment (Holmes & Papas, in press).

There has been increased use of remote sensing technology for wetland inventory (Caldwell & Koeln 1988; Johnston & Barson 1993; Blackman *et al.* 1995; Costa *et al.* 1996; Zalidis *et al.* 1996; Anon. 1997; Anon. 2000). Finlayson and Spiers (1999) state that the emphasis on remote sensing inventory approaches should not be a wholesale adoption of such techniques, but rather focus on the development of models that suit particular purposes linked to on-ground management activities, including effective ground truthing and monitoring. Within the Corangamite region, remote sensing has so far been limited to aerial photo interpretation in the 1970's (Corrick 1982).

Given the difficulties in obtaining even the most basic information for many smaller wetlands, there is a need to identify a basic data set to describe each wetland. This could include the location and area of the wetland and its ecological characteristics. The latter could include general indicators or descriptors of the water regime, water quality and biota. An agreed landform classification system would make it possible to compare sites and regions, and provide a basis for management decisions. This may also facilitate the collection of more specific information on threats, values and benefits, land tenure and management, and monitoring of wetlands (Beilharz 1996; Finlayson & Spiers 1999).

2.2.2 Wetland classification

Riggert (1966) and Goodrick (1970) have used classification schemes based on salinity, water regime and dominant vegetation types. Corrick and Norman (1980) expanded this system to include subcategories based on vegetation communities important to waterbirds. However, this system has been criticised for its inability to accurately define ecologically distinctive wetland types due to the use of broad wetland categories (Beilharz 1996). Wetland categories defined by Corrick and Norman (1980) reflect the duration for which water will be available to waterbirds but does not distinguish between different landforms or geomorphic origins. Thus, wetlands may be classed as the same category yet support quite different species and communities as a result of a widespread geographical/biophysical difference (Beilharz 1996). Hence, the Corrick wetland classification system is suitable for wetland classification at the regional scale although it has significant limitations in defining wetland categories at larger scales.

Attempts to produce a national classification of wetlands have identified the need for the classification of wetlands based on a minimum data set (Paigmans *et al.*1985; McComb & Lake 1988; Beilharz 1996). Beilharz (1996) developed a revised classification system to identify ecologically different wetland types throughout Victoria. The general consensus from both existing wetland classifications (Cowardin *et al.* 1979; Paigmans *et al.* 1985) and suggested minimum data sets (McComb & Lake 1988) is that the most important attributes are the wetland geomorphology, hydrology and water chemistry. It is stated by Beilharz (1996) that these factors, along with a biophysical regionalisation that incorporates geological and climatic differences between areas, provide a solid foundation for distinguishing ecological wetland classes. Vegetation, which is often used as an important attribute in classification, is therefore a reflection of these factors as an indirect attribute.

The majority of wetland inventories and research within the Corangamite region have used wetland classification systems produced by Corrick (1982). The Environment Australia (2001) used a wetland classification based on that used by the Ramsar Convention in describing Wetlands of International Importance.

2.2.3 Wetland condition

Wetland condition assessment has been investigated by Spencer *et al.* (1998) for the Murray-Darling floodplain and Danielson (2001) for the United States Environmental Protection Agency. Spencer *et al.* (1998) developed a rapid appraisal wetland condition index based on four attributes of wetlands – soils, fringing vegetation, aquatic vegetation and water quality. Indicators of ecological integrity within these attributes were assessed and allocated ratings in order to determine a condition index for each wetland (Spencer *et al.* 1998). Danielson (2001) provides a method for bioassessment of wetlands focusing on measuring attributes of a wetland's biological community that are reliable indicators of wetland condition including wetland vegetation, aquatic fauna, amphibians, fish and waterbirds. Bioassessments were based on the premise that the community of plants and animals living in a wetland would reflect the health of a wetland (Danielson 2001). The diversity of animals and plants of a damaged wetland often decreases and the composition of species changes. Typically, the proportion of organisms that were intolerant to human disturbances would decrease while the proportion of species more tolerant to disturbance would increase (Danielson 2001).

The only attempt to provide a condition/values assessment of wetlands within the Corangamite region on a large scale was conducted by the Australian Biological Research Group (1988). Wetlands contained within the Wetlands Database (DCNR 1995) were ranked using value systems and the computer database, Wetlands Resource Assessment Package (WRAP) (Australian Biological Research Group 1988).

The value system included the following attributes:

- Rarity/degree of endangerment of species;
- Rarity of wetland type;
- Wetland size;
- Importance for waterbirds;
- Naturalness;
- Scientific value; and
- Heritage value.

The values assessment examined data for each wetland and cross-referencing it to the value files (Australian Biological Research Group 1988). Wetlands supporting attributes that were of value were then sorted into classes on the basis of the types and significance level of the attributes. Shaw *et al.* (1990) suggest that such systems have many flaws - a major one being that wetlands with one outstanding attribute (such as a rare species) may not rank highly overall, yet society may feel that such a wetland should rank highly.

The database contained incomplete data on approximately 1, 500 wetlands within the Corangamite region. Data sources included in the WRAP were primarily from the Wetlands Database (DCNR 1995) supplemented by additional research papers and reports, including waterbird, fish and flora records. Detailed biological data is lacking for 98% of the wetlands incorporated in this database, severely limiting its usefulness to provide valid values assessment of wetlands.

The WRAP database identified a total of 340 wetlands as significant within the Corangamite region and rated them as A, B, C or D in relation to their conservation value (Australian Biological Research Group 1988). Notably, all wetlands identified as Class A wetlands were large (mostly lakes), possibly reflecting the distribution of available research and data.

Few other wetland inventory data sets contain information on the condition of wetlands other than those listed in the Directory of Important Wetlands or under the Ramsar Convention. Potential threats to individual wetlands are undocumented for the majority of wetlands within the study area. However, the Atlas of Victorian Wildlife (DNRE 2002a) and the Flora Information System (DNRE 2002b) provide locations of species recorded

throughout the State and show the current conservation status (e.g. rare, vulnerable, endangered) for each species. This data can readily be cross-referenced with known wetland regions in the Corangamite region, although actual records are sparse.

2.3 Character and condition of wetlands in the Corangamite region

The following sections provide a summary of the findings of research on factors influencing the character and condition of wetlands within the Corangamite region. Values and threats of wetlands in the Corangamite region were identified from the literature review and specific examples were provided. General trends and management implications are discussed in relation to specific values and threats where relevant. Deficiencies in available data for most wetlands occurring within the Corangamite have limited the ability to analyse the values, threats and trends.

Wetland values

Wetlands are among the most productive ecosystems, excelling in nutrient recycling, trapping sediments and providing habitat for a diverse range of fauna and flora (Department of Conservation and Environment 1992). Values of wetlands have been identified by the Department of Conservation and Environment (1992) and include:

- Provide habitat for plants and animals.
- Provide refuges for rare and threatened species.
- Assimilate and recycle nutrients.
- Trap sediments.
- Function as flood control basins.
- Provide hydrological stability to catchments (ground water and surface water).
- Are valuable recreation resources.
- Provide landscape values.
- Are sites of cultural, scientific and educational significance.
- Contribute economic values.

Values of wetlands within the Corangamite region have been identified by several authors and include all of the general values of wetlands listed above. Particular values commonly cited for the Corangamite region are summarised below.

Wetland representativeness

In Victoria wetlands have been classified by Corrick (1982) into eight categories (refer to Table 2.3). The Corangamite region contains wetlands of international and national significance, including extensive areas of inland saline lakes that have been identified as nationally significant (Environment Australia 2001). All eight wetland types identified by Corrick (1982) are represented within the Corangamite region including significant areas of the State's most depleted wetland habitats and wetlands least represented in Victoria's protected area network - freshwater meadows and shallow freshwater marshes (Corrick 1995).

Figure 2.3 and 2.4 illustrate the range of wetland types represented within the Corangamite region. Permanent open freshwater impoundments (Category 5.3) are by far the most numerous category (38%) (Figure 2.3), reflecting the large number of farm dams throughout the region.

Freshwater meadows (Category 2.1) and shallow freshwater marshes (Category 3.1) are also numerous (Figure 2.3). A significant proportion of Victoria's freshwater meadows and shallow freshwater marshes occur within the Corangamite region (Smith 1975; Shaw *et al.* 1990). These wetlands are easily drained and consequently many have been lost throughout Victoria.

Significant areas of permanent saline wetlands (Categories 7.2 and 7.3), including Lake Corangamite (the largest permanent saline lake in Australia) also occur within the region (Figure 2.4). Wetlands such as the Cheetham Saltworks (Category 21) and the Western Treatment Plant (Category 20) are artificial, although they generate a highly productive and valuable enriched coastal ecosystem (Parks Victoria 2002).

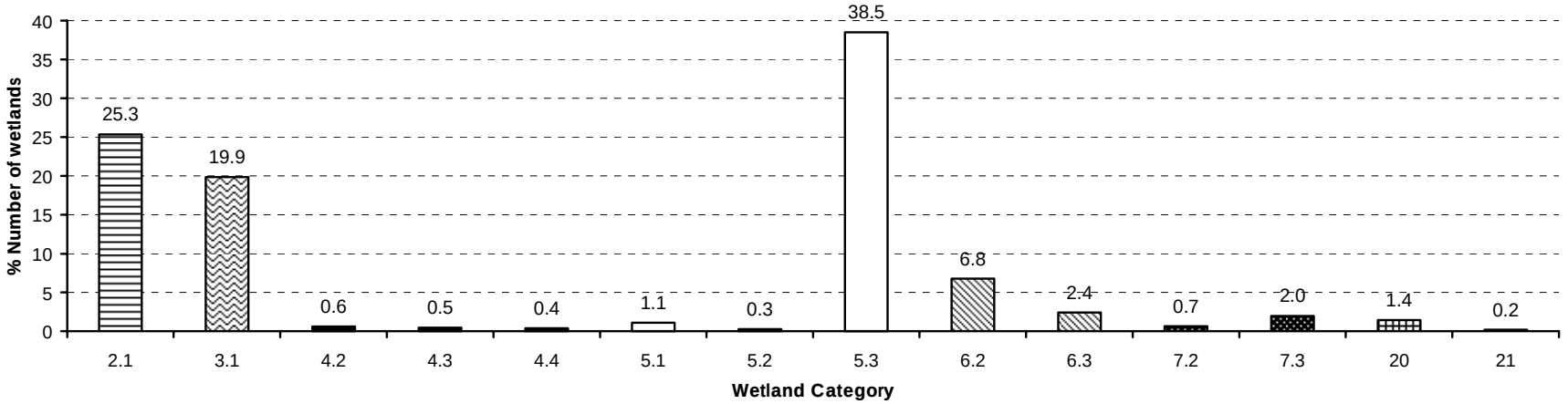


Figure 2.3 Percentage of total number of wetlands within each wetland category for the Corangamite region. (Refer to Table 2.3 for category descriptions. Source: WETLAND_1994 (DCNR 1995)).

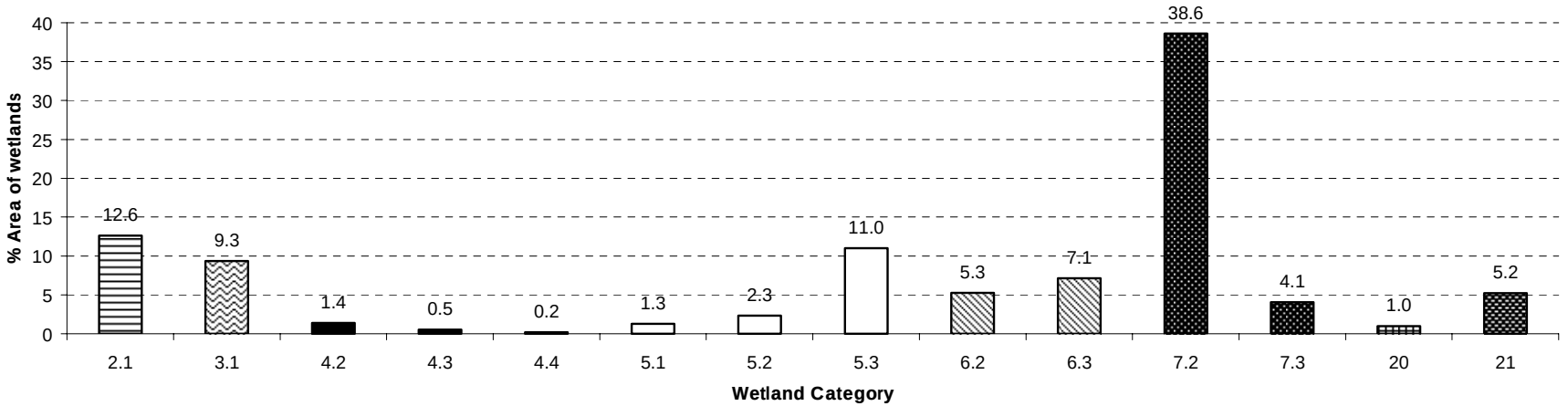


Figure 2.4 Percentage of total wetland area represented by each wetland category for the Corangamite region. (Refer to Table 2.3 for category descriptions. Source: WETLAND_1994 (DCNR 1995)).

The wetland inventory provided by Corrick (1982) has limited ability for demonstrating the distribution of wetland types within the Corangamite region. The wetland classification system used was broad and may not sufficiently illustrate the differences between wetlands of differing bioregions (Beilharz 1996). Additionally, as the Corrick data includes only wetlands 1 ha or greater, many wetlands were not included. These limitations affect the usefulness of data for management purposes.

Trends and management implications

Wetlands identified as nationally and internationally significant require appropriate management in order to maintain ecological values and control threatening processes. International agreements exist for wetlands listed under the Ramsar Convention regarding their wise use and maintenance of the ecological values for which the wetlands were recognised under the Ramsar Convention. A number of wetlands and lakes within the Corangamite region, including those listed as nationally and internationally important, were reserved under the *Wildlife Act 1975* as State Game Reserves and Nature Conservation Reserves, and under the *Crown Land (Reserves) Act 1978* as Lake Reserves. Wetlands and lakes reserved under legislature are required to be managed in accordance with objectives derived from recommendations of the former Land Conservation Council (LCC) (Parks Victoria 2001; 2002). Table 2.5 indicates land tenure of wetland categories within the Corangamite region.

Table 2.5 Land tenure of wetland types within the Corangamite region - No. wetlands (area ha).

Wetland Type (Corrick)	C/wealth Land	Freehold	Reserves	Public Land – water frontage	State Forest	National Park	Total
	No. wetlands (area ha)						
2. Freshwater meadow	6 (20.5)	331 (2, 894)	4 (279.4)	4 (24.27)	1 (18.24)	-	346 (3, 236.41)
3. Shallow freshwater marsh	1 (5.6)	276 (2, 464)	2 (130.29)	1 (1.85)	-	-	280 (2, 601.74)
4. Deep freshwater marsh	2 (2.75)	8 (236.66)	13 (516.6)	-	-	1 (9.6)	24 (765.61)
5. Open freshwater	1 (2.04)	385 (1, 349)	43 (2, 052)	1 (1.92)	13 (239.3)	4 (34.12)	447 (3, 678.38)
6. Semi-permanent saline	-	75 (1, 245)	40 (2, 074)	5 (101.6)	2 (15.2)	-	122 (3, 435.8)
7. Permanent saline	-	5 (77.03)	29 (1, 1978)	-	-	1 (2.78)	35 (12, 057.81)
20. Sewage Treatment Ponds	-	13 (218.74)	2 (6.21)	-	2 (34.8)	-	17 (259.75)
21. Saltworks	-	2 (1, 345)	1 (166.3)	-	-	-	3 (1, 511.3)

Source: DCNR 1995; GIS land status overlay: landmmt100

A large proportion of freshwater meadows and shallow freshwater marshes occur on privately owned freehold property (Table 2.5). Thus, wetland conservation on private property is critical to the preservation of particular wetland types, especially shallow freshwater wetlands. Management of wetlands on private land primarily involves public education increasing the awareness of the importance of wetlands within the rural community. Conservation covenants, rate-rebate schemes and other incentive and support programs can encourage wetland protection on private property.

The current reserve system appears inadequate to conserve representative wetland types in the region. Corrick (1995) suggested that further reservation of important wetlands for biodiversity conservation was required.

Additionally, limitations of wetland classification and gaps in the current wetland inventory data affect the ability to determine management needs or to quantify resource allocation requirements.

Biodiversity

Wetlands provide habitats that support numerous plant and animal species, many of which are dependant on such habitat. An individual wetland, or a series of wetlands, may be of critical importance to a species population or its importance may relate to the perpetuation of an ecological community and its evolved diversity (Norman & Corrick 1988). Significant flora and fauna values of Corangamite region wetlands are outlined below.

Waterbirds

The wetlands of the region support significant numbers of various species of waterbirds (Corrick 1982). Marshes and lake margins provide important nesting sites, and open waters provide areas for feeding. Mud flats associated with lakes provide important foraging areas for large numbers of waterbirds. A total of 101 water-dependant bird species have been recorded on wetlands within the Corangamite region (DNRE 2002a). Of these, 33 species have been listed as rare and threatened in Victoria and eight are listed as threatened under the *Flora and Fauna Guarantee Act 1988* (Appendix 3).

Species for which the Corangamite wetlands are important include all colonially nesting species such as Straw-necked Ibis, Sacred Ibis, Pied Cormorant, and Fairy Tern. The area is particularly important for Pelican and Gull-billed Tern, as it contains the only recently active breeding colonies known in Victoria (Corrick 1982). Non-colonial nesting species with restricted distributions in Victoria including Brolga, Australasian Bittern and Chestnut Teal also occur in the region (Appleby 1991; Harding 2001).

The region is also important for non-breeding populations of many nomadic migratory species including Great Crested Grebe, Hoary-headed Grebe, Black Swan, Grey Teal, Pink-eared Duck, Hardhead, Freckled Duck, Blue-billed Duck, Musk Duck, Banded Stilt, Red-necked Avocet, Eurasian Coot, and Whiskered Tern. Several migratory waders including three species listed under the *Japan and Australia Migratory Bird Agreement* (JAMBA) and 34 listed under the *China and Australia Migratory Bird Agreement* (CAMBA) (Appendix 3) have been recorded on wetlands within the Corangamite region. All of these migratory species are listed as matters of national importance under the *EPBC Act 1999*.

The large, open and permanent nature of many lakes within the Corangamite region (particularly Western District Lakes) also provides drought refuge for waterbirds and shelter for waterfowl during moulting when they are temporarily flightless (Parks Victoria 2001). Port Phillip Bay Ramsar sites are particularly important for migratory and resident shorebirds (Watkins 1993; Parks Victoria 2002). Ramsar sites within the Corangamite region have been listed under criteria relating to importance to waterbird species including the following:

- Regularly supports >20, 000 waterfowl;
- Regularly supports substantial numbers of individuals from particular groups of waterfowl; and
- Regularly supports 1% of the individuals of a population of one species or subspecies of waterfowl.

The Corangamite region also incorporates parts of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Shorebird site, specifically including the Lake Connewarre System. The Shorebird Site Network was an initiative of the Asia-Pacific Migratory Waterbird

Conservation Strategy: 1996-2000 (Asia-Pacific Migratory Waterbird Conservation Committee 2001), and identifies and promotes the wise use and conservation of sites of international importance for migratory shorebirds in the East Asian-Australasian Flyway.

Reptiles, amphibians and fish

Wetlands within the Corangamite region provide vegetated shallow water habitats suitable for a range of reptiles and amphibians. Nine frog species have been recorded on wetlands in the region including the nationally vulnerable Warty Bell Frog (*Litoria raniformis*) (DNRE 2002a). The nationally endangered Corangamite Water Skink (*Eulamprus tympanum* ssp.) was also recorded within the Western District Lakes (Parks Victoria 2001). Other threatened reptiles recorded from the region's wetlands include Swamp Skink (*Egernia coventryi*), Striped Legless Lizard (*Delma impar*) and the Leathery Turtle (*Dermochelys coriacea*) (DNRE 2002a; Parks Victoria 2002).

Chessman and Williams (1974) and Gutteridge *et al.* (1980) provide information on the distribution of fish in inland waters (primarily lakes) of the Corangamite region. As many wetlands within the region are temporary or internally draining, fish records are restricted to the larger permanent lakes. Threatened fish species recorded from the region's lakes and wetlands include Australian Grayling (*Prototroctes maraena*), Yarra Pigmy Perch (*Edelia obscura*), Mountain Galaxias (*Galaxias oldius*) and Spotted Galaxias (*Galaxias truttaceus*). Populations of Common Galaxid, Short-finned Eel, Big-headed Gudgeon and Southern Pygmy Perch have been recorded within Lake Corangamite and are an important food source for several species of waterbird.

Eels, Rainbow Trout and Chinook Salmon have been regularly stocked for recreational fishing purposes in Lakes Murdeduke and Colongulac (Bookaar Eel Culture Pty. Ltd 1983; Parks Victoria 2001). European Carp also occur in the region's wetlands. Introduced fish species are known to prey upon or out-compete native fish species within the region.

Macroinvertebrates

Studies concerning macroinvertebrate diversity within the Corangamite region have primarily focused upon saline lakes (Bayly & Williams 1966; Williams *et al.* 1990; Williams 1992; Williams 1995; Powling 1995). Williams (1992) provides detailed lists of macroinvertebrate fauna for 18 lakes throughout western Victoria.

In a study of 79 lakes of varying salinity ranges within the Corangamite region, 142 macroinvertebrate taxa were collected (Williams *et al.* 1990). Table 2.6 summarises the diversity of benthic fauna of the Corangamite lakes. Knowledge of macroinvertebrate diversity in temporary wetlands is limited, and Williams (2000) suggests that this is due to their relative inaccessibility as most are located on private properties. No formal list of rare or endangered invertebrates is presently available for Victoria, although the Atlas of Victorian Wildlife (DNRE 2002a) includes status information for some species. However, most macroinvertebrate fauna is endemic to Australia and there is evidence of considerable regional restrictions in geographic distributions, including restrictions in habitat utilisation (Butcher 1999; Williams 2000).

Table 2.6 Macroinvertebrate taxa recorded on wetlands within the Corangamite region.

Taxon	No. of species
CNIDARIA	1
MOLLUSCA	5
ANNELIDA	3
HYDRACARINA	1
CRUSTACEA: Copepoda	19
CRUSTACEA: Cladocera	18
CRUSTACEA: Ostracoda	24
CRUSTACEA: Malacostraca	6
INSECTA: Emphemeroptera	3
INSECTA: Odonata	9
INSECTA: Hemiptera	17
INSECTA: Diptera	14
INSECTA: Lepidoptera	1
INSECTA: Trichoptera	5
INSECTA: Coleoptera	16

Source: Williams *et al.* 1990

Flora

Summaries of higher aquatic plants were provided by Aston (1973). Briggs (1981) presented a brief review of wetland vegetation types, including those within the Corangamite region. The diversity of wetland environments present within the region provides habitat for many flora species, and 677 flora species have been recorded from mapped wetlands (DCNR 1995; DNRE 2002b). Of these 255 (37.6%) are exotic species and seven are listed as environmental weeds (DNRE 2002b). Few studies of wetland flora within the region were identified during the review, although most wetland management reports provide lists of flora specific to particular wetlands.

Twenty-four Victorian rare and threatened flora species have been recorded from the region's wetlands (DNRE 2002b). Of these, three species have been listed as nationally endangered and four species have been listed as nationally vulnerable. Six species are listed as threatened under the *Flora and Fauna Guarantee Act 1988* (Appendix 4). Rare and threatened flora located during the Corangamite Wetland Inventory are listed in Appendix 9.

Trends and management implications

Trends in the overall biodiversity of wetlands in the Corangamite region are not well known. Williams (1992) found that the biological status of most of the permanent saline lakes in the Corangamite region had not changed significantly since studies began. However, changes in salinity levels (see Section 4.2.4) were found to change the biological status of Cundare Pool and Lake Corangamite, and have contributed to a reduction in waterbird species present. Many rare and threatened flora and fauna species are reliant on the region's wetland habitats, and while individuals or population may be affected, no extinctions of species could be directly attributed to the loss of wetlands.

The adequacy of reservation of wetland types for biodiversity conservation has been investigated by Corrick (1995). Corrick (1995) found the diversity of waterbirds to be greater in reserved wetlands than in unprotected wetlands. Reserved wetlands were usually large, less likely to be heavily impacted by stock, and more likely to support emergent and surrounding vegetation.

Management of wetlands other than those reserved for conservation continues to be important to biodiversity, particularly for species that utilise shallow freshwater habitats (Corrick 1995). Managers of these areas and authorities providing advice should recognise the current limited knowledge regarding species habitat selection and utilisation of wetlands available to them. Factors influencing both species habitat selection and breeding success, particularly on wetlands subject to agricultural practices should be investigated before definitive advice and management prescription can be developed for a particular species or wetland type (Kingsford 1997).

Biological values such as waterbird diversity are the subject of international agreements (Ramsar Convention, JAMBA and CAMBA) and are matters of national importance (*Environment Protection and Biodiversity Conservation Act 1999*). Obligations exist for the sustainable management of wetlands for the protection of these values.

Natural function

Wetland natural function refers to the natural processes and derivation of benefits and values associated with wetland ecosystems. Wetlands within the Corangamite region function as natural flood mitigation areas, storing excess runoff and releasing it slowly during times of low flow. Wetlands act as a sink, or store, for sediments and nutrients washed from the surrounding catchments (Norman & Corrick 1988; Parks Victoria 2001). Many wetlands within the region have internal drainage basins and provide this function for small catchments.

Wetlands provide water purification through filtering and retention of sediments and resulting nutrients. Areas where these functions are particularly critical occur at Werribee, where the coastal wetlands absorb and recycle a large amount of nutrients and other pollutants from the Western Treatment Plant.

Many wetlands and lakes within the Corangamite region function as groundwater discharge (e.g. Lake Beeac and other lakes of the Lough Calvert area) and recharge or act as a groundwater throughflow (e.g. Colongulac and Gnarpurt) (Coram 1996).

Trends and management implications

Trends and management implications relating to natural functions are concerned with threatening processes, including water regulation, drainage and vegetation clearance which are discussed in section 4.2. The natural function of wetlands extends to whole catchment management and is affected by damming and diversion of water, clearance of vegetation from the catchment, and impacts of fertilisers and pesticides throughout the region. Judicious use and management of water on a local scale within the catchment also affects the natural function of wetlands.

Natural and cultural heritage

The Western District Lakes have been a focus for the Djargurd wurrung and Gulidjand Aboriginal people (Parks Victoria 2001). Over 48 archaeological sites have been registered within the Western District Lakes Ramsar site including fishtraps, surface scatters, middens, shelters, and tools (Parks Victoria 2001). Many Aboriginal sites have also been recorded for the Port Phillip Bay Ramsar site (Parks Victoria 2002). Databases containing sites of Aboriginal significance and National Estate listings are maintained and are likely to contain information on sites within the Corangamite region that are specific to other wetlands.

Trends and management implications

Legislative and international obligations exist for the management and treatment of sites of natural and cultural heritage (e.g. A*boriginal and Torres Strait Islander Heritage Protection Act 1984*; *Australian Heritage Commission Act 1975*). Identification of important cultural sites that are likely to occur within the region was beyond the scope of this report.

Economic

Direct economic benefits associated with wetlands of the Corangamite region include agriculture, fisheries, recreation and tourism. A number of particular economic benefits of wetlands in the Corangamite region are outlined below:

- Sewage treatment at the Western Treatment Plant provides an essential service for Victoria's capital city, thus contributing to the facilitation of economic activity in Melbourne (Parks Victoria 2002).
- Pastoral use of land adjoining wetlands, including cattle and sheep grazing, particularly the use of wetlands as drought relief grazing.
- The Swan Bay area provides regionally important tourism and boating.
- Commercial tourism operations in Port Phillip Bay, including fishing and boating in chartered vessels, and bird, seal and dolphin watching tours (Parks Victoria 2002).
- Commercial eel fishing within many of the Western District Lakes (Bookaar Eel Culture Pty. Ltd. 1983).

Indirect economic benefits of wetlands have been identified including farm water management, disease control in livestock and habitat for beneficial species for pest control (Oates 1994). Groundwater recharge, flood and flow control, and nutrient and sediment storage are also economic benefits associated with wetlands within the Corangamite region.

Trends and management implications

Economic activities operating on wetlands require management to ensure sustainability and to minimise impacts to the biodiversity of the wetlands. In regard to wetlands listed under the Ramsar Convention, economic uses of the area must take into consideration the conservation and wise use objectives that were obligations of the agreement.

Stock grazing on wetlands can be a significant threat to wetland values if poorly managed (refer to section 4.2.1). Commercial eel harvesting and eel culture occur on Lakes Murdeduke, Corangamite, Gnarpurt, and Colongulac. The impacts of these activities on the environmental values of these lakes are largely unknown (Parks Victoria 2001), however stocked eels were thought to have significant impacts on native fish populations.

It is believed that during the 1980's and 1990's there were considerable increases in the recreational fishing effort through changes in technology (e.g. depth sounders) and greater numbers of fishers in Port Phillip Bay. Fisheries regulations such as licences, bag limits, catch quotas, size limits, gear restrictions and seasonal or area closures were imposed to provide for the ecologically sustainable development of the State's fisheries resources (Parks Victoria 2002). Parks Victoria (2002) stated that it is unlikely that any single management measure will produce the desired stock conservation results, and a combination of several regimes are often used to allow resource use but also prevent overfishing.

Economic uses of wetlands often conflict with other values and regulation of the impact of economic gain on other values was required. The impacts associated with inappropriate resource utilisation were addressed through a range of measures including fencing and revegetating the shorelines of Ramsar lakes, re-establishing endangered native flora species, and enforcing grazing and commercial fishing licence conditions (Parks Victoria 2001).

Economic loss as a result of conserving wetlands on privately owned agricultural property may be an issue for conservation of biodiversity values. Mechanisms such as incentive schemes and reimbursement for economic loss for nature conservation of private land can help address this issue.

Scientific and education

This review has identified approximately 40 research papers with reference to wetlands within the Corangamite region. Research studies in the fields of hydrology, limnology and biology have occurred on many of the region's lakes and wetlands. In particular, W.D. Williams from the Department of Zoology, University of Adelaide, undertook a number of studies focusing on the biological status, physico-chemical features and the conservation and management of many saline lakes (Bayly & Williams 1966; Williams *et al.* 1990; Williams 1992; 1995; 2000; 2001).

Birds Australia, Bird Observers Club Australia, the Australasian Wader Studies Group and the Victoria Wader Studies Group have been involved in long-term monitoring of waterbirds and waders within the region.

Monash and Deakin Universities have also utilised the Corangamite region wetlands for ecological research and scientific teaching (e.g. Muston 2001). There is much potential for further scientific research throughout wetlands of the region (Parks Victoria 2002). It is likely that many of the region's wetland also provide a focus for biodiversity education for primary and secondary school students, as well as general nature study by other individuals.

Trends and management implications

Increasing interest and understanding of the ecological value of wetlands can lead to increased information available to managers to aid decision making. Providing incentives for research opportunities and educational programs promote the values of wetlands. As there is limited knowledge of many aspects of wetland character and condition, continuing research activity will be beneficial and aid in wetland conservation and management.

2.3.1 Threats

Threatening processes to wetlands within the Corangamite region have been widely discussed in relevant literature (e.g. Norman & Corrick 1988; Codd 1992; Platt & Corrick 1994; Parks Victoria 2001; 2002), however such processes have been rarely included in inventory data. Draft Strategic Management Plans for both the Western District Lakes and Port Phillip Bay Ramsar sites list threatening processes within all Ramsar sites and includes risk management recommendations(Parks Victoria 2001; 2002). The Directory of Important Wetlands (Environment Australia 2001) also provides an account of threats relevant to lakes and wetlands. Figure 2.5 indicates the frequency of threatening processes identified for Ramsar sites and wetlands listed on the Directory of Important Wetlands.

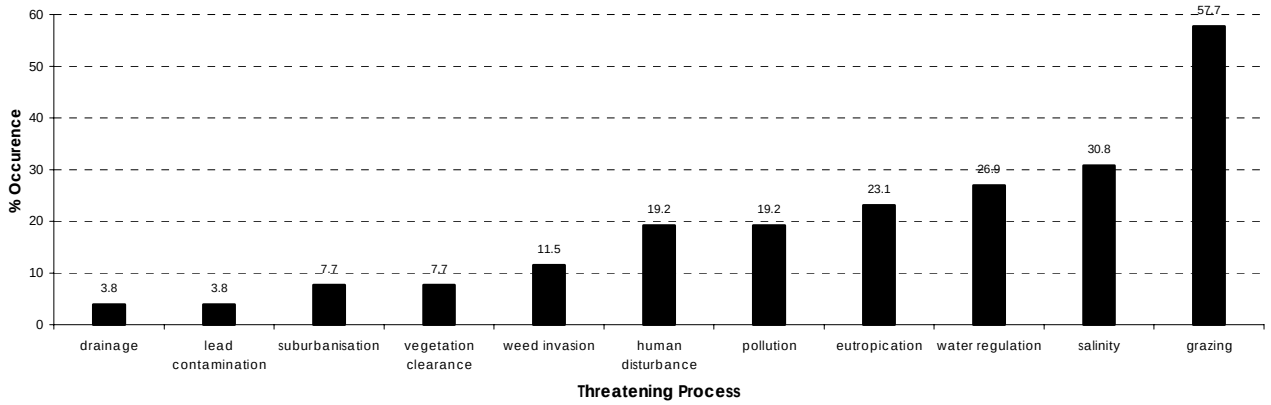


Figure 2.5 Frequency of threatening processes recorded for listed important wetlands and lakes within the Corangamite region (Source: Environment Australia 2001).

The frequency of grazing as a threat to wetland values was recorded for over half of the important wetlands identified. Increasing salinity, water regulation, pollution and eutrophication were also common threats. However, wetlands included within the Directory of Important Wetlands are primarily lakes and large wetlands, thus information presented in Figure 2.5 does not identify predominant threats to the majority of wetlands within the Corangamite region.

Drainage has been identified as one of the primary threats to many shallow freshwater wetlands on private property (Corrick 1995), however this threat was not indicated within the available wetland inventory data.

Stock trampling/grazing

Grazing by livestock can be a significant threat to the maintenance of wetland values (Hull 1993) and is generally not compatible with conservation objectives.

Livestock grazing directly causes a reduction in the vegetation cover through foraging and physical damage. This creates localised areas of disturbance that can lead to significant changes in the composition of vegetation communities, including weed invasion (DCFL 1986; Hull 1996). Livestock also eat and trample rare and threatened wetland plants and degrade the habitat for rare and threatened fauna (Hull 1996). The impacts of grazing will be greatest:

- Under high stocking rates;
- When plants (particularly annual species) are in their reproductive phase;
- Where grazing is heavy enough create bare areas and allow the establishment of weed species;
- When wildlife breed on the ground or in low herbaceous vegetation;
- Where the soil is wet; or
- When plant health and vigour is low because of stresses from disease, drought, fire or adverse changes to water regimes (Hull 1996).

Grazing has caused major changes to the vegetation surrounding many wetlands. Stock access to the water has also contributed to an increase in turbidity, reduction in oxygen levels and increased nutrient levels (Parks Victoria 2001). Over-grazing of temporary wetlands on private property has been identified as a threat to wetland nesting birds, such as the Brolga, which are dependant on emergent vegetation for nesting materials (Harding 2001).

Strategically managed grazing may however contribute to the maintenance of certain wetland values. Further research is required to determine grazing management regimes best suited to the maintenance and enhancement of the ecological character of different types of wetlands (DCFL 1986; Hull 1993; Parks Victoria 2001).

Trends and management implications

Over-grazing and trampling of wetlands is one of the most common threatening processes to wetlands on privately owned land (Platt & Corrick 1994), however no quantitative information on the type and extent of grazing practices on private land was documented in the literature reviewed. Shallow freshwater meadows and marshes occurring on privately owned land are thought to be the most at risk (Platt & Corrick 1994).

Grazing should be managed to minimise damage by restricting access to wetlands using appropriate fencing (Platt & Corrick 1994). Alternatively, restricting the duration, timing and number of livestock to a level where wetland values are maintained and damage minimised has also been recommended (Hull 1996). Public education and incentive programs to compensate landholders for fencing materials and loss of productive land could be explored.

The management of grazing for the maintenance of ecological values has been addressed by Hull (1993; 1996) who acknowledged the requirement for further research and experimentation with grazing regimes. Grazing exclusion plots and regular monitoring would assist in determining suitable grazing regimes for different wetland types.

Licences exist for the grazing of a number of publicly owned wetlands. Licences usually specify the type and number of stock permitted, but there are usually no restrictions on the season or duration of grazing (Hull 1996). Grazing licences have been issued in the past without considering potential detrimental effects to wetland ecosystems, and monitoring of these effects has been minimal.

Drainage

Corrick (1982) identified widespread changes in wetland area since European settlement. These changes included a large number of natural wetlands that have been drained. A total of 568 impoundments spread throughout the region and extensive sewage (283 ha) and salt evaporation (1, 511 ha) systems (DCNR 1995) have diverted water from many naturally occurring wetlands throughout the region. Codd (1992) identified drainage as the main threatening process to shallow freshwater wetlands of the Corangamite region.

Corrick (1982) reported a loss of 34% of the original area of freshwater wetland, 14% of freshwater meadow, 79% of shallow marshes, and 66% deep marshes in the area between Port Phillip Bay and Mt. Emu Creek, which encompasses the Corangamite region.

Drainage of wetlands for agricultural purposes continues to threaten wetlands, particularly those that are temporary in nature (freshwater meadows and shallow freshwater marshes), as they are the easiest to drain and degrade (Codd 1992; Department of Conservation and Environment 1992). The use of raised-bed cropping techniques has eliminated many small freshwater meadows and marshes on private property throughout the region (Harding 2000; 2001).

The detrimental effect of the loss of wetlands on waterbird populations has been apparent (Corrick 1982). Extensive areas of freshwater meadows, and marshes that have been drained originally would have supported substantial seasonal populations of waterbirds. Similar habitats have not been provided by the generally deeper wetlands created (e.g. water impoundments) since settlement (Corrick 1982). The loss of the original wetlands has contributed to the local disappearance and endangerment of some species (Codd 1992). Species most affected would presumably be those restricted to freshwater habitats (e.g. Latham's Snipe, Purple Swamphen, Crakes, Dusky Moorhen and Whiskered Tern) and particularly those that rely on such categories for breeding habitat (e.g. Brolga, Australasian Bittern and Black-winged Stilt) (Corrick 1982; Harding 2001).

Trends and management implications

The extent of wetland drainage since the Corrick (1982) wetland inventory has not been investigated and the need for updated wetland inventory information has been acknowledged (Beilharz 1996). There is currently no system for tracking wetland drainage on privately owned land and therefore the current extent of the threat is largely unknown. The identification of ecologically important wetlands within the region and their protection from further drainage is required.

The drainage of certain types of wetlands is a potential threat to particular threatened species. For example, as the Australasian Bittern and Brolga are reliant on shallow freshwater wetlands, drainage of significant proportions of this wetland type has a potentially large impact at the species level (Harding 2001).

Public education of the importance of wetlands and economic incentives to preserve wetlands on private land are likely to have an impact on the rate of drainage in the region.

Eutrophication

Pollutants such as sewage and other waste discharges can modify chemical balance within a wetland. Excessive nutrient enrichment, particularly by nitrogen or phosphates, causes eutrophication and may result in algal bloom (DCFL 1986; Williams 1992). The ecology may then change irreversibly, via a complex system that includes changes in dissolved solids, nutrient balance and oxygen levels (Norman & Corrick 1988). The effects of eutrophication have caused the death of eels at Lake Colongulac (Bookaar Eel Culture Pty. Ltd. 1983).

Algal bloom has been recorded as a threat to Lakes Colongulac, Colac, Murdeduke, Milangil, and Corangamite (Williams 1992; Environment Australia 2001). Eutrophication is primarily a threat to larger waterbodies within the Corangamite region that are currently receiving sewage and other nutrient rich pollutants.

Trends and management implications

Continued water quality monitoring of wetlands and subsequent regulation of pollutants entering waterways is important. The occurrence of eutrophication of privately owned wetlands is largely unknown.

The encouragement of industry best practice management in regard to waste discharges into lakes and wetlands on both public and private land would contribute to improved water quality.

Increased salinity

Research shows that salinity reduces the biological health of wetlands and lakes by reducing aquatic biota and in turn affecting the food chain for water-dependant birds (Williams *et al.* 1990; DCE 1991; Butler 1992; Williams 2000; Victorian Auditor General's Office 2000; Skinner *et al.* 2001). Due to increased salinity, margins of many wetlands no longer support submergent and emergent aquatic plants, thereby reducing the habitat available to fauna that would normally nest and feed in such vegetation. The composition of the biota is affected by increased salinity by favouring the dominance of salt-tolerant species. Increased salinity also favours certain blue green algae, thus increasing the likelihood and severity of algal blooms (Parks Victoria 2001). There is firm evidence that the biological status of Lake Corangamite has changed due to increased salinity and that it may no longer satisfy the criteria that formed the basis of its selection as a wetland of international importance under the Ramsar Convention (Williams 1992; 1995).

Much research has concentrated on salinity and relationships of salinity and fauna of the Western District Lakes. The increasing salinity levels of Lake Corangamite and some surrounding lakes is primarily due to altered water regimes. This has been shown to have a major effect on the composition of the biota - from one characteristic of a moderately saline lake to biota characteristic of a highly saline lake (Williams 1995). The change in salinity has resulted in the loss of major food sources for waterbirds including *Coxiella* (Gastropoda), *Austrochiltonia subtenuis* (Amphipoda), *Galaxias maculatus* (Pisces) and *Ruppia* (macrophyte), reducing the lake's ability to support a diverse avifauna. The number and abundance of waterbird species visiting the lake have consequently fallen and large concentrations of waterbirds have primarily been recorded in the vicinity of freshwater springs as the main waterbody becomes increasingly saline (DCE 1991). Numbers of colonial nesting species including Pelicans, Ibis, Spoonbills and Cormorants have decreased in recent years as a result of increasing salinity (Williams 1995).

All studies of fauna in salt lakes suggest a relationship between salinity and species diversity. The distribution of many water dependant bird species can be linked to the distribution of potential food, particularly as it is influenced by salinity (Corrick 1982). The upper salinity tolerances of various species of potential food for waterbirds are listed in Table 2.7.

Table 2.7 Upper salinity tolerances of aquatic plants and fauna.

Species	Upper salinity tolerance (parts per thousand)
Fish	
(*Galaxias maculatus*)	30 ppt
Aquatic Fauna	
Gastropoda (*Coxiella*)	100 ppt
Insecta	90-120 ppt
Isopoda (*Haloniscus*)	159 ppt
Ostracoda (*Platycypris*)	176 ppt
Anostraca (*Parartemia*)	298 ppt
Plants	
Ruppia	60 ppt
Lepilaena	65 ppt

(Source: Bayly & Williams 1966; Corrick 1982; Anon. 1986; Williams *et al.* 1990; Williams 1995)

Table 2.7 indicates that fish-eating species such as Grebes, Cormorants and Pelicans would be confined to salinities of less than 30 ppt. Grazing species such as Swans and Coots will not occur at salinities greater than 60 ppt unless they can feed on grassland above the waterline, and species feeding on benthic organisms such as Hardheads will be excluded from waters greater than 100 ppt. The prey of birds feeding on highly saline waters would be restricted to only a few species of microcrustaceans. This has been noted at Lake Beeac where large numbers of Banded Stilt and Red-necked Avocets have been recorded feeding on abundant brine shrimp (Anon. 1986; Anon. 1987; Williams 1992).

Secondary salinisation as a result of extensive tree clearing affects the Corangamite Basin by increasing the salinity of surface and groundwater entering lakes and wetlands within the region (ACIL Australia 1983; Nicholson *et al*. 1992; Parks Victoria 2001; Williams 2001). The extent of impacts to wetlands through secondary salinisation is currently unknown. Salinisation appears to be most threatening to lakes and wetlands that are naturally saline to some degree, where the threat is increased salinity to a level where the biological values of the lake are compromised. There was no indication in the literature that salinity was a major threat to freshwater meadows and marshes throughout the Corangamite region.

Trends and management implications

Research suggests that salinity is increasing in many lakes within the Corangamite region, some to levels where the biological values and the lakes are compromised. The affects of salinity on the majority of wetlands are unknown due to the lack of available data.

Closed drainage basins, which occur within the Corangamite region, require different management regimes than open drainage basins. Closed basins (usually saline lakes) naturally undergo extensive fluctuations in volume, area and salinity (Williams 1992) and many plant and animal species have adapted to withstand significant changes in salinity. However, higher than average salinity levels maintained over a longer period of time (as a result of water regulations) can have significant effects on the biological integrity of lakes.

Managing wetlands at a salinity level that best supports the invertebrates, which form the basis of the food chain in saline lakes, has been suggested by Williams (1992) and Coram (1996). Williams (1992) stated that there was a salinity level at which the food base for birds in lakes flourished and that this level should be the maxima which should be allowed to occur if the lake is to be managed for maximum numbers and diversity of bird life. This

would require managing water levels within lakes and the re-establishment of more natural water flows.

Further investigation into effects of dryland salinity on shallow freshwater wetlands within the Corangamite region is required to determine the extent and potential management of the threat. Water quality monitoring is also important to determine impacts of salinity throughout wetlands in the Corangamite region.

Regulation of water flow

Water diversion and regulation schemes have altered the natural water regimes of many lakes within the Corangamite region including most of the nine lakes that form the Western District Lakes. The impact of these changes has been most evident at Lake Corangamite where salinity has risen, water levels have fallen and the composition of the biota has changed (Williams 1995; Parks Victoria 2001). Water regimes have been altered in the Barwon River Catchment, particularly increased water extraction. Flows down the Barwon and Moorabool Rivers are important to the health of Lake Connewarre and associated wetlands, and to the availability of water for regulating levels in Reedy Lake (Parks Victoria 2002). The impacts of altered flows on the marine environment of Port Phillip Bay have not been well documented (Parks Victoria 2002).

The Woady Yaloak diversion scheme was constructed in 1959 to relieve flooding of agricultural land from Lake Corangamite during a period of high rainfall (DCE 1991; Williams 1995). The lakes major inflow river, the Woady Yaloak, was diverted into the Barwon River in order to maintain the lake at the lowest possible level to minimise the chance of flooding (DCE 1991). The scheme has significantly reduced the water level of the lake, which has caused salinity levels to rise (see Section 2.3.1). The changes have been most profound since 1980, where salinity levels have doubled and water levels have fallen by nearly two metres, eliminating islands that formerly served to protect nesting and roosting waterbirds from terrestrial predators (Williams 1995).

Under the current hydrological management regime, salinity will continue to rise creating a hypersaline lake and increasingly larger areas of the lakebed will become exposed (Williams 1995; Parks Victoria 2001). DCE (1991) predict that under current operating conditions the lake will become biologically dead within a few decades. The biological and agricultural values of exposed lakebed are low and salt blown from the dry lakebed may reduce agricultural production in surrounding areas (Williams 1995). Both DCE (1991) and Williams (1995) have provided recommendations for increasing the water level of the lake to limit periods of high salinity to exceptionally dry seasons.

Other hydrological modifications that have affected water regimes within lakes and wetlands of the Corangamite region include the following (Parks Victoria 2001; 2002):

- Artificially lowered outlets as a result of drainage works and accelerated soil erosion.
- Dam construction preventing natural water flow between wetlands.
- Modification of infrastructure – e.g. raised banks of an adjacent public road has increased the height and duration of flood events from Lake Milangil and retarded natural water flow between other lakes.
- Clearing of surrounding land for agricultural production has increased surface water runoff in some areas contributing to high water levels (Lake Beeac Catchment Plan Steering Committee 1998), and increasing sediment load and levels of nutrients entering a number of wetlands (Parks Victoria 2002).
- Increased number of farm dams within the landscape lower the available water run-off from local catchments that would under normal circumstances flow into wetlands.

The impacts of the above hydrological modifications are unknown (Parks Victoria 2001). However, the fundamental functions of wetlands are dependent upon the maintenance of appropriate water regimes (Platt & Corrick 1994). Changes in water regime may alter

wetland appearance and function, disrupting the natural productive cycles causing changes in vegetation and habitat (DCFL 1986).

Trends and management implications

Increasing demands on water supplies have resulted in a decrease of water available to some wetlands and an increase to other waterbodies used as reservoirs and farm dams. A significant amount of water, which would have been available to shallow freshwater wetlands, has now been diverted into farm dams. Water regulation schemes and storage dams throughout the Corangamite region have largely eliminated flooding as a natural process.

Further research on the effects of water regulation on the values of wetlands in the region and would assist to determine suitable management actions, including appropriate controls on water regulation.

Vegetation clearance

The clearing of adjacent wetland vegetation has been identified as a threat to wetlands. Loss of terrestrial vegetation can increase catchment run-off, which contributes to increased sedimentation and nutrient input to wetlands and the loss of habitat for wetland-dependant fauna species (Environment Australia 2001). The removal of Woolly Tea-tree (*Leptospermum lanigerum*) from heathland wetlands for example has been recorded as a threat to Princetown wetlands and the Lower Aire River wetlands (Environment Australia 2001).

Trends and management implications

The prevention of further vegetation clearance through appropriate regulation would limit further degradation. Revegetation of degraded wetlands initiated through education programs has also been suggested by Platt and Corrick (1994). Greening Australia has implemented re-vegetation of shorelines of many of the Western District Lakes sites, with use of Green Corps teams (A. Burns pers. com. 2003).

Pest plants and animals

Weed species threaten wetland ecosystems by displacing native shoreline vegetation (Platt & Corrick 1994). If not controlled, pest plants may dramatically alter the structure and composition of remaining native plant communities, potentially leading to a loss of indigenous plant species and changes in habitat characteristics for indigenous fauna (Parks Victoria 2002).

A total of 149 environmental weeds of herb-dominated freshwater wetlands and 42 of shrub-dominated freshwater wetlands have been identified (Carr *et al.* 1992). A significant proportion (38.7%) of all flora records within wetlands of the Corangamite region were identified as exotics or environmental weeds (DNRE 2002b). The large percentage of exotic species recorded on wetlands reflects the degraded nature of many wetlands within the region where some shallow wetlands have been reduced to little more than flooded pasture grasses (Australian Biological Research Group 1988).

In the Corangamite region, some introduced pasture species including Tall Wheat Grass (*Lophopyrum ponticum*), *Phalaris* species and Sweet Vernal-grass (*Anthoxanthum odoratum*) have been identified as threats to the Western District Lakes (Parks Victoria 2001). Spiny Rush (*Juncus acuta*) has been identified as the most significant threat to conservation values for the Western Treatment Plant (Parks Victoria 2002), and Cord Grass (*Spartina* spp.) was known to seriously degrade habitats for waterbirds, particularly shorebirds, by occupying and rendering unsuitable both feeding and roosting areas (Lane 1991).

Exotic flora species can also provide harbour for pest animals including foxes, feral cats, rabbits and introduced birds that prey upon or compete with native fauna for food and habitat. Predation of native wildlife by foxes and cats is known to impact many wetland-dependant species including:

- Reptiles, including the endangered Corangamite Water Skink (DNRE 2002a);
- Amphibians, including the endangered Warty Bell Frog (DNRE 2002a); and
- Waterbirds, particularly ground-nesting and ground-dwelling species, including Brolga, Red-capped Plover, Straw-necked Ibis, Great Cormorant, Pied Cormorant, Australian White Ibis, Black Swan, Pelican, Silver Gull and Gull-billed Tern, and moulting waterfowl (many ducks are flightless when moulting).

The impacts of foxes and cats on wetlands within the Corangamite region has not been documented, however they are likely prey upon a range of small mammal, bird and reptile species (Parks Victoria 2001).

The introduced Carp, which have been recorded in permanent lakes within the Corangamite region, are thought to impact on native fish diversity and to contribute to water quality problems (Williams 1992).

Trends and management implications

The occurrence of pest flora and fauna, and the extent of their impacts on the values of the wetland have not been well documented. Future inventories should provide information on weed species presence to allow analysis of the nature and extent of weed infestation in wetlands throughout the region.

Weed infestation in wetlands on private property many not be perceived as being important to wetland values as many exotic species occurring in these areas are likely to be pasture species, or species that do not present a threat to the agricultural values of the land. Weed management within wetlands has been addressed by Platt and Corrick (1994) who identify a need to provide wetland weed management information to landholders.

Vermin control programs should be incorporated into management plans for wetlands (Platt & Corrick 1994). Further research into the effects of Carp on wetlands within the Corangamite region would assist to assess the impacts and extent of the problem.

Lead contamination

Contamination of wetlands from the accumulation of lead shot was considered an environmental risk and was listed as a threatening process under the *Flora and Fauna Guarantee Act 1988*. Both publicly owned wetlands open to duck hunting and privately owned wetlands where the landholders allow access to hunters were at risk of lead contamination to varying degrees (DNRE 1992; Parks Victoria 2001). Wetlands most at risk of excessive lead deposition were those most popular with hunters – Lakes Corangamite, Murdeduke, Gnarpurt, and Colongulac. However, as waterbirds are generally highly mobile species, the affects of lead poisoning have not been confined to contaminated wetlands.

Lead is not quickly released into the environment and does not accumulate in water or vegetation, but remains in the sediment where it may be ingested by waterfowl or other birds. Waterfowl that feed on the bottom of wetlands, such as the deep diving Blue-billed Duck, Musk Duck, and Pacific Black Duck are at greatest risk of lead poisoning. However, lead poisoning could affect all waterbirds and fish that ingest lead shot, including scavengers and predators eating these species (DNRE 1992).

Lead poisoning of Victorian waterbirds has been investigated by the Department of Conservation and Environment on wings, gizzards and livers of ducks shot over the opening weekend of the 1990 duck season. This study found that over 14% of all ducks examined had ingested lead pellets, many at fatal doses (DNRE 1992). Pain and Rattner (1988) found that the ingestion of only one lead shot pellet may be sufficient to kill a bird.

No major outbreaks of lead poisoning in Victorian waterfowl have been reported, although monitoring of affects was difficult where poisoned birds tend to be secretive and predators and scavengers remove dead or dying birds (DNRE 1992).

Trends and management implications

The use of toxic lead shot (with some minor exemptions) was prohibited for duck hunting for the 2002 season and all subsequent duck opening seasons in Victoria (Parks Victoria 2002). This measure should reduce the potential for lead poisoning of wetland fauna.

Other measures to reduce the occurrence of lead poisoning were investigated by Mudge (1992) and included land cultivation, management of water levels and provision of grit. However, these methods were only temporary and largely inappropriate for the majority of wetlands affected.

Monitoring the incidence of lead poisoning in waterfowl has not continued in Victoria, however the incidence of poisoning was assumed to decrease following the banning of lead shot and given sufficient time for already deposited lead shot to become less prevalent within wetland ecosystems (DNRE 1992).

Pollution

Draft Strategic Management Plans for the Western District Lakes (Parks Victoria 2001) and Port Phillip Bay (Parks Victoria 2002) Ramsar sites provide a comprehensive account of pollution issues relevant to the Corangamite region. Some of the major issues within the region are outlined below.

Lake Colongulac currently receives discharge from Camperdown Sewage Treatment Works, Bonlac Foods and Camperdown Abattoir. These wastes have high Biological Oxygen Demand (BOD), suspended solids and dissolved organic matter. Pollution in the lake has resulted in a decrease in the number and diversity of native flora and fauna, eutrophication and diminished recreational and aesthetic appeal. There are also potential health risks to humans (Bookaar Eel Culture Pty. Ltd. 1983). Leaching from a rubbish dump into Lake Beeac has also been identified.

Port Phillip Bay Ramsar wetlands receive large amounts of pollutants including sewage discharge points and storm water. Storm water is a major contributor of litter, oils and heavy metals and represents potential risks to Reedy Lake and southern Swan Bay (Kefford 2000; Parks Victoria 2002). Untreated sewage leaks have been known to occur within the region.

The use of fertilisers and pesticides on agricultural land (particularly spraying) may also affect the water quality of many small wetlands throughout the Corangamite region (DCFL 1986; Norman & Corrick 1988). However, the extent of water quality issues in wetlands throughout the region is poorly known with the exception of most publicly owned lakes.

Trends and management implications

Licensing and monitoring of waste discharges into waterbodies is a responsibility of the Environment Protection Authority (EPA Victoria 2002). Monitoring programs involve the routine sampling of receiving waters and analysis of these samples for a wide range of water quality indicators. These results indicate whether water quality objectives are being met and whether the quality is improving, worsening or remaining stable over a given period. This information can then be used to decide whether additional pollution control measures are required (EPA Victoria 2002).

The sensitive use of pesticides and fertilisers by private landholders should be encouraged and best practice management awarded. Practices such as aerial spraying of wetlands, which can lead to spray, drift and run-off affects should be discouraged through education programs.

Human disturbance - recreational

Recreational activities including duck hunting, fishing, boating and trail-bike riding have been identified as threatening processes to some wetlands and lakes within the Corangamite region (Environment Australia 2001). Recreational damage is primarily a threat to the larger, deeper and publicly owned wetlands and lakes. Privately owned wetlands were not noted to be greatly affected by recreational activity.

The impacts of duck hunting on particular site values have not been determined (Parks Victoria 2001), however hunting can create both physical and noise disturbance to fauna and result in the accidental shooting of protected species. Accumulation of litter, including spent shells, and disturbance to shoreline vegetation from camping, trampling and hide construction are also associated with duck hunting (Parks Victoria 2001).

Recreational fishing is a popular activity on some of the deeper lakes and estuaries of the region. This has created localised problems associated with litter, fires, discarded fishing line and plastic packaging entangling waterbirds, human waste, and disturbance to shoreline vegetation.

Recreational activities (including fishing) also create significant disturbance to feeding, roosting and breeding birds (Parks Victoria 2002). Martindale (1982) states that disturbance to roosts can displace populations and may have several undesirable consequences, including:

- Removal of birds further from their feeding grounds, which may result in mortality, especially among migrating species.
- Inadequate roosts to accommodate larger populations at other locations, resulting in increased competition and mortality.
- Loss of highly specialised species that have adapted to particular areas that will likely be out competed by generalist species.
- Little information on the extent or impacts of recreational activities is available (Parks Victoria 2002).

Trends and management implications

Increasing population size and the proximity of wetlands of the Corangamite region to metropolitan areas such as Melbourne, Geelong, Ballarat and Colac and the potential for eco-tourism has resulted in increasing recreational pressure on large wetlands within the region. This has significant implications for management where increased enforcement and regulation of activities will be required (Norman & Corrick 1988).

Management of recreational activities including regulation of hunting activities and fishing catch limits in addition to visitor interpretation and education programs have been established (Parks Victoria 2001). Exclusions and seasonal closures of sensitive areas to recreational activity have also been implemented. This includes the closure of lakes in the incidence of significant populations of threatened species (e.g. Freckled Duck) and the presence of enforcement and monitoring of recreational activities.

Commercial development

Residential development is currently threatening wetlands close to existing developments. These include Ramsar wetlands near Werribee, where housing expansion and further development has the potential to negatively impact the site (Parks Victoria 2002). Although a large proportion of the Ramsar site north of the Werribee Treatment Plant has relatively low ecological value in comparison with other areas, it provides a valuable buffer zone that contributes to the protection of high value wetland areas.

Potential impacts from residential and commercial development in the area include urban runoff contributing to the pollution of the Werribee River, and the risk of wandering domestic animals impacting on the site (Parks Victoria 2002).

Trends and management implications

Protection of the values of the Port Phillip Bay Ramsar site from commercial development was implemented through planning processes, including environmental safeguards. The development of the area must take into consideration the conservation and wise use objectives that are an obligation under the Ramsar Convention (Parks Victoria 2002). Similar environmental safeguards would be important to mitigating impacts of residential development near other wetlands in the region.

2.3.2 Summary of trends

Corrick (1982) noted that wetlands in the Corangamite region have declined substantially in both area and condition since European settlement. Drainage of wetlands was clearly continuing, and smaller shallow freshwater meadows and marshes appear at the greatest risk. Significantly, the most numerous wetlands in private ownership are freshwater meadows and marshes. These incorporate 84% of the total number and 53% of the total wetland area throughout Victoria (Corrick 1995). Norman and Corrick (1988) state that loss of natural wetlands will continue unless action is taken to protect remaining wetlands. The current rate of drainage and modification is unknown and largely unregulated on private property within the Corangamite region.

Salinity in many lakes has been shown to be increasing, and the trend has been most pronounced in Lake Corangamite since 1980 (Williams 1995). The occurrence of pollution and eutrophication of lakes within the Corangamite region has been common. Water quality and artificial water levels have been thought to contribute to the decline in the values of lakes and wetlands (Corrick 1982; DCE 1991).

There is generally little information on the extent and implications of threatening processes identified for wetlands of the Corangamite region. This could be attributed to the distribution of data, where the threats and status of the majority of wetlands within the region are unknown. It was therefore difficult to identify trends in wetland status and the overall condition of wetlands.

2.3.3 Summary of management issues and implications

The Australian Biological Research Group (1988) identified the conservation values of wetlands as a vital tool for planning and management. Planning was concerned with the establishment of priorities for action and the optimum allocation of resources to achieve defined goals. The need for systematic reservation of wetland types in areas of sufficient size and number to ensure adequate representation of each ecosystem and its associated communities has also been identified (Corrick 1995; Norman and Corrick 1988).

In addition, threats to wetlands require management to minimise or eliminate further impacts and incentives should be investigated to ensure wetland continuance on private property (Norman & Corrick 1988; Harding 2001). Financial incentive payments, covenants and rate-rebates for land managed for conservation purposes have been investigated (Binning & Young 1999) and could be utilised for encouraging the conservation of wetlands within the Corangamite region.

Australia has national and international commitments to protect important wetlands (McComb & Lake 1988). Wetlands that are recognised by the Ramsar Convention (Western District Lakes and Port Phillip Bay) that support species listed under Japan-Australian migratory Birds Agreement, and the China-Australia Migratory Birds Agreement have important, representative, unique or outstanding features and their protection depends on the maintenance of hydrological processes (Gippel 1996).

2.4 Nature and extent of gaps in the information base

2.4.1 Inventory

The most complete wetland inventory data existing for the Corangamite region originated from surveys conducted by Corrick (1982) that were digitised to form the Wetlands Database (DCNR 1995). Wetlands identified by Corrick have been used within various other databases for differing purposes (Dale & Myers 1984; Australian Biological Research Group 1988). Figure 2.6 illustrates the distribution of wetlands recorded in the database throughout the Corangamite region. Notably the largest areas of wetlands occur in the Western District Lakes area and comprise many large permanent saline lakes. The number of wetlands within the region are unknown, as many wetlands smaller than 1 ha are not shown in the database (Figure 2.6).

The wetland data contained in this database has several limitations including:

- Wetlands under 1 ha in area are not included, thus a significant proportion of the region's wetlands are not represented.
- River floodplains that are inundated only during floods were excluded.
- The classification of wetlands is very broad and may not reflect the representativeness of wetland types within the region.
- The database is now out-dated, whereby significant changes in wetland area and classification are likely to have occurred due to further drainage, changes in climate, and water regulation.
- Fields within the database fail to identify values, threats and general condition of each wetland, limiting its usefulness for management purposes.

Information contained within National and International wetland inventories (Environment Australia 2001; Ramsar Convention Bureau 2002) for the Corangamite region typically include wetlands that are large, easily accessible, or unusual in some way. Significant amounts of data are available for these wetlands including lists of known values, threats and management recommendations.

Figure 2.6 Distribution of wetlands inventoried for the Corangamite region (Source: DCNR 1995).

It is apparent that an adequate wetland database is required that not only provides location and area data, but also includes meaningful wetland classifications, values, threats and an indication of wetland condition. Mapping at a finer scale that also identifies wetlands less than 1 ha in size is also desirable.

Classification

The usefulness of wetland inventory data for the selection of high value wetlands and the allocation of funding resources is dependant on the classification system adopted. The Corrick classification system is restricted because all wetlands of one classification (e.g. Herb-dominated freshwater meadows) were assumed to have similar ecological values. However, wetlands of the same category as defined by Corrick (1982) were shown to differ between geomorphological regions (Shaw *et al.* 1990). Shaw *et al.* (1990) state that hydrology, climate and water chemistry are also important in classifying wetlands. Therefore, significant flaws and gaps in the current classification system used throughout the Corangamite region exist. There is a need for more detailed classification to achieve full representation for the requirements of management and resource allocation. Minimum data sets for wetland inventory have been suggested by many authors (Cowardin *et al*. 1979; Paigmans *et al*. 1985; McComb & Lake 1988; Shaw *et al*. 1990; Beilharz 1996) and the requirement for a data set specific to the Corangamite region and to meet management objectives is acknowledged.

Table 2.8 gives fields for minimum data sets suggested by Beilharz (1996) and the ANPWS (n.d). The Wetlands Database (DCNR 1995) indicates deficiencies in meeting minimum data requirements, including many fields that are listed as essential. Wetlands listed under the Ramsar Convention and the Directory of Important Wetlands are more extensively covered, however the data exists as descriptive text and is not easily incorporated into a database form useful in Geographic Information System analysis.

Table 2.8 Minimum data sets for wetland inventory (Source: ANPWS n.d; DCNR 1995; Beilharz 1996; Environment Australia 2001; Ramsar Convention Bureau 2002).

Minimum Data Set	Wetlands Database	Directory of Important Wetlands - Australia	Ramsar Directory of Internationally Important Wetlands
Wetland identification and location			
Accurate location – Australian Map Grid (AMG) Reference	◆	◆	◆
Name of wetland – if known		◆	◆
Compilers details		◆	◆
Date and time	◆	◆	
Essential information			
System – inland or marine		◆	◆
Biophysical region			
Morphology		◆	◆
Geomorphic origin		◆	◆
Water regime – frequency and duration of flooding	◆	◆	◆
Water chemistry - pH, salinity, conductivity, colour, turbidity			
Dominant plant growth form	◆	◆	◆
Area	◆	◆	◆
Land status – tenure/conservation status	◆	◆	◆
Desirable information			
Landuse – local and the catchment		◆	◆
Threatening processes		◆	◆
Species presence		◆	◆
Groundwater – depth/salinity			
Wetland type	◆	◆	◆

Minimum Data Set	Wetlands Database	Directory of Important Wetlands - Australia	Ramsar Directory of Internationally Important Wetlands
Land tenure		◆	◆
Conservation/management status		◆	◆
Climatic region		◆	◆
Elevation		◆	◆
Rare and threatened species present		◆	◆

Condition

Condition assessment of wetlands has not been undertaken for the majority of wetlands within the Corangamite region, thus compromising the capacity of managers to allocate resources. Rutherford *et al.* (1999) suggests priorities for conservation that take into account the following features: rarity (rare before common), condition (good before bad), trajectory (deteriorating before improving) and ease to fix (easy before hard). However, in order for a system of resource allocation such as this to work, increased information on the majority of wetlands in the Corangamite region is required.

Wetlands listed on the Directory of Important Wetlands (Environment Australia 2001) and Wetlands listed under the Ramsar Convention (Ramsar Convention Bureau 2002) contain information on the general condition of each wetland, although the same level of information is unavailable for all other wetlands. The development of a condition index for wetlands such as described by Spencer *et al*. (1998) would require significant amounts of information to be obtained for the majority of wetlands where no data currently exists.

An index of wetland condition for Victoria is currently being investigated by the Department of Sustainability and Environment (Holmes & Papas, in prep). This document suggests that indicators should possess most of the following attributes:

- Universal (state-wide) applicability;
- A reference condition available or easily determined;
- Integrates the effects of natural and temporal variation;
- Be responsive to condition change at short and medium scales;
- Be repeatable in their measure;
- Be unambiguous in their interpretation;
- Have a known relationship with condition;
- Be cost effective and simple to apply;
- Be biologically relevant;
- Not have frequent measurements required;
- Be simple or commonly measured parameter;
- Be non-destructive on the ecosystem; and
- Have results that can be understood by people who are not experts in wetland assessment.

These 'attributes' will assist in the assessment of indicators for the Index of Wetland Condition for Victoria.

2.4.2 Values

Values assessment for wetlands in the Corangamite region has been restricted to those wetlands listed under national and international inventories. Thus, specific values for the majority of wetlands are generally unknown. The distributions of existing flora and fauna records can be analysed using the Atlas of Victorian Wildlife (DNRE 2002a) and the Flora

Information System (DNRE 2002b). Figure 2.6 illustrates the distribution of survey records within wetland types identified by Corrick (DCNR 1995) (refer to Table 2.3 for category descriptions). Appendix 5 provides associated data.

There are generally few flora and fauna survey records for the region's wetlands. The exception is Salt Works (Category 21) where all identified wetlands in this category (3 wetlands) contain records. Freshwater meadows (Category 2), shallow freshwater marshes (Category 3) and permanent open freshwater (Category 5) have the least records (Figure 2.7). This may be due to the substantial number of freshwater meadows and shallow freshwater marshes that occur on private property, which are less likely to be surveyed. The low survey numbers for permanent open freshwater reflects the number of farm dams within this category. Farm dams are less likely to contain survey records due to their relative inaccessibility (usually within private property) and their unappealing nature to scientists and naturalists.

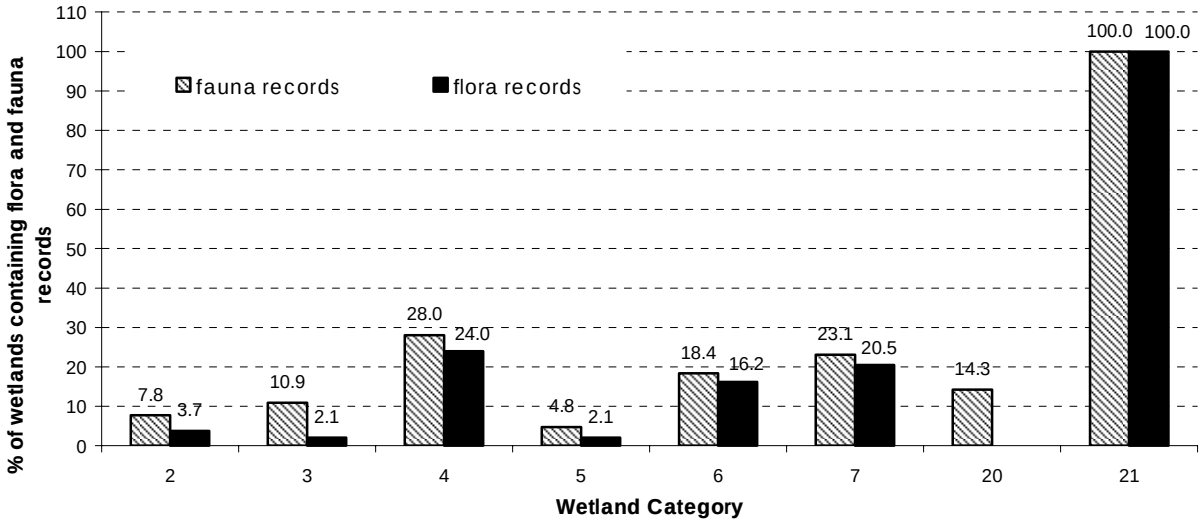


Figure 2.7 Percentage of wetlands within each wetland category containing flora and fauna records (refer to Table 2.3 for wetland category description. Source: DCNR 1995; DNRE 2002a; DNRE 2002b).

Given the value placed on rare species and communities, more detailed floristic and faunal information is required in wetland surveys. Without such information, attributes such as diversity or rarity cannot be assessed.

Figure 2.8 illustrates the spatial distribution of survey effort on wetlands throughout the Corangamite region. Notably, the highest numbers of waterbird and flora records are in the area of Ramsar wetlands. This may reflect greater numbers of waterbirds in these areas or increased survey effort. Flora records are not as numerous as waterbird records throughout the region, indicating the lack of flora survey on wetlands. The majority of privately owned wetlands contain no survey records.

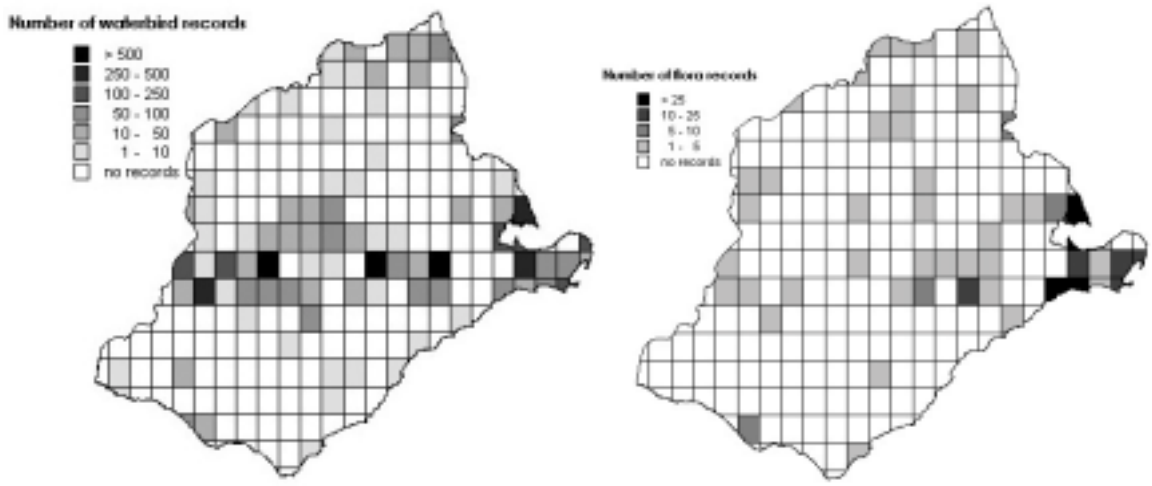


Figure 2.8 Distribution of waterbirds and flora records on wetlands within the Corangamite region (Source: DCNR 1995; DNRE 2002a; 2001b).

2.4.3 Threats

There appears to be adequate knowledge of the range of threats to wetlands within the Corangamite region, particularly with regard to larger waterbodies. However, there is insufficient data on the majority of wetlands to identify the extent of threats and impacts to the overall integrity of different wetland types within the region. There is a need for future inventories to identify current and potential threatening processes in order to gain a better understanding of the extent of threats and priorities for management.

Williams (1992) and Appleby (1991) indicate that considerable long term monitoring is required to develop an understanding of the subtle changes to wetlands that occur throughout the Corangamite region as a result of increased salinity levels. Codd (1992) identified flora and fauna surveys, water level monitoring, water quality monitoring, restoration and protection of wetland vegetation as high priorities within the Corangamite Salinity Region.

Knowledge concerning threats such as the impact of grazing on wetlands and the management of beneficial grazing regimes was limited.

The impact of identified wetland threats on populations of both plant and animal species also requires further investigation (Norman & Corrick 1988). Priority conservation and adequate habitat reservation is recommended for highly threatened communities or species (Norman & Corrick 1988).

3. CORANGAMITE WETLAND INVENTORY

3.1 Method

Wetland inventory is the process for determining and recording the location, number and specific characteristics of wetlands within a given area (Costa *et al.* 1996). The Corangamite Wetland Inventory recorded data such as wetland location and size, physical and biological features, human activities and impacts, and wetland function and values for the Corangamite region. Digital databases linked to spatial wetland boundary data in Geographic Information System (GIS) format were created to store information gathered through the inventory process.

Figure 3.1 illustrates the steps involved in developing a wetland inventory for the Corangamite region. The inventory process was divided into four phases:

- Phase 1 – Review of current information and inventories within the study area (Section 2);
- Phase 2 – Development of an assessment protocol and sampling design for assessing wetlands;
- Phase 3 – Mapping of wetland areas, field survey and database development;
- Phase 4 – Analysis of wetland data.

3.1.1 Protocol development

Based on the rationale presented in the review report (Phase 1, Section 2) and from the analysis of above mentioned wetland inventory and survey techniques, the Corangamite Wetland Inventory aimed to develop a wetlands survey protocol that:

- Is consistent with existing State, Commonwealth and International assessment protocols;
- Provides a rapid assessment of wetlands values, character, condition and threats that is easily applied by both specialists and non-specialists;
- Maximises the value of data collected (where value is defined in terms of usefulness in guiding management activities, project implementation and funding decisions);
- Provides standardised field data collection sheets; and
- Is capable of regular revisions and updates of information providing for future long-term analysis.

A survey protocol was developed specifically for the Corangamite Wetland Inventory allowing the rapid collection of essential biological and physical quantitative data including subjective assessments of selected wetlands.

Numerous existing wetland inventory methods were researched and elements of all were adapted to suit the specific requirements of the Corangamite Wetland Inventory. Table 3.1 lists particular wetland inventories adapted for the Corangamite Wetland Inventory. A draft protocol was formulated and edited by several wetland ecologists and members of the field survey team before the final protocol was set.

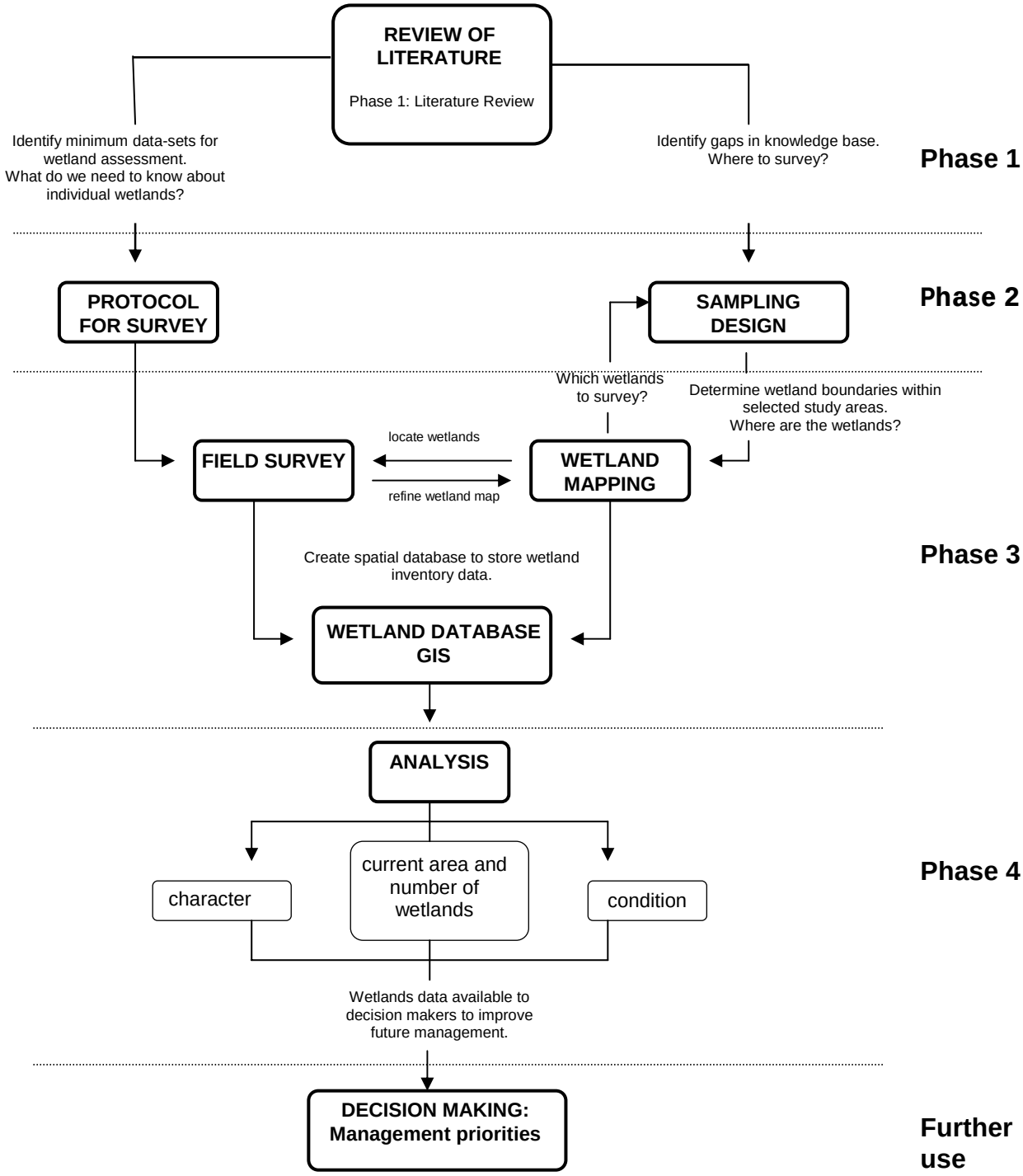


Figure 3.1 Method for the development of the Corangamite Wetland Inventory.

Table 3.1 Existing wetland inventory methods used in the development of the Corangamite Wetland Inventory.

Title	Reference
Simplified method for wetland habitat assessment.	Cable *et al.* 1989
Techniques for survey, inventory and classification. In: *Manual of Wetlands Management*.	Beilharz 1996
Mediterranean Wetland Inventory: A Reference Manual.	Costa *et al.* 1996
Development and testing of a rapid appraisal wetland condition index.	Spencer *et al.* 1998
Rapid Assessment of Vegetation Condition: development and trial of techniques.	Leversha *et al.* 2001
A Manual for an Inventory of Asian Wetlands: Version 1.0.	Finlayson *et al.* 2002
A Ramsar framework for wetland inventory. In: *Wetlands: water, life, and culture*.	Ramsar Convention Bureau 2002
Wetland Inventory for the Mount Lofty Ranges.	Seaman 2002a

3.1.2 Wetland site selection and sampling procedure

The Corangamite Wetland Inventory protocol was designed to focus on defining and describing wetlands at the "habitat" scale. Differing wetland habitats can occur in the same wetland complex, and have variable characteristics. For example, wetland habitats may not necessarily experience the same water regime, ecological characteristics or require/undergo the same form of management (Finlayson *et al.* 2002). Thus, many of the larger wetland complexes were assessed in sectors where habitats and management related issues were variable. Figure 3.2 illustrates wetland site selection for differing wetland complexities.

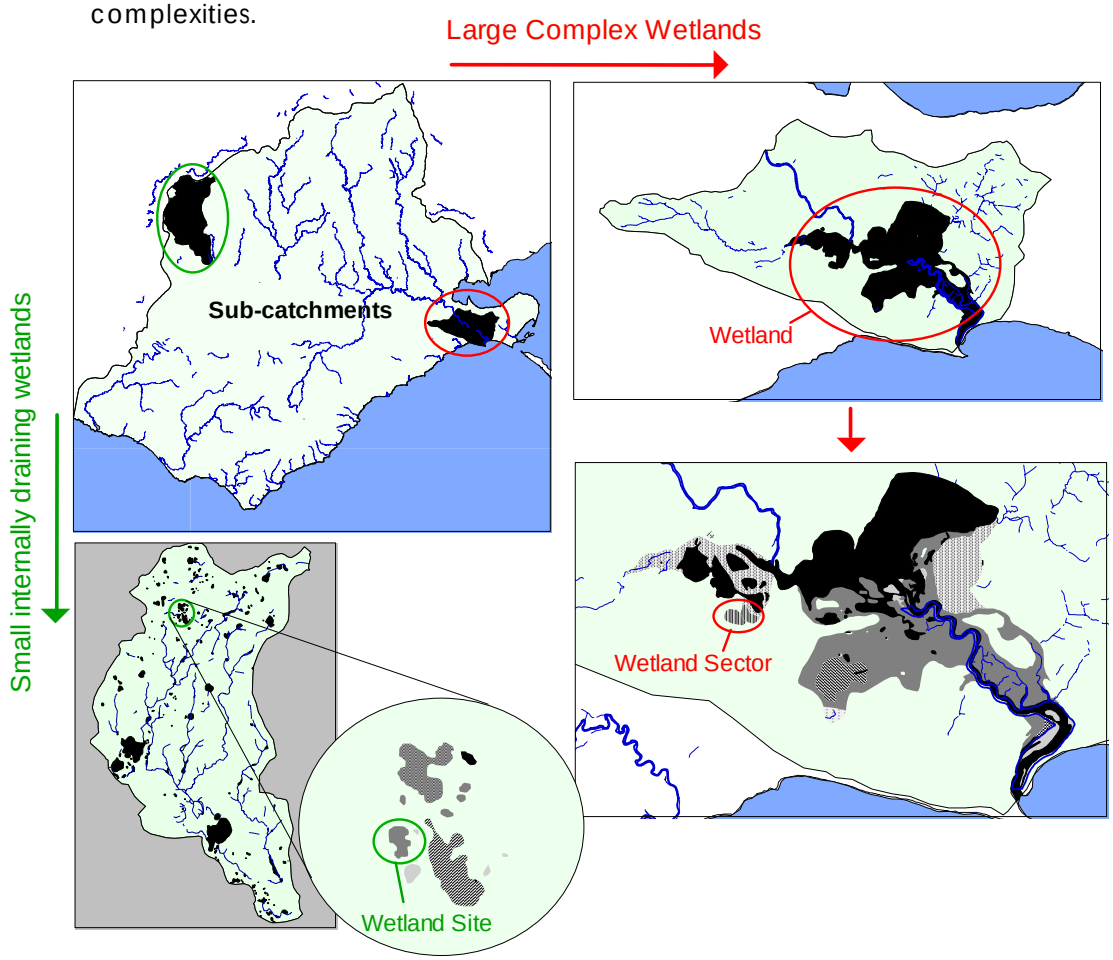


Figure 3.2 Defining wetland sites for field survey.

A sampling procedure was designed to sample a broad range of wetland types across the Corangamite region. Due to the very large study area, bounded regions were chosen to concentrate mapping and survey effort. Rectangular land areas or administrative units are usually deficient in ecological meaning (Liu *et al.* 2003) and inappropriate for the comparison of wetland values. Thus, sub-catchments (or local watershed areas) were used as the boundaries for the survey efforts (Figure 3.3). Sub-catchment boundaries refer to an area of land that drains to a common point. As wetlands are dependant on hydrological processes and are easily impacted within the water catchment area, wetland assessments concentrated on individual sub-catchments provided meaningful data on wetland condition and processes.

Figure 3.3 shows the sub-catchment boundaries within the Corangamite region. Shaded areas indicate sub-catchments included within this inventory and include:

- Salt Creek Catchment;
- Kooraweera Lakes Catchment;
- Dereel Catchment;
- Warrambine Creek Catchment; and
- Connewarre Catchment.

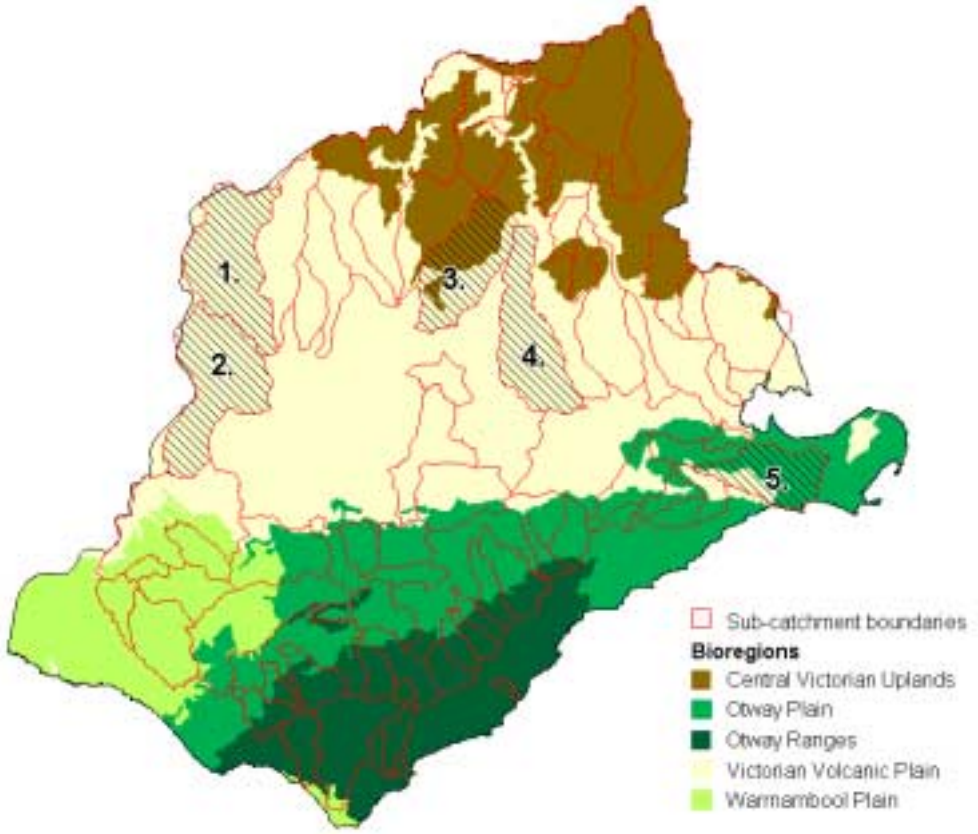
A number of factors were considered when choosing the sample sub-catchments:

- Bioregion type; influences the geology and plant communities likely to be present;
- Areas known to be lacking in wetland data;
- Areas known to contain threatened wetland ecosystems;
- Accessibility to sites on private land;
- Proximity to wetlands listed under the Ramsar Convention; and
- Cost-effectiveness.

Additional factors such as time constraints, accessibility and the project budget limited the number of wetlands that were physically surveyed. Thus, it was impractical to survey all wetlands within the chosen sub-catchments. It was also impractical in most instances to randomly select wetlands to be surveyed due to inaccessibility and lack of water in many of the wetlands due to abnormally dry conditions over the study period.

A total of 96 physical wetland surveys were completed within the five sub-catchments sampled. (An additional 10 surveys were conducted in areas outside the sub-catchments of interest, and have not been included in analysis). The number and types of wetlands surveyed within each sub-catchment was distributed with respect to both the number and the area of wetlands within each sub-catchment. This was achieved by calculating the total perimeter of all wetlands within each sub-catchment and for each wetland type identified (Figure 3.3). All calculations were performed using digital wetland boundaries produced through the mapping process (see Section 3.1.3). The wetland surveys allowed for were then distributed proportionately between the five sub-catchments and between respective wetland types identified through the remote sensing procedure described in Section 3.1.3.

Ideally, a larger number of wetlands within each sub-catchment should be surveyed to provide a more comprehensive analysis of the wetland resources for each area. More surveys were not allowed for within the scope of this project, however further wetland assessments can easily be incorporated into the inventory wetland database created through the Corangamite Wetland Inventory process.



Sub-catchment Name	No. of wetlands*	Total perimeter of wetlands (km)*	Number of wetland surveys
1 Salt Creek	438 (1, 596 ha)	202.1	23
2 Kooraweera Lakes	367 (1, 734 ha)	227	26
3 Dereel	296 (375 ha)	89.4	10
4 Warrambine Creek	202 (459 ha)	76.5	9
5 Connewarre	364 (3, 790 ha)	319.9	28
Total		914.9 km	96

* Determined through remote sensing procedure described in Section 3.1.3. Totals include all mapped waterbodies.

Figure 3.3 Sampling areas for wetland inventory within the Corangamite region.

3.1.3 Wetland mapping

Wetland mapping for the Corangamite region consisted of identifying, delineating and broadly classifying wetlands from remotely sensed images. Existing wetland geographic data for the Corangamite region was found to be lacking wetland areas under one hectare in size (Section 2.4). The use of remote sensing data on a regional scale was considered the most cost-effective and efficient method for mapping the extent of

inundated areas. This is in accordance with the results of previous studies (eg. Kingsford 1995; Brady *et al.* 1997; Kingsford & Thomas 1997; Shaikh *et al.* 1998; Devonport & Bull 1999).

Wetland maps produced through the inventory were at a scale of 1:15, 000 for the purposes of field survey. All wetlands and deepwater habitats as defined by the Ramsar Convention Bureau (2001) that were able to be distinguished using Landsat Thematic Mapper (TM) imagery and aerial photographs were mapped. The remote sensing data used allowed for a minimum mapping unit of 0.1 ha.

All wetlands and waterbodies were mapped within the five sub-catchment boundaries. Fine scale mapping of wetlands within the entire Corangamite CMA region was not within the scope of this project, however could be completed using methods outlined within this report.

Data sources used for the mapping of wetlands within the Corangamite region are listed in Appendix 6.

Remote sensing analysis

Remote sensing analysis using Landsat 7 TM imagery was used to identify, delineate and broadly classify inundated areas within selected sub-catchments of the Corangamite region.

Image processing was conducted using raster based Geographic Information System (GIS) Idrisi32® software. The vector based GIS MapInfo® Version 6.0 was used for analysis of vector data and final wetland mapping.

Imagery acquisition

Landsat 7 Thematic Mapper (TM) data was purchased for the entire Corangamite CMA region (run 93/87 184 x 200 km, 10 October 2000; run 94/87 20 x 30 km, 12 November 2000). Late spring Landsat TM data in a year of average rainfall was chosen for the delineation of inundated areas. Late spring imagery was selected as it represented the closest available data that corresponded to the 'normal' seasonally wet period (determined using meteorological records). It also provided ideal conditions for the discrimination of major wetland classes where emergent wetland species are present during the growing season (Hodgson et al. 1988; Johnston & Barson 1993; Kempka *et al.* 1996; Lunetta & Balogh 1999; Harding 2001). Jensen *et al.* (1986) found that multispectral satellite imagery acquired in spring and early summer best distinguished palustrine persistent inland wetland types such as herbaceous, forest, and agricultural wetland categories.

Year 2000 data was chosen in preference to more recent data due to low rainfall throughout 2001 and 2002. Many shallow wetlands would not have contained water during these years and consequently may not have been identified as wetlands through the classification procedure. Imagery during a year of typical hydrologic conditions for a specific location was considered ideal for wetland mapping purposes (Lunetta & Balogh 1999).

Cloud-free imagery of the entire Corangamite region between spring and early summer was unable to be located. Some cloud interference was experienced particularly along coastal regions of the study area. Where cloud interference occurred, aerial photographs were used.

Imagery bands 1-5 and 7 were used for this analysis (refer to Appendix 6). Subsets of the satellite imagery were extracted from the entire image for each sub-catchment analysis. Due to the large area of the study region and variable landcover characteristics, spectral analysis at the sub-catchment scale enabled adjustments in the classification procedure to be made for specific regional conditions.

Image processing and visual enhancement

Image processing was performed on the spectral information content of the Landsat TM data to enhance the visual identification of inundated areas. A number of methods have been shown to enhance wetlands within satellite imagery. Image transformation methods such as the Tassled Cap Transformation (Crist & Cicone 1984) have been used extensively for water body delineation (Hodgson et al. 1988; Kondoh *et al.* 1994; Spruce *et al.* 1996). Varying composites of TM bands have been used to enhance specific landcover types. Both TM band 5 and TM band 7 (middle infrared bands) are well documented in their ability to detect moisture (Bennet 1987; O'Neil 1987; Johnston & Barson 1993; Sader *et al.* 1995; Lunetta & Balogh 1999).

Greyscale images of the individual bands used in this analysis illustrated that bands 4, 5 and 7 (near infrared and middle infrared) were the most useful bands for delineating water bodies (Figure 3.4). Water is less reflective than adjacent landcover types in both the green (TM2) and red (TM3) spectral bands. However occlusion of shallow waterbodies due to resultant reflectance off bottom sediments and emergent vegetation occurs in these bands. Water absorbs the energy of infrared wavelengths, resulting in lower reflectance values for saturated areas than for drier areas even in shallow waters (Lunetta & Balogh 1999; Shaikh *et al*. 2001). This resulted in significantly better tonal contrast in the infrared bands (TM4, 5, and 7). Figure 3.4 shows greyscale images of each TM band within a typical volcanic plain subset of the study area. Note that dark areas within the images for bands 4, 5 and 7 indicate wet areas.

Composite images were produced to assist in the interpretation of the spectral information contained in each spectral band. Composite images were created by assigning Red, Green, or Blue colour to one of the three component bands (given in the order of RGB) (Gao 1997). The spectral information from the three different bands was converted to an index number ranging between 0 and 255 (Lorup 1999). This produced a pseudo-colour composite image from the three specified bands for display and visual analysis.

Figure 3.4 shows three composite images that were used for delineating waterbodies from dryland. Combinations of near infrared and middle infrared bands were found to be the most effective for identifying inundated areas distinguished by the dark regions on each of the three images. Composite image using TM bands 7, 5, and 3 showed different vegetative characters of wetlands (indicated by varying levels of red within the waterbodies).

Image classification

The classification of remotely sensed imagery involves the categorisation of geographic areas according to spectral signatures within the Landsat TM bands (Lillesand & Kiefer 1994). Sub-catchments that were mapped were extracted from the entire Corangamite region image for the purposes of classification.

A combination of supervised and unsupervised classification techniques was used. Aerial photographs, ancillary data, Wetlands Database, and field data were used to identify training sites and label spectral clusters. Post-classification modelling was performed using ancillary data (Wetland_1994, Wetland_1788, hydrology data (Appendix 6) to further refine the classification of wetlands.

The purpose of satellite image classification was to identify inundated areas. Other (non-inundated) landcover categories present within the study area such as agricultural land, tree vegetation, pine plantations, grasslands etc. were not of primary importance and were broadly classified. The accuracy of non-inundated landcover classes was not assessed.

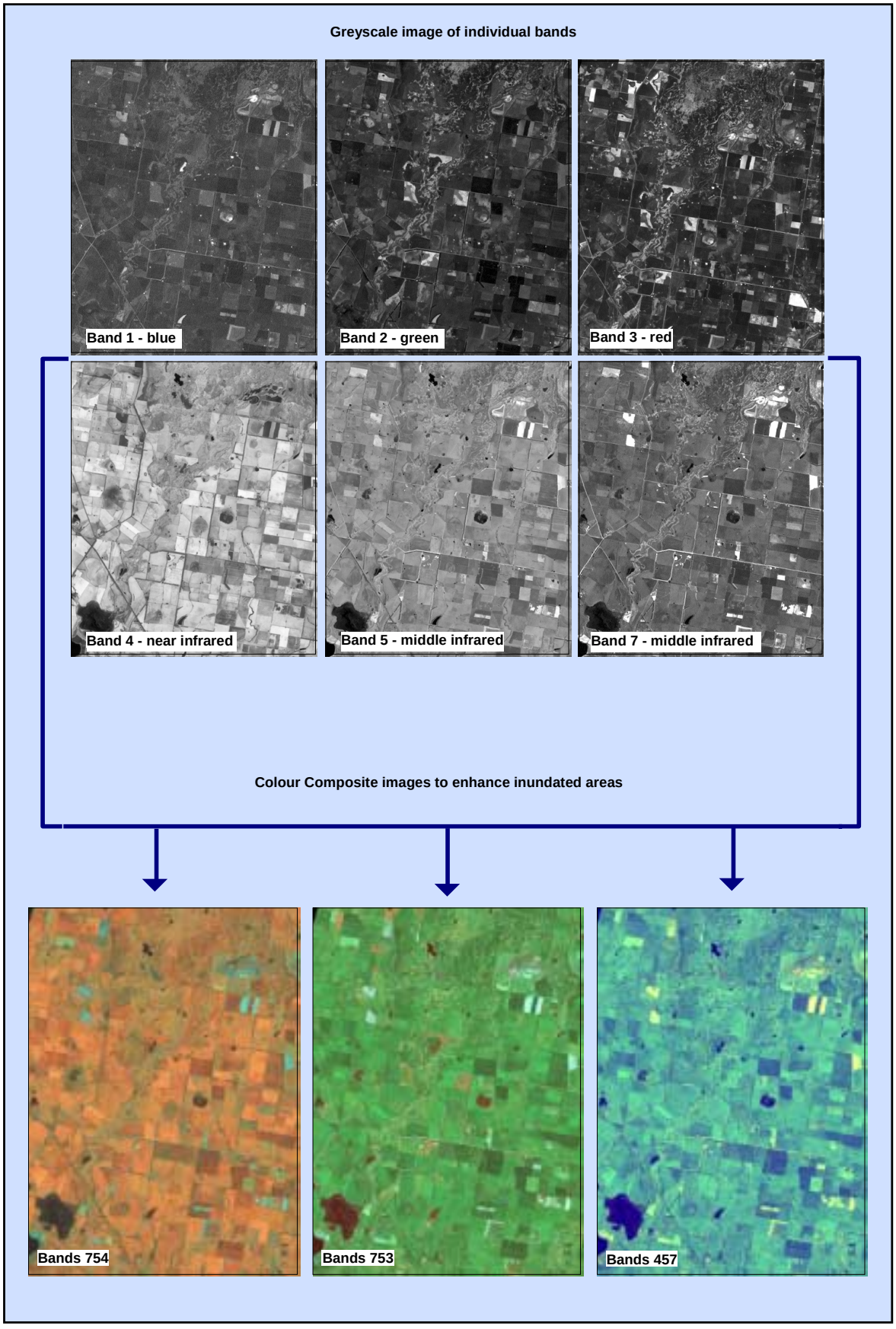


Figure 3.4 Enhancement of spectral bands for identifying inundated areas.

Threshold Level Slicing

Initial identification of inundated areas was conducted using simple threshold level slicing of the unenhanced TM bands in the visible and infrared spectrums. Delineation of land from water based on the electromagnetic reflectance from the earth's surface was found to be highly successful when used in combination with image enhancement techniques (Bennett 1987; O'Neill 1987; Braud & Feng 1997). Mid-infrared TM band 5 was the most effective for delineating inundated areas from dry. TM band 5 exhibits a strong contrast between dry and inundated features due to the high degree of absorption of mid-infrared by water and the strong reflectance by vegetation and other landcover categories (Braud & Feng 1997).

The frequency histogram of TM band 5 (Figure 3.5) displayed the typical double peaked curve characteristic of low reflectance in water and high reflectance in vegetation. The transition between inundated and dry was defined between the peaks (Digital Number = approx. 25). Threshold values were derived for each sub-catchment area using interactive contrast histogram tools to determine the optimum position of the inundated/non-inundated boundary. The reflectance values represented as digital numbers were sliced into two discrete zones: inundated and dry.

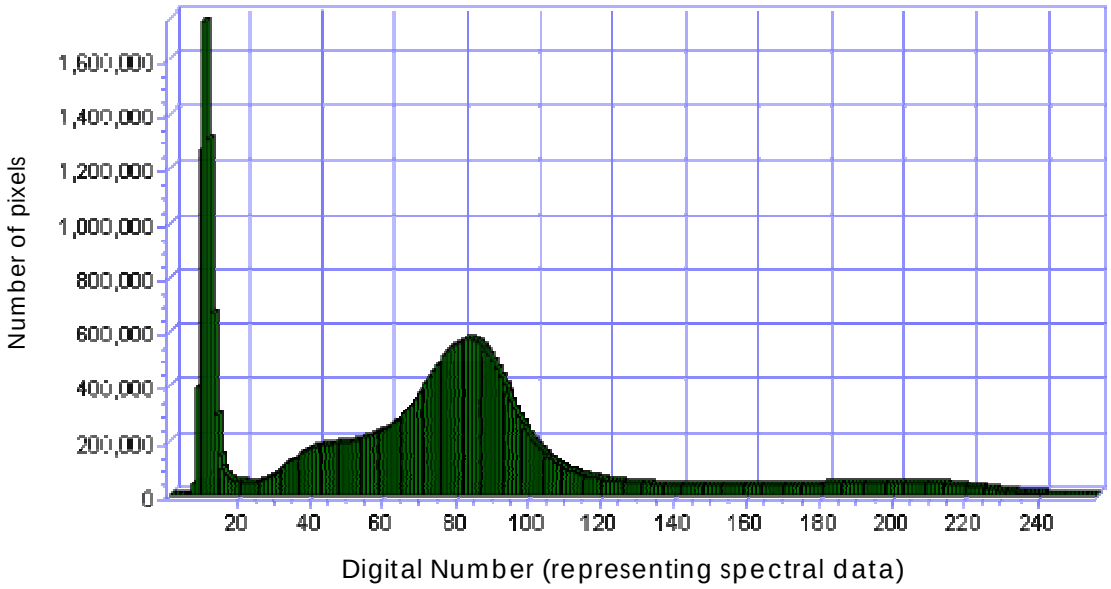


Figure 3.5 Histogram of TM Band 5 for the Corangamite region.

Occlusion of water by emergent vegetation in shallow wetlands using this method was evident when compared with existing wetland boundary data (DCNR 1995). Additionally some wetlands including estuarine salt marsh did not contain water at the imagery date. A combination of supervised and unsupervised classification techniques were used to delineate shallow waterbodies not defined through the threshold level slicing process.

Supervised classification

Supervised classification requires examples of landcover categories to classify the image. The user trains the system to recognise each landcover category using training areas (Lillesand & Kiefer 1994). The system extracts the spectral signature of each class from these examples and performs the classification of the whole image.

Training areas were defined using Wetlands Database digital wetland boundaries (DCNR 1995), hydrological overlays, inundated area polygons created by the threshold level slicing process, aerial photographs, and Ecological Vegetation Class boundaries. A Minimum Distance classification technique was used to classify the images. The Minimum Distance technique assigns each pixel to the class it is closest to in band-space

(MacKenzie 1999). TM bands 1-5 and 7 were processed in the supervised classification procedure to detect spectral differences in all wavelengths.

Wetlands were classified into five broad classes through the supervised classification procedure:

- Deep open water (freshwater)
- Shallow emergent (freshwater)
- Saline
- Salt marsh
- Mud flat

Other landcover classes identified not associated with inundated areas were masked out of the image. Figure 3.6 illustrates the classification procedure used to delineate wetlands within each sub-catchment.

Comparisons with known wetland boundaries and the wetlands identified through the supervised classification technique were made.

Unsupervised classification

An unsupervised clustering technique was used to identify spectral differences between inundated areas identified through the threshold level slicing and supervised classification procedures.

Unsupervised classification is a method, which examines a large number of unknown pixels and divides them into a number of classes based on natural groupings present in the image band values. The resultant classes are spectral classes, whose identities were initially unknown. The classes were compared with reference data (aerial photographs, existing wetland classification data (Wetland_1994) to determine classification details. Field data collected for this inventory was used to refine the classification for the final mapping.

The unsupervised Iterative Self Organised Data Analysis (ISODATA) clustering algorithm has been commonly used for classification of complex wetland areas and was found to be a highly successful semi-automated process (Herr & Queen 1993; Sader *et al.* 1995; Spruce *et al.* 1996; Braud & Feng 1997; Gao 1997; Reid *et al.* 1997). ISODATA clustering was run on composite images of TM bands 4, 5 and 7 and composite images of TM bands 3, 4, and 5 to determine spectral differences in areas already identified as inundated.

Clusters developed through the unsupervised classification were used to detect spectrally similar wetlands (refer to Figure 3.6 for an example of the classification process). Areas identified as wetlands through the classification procedure were converted to vector polygons in MapInfo® format with associated Microsoft Access 2000® database.

Aerial photo interpretation

Aerial photographs were used to eliminate any miss-classifications and to determine natural and human origin wetland classes. Wetland boundaries were refined to reflect the full area of wetlands that were not at their maximum inundation level at the time the satellite imagery was taken. Those areas miss-classified as wetlands were deleted, and very small areas of water such as farm dams that were missed by the image classification (waterbodies less than 30 x 30 metres in area) were manually digitised into the polygon layer.

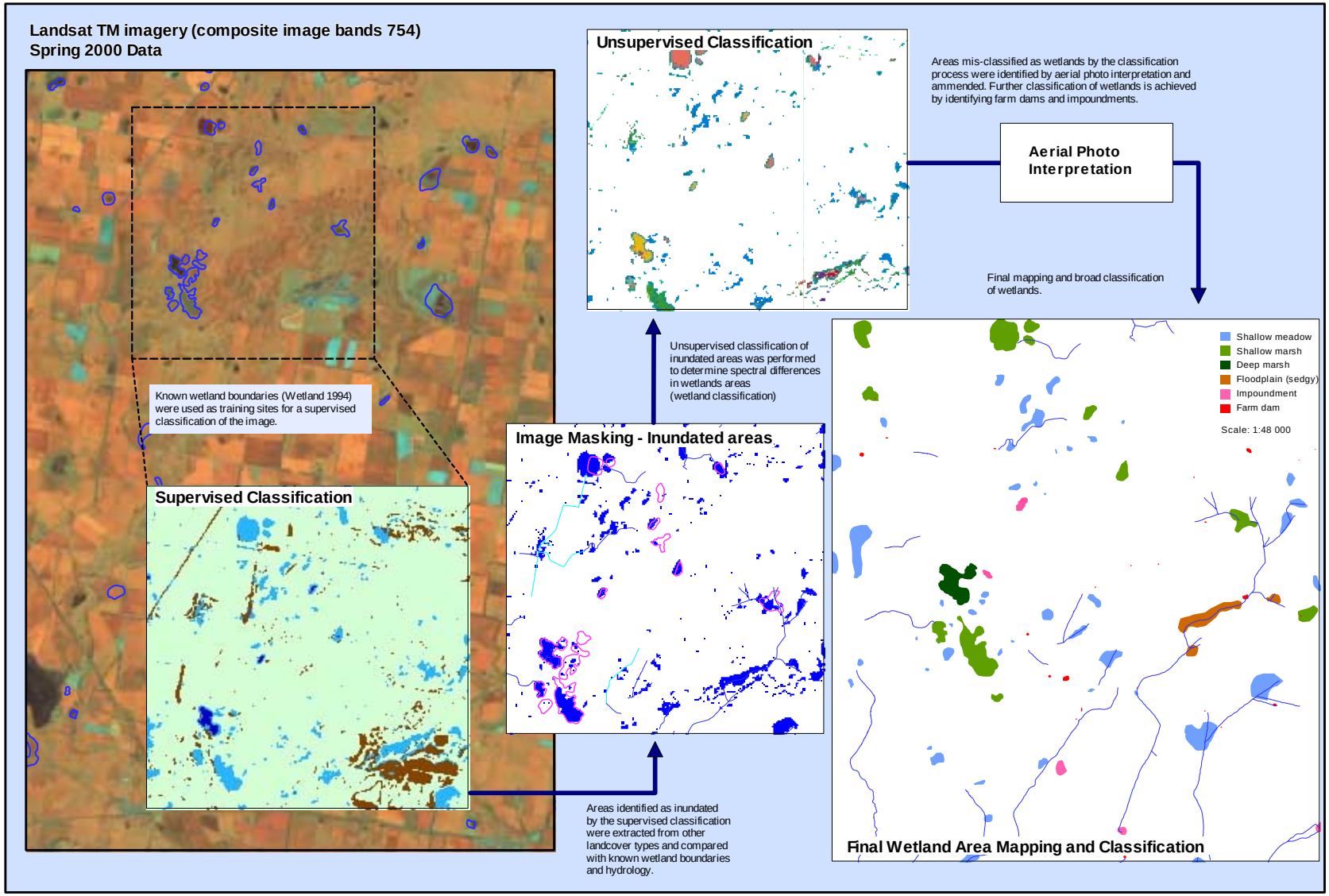


Figure 3.6 Remote sensing of wetlands – delineation and classification method.

Accuracy assessment

The accuracy of mapped waterbodies was assessed during field surveying and by comparison with existing wetland mapping (Wetland Database, DCNR 1995). The use of aerial photograph interpretation to refine the image classification resulted in high accuracy of the final maps. An accuracy of 99% for the detection of wetlands can be expected for all mapped sub-catchments. Errors were more likely to occur in the broad classification of wetland types through the remote sensing procedure (88.9% accuracy), although field survey of each sub-catchment rectified any classifications unable to be accurately determined remotely.

Errors may also occur where the mapping unit is less than 30 x 30 metres, or where wetlands were dry at the time of image acquisition.

Wetland types

Seventeen wetland types have been described in the Corangamite wetland inventory. These correspond to wetland types described in the wetland database (DCNR 1995) as shown in Table 3.2.

Table 3.2 Wetland types described in the wetland database (DNCR 1995) and the wetland mapping (Corangamite Wetland Inventory).

Wetland database (DNCR 1995)	Wetland mapping (Corangamite Wetland Inventory)
Deep freshwater marsh	Deep marsh
Farm dams	Dam
Floodplain	Floodplain
Hypersaline lakes	Hypersaline open water
Impoundments	Impoundment
Intertidal mudflats	Tidal mudflats
Mangroves	Mangroves
Permanent saline wetlands	Saline open water
Permanent shallow saline	Permanent shallow brackish
Salt flats	Salt flats
Salt meadow	Salt meadow
Salt pan	Salt marsh
Salt pan	Shallow saline marsh
Shallow brackish marsh	Shallow brackish
Shallow freshwater marsh	Shallow freshwater marsh
Shallow freshwater meadow	Shallow freshwater meadow
Shallow permanent open freshwater	Freshwater open water

3.1.4 Field survey

Field survey of wetlands within each of the sampled sub-catchments was conducted in spring to early summer 2002 and 2003 (October – December). Due to the large number of shallow seasonal wetlands in the study area, it was considered important to survey in optimal conditions; when the wetlands were inundated and aquatic vegetation present.

Sampling was intended to be complete in spring of 2002. Unseasonably dry conditions throughout 2002 resulted in many of the shallow seasonal wetlands remaining dry over spring and aquatic vegetation absent. Field survey was therefore extended to include spring 2003 for affected regions of the study area.

Access to private property was gained by contacting landholders with wetlands on their properties identified through the remote-sensing procedure described in Section 3.1.3. GIS analysis of wetland areas and property boundaries enabled a list of landholders to be formulated for each sub-catchment. Postal notification was used to inform landholders of the wetland inventory prior to field survey. Phone conversation between field teams and landholders were used to arrange site visitation. Wetlands surveyed were therefore dependant on ability to gain access to private land.

The protocol developed for the Corangamite wetland inventory was designed to allow rapid assessments of each wetland surveyed. The survey forms were developed to be completed within 1 – 1.5 hours of field survey time at each wetland site, allowing for a standardised survey effort for each site.

The wetland survey data sheets used for this inventory and the accompanying instruction manual are presented in Appendix 7 and 8 respectively. Details of private property ownership were not collected due to privacy clauses and this information was not included in the resulting databases. For each wetland (or sector of a wetland) surveyed, the following data attributes were collected:

Reference data

Attributes of each wetland site were collected to allow re-location of the site, and to describe the site and survey details including:

- date and time,
- compiler details,
- organisation conducting the survey,
- location description,
- wetland ID (reference number),
- wetland name,
- GPS location,
- area of the wetland, and
- elevation.

Land tenure and landuse

Tenure was recorded to indicate if wetlands (on-site) and areas directly surrounding the wetland were privately or publicly owned. Landuse of the wetland was indicated both on-site and surrounding, by selecting appropriate landuse categories.

Biophysical attributes

Biophysical attributes of the site were collected including:

- bioregion (identified from maps provided),
- morphology (separated into inland, human origin, and marine systems, and recorded as one of a number of categories provided),
- origin (separated into categories within different wetland morphologies as described above. Morphology described using categories provided,
- water regime (separated into marine and inland systems to describe water source using categories provided),
- water source (indicated using categories provided),

- maximum and average depth (an estimation of the maximum and average depth of the wetland when full in metres),
- percent cover of water (percent cover of water present relative to full at the time of survey),
- time since inundation number of months since the last inundation (if known), and
- bottom sediment (simple visual/textural method of classifying the substrata applied using defined categories.

Wetland classification

Wetland classification was based on that used by the Ramsar Convention in describing Wetlands of International Importance and Directory of Important Wetlands in Australia.

Threatening processes

Disturbance and management issues at the site were recorded. The extent of each disturbance was recorded on a four point scale from minimum to severe. Any conservation measures, such as fencing, revegetation and pest control were recorded.

Surface water chemistry

Salinity was measured as (total dissolved salts) in parts per thousand, and a broad salinity category was also recorded (Note: salinity levels may fluctuate greatly between years). PH was recorded as one of three pH categories; acidic, neutral or alkaline. Secchi depth was measured with a Secchi disk and water colour was measured.

Biological characteristics

Information on the fauna and flora at each site was also recorded. Biological parameters included:

- vegetation zones – recorded as one of seven zones (buffer, bank, shore, emergent, aquatic submerged and emergent <1 m, aquatic >1 m, and open water;
- vegetation layers present (plant growth forms in riparian and aquatic habitats);
- width of buffer zone measured in metres;
- percent cover of aquatic vegetation;
- amount of attached algae (little, medium or abundant);
- noteworthy flora (rare and threatened flora species that occur at the site);
- noteworthy fauna rare and threatened fauna species that are present at the site, including species listed under JAMBA and CAMBA. Also any species that occur in notable numbers or that are regionally significant). Approximate numbers of individuals of each species were recorded and evidence of breeding;
- flora diversity – all dominant species within each vegetation zone were recorded along with a cover abundance value for each;
- fauna diversity and presence – all species noted at the time of survey were recorded; and
- weediness – estimates of the species richness and cover within each wetland zone were recorded.

Rapid condition assessment

A rapid assessment of the condition of water dependant fauna (aquatic invertebrates, fish and water dependant birds), aquatic vegetation and riparian vegetation (shore, bank and buffer) was performed in the field. The rapid assessment was performed to indicate the abundance, diversity and relative condition of each of these elements which were

allocated in one of three categories: low, moderate, high (see Appendix 8 for instructions for field survey).

A wetland condition score was also subjectively assessed in the field, based on the combination of the rapid assessment scores and the interpretation of other parameters recorded during the survey (such as land degradation and water chemistry).

In addition, a sum of the rapid assessment variables, including the subjective condition value was calculated to produce a total rapid assessment score. This rapid assessment score provides a quick means of assessing the environmental attributes of wetlands based on survey parameters. A similar approach has been used in other wetland inventories to provide an indication of the environmental attributes of wetlands surveyed (Seaman 2002a; Seaman 2002b). Total rapid assessment scores were grouped into three classes:

- 0-6 low wetland values
- 7-18 moderate wetland values
- 19-28 high wetland values

Wetlands scoring high total rapid assessment scores should be carefully monitored to ensure wetland values are conserved.

3.1.5 Database

A database was created in Microsoft Access 2000® format containing all data collected through the inventory process (Corangamite Wetland Inventory Database; Compact Disc attached to this document). The database contains all fields outlined in Appendix 8 and is designed for easy data entry from the standardised data sheets (Appendix 7). The wetland inventory database for the Corangamite region is a computerised database engine with data/metadata entry and querying interfaces, and GIS display and querying capabilities. This database served as the primary data management/storage/retrieval component of the project.

The database was designed for public usage. All wetlands surveyed were given an identifying number and survey locations recorded in Australian Map Grid (AMG), Australian Geodetic Datum 1966 projection.

A numbering system was developed for identifying individual wetlands or sectors of wetlands specific for this inventory. The numbering system included a two letter prefix relating to the sub-catchment the wetland falls within, followed by a three digit number - numbered sequentially by the field survey team. In the case of very large wetland complexes, a sector number was also recorded. For example, the first sector of the first wetland surveyed within the Salt Creek catchment would be given the identification number SC 001 – 1 (Refer to Appendix 8 for further explanation).

Database analysis

Mapping

Comparisons were made between the previous inventory mapping within the Wetland Database (DCNR 1995) and the mapping completed for the Corangamite Wetland Inventory. Both spatial databases were analysed using the querying and overlay capabilities of MapInfo® GIS.

Data contained within the Wetland Database (DCNR 1995) originated from mapping work undertaken in the 1970s (Corrick 1981; 1982). There were two layers in the GIS: the first indicating pre-settlement wetland areas (less than 1 ha), divided into categories based on salinity and water regime (Wetland_1788); and the second detailing current wetland distribution, divided into categories and sub-categories based largely on subjective description of vegetation types (Wetland_1994) recognisable from aerial photographs. Refer to the review document (Section 2) for further description of existing wetland databases.

For the purpose of comparing wetland types between the Wetland Database and the Corangamite Wetland Inventory GIS layers, a common broad classification was developed based on salinity and water regime. Both the area and number of wetlands within each category were compared between databases. Analysis of the spatial overlap between the two databases was also performed using an overlay function in MapInfo.

It should be noted that the average yearly rainfall prior to the mapping work conducted by Corrick (1982) was much higher than that of recent years. Therefore it is likely that many wetlands will presently contain less water or may have remained dry for a long period of time.

Database

Analysis of the Corangamite Wetland Inventory Database was undertaken to examine and present data collected through the wetland inventory process. Wetland inventory data were analysed at three different scales: (i) individual wetland sites, (ii) sub-catchments and (iii) the Corangamite catchment.

Microsoft Access 2000® queries and reports were used to analyse and display the data collected at each wetland site. The report interface was designed for public use, and enables a summary of each wetland site to be displayed. Summary reports include all parameters collected during the study (fields outlined in Appendix 8), including the identifying number and survey locations recorded in Australian Map Grid (AMG), Australian Geodetic Datum 1966 projection. A location map in the report indicates survey site position within the Corangamite catchment, and a small-scale locality map shows the site in relation to local wetlands and roads. A photo has been included of many wetland sites, and general comments on the wetlands have also been incorporated into the summary reports.

At the sub-catchment scale, queries were generated to summarise relevant data across each sub-catchment. Data were analysed for each sub-catchment under three main headings: character, condition and threats. A sub-catchment summary report has been prepared to analyse all data surveyed within each sub-catchment. This will enable the analysis of any additional data entered into the database from future wetland surveys. The sub-catchment summary reports are presented in Appendix 11. Table 3.3 lists the tables and figures presented in the sub-catchment summary report, and a description of how the data was analysed.

Table 3.3 Analysis of sub-catchments – description of parameters presented in sub-catchment report summaries (Appendix 11).

Table/Figure no.	Table/Figure	Description of analysis
Wetland character		
Table 1	No. of wetlands surveyed in each morphological class	Count of wetland sites surveyed in each morphological class for the sub-catchment.
Table 2	Water source of wetlands surveyed	Count of number of wetland sites for each water source category for the sub-catchment.
Table 3	Summary of land tenure - number of sites on private and public land within the sub-catchment	Number of sites where land tenure is listed as private or public. This has been recorded for both wetland site and surrounding land.
Table 4	Land uses recorded on wetland sites and surrounding areas	A count of each land use category recorded in the sub-catchment.
Table 5	Average, minimum and maximum wetland depth	Average, minimum and maximum of the wetland depth figure recorded in the inventory.

Table/Figure no.	Table/Figure	Description of analysis
Table 6	Rare and threatened fauna observed during surveys of wetlands in the sub-catchment	All rare and threatened fauna species noted during surveys within the sub-catchment (DNRE 2002a)
Table 7	Rare and threatened flora recorded during surveys of wetlands in the sub-catchment	All rare and threatened flora species recorded during surveys within the sub-catchment (DNRE 2002b).
Table 8	Summary of flora recorded during surveys of wetlands in the sub-catchment	Total number of native flora species, exotic species and rare and threatened species recorded within the sub-catchment.
Table 9	Most frequently occurring flora species in each wetland zone across the sub-catchment	Species occurring at more than 24% of sites listed for each zone and total number of sites in each zone.
Figure 1	Frequency of wetland types surveyed in the sub-catchment (Based on Ramsar classification groups)	Bar chart showing the number of wetlands recorded within each major classification group.
Figure 2	Salinity of wetlands surveyed in the sub-catchment	Pie chart showing the number of wetland sites occurring in each of six salinity categories or a 'dry wetland' category.
Wetland Condition		
Table 10	Average rapid condition assessment values (fauna, aquatic and riparian vegetation) across the sub-catchment	The number of values recorded as low, moderate or high for each parameter, tallied across the sub-catchment.
Table 11	Summary of rapid assessment of overall wetland condition	The numbers of wetlands in the sub-catchment within each field condition class.
Figure 3	Summary of Total Assessment Scores calculated from rapid assessment parameters	The number of wetlands in each total rapid assessment class presented in a pie chart (see Section 3.1.4 for description of rapid assessment condition index).
Threats		
Table 12	Frequency of management issues identified in the sub-catchment	Management issues identified in the sub-catchment have been listed together with frequency of the issue within the sub-catchment.

Terminology and Abbreviations

Flora and fauna nomenclature follows the Flora Information System (FIS) (DNRE 2002b) and the Atlas of Victorian Wildlife (DNRE 2002a).

The following conservation status code abbreviations have been used throughout this report.

Victorian Rare and threatened Species (VROT) Fauna

v = vulnerable

e = endangered

c = conservation dependant

i = insufficiently known

l = listed

Victorian Rare and threatened Species (VROT) Flora

e = endangered

v = vulnerable

r = rare

k = poorly known

Flora and Fauna Guarantee Act (FFG)

L = Listed as threatened

N = nominated for listing

I = rejected for listing

D = delisted

EPBC Act

CR = critically endangered

EN = endangered

VU = vulnerable

I = listed

3.2 Results

Structure of results

For each sub-catchment surveyed, an overview of wetlands is presented, including dominant wetland types, wetland tenure, and percentage area of wetlands within the sub-catchment. Results of the wetland mapping are summarised for each sub-catchment, and comparisons are made with previous map data (Wetland_1994 layer (Corrick 1982; DCNR 1995)).

A summary of the wetland inventory data collected at each sub-catchment is presented including wetland character, tenure, condition, threats and significant wetlands surveyed (a full analysis of each sub-catchment (see table 3.2 for list of parameters) is presented in Appendix 11). The final section of this chapter summarises the results of wetland inventory surveys across the Corangamite catchment.

3.2.1 Salt Creek Catchment

The Salt Creek Catchment (totalling 35, 598 ha) is dominated by privately owned agricultural land (97%) used primarily for sheep and cattle grazing. Volcanic stony rises within this region confine cropping practices to the surrounding plains. Wetlands within this catchment include many herb-dominated shallow freshwater meadows and marshes characteristic of the Victorian Volcanic Plains bioregion. All wetlands identified within this sub-catchment occur on privately owned land, with the exception of permanent waterbodies designated as Lake Reserves: Lake Tooliorook, Lake Koonangurt, Deep Lake, and Logans Lake. Wetlands incorporate less than 5% of this sub-catchment area. Table 3.4 indicates land tenure of wetland categories within the Salt Creek Catchment.

Many shallow waterbodies identified were internally draining catchments occurring within volcanic stony rises. Natural springs also occur within the stony rises and provide a semi-permanent source of water to wetlands within the Banongil Network.

A total of 23 wetlands were surveyed within the Salt Creek Catchment including both the 2002 and 2003 spring survey periods. Map 2 provides the locations of wetlands included in this inventory for the Salt Creek Catchment area.

Table 3.4 Land tenure of wetland types within the Salt Creek Catchment.

Wetland Type	Freehold	Lake Reserve	Total
	Area (% of total wetland area for each type within the sub-catchment)		
Shallow freshwater meadow	257.2 ha (98.3%)	4.3 ha (1.7%)	261.6 ha
Shallow freshwater marsh	370.6 ha (96.8%)	12.3 ha (3.2%)	383.8 ha
Deep freshwater marsh	38.7 ha (100%)		38.7 ha
Shallow permanent open freshwater	121.3 ha (16.9%)	594.8 ha (83.1%)	716.1 ha
Impoundments	50.3 ha (100%)	-	50.3 ha
Farm dams	43.6 ha (100%)	-	43.6 ha
Floodplains	101.9 ha (100%)	-	101.9 ha

Source: Wetland mapping: Corangamite Wetland Inventory; land status overlay: landmmt100

Mapping

A total of 438 waterbodies were identified within the Salt Creek Catchment through the mapping procedure for the Corangamite Wetland Inventory. The large majority of these were small farm dams (257; each < 1 ha in size). A significant number of shallow freshwater meadows (96) and marshes (49) were also identified.

Comparison with Wetland Database (DCNR 1995) Wetland_1994 layer

Comparisons with existing wetland databases, Wetland_1994 layer (Corrick 1982; DCNR 1995) and the wetland mapping performed for this inventory indicate a substantial improvement in the detection of wetlands within this region due to numerous very small shallow wetlands. Figure 3.7 gives a comparison of the wetland maps produced through this inventory with that conducted by DCNR (1995).

Inventory and existing wetland mapping (DCNR 1995) for the Salt Creek sub-catchment

The total number of wetlands identified through this inventory is substantially improved in the shallow freshwater meadow (94 wetlands), shallow freshwater marsh (50 wetlands), and farm dam (252 waterbodies) categories. A large number of these wetland categories are under 1 ha in size, which was not included in the Wetland Database (DCNR 1995). A total of 43 shallow freshwater meadow wetlands less than 1 ha in size were detected and mapped through the wetland mapping process for the Corangamite Wetland Inventory. This inventory process also identified areas subjected to flooding from creeklines, which were not mapped in the Wetland Database (DNCR 1995).

Figure 3.7 shows increases in the number and area for most wetland categories compared to previous mapping. This however does not reflect an increase in wetland area since the 1995 mapping, but reflects the addition of smaller wetlands, and several wetlands not identified in previous mapping for unknown reasons.

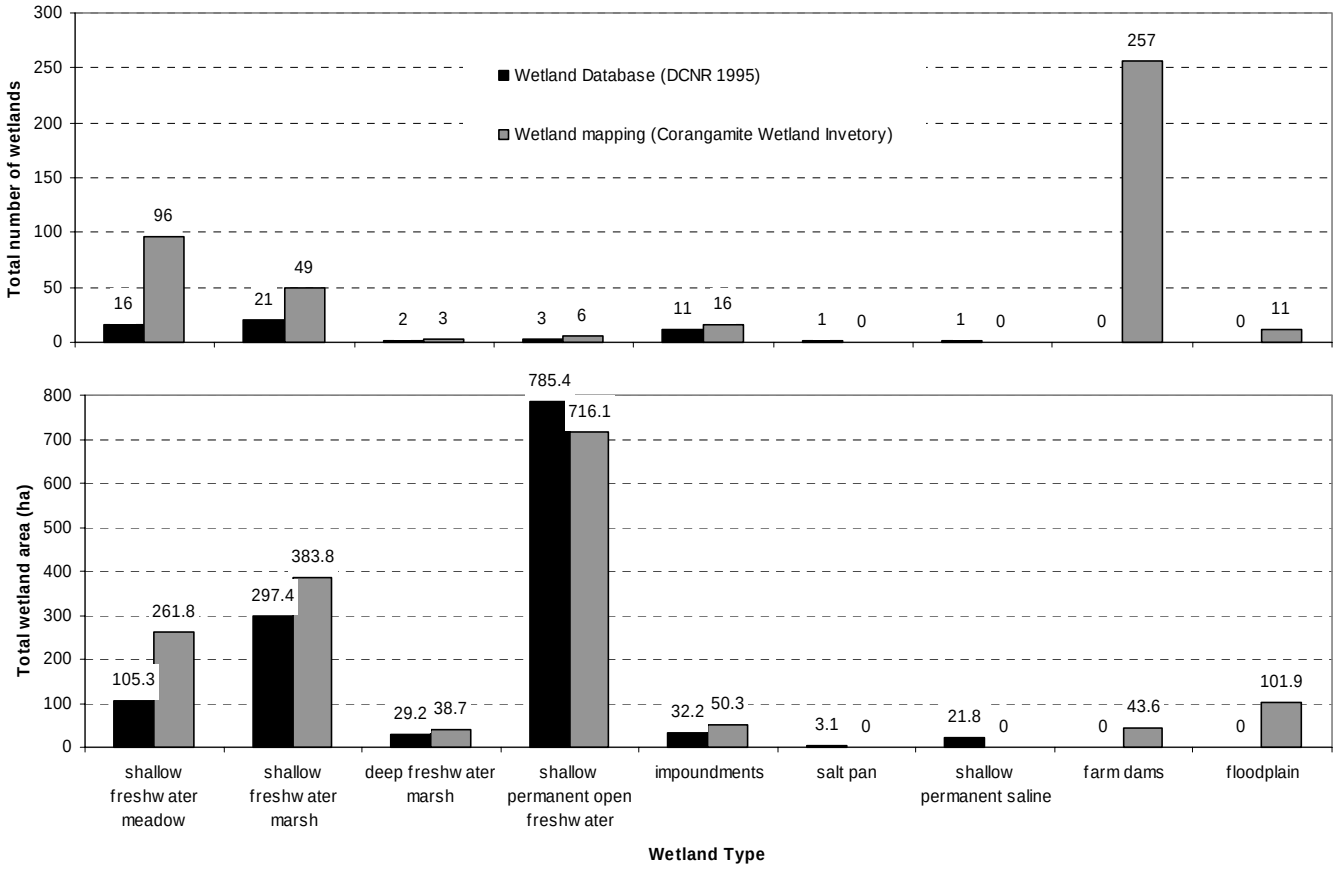


Figure 3.7 Comparison between wetland mapping for the Corangamite Wetland.

Overlap with Wetland Database (DCNR 1995) Wetland_1994 layer

Figure 3.8 indicates the extent of overlap between both mapping procedures within each wetland type identified. This shows the extent to which the existing mapping (DCNR 1995) and the wetland mapping for the Corangamite Wetland Inventory correspond and is calculated using an overlay function in MapInfo.

The data indicates that there was substantial difference in the mapped areas for shallow freshwater meadow and shallow freshwater marsh categories between both wetland map layers. Several wetlands identified by the Wetland Database (DCNR 1995) were not identified as "wet" through the mapping procedure for this inventory. This indicates that the wetland was dry at the time of imagery acquisition, and therefore may have been

drained since the Wetland Database mapping or had not received sufficient rainfall to hold water for a long period. Additionally, the area of many wetlands identified by the Wetland Database mapping has since reduced in size (likely to be due to insufficient rainfall or partial drainage). Figure 3.8 indicates very little difference in the area of shallow permanent open freshwater between the two mapping events. No overlap was identified between salt pan, shallow permanent saline, farm dams and floodplains for this sub-catchment.

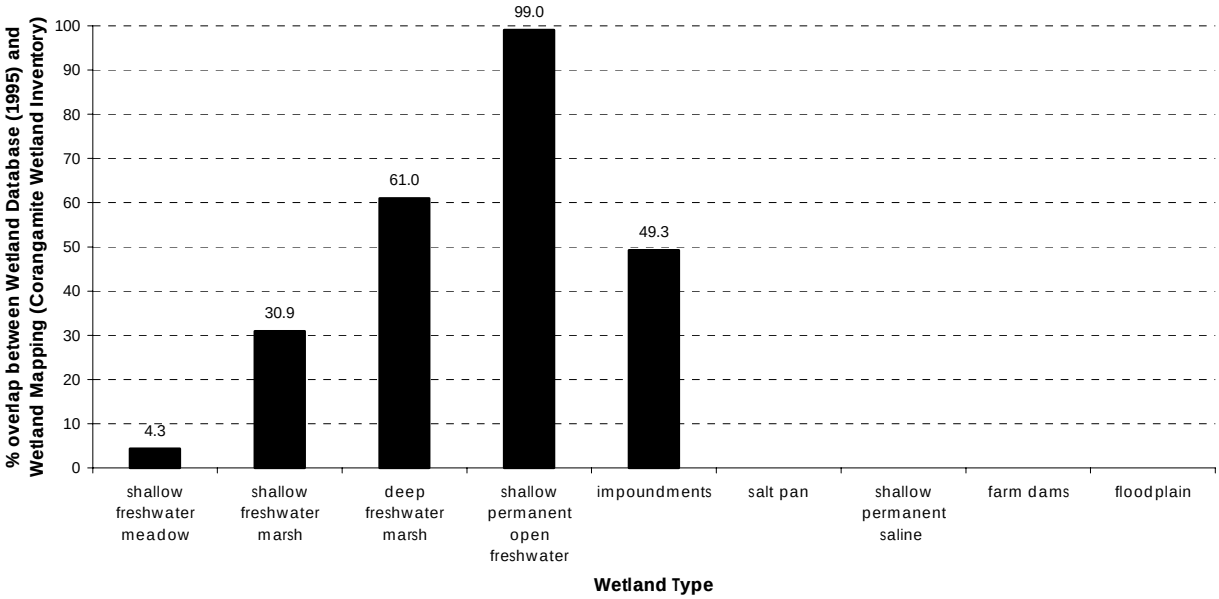


Figure 3.8 Percentage overlap between wetland mapping for the Corangamite Wetland Inventory and existing wetland mapping (DCNR 1995) for the Salt Creek sub-catchment.

Many wetlands previously identified as shallow freshwater marshes (DCNR 1995) were categorised as shallow freshwater meadows through the mapping procedure for this inventory. This was due to lower water levels as a result of poor rainfall over a long period of time, which has altered the water regime of many waterbodies (i.e. lengthening dry periods).

The total overlap between both wetland map layers was 61.2%. Map 2 provides the boundaries of wetlands mapped for this inventory.

Comparison with Wetland Database (DCNR 1995) Wetland_1788 layer

Comparisons with pre-settlement wetland mapping (Wetland_1788 layer) within the Wetland Database (DCNR 1995) indicated a current loss of 61% of the total natural wetland area within the Salt Creek catchment. Less than half of the original extent of shallow freshwater marsh (23%), deep freshwater marsh (20%) and saline wetland remains.

Character

Analysis of field survey data from the Salt Creek sub-catchment can be viewed in summary reports in Appendix 11. All references to tables and figures not appearing within the text refer to this document.

Seasonal freshwater marshes (13 sites) were the most frequently recorded Ramsar wetland type in the Salt Creek sub-catchment. Permanent saline/brackish lakes (3 sites), and seasonal saline marshes (3 sites) were also recorded at locations across the sub-catchment (Salt Creek Figure 1).

Most wetlands surveyed were formed from shallow basins (Salt Creek Table 1), with local runoff (12 sites) the most common water source of wetlands surveyed in the sub-

catchment (Salt Creek Table 2). Springs (6 sites), streams (5 sites) and groundwater sources (1 site) also contributed to wetlands surveyed.

Almost three-quarters (17 sites) of wetlands surveyed within the sub-catchment are brackish (500 – 18, 000 µs), with only three freshwater wetlands recorded (Salt Creek Figure 2). Average wetland depth when full ranged from 0.1 to 15 m, with an overall average depth of 1.26 m for wetlands surveyed across the sub-catchment (Salt Creek Table 5).

A number of rare and threatened flora and fauna species were located within the sub-catchment (Table 3.5 & 3.6, Salt Creek Table 6 & 7).

Table 3.5 Rare and threatened flora located during wetland inventory surveys in the Salt Creek sub-catchment.

Species name	Common Name	No. sites	VROT	FFG	EPBC
Amphibromus fluitans	River Swamp Wallaby-grass	2	k	L	I
Austrostipa setacea	Corkscrew Spear-grass	1	r		
Berula erecta	Water Parsnip	1	k		
Elymus multiflorus	Short-awned Wheat-grass	1	k		
Helichrysum aff. *rutidolepis* (Lowland Swamps)	Pale Swamp Everlasting	1	v		
Juncus revolutus	Creeping Rush	4	r		
Microseris sp. 1	Plains Yam-daisy	1	v		
Persicaria attenuata	Velvet Knotweed	1	k		
Pimelea spinescens ssp. *spinescens*	Spiny Rice-flower	1	e	L	
Poa sallacustris	Salt-lake Tussock-grass	3	v	L	
Ranunculus aff. *inundatus* (South-west)	South-west River Buttercup	1	k		
Ranunculus diminutus	Lesser River Buttercup	7	r		

Table 3.6 Rare and threatened fauna located during wetland inventory surveys in the Salt Creek sub-catchment.

Species	No. sites	VROT	FFG	EPBC
Whiskered Tern	3	I		
Brolga	8	v	L	
Glossy Ibis	1	v		
Great Egret	1	e	L	
Australasian Shoveler	4	v		
Hardhead	1	v		
Blue-billed Duck	1	v	L	
Pectoral Sandpiper	1	i		
Corangamite Water Skink	1	c		
Warty Bell Frog	1	v		V
Damselfly	1	v	L	

In total, 162 native vascular plant species were identified across the sub-catchment, with 72 exotic species recorded (Salt Creek Table 8). Table 9 lists frequently occurring flora (frequency ≥ 0.25) within each wetland zone. A buffer zone was recorded at only eight wetlands, and frequently occurring species within buffer regions were native, including

Hymenanthera dentata s.l., *Bursaria spinosa* ssp. *lasiophylla* and *Austrodanthonia caespitosa* (Salt Creek Table 9).

Tenure and landuse

Three wetland sites surveyed were on public land, and 20 were on privately owned land. All land surrounding wetlands was privately owned (Salt Creek Table 3). Grazing by sheep (8 sites), cattle or horses (12 sites) was recorded on many wetlands in the sub-catchment, and all land surrounding the wetlands was either cropped or grazed (Salt Creek Table 4).

Condition

The condition values for macroinvertebrates were relatively evenly distributed between the low (5 sites), moderate (7 sites) and high (7 sites) condition categories (Salt Creek Table 10). No sites were in the high condition category for fish, with most fish sites (11) having a low condition value. It should be noted that condition values were derived by rapid assessment (i.e. expert opinion based on habitat quality and availability) and surveys of macroinvertebrates and fish were not undertaken. The condition values for birds were more favourable, with nine sites supporting high bird species diversity and abundance.

Riparian vegetation in the buffer zone was commonly described as degraded (16 sites), with only one intact buffer zone surveyed within the sub-catchment. Similarly bank vegetation was often degraded (11 sites), however, shore vegetation appeared less degraded, with three intact sites, and nine sites in moderate condition. The condition of aquatic vegetation was distributed between low (4 sites), moderate (7 sites) and high (8 sites) condition classes (Salt Creek Table 10).

The subjective condition values revealed no pristine sites surveyed within the Salt Creek sub-catchment. However, eight sites were intact and 10 sites in moderate condition. Only three sites were degraded (Salt Creek Table 11).

The total rapid assessment scores highlight three sites with high environmental values:

(1) Banongill Network (SC 002)

(2) Perched Brolga Swamp (SC 026)

(3) Hillside Soak and Subsaline Creek (SC 028)

(Refer to Map 2).

Threats

Threatening processes recorded within the Salt Creek sub-catchment are listed in Salt Creek Table 12. Weeds are the most commonly listed management issue within the catchment (18 sites), followed by changed soil character due to pugging (13 sites), grazing (12 sites), and altered water regime (10 sites).

The most frequently noted weed problems were agricultural weeds (17 sites), with environmental weeds noted at six sites, and noxious weeds recorded at three sites. Problems with altered water regime included increased water (3 sites), decreased water (6 sites) and complete drainage (1 site).

Significant wetlands

Three sites with high environmental values, including fauna, riparian vegetation and aquatic vegetation were identified: Banogill network (SC 002) Perched Brolga Swamp (SC 026) and Hillside Soak and Subsaline Creek (SC 028). Details on management issues and threats to the Banongil network (SC 002) are outlined below.

Banongill network (SC 002)

This wetland is a permanent freshwater marsh occurring on an inland shallow basin originating from lava flow (Figure 3.9). The area of the wetland is 23.1 hectares, and it is located on private land. The water was found to be fresh, brown and slightly turbid.

This wetland appears to be an important site for waterbirds, with approximately 3, 000 birds observed at the time of survey. Four rare and threatened birds were found at this wetland: Brolga, Blue-billed Duck, Latham's Snipe and Pectoral Sandpiper.

No rare or threatened vascular plant species were found at this site, however, a range of riparian and aquatic layers were present, and exotic vegetation cover and species richness was low in all wetland zones except the shore.

Figure 3.9 Banongill network (SC 002), a wetland with high environmental values in the Salt Creek sub-catchment.

The wetland is used for grazing cattle or horses, and for eel fishing. Sheep and cattle or horses also graze surrounding land. Pugging and grazing on banks and shore vegetation were observed at the time of survey and Swans were noted to be contributing to this.

The management issues identified at the Banongill network are typical of many wetlands within the Salt Creek sub-catchment, where most wetlands are on private land. Grazing and pugging are the most common threatening processes to wetlands on privately owned land (Platt & Corrick 1994). To minimise damage by grazing animals, management of grazing duration, timing and number of livestock could be considered to maintain wetland values (Hull 1996). Reduced stocking rates have been implemented at the Banongill network to protect environmental values. Public education and incentive programs to compensate landholders for fencing materials and loss of productive land may need to be explored.

Foxes pose a high threat to the large numbers of waterbirds using this wetland. Fox control is currently being undertaken to protect native fauna, particularly the endangered and vulnerable bird species identified at this site.

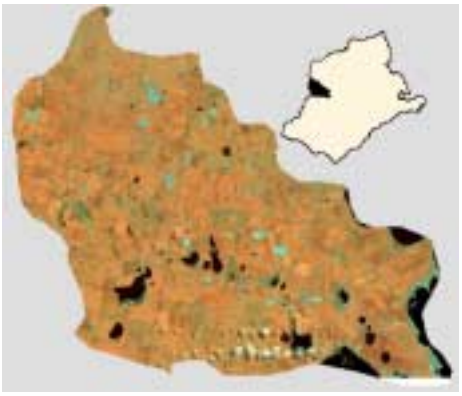
Four additional significant wetlands were noted during the survey of Salt Creek sub-catchment for their environmental values:

- Deep Lake (SC 011) supports a number of rare and threatened flora and fauna and is an important drought refuge for waterbirds. Deep Lake also supports diverse and significant vegetation communities including intact Escarpment Shrubland and Brackish Wetland Herbland.
- Molo Molo Spring-fed Wetland (SC 017) supports rare and threatened flora and fauna and provides an important drought refuge for waterbirds

- Mt Elephant Estate Spring (SC 020) is an interesting mounded spring with a significant accumulation of peat, supporting diverse vegetation (60 indigenous species) including a number of rare and threatened species.
- Brolga Swamp (SC 022) provides important breeding habitat for Brolga.

(Refer to Map 2).

3.2.2 Kooraweera Lakes Catchment



The Kooraweera Lakes Catchment (totalling 31, 250 ha) is dominated by privately owned agricultural land (96%) used primarily for stock grazing and dairying. The catchment occurs within the Victorian Volcanic Plains bioregion. Basalt stony rises and lakes formed by craters and depressions in lava flows dominate the landscape. Lakes within this region are of variable salinity, ranging from hypersaline to fresh (Williams 1992). Salt meadows and marshes and numerous small freshwater meadows and marshes also occur within the stony rises.

The Kooraweera Lakes Catchment contains wetlands listed under the Ramsar Convention (Western District Lakes). Within the study area, these include Lake Milangil and Lake Terangpom. The catchment is bounded to the east by Lake Corangamite. Several waterbodies designated as Lake Reserves and Wildlife Reserves occur and include: Lake Tatutong, Lake Punpundal, Lake Bulkil Narra, Lake Terang-Goodtditch, Lake Coradgill, Kooraweera Lakes network (10 wetlands), and Round Lake. All lakes within the study area are listed as significant wetlands for the Victorian Volcanic Plains bioregion and support large numbers of waterbirds (Environment Australia 2001). A total of 49% of the area of all mapped wetlands occurs on privately owned land and includes all freshwater meadows and marshes. Wetlands incorporate 5.3% of this sub-catchment area. Table 3.7 indicates land tenure of wetland categories within the Kooraweera Lakes Catchment.

A total of 26 wetlands were surveyed within the Kooraweera Lakes Catchment within the 2003 spring survey periods. Map 3 provides the locations of wetlands included in this inventory for the Kooraweera Lakes Catchment area.

Table 3.7 Land tenure of wetland types within the Kooraweera Lakes Catchment

Wetland Type	Freehold	Lake Reserve	Wildlife Reserve	State Forest	Total
	Area (% of total wetland area for each type within the sub-catchment)				
Shallow freshwater meadow	265.6 ha (100%)	-	-		265.6 ha
Shallow freshwater marsh	151 ha (99.7%)	0.2	0.2		151.4 ha
Shallow permanent open freshwater	26.4 ha (17.6%)	-	123.2 (82.4%)		149.6 ha
Impoundments	11.6 ha (96.7%)	-	0.4		12 ha
Salt pan	172.1 ha (31.8%)	237.3 (43.8%)	131.8 (24.4%)		541.2 ha
Salt meadow	25.8 ha (84.6%)	4.7 (15.4%)			30.5 ha
Hypersaline lakes	46.9 ha (47.8%)	51.3 (52.2%)	-		98.2 ha
Permanent saline wetlands	122.8 ha (26.7%)	22.4 ha (4.9%)	295.6 ha (64.2%)	19.4 ha (4.2%)	460.2 ha
Farm dams	24.5 ha (98.4%)	0.2 ha	0.2 ha		24.9 ha

Source: Wetland mapping: Corangamite Wetland Inventory; land status overlay: landmmt100

Mapping

A total of 367 waterbodies were identified within the Kooraweera Lakes Catchment through the mapping procedure for the Corangamite Wetland Inventory. The large majority of these were small farm dams (164; each < 1 ha in size). A significant number of

shallow freshwater meadows (108) were also identified. Permanent saline wetlands and saltpans comprised the largest overall area of the wetland types present (460 ha and 541 ha respectively).

Comparison with Wetland Database (DCNR 1995) Wetland_1994 layer

Comparisons with existing wetland databases, Wetland_1994 layer (Corrick 1982; DCNR 1995) and the wetland mapping performed for this inventory indicate a substantial improvement in the detection of wetlands within this region due to numerous very small shallow wetlands. Significant retractions in the areas of shallow freshwater meadows and marshes within the catchment were also evident. Figure 3.10 gives a comparison of the wetland maps produced through this inventory with that conducted by DCNR (1995).

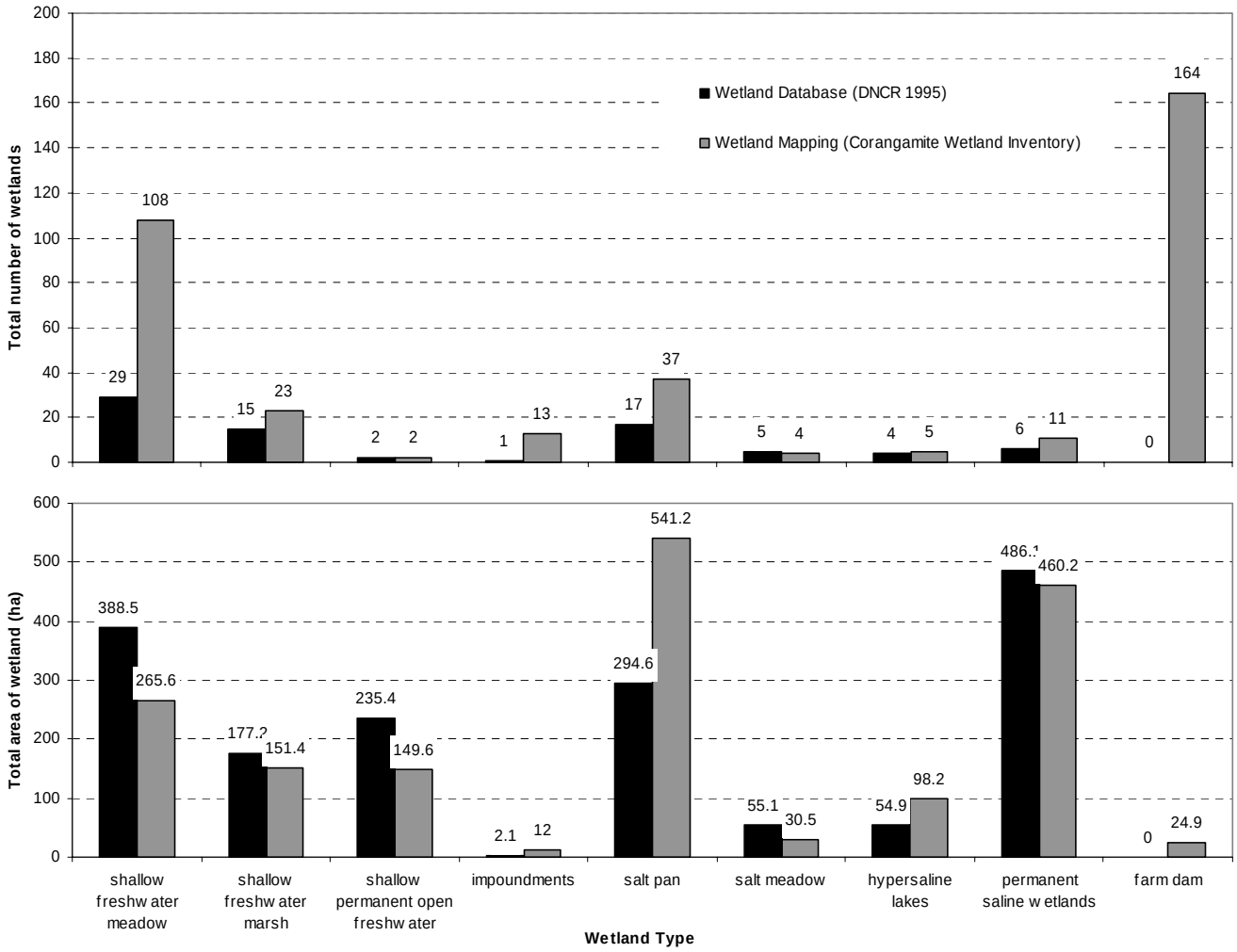


Figure 3.10 Comparison between wetland mapping for the Corangamite Wetland Inventory and existing wetland mapping (DCNR 1995) for the Kooraweera Lakes sub-catchment.

The total number of wetlands identified through this inventory is substantially improved in the shallow freshwater meadow (an additional 79 wetlands), and farm dam (164 waterbodies) categories. A large number of these wetland categories are under 1 ha in size, which were not included in the Wetland Database (DCNR 1995). A total of 33 shallow freshwater meadow wetlands less than 1 ha in size were detected and mapped through the wetland mapping process for the Corangamite Wetland Inventory.

Figure 3.10 shows increases in the number of mapped wetlands for all categories compared to previous mapping. This reflects the addition of smaller wetlands, and numerous wetlands not identified in previous mapping due to unknown reasons.

The comparison of area values for each wetland type does not however uniformly reflect the increase in wetland numbers. Significant decreases in the total area of shallow freshwater wetland categories are evident despite the increase in the number of mapped wetlands within these categories. This suggests the loss of larger wetland bodies and retraction of some larger wetlands into discrete wetland areas caused reduced water levels. Increases in the area of salt pan with the study region can also be attributed to decreasing water levels and changing character of saline wetlands within the catchment.

The total overlap between both wetland map layers was 65.7%. Map 3 provides the boundaries of wetlands mapped for this inventory.

Overlap with Wetland Database (DCNR 1995) Wetland_1994 layer

Figure 3.11 indicates the extent of overlap between both mapping procedures within each wetland type identified. This shows the extent to which the existing mapping (DCNR 1995) and the wetland mapping for the Corangamite Wetland Inventory correspond and is calculated using an overlay function in MapInfo.

The data indicates that there was substantial difference in the mapped areas for shallow freshwater meadow, shallow freshwater marsh, salt pan and salt meadow categories between both wetland map layers. Several wetlands identified by the Wetland Database (DCNR 1995) were not identified as "wet" through the mapping procedure for this inventory. This indicates that these wetlands were dry at the time of imagery acquisition, and therefore may have been drained since the Wetland Database mapping or had not received sufficient rainfall to hold water for a long period of time. Additionally, the area of many wetlands identified by the Wetland Database mapping has since reduced in size (likely to be due to insufficient rainfall or partial drainage). Notably, many shallow freshwater wetlands mapped within the Wetland Database that appear to have severely retracted in size or were not detected through the Corangamite Wetland Inventory mapping have been modified to contain farm dams or impoundments.

Figure 3.11 indicates very little difference in the area of hypersaline lakes, shallow permanent open freshwater and impoundments between the two mapping events.

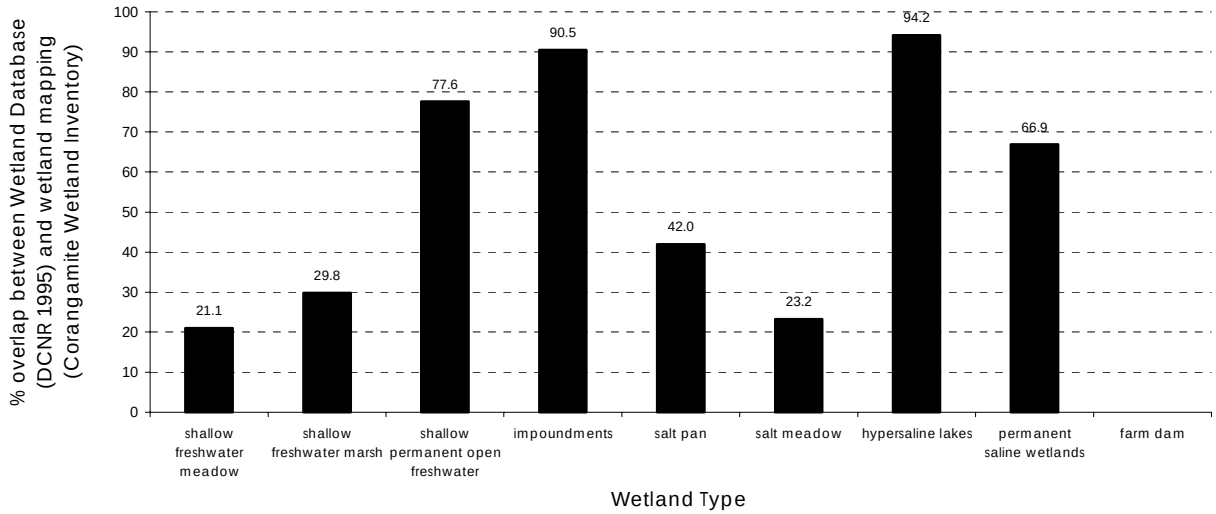


Figure 3.11 Percentage overlap between wetland mapping for the Corangamite Wetland Inventory and existing wetland mapping (DCNR 1995) for the Kooraweera Lakes sub-catchment.

Many wetlands previously identified as shallow freshwater marshes (DCNR 1995) were categorised as shallow freshwater meadows through the mapping procedure for this inventory. This was due to lower water levels as a result of poor rainfall over a long period of time which has altered the water regime of many waterbodies (i.e. lengthening dry periods).

Comparison with Wetland Database (DCNR 1995) Wetland_1788 layer

Comparisons with pre-settlement wetland mapping (Wetland_1788 layer) within the Wetland Database (DCNR 1995) indicated a current loss of 58% of the total natural wetland area that once occurred within the Kooraweera Lakes catchment.

Character

Specific analysis of this sub-catchment can be viewed in summary reports in Appendix 11. All references to tables and figures not appearing within the text refer to this document.

Permanent saline/brackish lakes (12 sites) were the most frequently recorded wetland type in the Kooraweera Lakes sub-catchment. Seasonal freshwater marshes were also commonly recorded, along with many other inland wetland types (Kooraweera Lakes Figure 1). Most wetlands surveyed were formed from shallow basins in inland systems (Kooraweera Lakes Table 1). The water source of most wetlands was local runoff (14 sites), with five stream-fed wetlands (Kooraweera Lakes Table 2).

Wetlands covering a wide variety of salinity values were recorded within the Kooraweera Lakes sub-catchment. Almost half of all wetlands surveyed were brackish (12 sites) and a number were dry at the time of survey (5 sites) (Kooraweera Lakes Figure 2). Average wetland depth ranged from 0.05 to 1.5 m, with an overall average depth of 0.42 m for wetlands surveyed across the sub-catchment (Kooraweera Lakes Table 5).

A number of rare and threatened flora and fauna were located within the Kooraweera Lakes sub-catchment (Table 3.8 & 3.9, Kooraweera Lakes Table 6 & 7).

Table 3.8 Rare and threatened flora recorded during wetland inventory surveys of the Kooraweera Lakes sub-catchment.

Species name	Common Name	No. sites	VROT	FFG	EPBC
Craspedia paludicola	Swamp Billy-buttons	1	v		
Cuscuta tasmanica	Golden Dodder	3	k		
Juncus revolutus	Creeping Rush	5	r		
Lawrencia spicata	Salt Lawrencia	5	r		
Lotus australis	Austral Trefoil	1	k		
Microseris sp. 1	Plains Yam-daisy	2	v		
Poa sallacustris	Salt-lake Tussock-grass	7	v	L	
Ranunculus diminutus	Lesser River Buttercup	13	k		

Table 3.9 Rare and threatened fauna recorded during wetland inventory surveys of the Kooraweera Lakes sub-catchment.

Species	No. sites	VROT	FFG	EPBC
Whiskered Tern	3	l		
Caspian Tern	2	v		
Brolga	2	v	L	
Royal Spoonbill	1	v		
Cape Barren Goose	1	v		
Magpie Goose	1	e		
Fat-tailed Dunnart	2	i		
Striped Legless Lizard	1	e	L	
Warty Bell Frog	1	v		V

A previously undescribed *Poa* species was identified in the Kooraweera Lakes during the wetland surveys, and is currently being investigated by the National herbarium of Victoria. It has been given a provisional name – *Poa* aff. *labillardieri* (N. Walsh pers comm. 2004). It is highly likely that this species will be rare or vulnerable both within Victoria, and nationally, as it has been located at only three sites in the Kooraweera Lakes sub-catchment area.

A total of 132 native vascular plant species were identified during the surveys within the Kooraweera Lakes, with 72 (35.3 %) exotic species. Buffer vegetation was recorded at 18 sites, although four of the five most frequently occurring species were exotic (Kooraweera Lakes Table 9).

Tenure and landuse

The majority of wetlands surveyed within the Kooraweera Lakes sub-catchment were on private land (22 sites). Five publicly owned wetlands were also surveyed, including Corangamite North West Shore (KL 004), Terrangpom Lake (KL 006), Lake Milangil (KL 007), Foxhow Roadside (KL 014), and Corangamite Lakes (KL 025). Surrounding land was almost exclusively privately owned (25 out of 26 sites) (Kooraweera Lakes Table 3). Thirteen of the wetland sites surveyed were managed for conservation, with ten of these unused for other purposes. Grazing of sheep (6 sites) and cattle or horses (3 sites) took place on a number of wetland sites. All land surrounding wetlands was either cropped or grazed (Kooraweera Lakes Table 4).

Condition

Most wetland sites scored moderate for macroinvertebrates (11 sites) and birds (11 sites), whilst most recorded poor scores for fish (15 sites) (Kooraweera Lakes Table 10). It should be noted that condition values were derived by rapid assessment (i.e. expert opinion based on habitat quality and availability) and surveys of macroinvertebrates and fish were not undertaken. All buffer vegetation was recorded as degraded (22 sites). Shore and bank vegetation were commonly described in moderate condition (11 sites and 12 sites respectively), however, aquatic vegetation generally scored higher, with 13 sites recorded as being in high condition in the Kooraweera Lakes sub-catchment (Kooraweera Lakes Table 10).

Wetlands in the Kooraweera sub-catchment scored well on the subjective condition value. One site was identified as pristine - Lake Milangil. A further 15 sites were described as intact, with only five moderate and five degraded sites surveyed within the sub-catchment.

The total rapid assessment score identified five sites with high environmental values:

1. Gahnia Swamp (KL 016)
2. West Lake (KL 017)
3. Fresh Lake (KL 019)
4. Brackish Wetland (KL 022)
5. Corangamite Lakes (KL 025)

(Refer to Map 3)

Threats

Management issues and potential threats for wetlands in the sub-catchment are listed in Kooraweera Table 12. The most frequently noted threat was weeds (15 sites) with environmental weed problems noted at 11 sites. Grazing by stock was identified as a management issue at seven sites, and altered water regimes were of concern at five sites (four sites due to decreased water regimes and one site due to increased water).

Significant wetlands

The total rapid assessment score (Section 3.1.4) identifies five sites with high environmental values. A detailed outline of the values, issues and threats to one of these sites - Fresh Lake (KL 019) has been presented below.

Fresh Lake - (KL 019)

Fresh Lake is a permanent fresh-water lake on an inland shallow basin formed in a deflation basin (Figure 3.12). It extends for approximately 60 ha, and at the time of survey, the lake was brackish (EC 2, 000 µs), pH neutral and very clear.

Figure 3.12 Fresh Lake - (KL 019), a wetland with high environmental values (photo showing Mt Elephant in the background).

This wetland occurs on private land, and is managed exclusively for conservation, however, surrounding land is cropped, grazed by sheep and cattle or horses.

Three flora species that have been listed as rare and threatened (DNRE 2002b) were found at this lake, *Ranunculus diminutus*, *Juncus revolutus* and *Poa sallacustris*. The latter is also listed as vulnerable under the EPBC Act. Four fauna species that have been listed as rare and threatened were also observed at Fresh Lake; including a large population of Warty Bell Frog (vulnerable within Victoria and nationally), Brolga (vulnerable), and Cape Barren Goose and Caspian Tern (near threatened). This wetland provides an important freshwater drought refuge for birds.

A moderate threat to this wetland from environmental weeds has been identified. Fencing and revegetation works have already been undertaken to protect the environmental values of this wetland. However, pest plant and animal control should also be considered to protect the flora and fauna of Fresh Lake.

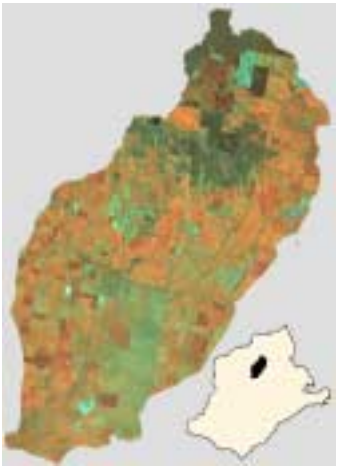
A number of wetlands with significant environmental values were also identified during surveys of the sub-catchment:

1. Roadside Grassy Wetland (KL 003) - supports rare and threatened flora. Whilst this wetland was dry at time of survey, it would be worth revisiting following a wet winter.
2. Lake Corangamite NW shore, south of Carters Road (KL 004) - supports rare and threatened flora and fauna including diverse Saltmarsh and Brackish Grassland vegetation with important habitat for rare fauna.
3. Lake Coradgill (KL 005) - very diverse saltmarsh including an interesting island, which is submerged at times when the lake is full. Supports many rare and threatened flora and fauna.
4. Lake Terangpom (KL 006) - provides important drought refuge for waterbirds with abundant and diverse aquatic vegetation including rare and threatened flora.

5. Lake Milangil (KL 007) supports rare and threatened flora including *Poa sallacustris*.
6. Constructed Wetland (KL 012) supports rare and threatened flora, and provides breeding habitat for Brolga.
7. Salt Lake (KL 018) supports rare and threatened flora including *Lawrencia spicata* and *Poa sallacustris*.

Freshwater Lake (KL 019) is an important drought refuge for waterbirds and frogs with abundant and diverse aquatic vegetation supporting rare and threatened flora and fauna including a large population of Warty Bell Frog.

3.2.3 Dereel Catchment



The Dereel Catchment (totalling 27, 970 ha) is dominated by privately owned agricultural land (94.8%) used primarily for stock grazing and cereal cropping. Pine and blue-gum plantations are also present in the north of the sub-catchment.

The Dereel Catchment comprises two bioregions; Central Victorian Uplands (14, 880 ha) and Victorian Volcanic Plain (13, 090 ha). Wetlands within the Central Victorian Uplands were typically brackish floodplains and impoundments of human origin (often created by historic mining activity). Dereel Lagoon Wildlife Reserve is the only publicly owned wetland within the catchment and is an excellent representative of a naturally occurring deep freshwater marsh of this region.

Shallow freshwater meadows and marshes were largely confined to the Volcanic Plains and were often associated with remnant native grasslands, particularly amongst stony rises to the south of the catchment. Wetlands incorporate less than 2% of the Dereel Catchment area. Table 3.10 indicates the land tenure of wetland categories within the Dereel Catchment.

Table 3.10 Land tenure of wetland types within the Dereel Catchment.

Wetland Type	Freehold	Public Land Water Frontage	Wildlife Reserve	Softwood or Hardwood Plantation	Total
	Area (% of total wetland area for each type within the sub-catchment)				
Shallow freshwater meadow	41.1 ha (100%)	-	-	-	41.1 ha
Shallow freshwater marsh	98.5 ha (100%)	-	-	-	98.5 ha
Deep freshwater marsh	-	-	36.2 ha (100%)	-	36.2 ha
Impoundments	31.6 ha (94%)	-	0.6 ha (1.7%)	1.4 ha (4.2%)	33.6 ha
Farm dams	26.8 ha (94%)	0.15 ha (0.5%)	-	1.6 ha (6%)	28.4 ha
Floodplain	99.9 ha (96%)	2.9 ha (3%)	-	1.4 ha (1%)	104.2 ha

Source: Wetland mapping: Corangamite Wetland Inventory; land status overlay: landmmt100

A total of ten wetlands were surveyed within the Dereel Catchment during the 2002 and 2003 spring survey periods. Map 4 provides the locations of wetlands included in this inventory for the Dereel Catchment area.

Mapping

A total of 296 waterbodies were identified within the Dereel Catchment through the mapping procedure for the Corangamite Wetland Inventory. The large majority (71%) of these were small farm dams (209; each < 1 ha in size). A significant number of larger impoundments (41) also occurred. Relatively smaller numbers of naturally occurring wetlands including shallow freshwater meadow (18), shallow freshwater marsh (16), floodplain (11) and deep freshwater marsh (1) were identified. Floodplain wetlands comprised the largest area (totalling 104 ha) of all wetland types identified within the catchment.

Comparison with Wetland Database (DCNR 1995) Wetland_1994 layer

Comparisons with existing wetland databases, Wetland_1994 layer (Corrick 1982; DCNR 1995) and the wetland mapping performed for this inventory indicate an improvement in the detection of wetlands within this region, particularly the identification of small waterbodies and the addition of floodplain wetlands. Figure 3.13 gives a comparison of the wetland maps produced through this inventory with that conducted by DCNR (1995).

The total number of wetlands identified through this inventory is substantially improved in most wetland categories, and unchanged for deep freshwater marsh. A large proportion (84%) of the wetlands mapped within these wetland categories are under 1 ha in size, which were not included in the Wetland Database (DCNR 1995). This inventory process also identified areas subjected to flooding from creeklines, which were also not mapped in the Wetland Database (DNCR 1995).

Figure 3.13 shows increases in the total area for all wetland categories compared to previous mapping. This however does not reflect an increase in wetland area since the 1995 mapping, but reflects the addition of smaller wetlands, floodplains, and several wetlands not identified in previous mapping for unknown reasons.

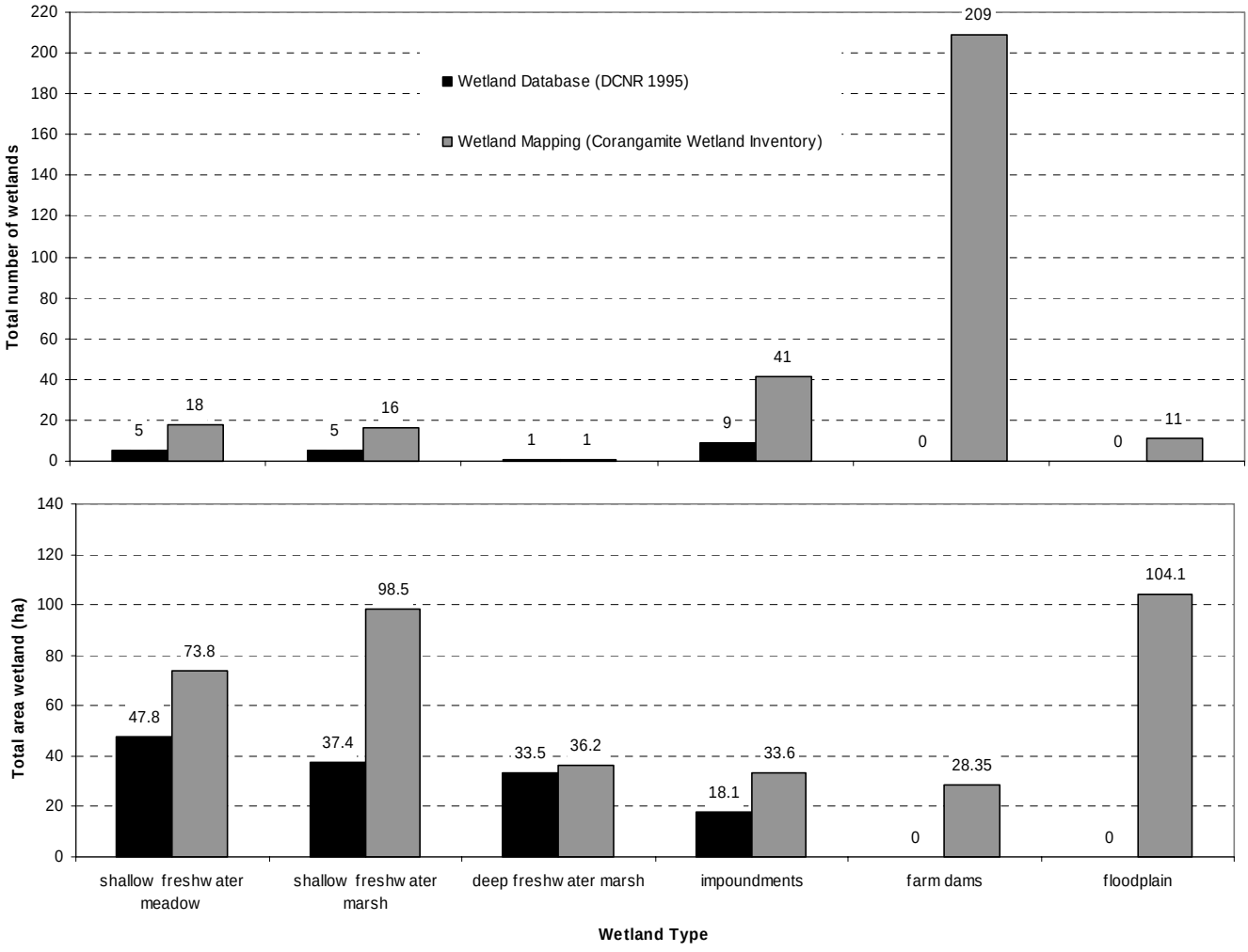


Figure 3.13 Comparison between wetland mapping for the Corangamite Wetland Inventory and existing wetland mapping (DCNR 1995) for the Dereel sub-catchment.

Overlap with Wetland Database (DCNR 1995) Wetland_1994 layer

Figure 3.14 indicates the extent of overlap between both mapping procedures within each wetland type identified. This shows the extent to which the existing mapping (DCNR 1995) and the wetland mapping for the Corangamite Wetland Inventory correspond and is calculated using an overlay function in MapInfo.

The data indicates that there was a decrease in the mapped areas for shallow freshwater meadow, shallow freshwater marsh and impoundment categories between both wetland map layers. However, within this sub-catchment, this did not reflect the loss of individual wetlands mapped by DCNR (1995), but a decrease in the inundated area of many wetlands. The area of wetlands within these categories identified by the Wetland Database mapping has since reduced in size (likely to be due to insufficient rainfall or partial drainage).

Figure 3.14 indicates no change in the area of deep freshwater marsh between the two mapping events. No areas were identified in the farm dams and floodplain categories in both mapping procedures.

The total overlap between both wetland map layers was 82.5%. Map 4 provides the boundaries of wetlands mapped for this inventory.

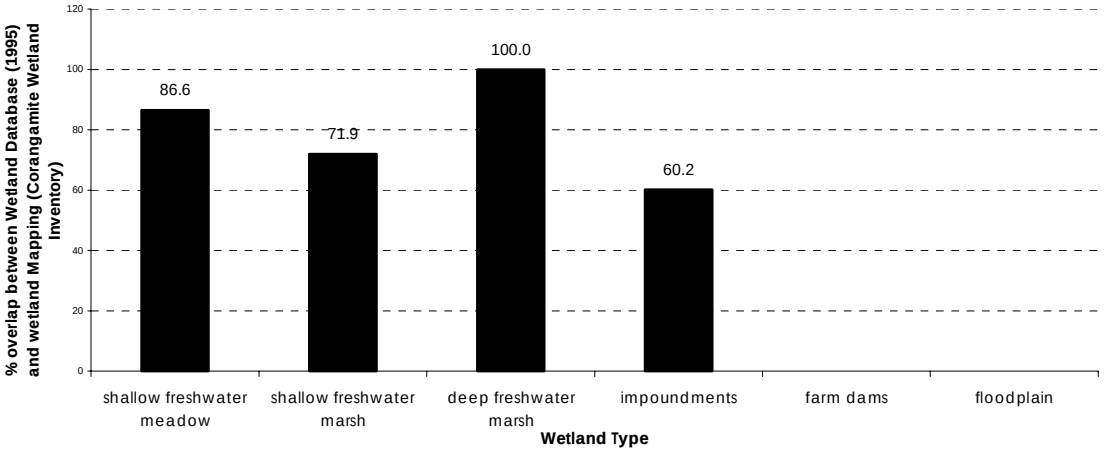


Figure 3.14 Percentage overlap between wetland mapping for the Corangamite Wetland Inventory and existing wetland mapping (DCNR 1995) for the Dereel sub-catchment.

Comparison with Wetland Database (DCNR 1995) Wetland_1788 layer

Comparisons with pre-settlement wetland mapping (Wetland_1788 layer) within the Wetland Database (DCNR 1995) indicated a current loss of 14.3% of the total natural wetland area within the Dereel catchment. The most affected category was deep freshwater marsh where less than half of the original extent remains.

Character

Specific analysis of this sub-catchment can be viewed in summary reports in Appendix 11. All references to tables and figures not appearing within the text refer to this document.

Seasonal freshwater marshes were the most frequently recorded wetland type in the sub-catchment (6 sites), seasonal rivers and streams (3 sites), and permanent freshwater lakes (>8 ha) (1 site) were also surveyed within the sub-catchment (Dereel Figure 1). Most wetlands surveyed were formed in shallow basins (7 sites), with three wetlands occurring on flat areas (Dereel Table 1). The water-source of most wetlands surveyed was local runoff (6 sites), but wetlands in the sub-catchment also received water from streams (3 sites).

Four of the wetlands surveyed within Dereel were brackish and four fresh, with two sites dry at the time of survey (Dereel Figure 2). Average wetland depth ranged from 0.1 to 0.5 m, with an overall average depth across the sub-catchment of 0.29 m (Dereel Table 5).

Brolga are listed as vulnerable in Victoria (DNRE 2002a) and were located at two sites within the sub-catchment. Six rare and threatened flora were also recorded (Table 3.11).

Buffer vegetation was recorded at eight out of ten sites surveyed, and the most frequently occurring species in the buffer vegetation were native (Dereel Table 9). Aquatic vegetation was also dominated by native species (Dereel Table 9).

Table 3.11 Rare and threatened flora recorded during wetland inventory surveys of the Dereel sub-catchment.

Scientific name	Common name	No. sites	VROT	FFG	EPBC
Amphibromus fluitans	River Swamp Wallaby-grass	5	k	X	VU
Chorizandra australis	Southern Bristle-sedge	1	k		
Helichrysum aff. *rutidolepis* (Lowland Swamps)	Pale Swamp Everlasting	1	v		
Juncus revolutus	Creeping Rush	2	r		
Schoenus nanus	Tiny Bog-sedge	1	k		
Schoenus sculptus	Gimlet Bog-sedge	1	r		

Tenure and landuse

The majority of wetlands surveyed and their surrounds were privately owned, with only one wetland occurring on public land within the sub-catchment. Two of the privately owned wetland sites are managed for conservation, however the remaining privately owned wetlands are grazed by sheep (5 sites) and cattle or horses (3 sites). The land surrounding wetlands was frequently grazed by sheep (5 sites) and cattle or horses (3 sites) (Dereel Table 4).

Condition

The condition of macroinvertebrates was evenly distributed across the three classes: low (3 sites), moderate (4 sites), and high (3 sites). Fish were generally recorded in low condition. High bird condition was recorded at five sites (Dereel Table 10). It should be noted that condition values were derived by rapid assessment (i.e. expert opinion based on habitat quality and availability) and surveys of macroinvertebrates and fish were not undertaken.

Few sites with intact riparian vegetation were observed — Buffer (1 site), Bank (2 sites), Shore (2 sites) — however, aquatic vegetation was commonly recorded in high condition (6 sites) (Dereel Table 10). The subjective wetland condition value indicated that six of the sites surveyed in Dereel were intact, with only one appearing degraded, the remaining three sites were in moderate condition (Dereel Table 11).

The total rapid assessment score identifies four sites with high environmental values:

1. Dereel Lagoon (DE 003)
2. Swamp (DE 004)
3. Wurrook North Hayshed Wetland (DE 006)
4. Saline Wetland (DE 007)

(Refer to Map 4).

Threats

Weeds (8 sites) were the most frequently identified management issue in the Dereel sub-catchment, followed by grazing (7 sites), altered soil characteristics (6 sites), and nutrient enrichment (6 sites) (Dereel Table 12). Pasture weeds were the most commonly recorded weed problem (7 sites), with three sites recording environmental weeds.

Significant wetlands

Four sites were identified as supporting high environmental values within the Dereel sub-catchment; one of these, Saline Wetland (DE 007) will be presented in further detail.

Saline Wetland (DE 007)

This wetland was classified as B2 (seasonal rivers or streams), and consists of a stream-fed wetland on a flat floodplain. The wetland was approximately 8.7 hectares in area, and at the time of survey the water was brackish (12, 400 uS), alkaline and very clear.

Saline Wetland is a floristically rich example of an unreserved floristic community (Brackish drainage-line herbland/rushland). A rare plant species, *Juncus revolutus* was found at the site (DNRE 2002b), and whilst no rare and threatened fauna were observed at the site, a number of bird species were observed to be utilising the site.

The site is privately owned and sheep graze the wetland and surrounding land. This has led to a large number of management issues being identified at the site (Table 3.12). A severe problem with pugging has been identified, which is one of the most common management issues occurring on privately owned wetlands (Platt & Corrick 1994). Stock grazing and associated erosion of the waterway have also been identified as high threats at this site. Pest plants and animals have been identified as moderate management issues.

Table 3.12 Management issues identified at Saline Wetland (DE 007).

Management issue	Extent
Changed soil character - pugging	Severe
Grazing - stock	High
Erosion - waterway	High
Nutrient enrichment - agricultural	Moderate
Vermin - foxes	Moderate
Vermin - rabbits	Moderate
Weeds - pasture	Moderate
Altered water regime - increased	Minimum
Vermin - hares	Minimum

Sheep grazing of the wetland threatens the significant environmental values of this wetland. This wetland may benefit from fencing to reduce erosion, decrease pugging and manage grazing of the wetland. Pest plant and animal control may also assist in protecting and maintaining the high environmental values identified at this site.

Many of the other wetlands surveyed within the Dereel sub-catchment also had significant environmental values. Most sites supported at least one species of rare and threatened flora, and only one site was observed to be in low condition. As only ten wetlands were surveyed within this sub-catchment, no further examples of significant wetlands have been outlined.

3.2.4 Warrambine Creek Catchment

The Warrambine Creek Catchment (totalling 29, 040 ha) is dominated by privately owned agricultural land (99%) used primarily for stock grazing and cereal cropping. Wetlands within public land include Bingley and Wingeel Swamp Reserves, Gumley Lake water reservoir, and impoundments on Warrambine Creek. Warrambine Creek Catchment is within the Victorian Volcanic Plain bioregion.

Wetlands within this catchment include many sedge-dominated brackish marshes and herb-dominated freshwater meadows characteristic of the Victorian Volcanic Plains bioregion. Brackish sedge-dominated drainage lines and small complexes of gilgai wetlands also occur within this catchment often associated with native grasslands. Several wetland dependant threatened flora and fauna species have been recorded in wetlands within this catchment. Wetlands incorporate less than 2% of this sub-catchment area. Table 3.13 indicates land tenure of wetland categories within Warrambine Creek Catchment.

A total of 9 wetlands were surveyed within the Warrambine Creek Catchment including both the 2002 and 2003 spring survey periods. Map 5 provides the locations of wetlands included in this inventory for the Warrambine Creek Catchment area.

Table 3.13 Land tenure of wetland types within the Warrambine Creek Catchment.

Wetland Type	Freehold	Water Production Area	Wildlife Reserve	Total
	Area (% of total wetland area for each type within the sub-catchment)			
Shallow freshwater meadow	75.1 ha (100%)	-	-	75.1 ha
Shallow freshwater marsh	25.8 ha (100%)	-	-	25.8 ha
Shallow brackish marsh	40.9 ha (100%)	-	-	40.9 ha
Impoundments	64.2 ha (95%)	3.6 ha (5%)	-	67.8 ha
Permanent shallow saline	122.9 ha (72%)	-	48 ha (28%)	170.9 ha
Farm dams	20.3 ha (100%)	-	-	20.3 ha
Floodplain	57.6 ha (100%)	-	-	57.6 ha

Source: Wetland mapping: Corangamite Wetland Inventory; land status overlay: landmmt100

Mapping

A total of 202 waterbodies were identified within the Warrambine Creek Catchment through the mapping procedure for the Corangamite Wetland Inventory. The large majority of these were small farm dams (137; each < 1 ha in size). A significant number of shallow freshwater meadows (21) and large human-origin impoundments (24) were identified.

Comparison with Wetland Database (DCNR 1995) Wetland_1994 layer

Comparisons with existing wetland databases, Wetland_1994 layer (Corrick 1982; DCNR 1995), and the wetland mapping performed for this inventory indicate a substantial improvement in the detection of wetlands within this region. Figure 3.15 gives a comparison of the wetland maps produced through this inventory with that conducted by DCNR (1995).

The total number of wetlands identified through this inventory is improved in all wetland categories. Shallow freshwater meadow and shallow freshwater marsh categories show significant increases in detection, both in total number and area. Shallow brackish marsh was unable to be spectrally differentiated from shallow freshwater categories through the classification process. However, field survey of the catchment indicated that brackish wetlands were typical of this sub-catchment, and were structurally different from shallow freshwater categories.

Additionally, a total of 151 waterbodies less than 1 ha in size were mapped through the Corangamite Wetland Inventory. The inventory process also identified a total of 57.6 ha subjected to flooding from creeklines, which was also not mapped in the Wetland Database (DCNR 1995).

Figure 3.15 shows increases in the number and area for most wetland categories compared to previous mapping. This however does not reflect an increase in wetland area since the 1995 mapping, but reflects the addition of smaller wetlands, and several wetlands not identified in previous mapping for unknown reasons.

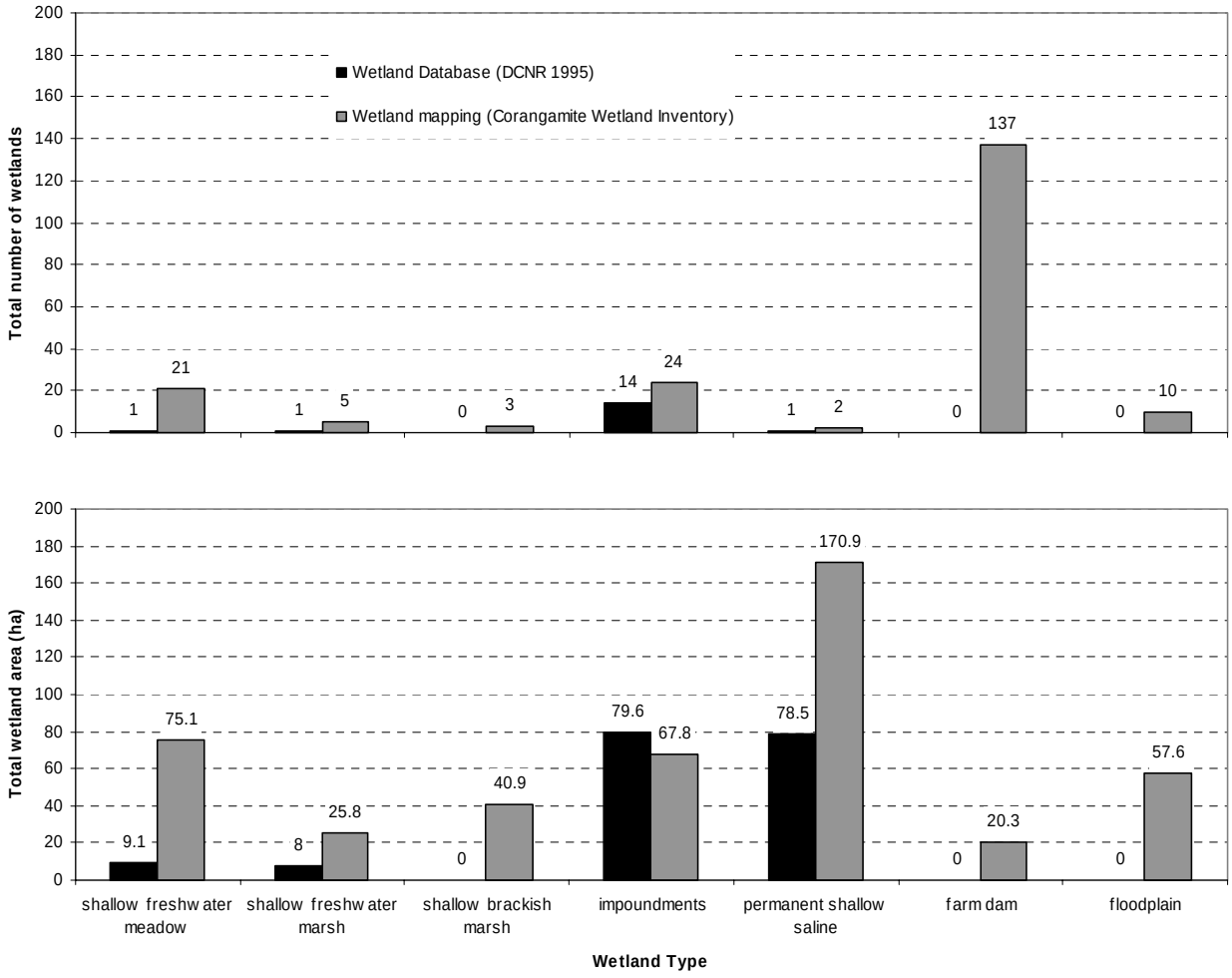


Figure 3.15 Comparison between wetland mapping for the Corangamite Wetland Inventory and existing wetland mapping (DCNR 1995) for the Warrambine Creek sub-catchment.

Overlap with Wetland Database (DCNR 1995) Wetland_1994 layer

Figure 3.16 indicates the extent of overlap between both mapping procedures within each wetland type identified. This shows the extent to which the existing mapping (DCNR

1995) and the wetland mapping for the Corangamite Wetland Inventory correspond and is calculated using an overlay function in MapInfo.

The data indicates that there was substantial difference in the mapped areas for shallow freshwater meadow and shallow freshwater marsh categories between both wetland map layers. The Wetland Database (DCNR 1995) mapping of the Warrambine sub-catchment identified only one wetland each in both the shallow freshwater meadow and shallow freshwater marsh categories. Comparison with Corangamite Wetland Inventory mapping revealed that the shallow freshwater meadow was not identified as "wet" through the mapping procedure and now contains a farm dam. The shallow freshwater marsh was still extant, however at a reduced size.

Several wetlands within this sub-catchment that were identified in previous mapping were found to be dry at the time of imagery acquisition, and therefore may have been drained since the Wetland Database mapping or had not received sufficient rainfall to hold water for a long period of time. Additionally, the areas of many wetlands identified by the Wetland Database mapping have since reduced in size (likely to be due to insufficient rainfall or partial drainage). Figure 3.16 indicates very little difference in the area of shallow permanent saline wetlands between the two mapping events. No overlap was identified between shallow brackish wetlands, floodplain wetlands, and farm dams as these categories were not mapped in the Wetland Database (DCNR 1995).

The total overlap between both wetland map layers was 64.3%. Map 5 provides the boundaries of wetlands mapped for this inventory.

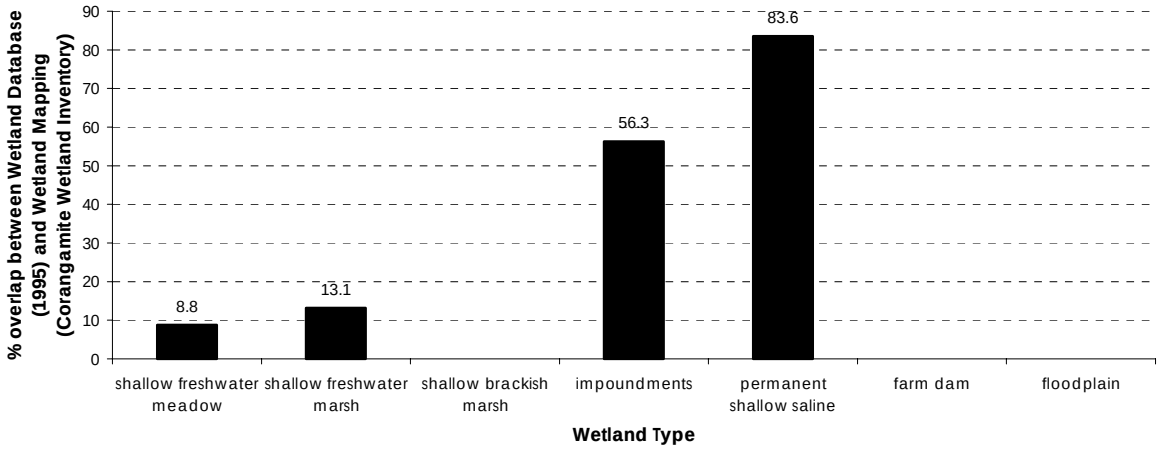


Figure 3.16 Percentage overlap between wetland mapping for the Corangamite Wetland Inventory and existing wetland mapping (DCNR 1995) for the Warrambine Creek sub-catchment.

Comparison with Wetland Database (DCNR 1995) Wetland_1788 layer

Comparisons with pre-settlement wetland mapping (Wetland_1788 layer) within the Wetland Database (DCNR 1995) indicated a current loss of 41.6 % of the total natural wetland area within the Warrambine Creek catchment. Less than half of the original extent of shallow freshwater meadow and shallow freshwater marsh remains within the catchment.

Character

Specific analysis of this sub-catchment can be viewed in summary reports in Appendix 11. All references to tables and figures not appearing within the text refer to this document.

Six major wetland classification groups were surveyed within the Warrambine Creek sub-catchment including permanent freshwater lakes (>8ha) (2 sites), seasonal rivers and streams (2 sites), and water storage areas (>8 ha) (2 sites) (Warrambine Creek Figure 1).

The water source of wetlands was derived from local runoff (4 sites) and streams (6 sites) (Warrambine Creek Table 2). The salinity of five of the wetland sites was classified as brackish, two sites were dry at the time of surveys, and the remaining two sites were fresh. The average wetland depth ranged from 0.1 to 2.0 m, with an overall average of 0.89 for all wetlands surveyed across the sub-catchment.

A number of rare and threatened flora and fauna species were recorded within wetlands in the Warrambine Creek sub-catchment (Table 3.14, Warrambine Creek Table 11).

Table 3.14 Rare and threatened flora recorded during wetland inventory surveys in the Warrambine Creek sub-catchment.

Species name	Common name	No. sites	VROT	FFG	EPBC
Amphibromus sinuatus	Wavy Swamp Wallaby-grass	2	v		
Cullen parvum	Small Scurf-pea	2	e	L	EN
Juncus revolutus	Creeping Rush	1	r		

Three fauna species listed as vulnerable in Victoria were also located in the Warrambine wetland surveys; the Australasian Shoveler (1 site), Hardhead (1 site) and Warty Bell Frog (also vulnerable nationally - 2 sites).

Six sites recorded buffer zone vegetation, with the most frequently occurring species including *Poa labillardieri*, *Cullen parvum*, and *Hymenanthera dentata* s.l. (Table 9). Emergent zone vegetation was recorded at seven sites and aquatic vegetation at four sites (Warrambine Creek Table 9).

Tenure and landuse

Of the nine sites surveyed, all occurred on private land, although one site also included a section of public land (Warrambine Creek Table 3). Grazing by sheep (4 sites) was the most commonly observed land use of wetlands surveyed, although three sites are unused (Warrambine Creek Table 4). Land adjoining wetlands was commonly grazed by sheep (7 sites) and horses or cattle (2 sites).

Condition

Macroinvertebrate populations in wetlands surveyed in the Warrambine Creek sub-catchment were evenly distributed between low (3 sites), moderate (3 sites) and high (3 sites) condition classes. Seven sites recorded low fish condition, with two sites in moderate condition. Most sites recorded high (4 sites) or moderate (3 sites) bird condition values (Warrambine Creek Table 10). It should be noted that condition values were derived by rapid assessment (i.e. expert opinion based on habitat quality and availability) and surveys of macroinvertebrates and fish were not undertaken.

The subjective wetland condition value rated four wetlands as intact. No wetlands in the Warrambine sub-catchment were found to be in pristine condition. Two of the wetlands surveyed were severely degraded, and one site was degraded (Warrambine Creek Table 11).

The total rapid assessment score identifies three sites with high environmental values;

1. Lawaluk Creek Impoundment (WA 003)
2. Warrambeen Impoundment (WA 011)
3. Waterholes Warrambine Creek (WA 012) (Refer to Map 5).

Threats

Weeds were most consistently recorded threat within the Warrambine Creek sub-catchment (9 sites). Pasture weeds were recorded as a management issue at all sites, with environmental weeds, recorded at seven sites. Stock grazing (4 sites) and nutrient enrichment (4 sites) were also recorded as significant management issues within the sub-catchment.

Significant wetlands

The total rapid assessment score (Section 3.1.4) identified three sites with high environmental values. A detailed outline of the values, issues and threats to one of these sites - Waterholes Warrambine Creek (WA 012) has been presented below.

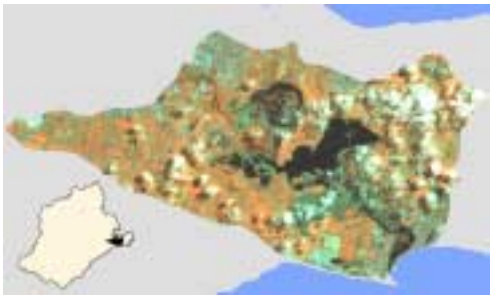
Waterholes Warrambine Creek (WA 012)

Waterholes Warrambine Creek consists of a chain of deep, clear pools separated by riffles and a broad depression on the creek floodplain which was also shallowly inundated at the time of survey. At the time of survey, the water was brackish (EC 4900 uS), neutral and very clear, with an average depth of 1 m.

One flora species, Small scurf-pea (*Cullen tenax),* which is listed as endangered under the EPBC Act, was located at this site. Wavy Swamp Wallaby-grass (*Amphibromus sinuatus)* was also located during the survey of this site, and is vulnerable within Victoria. Warty Bell Frogs were located at this site and are listed as vulnerable in Victoria and nationally.

The area is privately owned, however, the wetland is currently unused. Land surrounding the wetland is grazed by sheep. The wetland has been fenced, however, a severe threat from weed encroachment was noted, including noxious, environmental and pasture weeds. A high threat from encroachment by gardening, and a potential threat from increased salinity were also noted at this site.

3.2.5 Connewarre Catchment



The Connewarre Catchment (totalling 18, 890 ha) is dominated by privately owned land (79%). Suburban house blocks occupy approximately 10% of freehold land including the outer Geelong suburbs of Ocean Grove, Barwon Heads, Leopold and Belmont. Agricultural areas are used for a variety of purposes including dairying, stock grazing, hobby farms, and horses.

Lake Connewarre State Wildlife Reserve contains over 90% of the total area of wetlands mapped within this catchment. The reserve totals 3, 370 ha (18% of the catchment area) and includes Lake Connewarre, surrounding salt flats and Reedy Lake. The reserve incorporates all of the deep freshwater marsh, salt meadow and tidal mudflat wetland categories mapped within the sub-catchment. This area is included within Port Phillip and Western Shoreline Ramsar site. Other smaller reserves containing wetlands include Lorne-Queenscliff Coastal Reserve (51 ha) and Mud Islands Wildlife Reserve (52 ha). Table 3.15 indicates land tenure of wetland categories within the Connewarre Catchment area.

Wetlands within the sub-catchment are predominantly supratidal salt flats and floodplains. Mangroves and mudflats exist along the Barwon River estuary which occurs within the Otway Plains bioregion. Smaller shallow freshwater meadows and marshes exist in the south - west of this sub-catchment within the Victorian Volcanic Plain bioregion on privately owned land. Reedy Lake is the largest area of deep freshwater marsh within the CCMA region.

A total of 28 surveys were completed within 24 wetlands, due to the very large nature of some of the wetlands within the Connewarre Catchment. Map 6 provides the locations of wetlands included in this inventory for the Connewarre Catchment area.

Mapping

A total of 362 waterbodies were identified within the Connewarre Catchment through the mapping procedure for the Corangamite Wetland Inventory. The large majority of these were small farm dams (233; most < 1 ha in size). Wetlands within this catchment incorporate a total area of 3, 760 ha (20% of the total catchment area). Extensive areas of permanent saline waters (1, 278 ha), salt flats (1, 135 ha), deep freshwater marsh (476 ha), and tidal floodplains (461 ha) were mapped.

Comparison with Wetland Database (DCNR 1995) Wetland_1994 layer

Comparisons with existing wetland databases, Wetland_1994 layer (Corrick 1982; DCNR 1995) and the wetland mapping performed for this inventory indicates generally similar mapping results between the two databases. Figure 3.17 gives a comparison of the wetland maps produced through this inventory with that conducted by DCNR (1995).

The total number of wetlands identified through this inventory was slightly improved in most wetland categories. Notable increases in the number of mapped impoundments, salt flats and permanent saline waterbodies were shown (Figure 3.17). A total of 270 waterbodies less than 1 ha in size were detected through the wetland mapping process for the Corangamite Wetland Inventory. The majority (95%) of these were in the farm dam and impoundment categories. This inventory process also identified areas subjected to flooding from creeklines and rivers (461 ha) and identified mangrove dominated wetlands (11.1 ha) that were not mapped in the Wetland Database (DNCR 1995).

Table 3.15 Land tenure of wetland types within the Connewarre Catchment.

Wetland Type	Freehold	Coastal Reserve	Wildlife Reserve (Ramsar site)	Public Land Water Frontage	Education area	State Forest	Total
	Area (% of total wetland area for each type within the sub-catchment)						
Shallow freshwater meadow	35.1 ha (100%)	-	-	-	-		35.1 ha
Shallow freshwater marsh	50.8 ha (96%)	-	2.1 ha (4%)	-	-		52.9 ha
Deep freshwater marsh	23 ha (5%)	-	453.3 ha (95%)	-	-		477.4 ha
Impoundments	53.7 ha (83%)	-	9.7 ha (15%)	0.5 ha (<1%)	1 ha (1%)		65.1 ha
Salt pan	57.6 ha (72%)	-	-	22.2 ha (28%)	-		79.8 ha
Salt meadow	-	-	88.9 ha (100%)	-	-		88.9 ha
Salt flats	235.8 ha (21%)	-	899.4 ha (79%)	-	-		1, 135.2 ha
Permanent saline wetlands	112.7 ha (9%)	1.8 ha (<1%)	1, 149.8 ha (90%)	-	-	15.6 ha (1%)	1, 278.2 ha
Intertidal mudflats	1.7 ha (3%)	-	52.1 ha (97%)	-	-		53.9 ha
Farm dams	41.2 ha (91%)	-	2.2 ha (5%)	1.5 ha (1%)	0.1 ha (<1%)	0.1 ha (<1%)	45.2 ha
Floodplain	355 ha (77%)	-	100.8 ha (22%)	-	-	5.4 ha (1%)	462.4 ha
Mangroves	35.1 ha (100%)	-	-	-	-		11.1 ha

Source: Wetland mapping: Corangamite Wetland Inventory; land status overlay: landmmt100

Figure 3.17 generally shows little change in the total area of most wetland categories compared to previous mapping. Decreases in the total area of deep freshwater marsh reflect areas re-classified as open water within Reedy Lake through the mapping process, and not contraction of this wetland. Notably the area of many individual shallow freshwater marshes and meadows identified by DCNR (1995) were identified as much smaller through the mapping procedure for the Corangamite Wetland Inventory.

Overlap with Wetland Database (DCNR 1995) Wetland_1994 layer

Figure 3.18 indicates the extent of overlap between both mapping procedures within each wetland type identified. This shows the extent to which the existing mapping (DCNR 1995) and the wetland mapping for the Corangamite Wetland Inventory correspond and is calculated using an overlay function in MapInfo.

The data indicates only small differences between the two map layers in the salt meadow, salt flats and permanent saline wetland categories. These wetland categories occur almost exclusively within Lake Connewarre State Wildlife Reserve and are fed by marine waters. Therefore, no changes were expected between the mapping efforts for these wetlands.

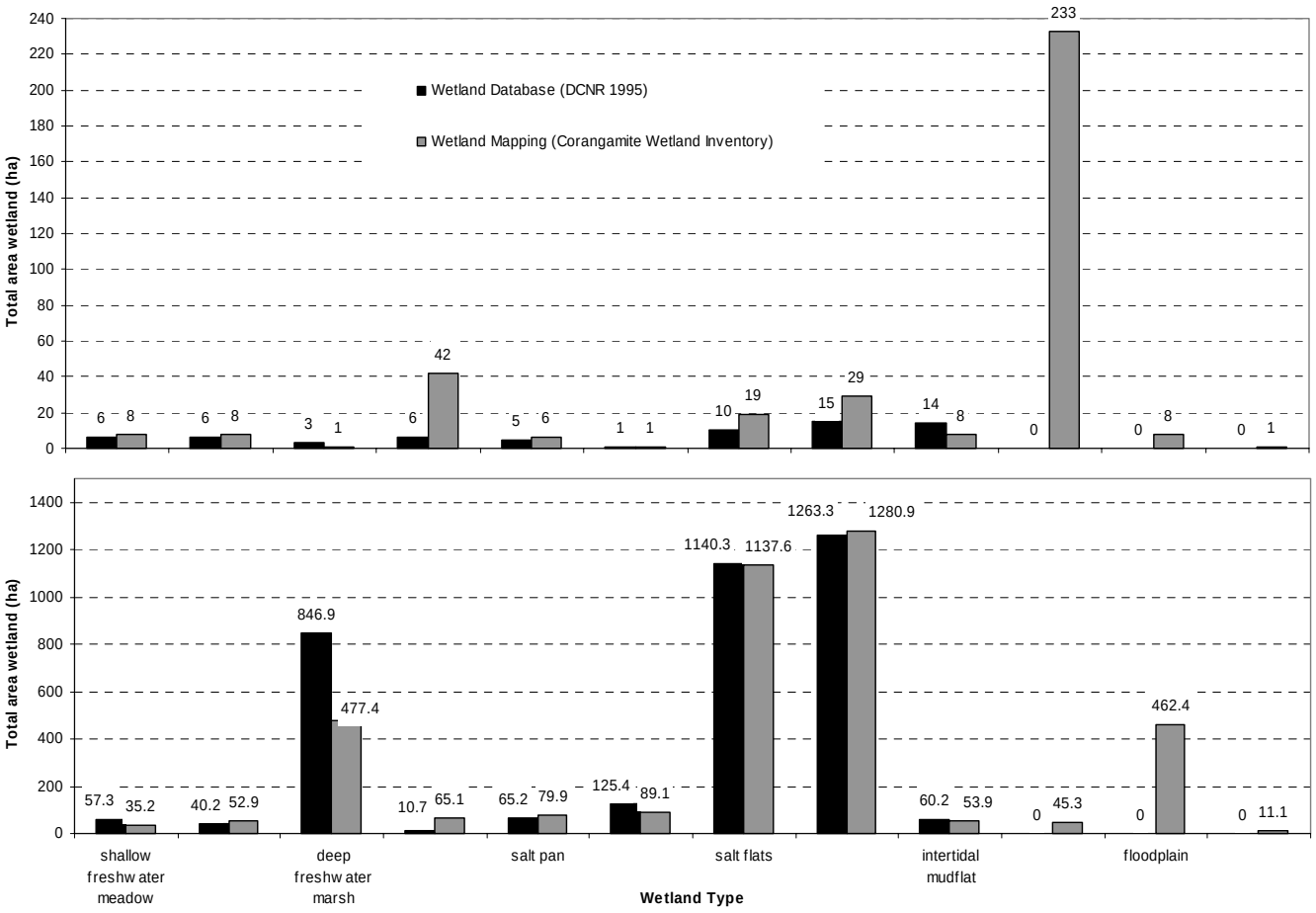


Figure 3.17 Comparison between wetland mapping for the Corangamite Wetland Inventory and existing wetland mapping (DCNR 1995) for the Connewarre sub-catchment.

All shallow freshwater meadows identified by the Wetland Database (DCNR 1995) were also mapped for the Corangamite Wetland Inventory. However, most of these wetlands were identified as much reduced in area than that of previous mapping. The data presented in Figure 3.18 indicates that only 25 % of the shallow freshwater meadow area mapped by DCNR (1995) remains within this catchment. This may be attributed to insufficient rainfall or partial drainage since the previous mapping. Similarly, shallow freshwater marsh, deep freshwater marsh, impoundments and salt pan wetland categories have also shown significant reductions in area.

Only five wetlands identified by the Wetland Database (DCNR 1995) were not identified as containing any "wet" areas at all through the mapping procedure for this inventory. This indicates that these wetlands were dry at the time of imagery acquisition, and therefore may have been drained since the Wetland Database mapping or had not received sufficient rainfall to hold water for a long period of time. No overlap was identified between farm dams, floodplains and mangrove wetlands for this sub-catchment.

The total overlap between both wetland map layers was 86.4 %. Map 6 provides the boundaries of wetlands mapped for this inventory.

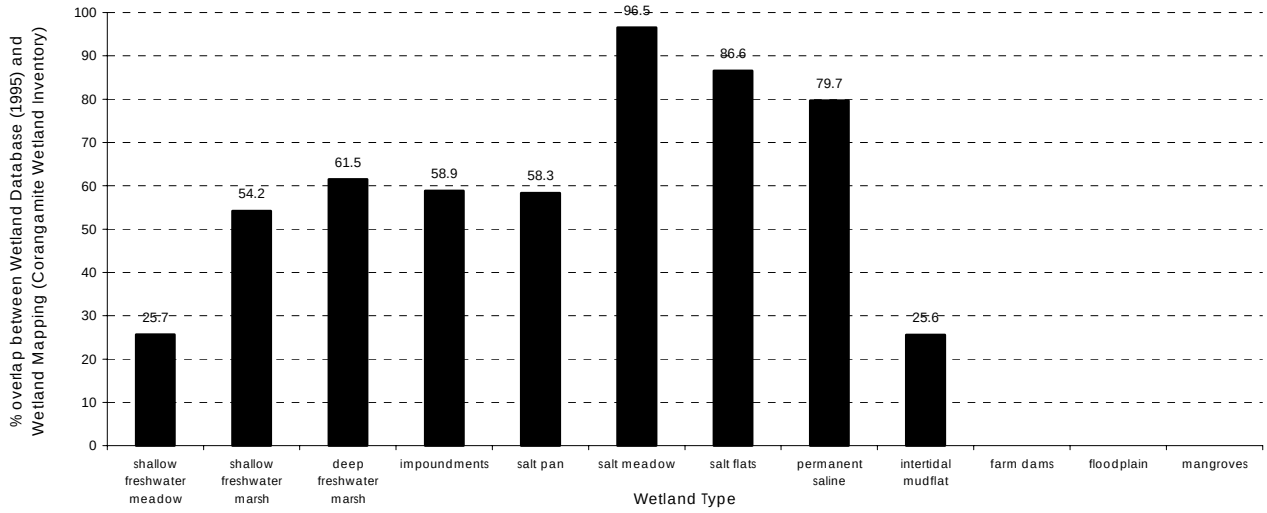


Figure 3.18 Percentage overlap between wetland mapping for the Corangamite Wetland Inventory and existing wetland mapping (DCNR 1995) for the Connewarre sub-catchment.

Comparison with Wetland Database (DCNR 1995) Wetland_1788 layer

Comparisons with pre-settlement wetland mapping (Wetland_1788 layer) within the Wetland Database (DCNR 1995) indicated a current loss of 34.5% of the total natural wetland area that once occurred within the Connewarre catchment.

Character

Specific analysis of this sub-catchment can be viewed in summary reports in Appendix 11. All references to tables and figures not appearing within the text refer to this document.

The most frequently surveyed wetland type in the sub-catchment was intertidal marshes (12 sites), with one or more wetlands surveyed in many other wetland types (Connewarre Figure 1). The morphology of wetlands was equally diverse. Tidal flats within marine systems (10 sites) and inland shallow basins (8 sites) were the most frequently surveyed morphology types in the sub-catchment (Connewarre Table 1). The water source of wetlands in the sub-catchment was most commonly from local runoff (24 sites), but also included marine (9 sites), and off-stream during floods (11 sites) (Connewarre Table 2).

Ten of the wetlands in Connewarre were dry at the time of survey. The salinity of those remaining was commonly brackish (8 sites) or saline (4 sites), however the full range of wetlands from fresh to ultra saline were recorded within the sub-catchment (Connewarre Figure 2). Average wetland depth of wetlands surveyed within the Connewarre sub-catchment ranged from 0.05 to 2 m, with an overall average depth of 0.38 m.

A number of rare and threatened flora and fauna species were located during the field surveys within the Connewarre sub-catchment (Table 3.16 & 3.17, Connewarre Table 6 & 7).

Tenure and landuse

Land surveyed within the Connewarre sub-catchment contained more public land than other sub-catchments (16 out of 28 wetlands). Of the public land wetlands, all were managed for conservation. All except one of these conservation sites also allowed recreational use, and grazing of sheep occurred at one site, and grazing of stock/horses at three.

Land adjoining the wetlands also included five publicly owned areas, with the remainder privately owned (Connewarre Table 3). Land uses on land adjoining wetlands include grazing by cattle or horses (17 sites), grazing by sheep (11 sites), conservation (8 sites) and recreational uses (7 sites) (Connewarre Table 4).

Table 3.16 Rare and threatened fauna recorded during wetland inventory surveys of the Connewarre sub-catchment.

Species	No. sites	VROT	FFG	EPBC
Black-faced Cormorant	1	v		
Pied Cormorant	1	l		
Whiskered Tern	11	l		
Caspian Tern	1	v		
Little Tern	1	v	L	
Glossy Ibis	6	v		
Royal Spoonbill	4	v		
Little Egret	3	c		
Great Egret	6	e	L	
Australasian Bittern	3	e		
Magpie Goose	2	e		
Hardhead	2	v		
Pectoral Sandpiper	1	i		
Yarra Pigmy Perch	3	l	L	

Table 3.17 Rare and threatened flora recorded during wetland inventory surveys of the Connewarre sub-catchment.

Species name	Common name	No. sites	VROT	FFG	EPBC
Atriplex australasica	Native Orache	11	k		
Atriplex paludosa ssp. *paludosa*	Marsh Saltbush	4	r		
Avicennia marina ssp. *australasica*	White Mangrove	4	r		
Eucalyptus leucoxylon ssp. *bellarinensis*	Yellow Gum	1	e	L	
Limonium australe	Yellow Sea-lavender	1	r		
Melaleuca armillaris ssp. *armillaris*	Giant Honey-myrtle	2	r		

Condition

The majority of wetlands within the Connewarre sub-catchment supported very few macro-invertebrates at the time of survey. High species diversity and abundance of macro-invertebrates was observed at four wetlands in the sub-catchment, including many of the freshwater marshes (e.g. Reedy Lake & Hospital Swamps). The condition category of fish in Connewarre wetlands was generally low (18 sites) with three sites supporting high species diversity and abundance of fish (Connewarre Table 10). Connewarre wetlands commonly supported moderate condition bird communities (14 sites), with seven sites recording high condition for birds. It should be noted that condition values were derived by rapid assessment (i.e. expert opinion based on habitat quality and availability) and surveys of macroinvertebrates and fish were not undertaken.

Buffer zone vegetation was generally in the condition category of degraded (16 sites), with no sites found to have intact buffer vegetation, and nine sites supporting moderate

condition buffer vegetation. Shore and bank vegetation were more frequently observed in moderate condition (14 and 12 sites respectively). Aquatic vegetation was also frequently in moderate condition (13 sites) (Connewarre Table 10).

The subjective condition value found one pristine wetland surveyed within the Connewarre sub-catchment (Reedy Lake CO 006). This is one of only two pristine wetlands recorded within the current wetlands inventory. A further eight sites were found to be intact, with three sites listed as severely degraded.

The total rapid assessment score highlighted four wetlands across five sites with high environmental values:

1. Reedy Lake (CO 006-1) and (CO 006-2)
2. Barwon River Mangrove Mudflat (CO 008)
3. Taits Rd. Salt Marsh (CO 010)
4. Lake Connewarre Saltmarsh (CO 024)

Threats

Pest plants and animals were listed as management issues on most wetlands surveyed within the Connewarre sub-catchment (25 out of 28 sites). Pasture weeds were recorded at 20 sites, environmental weeds were recorded at 14 sites, and noxious weeds were recorded at seven sites. Foxes were the most commonly recorded vermin (24 sites), but rabbits, hares, cats and dogs were also observed on wetlands within the sub-catchment.

Altered water regimes (19), nutrient enrichment (14), grazing (14) and encroachment (14) were other commonly recorded management issues on wetlands within the Connewarre sub-catchment (Connewarre Table 12).

Significant wetlands

Five sites with high environmental values indicated by the total rapid condition score (Section 3.1.4) were listed above. Details on management issues and threats to the Barwon River Mangrove Mudflat (CO 008) are outlined below.

Barwon River Mangrove Mudflat (CO 008)

This intertidal mudflat is located west of the Barwon Heads boat ramp, near the Barwon River Golf Club (Figure 3.19). The mudflats extend for approximately 20 ha. At the time of survey, the water was saline and quite clear. Land tenure of the wetland and surrounding land is public, and land uses include conservation, recreation and fishing. The surrounding land is managed for recreation, and includes the nearby golf course.

Three flora species listed as rare within Victoria were located during surveys of the Barwon River Mangrove Mudflat: *Atriplex paludosa* ssp. *paludosa*, *Avicennia marina* ssp. *australasica*, and *Limonium australe*. No rare and threatened fauna were located on the day of survey, however, seven species of water bird were observed at the site.

Figure 3.19 Barwon River Mangrove Mudflat (CO 008).

Management issues identified at the site reflect the urban nature of the locality, and the recreational uses of the wetland (Table 3.18).

Table 3.18 Management issues identified at Barwon River Mangrove Mudflat (CO 008).

Management Issues	Extent
Tracks - walking	High
Erosion - waterway	High
Nutrient enrichment - lawns	High
Dumping - household refuse	Moderate
Nutrient enrichment - urban runoff	Moderate
Weeds - pasture	Minimum
Encroachment - residential	Potential

Fencing has been undertaken at the wetland, and there was some regeneration of mangroves evident. Recreational pressure on large wetlands within the sub-catchment has significant implications for management where increased enforcement and regulation of activities will be required (Norman & Corrick 1988). Management of recreational activities including regulation of hunting activities and fish catch limits in addition to visitor interpretation and education programs have been established at some large recreational reserves within the sub-catchment (Parks Victoria 2001).

The Barwon River Mangrove Mudflat also highlights the issues facing wetlands in areas that are becoming increasingly urbanised. Prior to any further development of areas such as the Barwon River Mangrove Mudflat, environmental safeguards to mitigate impacts of residential development should be considered.

3.3 Corangamite CMA Summary

3.3.1 Character

A total of 96 sites were assessed during the field survey of wetlands within each of the sample sub-catchments. Wetland representativeness is reflected in the wetlands surveyed for the inventory, with wetlands of 17 major classification groups sampled (Table 3.19).

Table 3.19 Major wetland classification groups (Environment Australia 2001) of field survey sites from the Corangamite Wetland Inventory.

Classification		No. sites surveyed
A6	Estuarine waters	1
A7	Intertidal mud, sand or salt flats	1
A8	Intertidal marshes	12
B10	Seasonal freshwater marshes	26
B11	Permanent saline/brackish marshes	5
B12	Seasonal saline marshes	7
B14	Seasonal freshwater swamp forest	1
B15	Peatlands	1
B2	Seasonal rivers and streams	5
B4	Riverine floodplains	2
B5	Permanent freshwater lakes (>8ha)	8
B6	Seasonal freshwater lakes (>8ha)	1
B7	Permanent saline/brackish lakes	16
B8	Seasonal saline lakes	2
B9	Permanent freshwater marshes (<8ha)	1
C1	Water storage areas (>8ha)	3
C2	Ponds (farm dams, stock waterholes etc.)	4

Wetlands surveyed in the inventory also captured variability in water chemistry with electrical conductivity ranging from 300 (fresh) to 300, 000 (ultrasaline) µS at wetlands surveyed (Table 3.20).

The majority of wetlands surveyed were brackish (48 sites), with 12 wetlands surveyed fresh (<500 µS) at the time of survey. It should however be noted that wetlands within the Corangamite region vary greatly in salinity levels on a seasonal and water availability basis. Therefore, snap-shot data, such as that which is collected through wetland inventory fails to provide the full range of salinity experienced in particular wetlands.

Table 3.20 Salinity of wetlands surveyed across the Corangamite CMA – Spring 2002 – Spring 2003.

Salinity	No. of sites
Fresh	11
Brackish	46
Semi-saline	3
Saline	7
Hypersaline	4
Ultrasaline	4
Wetland Dry	21

The source of water for most wetlands in the catchment was from local runoff (60 sites), with stream fed wetlands (21 sites) also commonly recorded within the sub-catchment (Table 3.21).

Table 3.21 Water source of wetlands within the Corangamite CMA.

Water Source	Number of sites	Percentage of sites
Channel fed	6	6.3
Groundwater	2	2.1
Local runoff	60	62.5
Marine	9	9.4
Off-stream	12	12.5
Spring	8	8.3
Stream fed	21	21.9

Note – Wetlands may receive water from multiple sources.

A total of 461 flora species were recorded during the field surveys, with 131 (28.4%) exotic species, and 330 (71.6%) native species. A number of threatened flora species were recorded within wetland ecosystems of the Corangamite region. Notable species include:

- Spiny Rice-flower (*Pimelea spinescens* ssp. *spinescens*) (identified as critically endangered under the EPBC Act);
- Small Scurf-pea (*Cullen parvum*), (identified as nationally endangered);
- River Swamp Wallaby-grass *(Amphibromus fluitans)* (nationally vulnerable species); and,
- Salt-lake Tussock-grass *(Poa sallacustris) (*nationally vulnerable species).

Three species endangered in Victoria, eight species listed as rare in Victoria, and five species listed as vulnerable in Victoria were also located during the field survey (Appendix 9).

Additionally, a previously undescribed *Poa* species (*Poa* aff. *labillardieri)* was identified in the Kooraweera Lakes during the wetland surveys, and is currently being investigated by the National herbarium of Victoria.

A total of 103 fauna species were recorded during the survey, with 24 of these listed as rare and threatened in Victoria, or Australia. Two species listed under the EPBC Act as nationally vulnerable were also observed during the field survey: the Striped Legless Lizard (1 site) and Warty Bell Frog (5 sites, Appendix 10). A total of 90 sightings of rare and threatened fauna were recorded during the field survey.

3.3.2 Tenure and landuse

The vast majority of wetlands surveyed are under private land tenure (73 sites), and this figure increases for land directly surrounding the wetland (94 sites). A number of wetlands surveyed were publicly owned (26 sites), however, this figure reduced considerably for surrounding land (7 sites). Some wetlands contained both private and publicly owned sections.

Many of the wetlands surveyed are managed for conservation (40 sites), although multiple uses in many of these areas result in wetlands also supporting recreational activities and fishing. Grazing is the dominant land use on land surrounding wetlands (Table 3.22).

It is likely that field survey may have been skewed towards surveying wetlands on publicly owned land simply due to ease of access. It is also likely that sampling on private land may have been skewed towards areas managed for conservation as these landowners were more receptive to having surveys done on their land.

Table 3.22 Land use of wetlands sampled and surrounding land.

Land use category	No. wetlands	No. surrounding land
Conservation	40	8
Cropping cereals/legumes	2	14
Fishery	5	0
Forestry	0	3
Grazing - cattle or horses	33	45
Grazing - sheep	27	55
Irrigation	2	0
Recreational activity	0	7
Residential	25	0
Road reserve	0	5
Rubbish tip	1	1
Stock water supply	0	1
Unused	1	0

3.3.3 Condition

The subjective condition categories were evenly distributed between poor, moderate and high for macroinvertebrates. The majority of sites surveyed recorded low fish condition, whereas more sites demonstrated moderate and high condition for birds (Figure 3.20). It should be noted that condition values were derived by rapid assessment (i.e. expert opinion based on habitat quality and availability) and surveys of macroinvertebrates and fish were not undertaken. Many of the surveys were undertaken during low water conditions which may have led some surveyors to determine that there was less quality habitat available for fish and macroinvertebrates. A field survey for fish and macroinvertebrates at these sites would be required to determine if this assumption is correct.

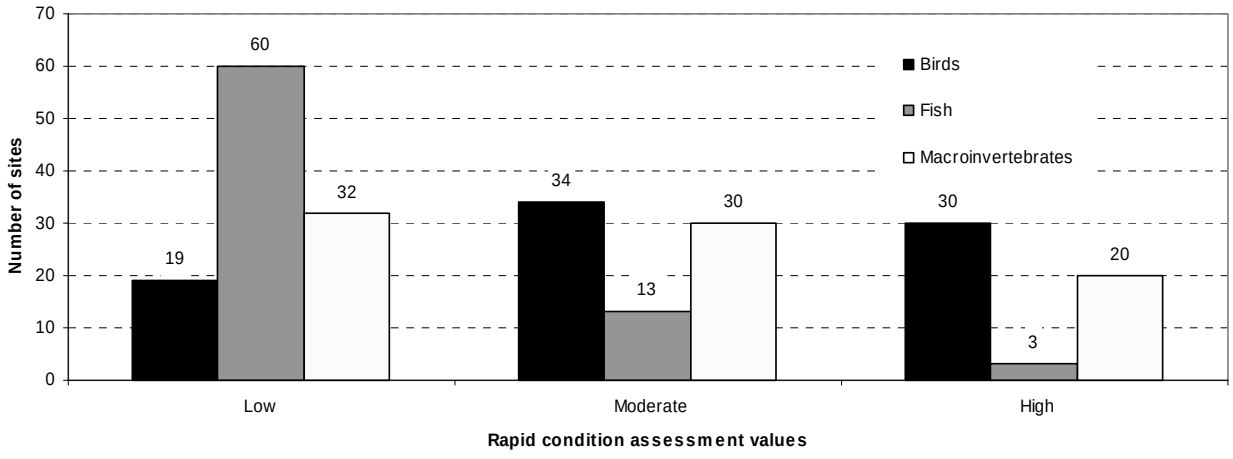


Figure 3.20 Condition categories of fauna during wetland inventory surveys within the Corangamite CMA.

The condition categories for riparian vegetation show that the buffer vegetation is degraded in most wetlands in the Corangamite CMA. The riparian vegetation of banks

was more commonly in moderate condition, whilst shore vegetation showed the highest number of intact sites (Figure 3.21).

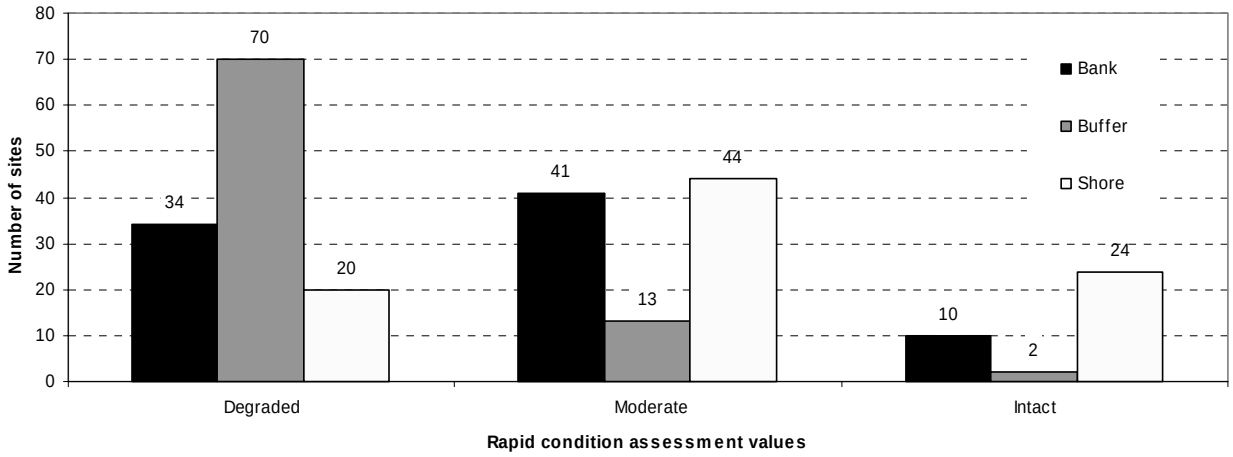


Figure 3.21 Condition categories of vegetation during wetland inventory surveys within the Corangamite CMA.

The subjective condition value for wetlands surveyed within the Corangamite CMA shows wetlands were most commonly observed to be intact. Only two pristine wetlands were surveyed, but few wetlands (5 sites) were found to be severely degraded (Figure 3.22).

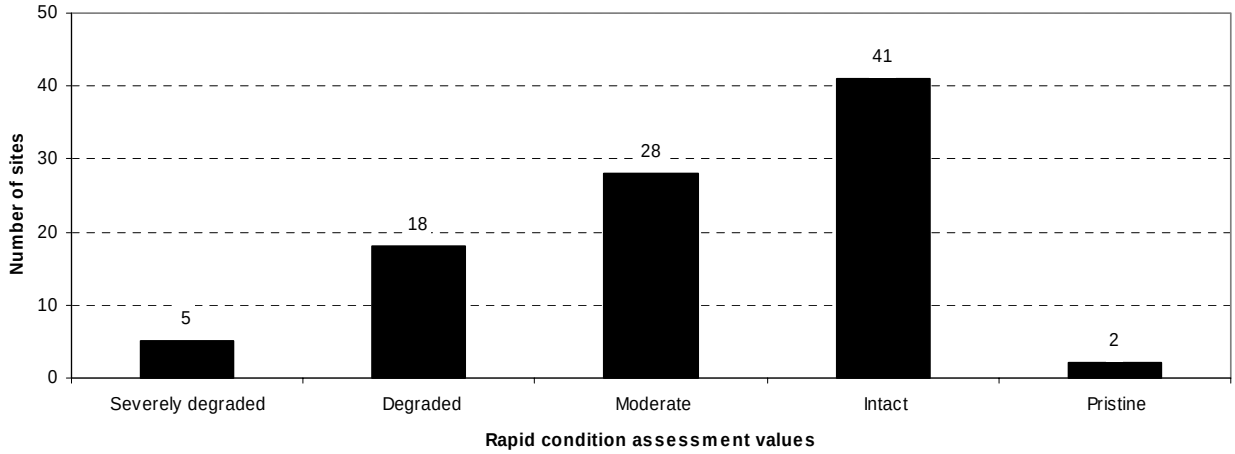


Figure 3.22 Rapid assessment of overall condition values during wetland inventory surveys within the Corangamite CMA.

The total rapid assessment score indicates 20.8% of sites surveyed were in high condition, with the majority (38.5%) in moderate condition (Figure 3.23). The total rapid assessment score was unable to be assessed for 24 wetlands due to missing data on one or more parameters.

It should be noted that these results are unlikely to be representative of the CCMA region as the field survey was skewed towards wetlands on reserves (and therefore in better condition).

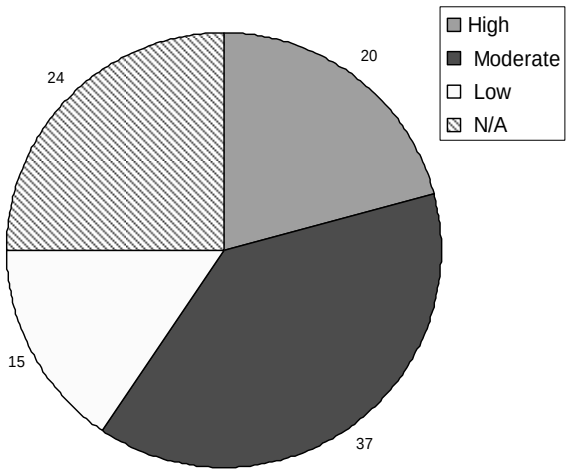


Figure 3.23 Condition classes based on total rapid assessment scores.

3.3.4 Threats

Weeds constituted the most commonly recorded threat to wetlands across the sub-catchment (Table 3.23). Pasture weeds were the most commonly recorded weed problem (57 sites), followed by environmental weeds (41 sites). Threats from grazing sheep, cattle and horses, and altered water regimes were also prevalent. Altered water regime was a commonly recorded threat to wetlands, frequently due to a decrease in water supply (21 sites), although increased water supply (from the natural state) was a problem at ten sites.

Table 3.23 Management issues identified during wetland inventory surveys within the Corangamite CMA.

Management Issue	No. sites	Management Issue	No. sites
Weeds	75	Contamination	11
Grazing	44	Tracks	9
Altered water regime	39	Vegetation destruction	7
Pest animals	37	Increased salinity	4
Changed soil character	34	Erosion	3
Nutrient enrichment	28	Plantation	1
Encroachment	18	Mining	1
Dumping	11		

Actions to reduce the impact of threats on wetlands were being undertaken at many sites (Table 3.24). Fencing was the most commonly observed management action (37 sites), with revegetation works also occurring at a number of sites (20). At least some form of management action was recorded at 45.8% of sites (52 sites with no management actions recorded).

Table 3.24 Management actions being undertaken on wetlands surveyed during wetland inventories within the Corangamite CMA.

Management Actions	No. sites
Fencing	37
Islands for waterbirds (constructed)	1
Nest boxes	2
None	52
Pest Control (Animal)	8
Pest Control (Plant)	5
Reduced stocking rates	1
Restoration of Water Regime	3
Within reserve	6
Revegetation	19
Structures: boardwalk/pontoons	1

4. DISCUSSION AND CONCLUSIONS

This report analysed the extent and adequacy of Wetland Inventory information and associated past research relevant to wetlands within the Corangamite region. The review highlighted the limitations of existing wetland inventory data within the Corangamite region. Inventory data was found to be limited in scope, classification accuracy, and information on values and threats for the majority of wetlands. Existing wetland mapping was found to be lacking for wetlands under 1 ha in size, wetland classification was very broad, and river floodplain areas were excluded.

Remote sensing was used at a regional scale to map and classify wetlands in the Corangamite region. The total number of wetlands identified through the inventory was substantially improved from previous mapping. This was largely due to the identification of smaller wetlands (< 1 ha), such as shallow freshwater meadows, shallow freshwater marshes, farm dams, and areas subjected to flooding from creeklines, which were not mapped in the Wetland Database (DNCR 1995).

Based on the review of existing methodologies and expertise of several wetland ecologists, a survey protocol was developed for the Corangamite Wetland Inventory. The protocol was developed to enable the rapid collection of essential biological and physical quantitative data including subjective assessments of selected wetlands.

A total of 96 sites were surveyed within five sub-catchments of the Corangamite Catchment Management Authority (CCMA), providing valuable baseline data on wetland character, condition and threats. Data from the Wetland Inventory have been entered into a Microsoft Access 2000® format database. This allows the Wetland Inventory data to be easily accessible and updated as further wetland inventories are undertaken.

Review of literature

This review aimed to identify the scope of past inventory data and research concerning wetlands of the Corangamite region. The extent of gaps in current knowledge was assessed in relation to how these gaps compromise the capacity of effective resource allocation.

To develop effective management strategies for the conservation of wetlands it is necessary to have detailed information on the extent and distribution of wetland types in the region (Watkins 1999). Present wetland inventory data within the Corangamite region was found to be limited in scope, classification accuracy, and information on values and threats for the majority of wetlands. This lack of detailed information for 98% of mapped wetlands is due to a number of factors. Many of the natural wetlands are small and non-permanent or drained, and have often been extensively modified so that they were little more than flooded pasture. Many others were artificial (farm dams) and both professional biologists and amateur naturalists tend not to study such areas (Australian Biological Research Group 1988). This was compounded by the lack of public access to many of these wetlands, especially those on private land.

Gaps within wetlands data within the Corangamite region are extensive. Of those wetlands mapped for the region, the majority have only very basic location, area and Corrick's classification data available. Many wetlands smaller than 1 ha have no data available and their location and status are unknown. Remote sensing technology has been utilised for the detection and mapping of waterbodies over large areas and could be applied for inventory purposes within the Corangamite region. The capacity of land managers and funding bodies to make decisions about priorities for the allocation of resources to wetland management and conservation has been restricted by the lack of the most basic data for the majority of wetlands in the region.

Conversely, detailed information exists for most wetlands and lakes listed on the Directory of Important Wetlands (Environment Australia 2001) and under the Ramsar Convention

(Ramsar Convention Bureau 2001). However, these inventories only provide details for a proportion of the wetland resources and the sites included are biased towards large wetlands in protected areas (Watkins 1999).

Trends in wetland condition throughout the Corangamite region were difficult to identify due to a lack of data for the majority of wetlands. However, the occurrence of drainage activity, increasing salinity, and various water quality issues attributed to water regulation has been identified as generally affecting wetland condition. Declines in waterbird records have been attributed to increasing salinity in some lakes.

Corangamite Wetland Inventory - mapping

The existing wetland inventory data for the Corangamite region originated from surveys conducted by Corrick (1982) that were digitised to form the Wetlands Database (DCNR 1995). The total number of wetlands within the Corangamite region were not able to be identified from this database, as many wetlands smaller than 1 ha are not shown in the database. Several limitations were identified within the database including:

- Wetlands under 1 ha in area were not included, thus a significant proportion of the region's wetlands were not represented.
- River floodplains inundated only during floods were excluded.
- The classification of wetlands was very broad and may not reflect the representativeness of wetland types within the region.
- The database is now out-dated, whereby significant changes in wetland area and classification are likely to have occurred due to further drainage, changes in climate, and water regulation.
- Fields within the database fail to identify values, threats and general condition of each wetland, limiting its usefulness for management purposes.

To map and classify wetlands in the Corangamite region, this project used remote sensing at a regional scale. Analysis of Landsat 7 TM imagery was used to identify, delineate and broadly classify inundated areas within five selected sub-catchments of the Corangamite region. Late spring Landsat TM data in a year of average rainfall was chosen for the delineation of inundated areas. Year 2000 data was chosen in preference to more recent data due to low rainfall throughout 2001 and 2002. Many shallow wetlands would not have contained water during these years and consequently may not have been identified as wetlands through the classification procedure.

Landsat bands 4, 5 and 7 (near infrared and middle infrared) were found to be the most useful bands for delineating water bodies and a pseudo-colour composite image was produced from these bands for display and visual analysis. A combination of supervised and unsupervised classification techniques were used to identify inundated areas. Aerial photographs, ancillary data, Wetlands Database, and field data were used to identify training sites and label spectral clusters. Post-classification modelling was performed using ancillary data (Wetland_1994 layer, Wetland_1788 layer and hydrology data) to further refine the classification of wetlands.

All wetlands and waterbodies were mapped within the five sub-catchment boundaries. Fine scale mapping of wetlands within the entire CCMA region was not within the scope of this project, however could be completed using methods outlined within this report.

The total number of wetlands identified through the inventory was substantially greater than from previous mapping, Wetland_1994 layer (Corrick 1982; DCNR 1995), for all sub-catchments except Connewarre. The increase in wetland identification was largely due to the identification of smaller wetlands (<1 ha), such as shallow freshwater meadows, shallow freshwater marshes, farm dams, and areas subjected to flooding from creeklines. In the Connewarre sub-catchment the number of wetlands identified was similar to previous databases (Corrick 1982; DCNR 1995). However, the area of many individual shallow freshwater marshes and meadows identified by DCNR (1995) were identified as

much smaller through the mapping procedure for the Corangamite Wetland Inventory. Only 25% of the shallow freshwater meadow area mapped by DCNR (1995) was identified within the Connewarre sub-catchment. This may be due to insufficient rainfall or partial drainage since the previous mapping. Similarly, shallow freshwater marsh, deep freshwater marsh, impoundments and salt pan wetland categories also showed significant reductions in area.

Corrick (1982) noted that wetlands in the Corangamite region have declined substantially in both area and condition since European settlement. Comparisons of the wetland inventory mapping with pre-settlement wetland mapping (Wetland_1788 layer) within the Wetland Database (DCNR 1995) support this finding. Wetland area was found to have decreased by up to 61% in the Salt Creek sub-catchment, and was similarly high for Kooraweera Lakes. Warrambine Creek and Connewarre also show wetland area losses of over 30%, although relatively small losses (14.3%) were calculated in Dereel.

Norman and Corrick (1988) state that loss of natural wetlands will continue unless action is taken to protect remaining wetlands. The current rate of drainage and modification is unknown and largely unregulated on private property within the Corangamite region. The results of this mapping highlight the importance of conserving remaining wetlands, particularly those on private property.

Corangamite Wetland Inventory – field survey

Numerous existing wetland inventory methods were researched and elements were adapted to suit the specific requirements of the Corangamite Wetland Inventory. A survey protocol was developed for the Corangamite Wetland Inventory to allow the rapid collection of essential biological and physical quantitative data including subjective assessments of selected wetlands. Field survey of wetlands within each of the sampled sub-catchments was conducted in spring to early summer 2002 and 2003 (October – December). Due to the large number of shallow seasonal wetlands in the study area, it was considered important to survey in optimal conditions; when the wetlands were inundated and aquatic vegetation present.

Information collected included biophysical attributes such as morphology and origin, water regime and water source. Wetlands were classified according to the adapted Ramsar wetland classification system (Environment Australia 2001), and surface water chemistry was assessed, including salinity, pH and Secchi depth.

It has been reported that salinity is increasing in many lakes within the Corangamite region, some to levels where the biological values and the lakes are compromised (ACIL Australia 1983; Nicholson *et al*. 1992; Parks Victoria 2001; Williams 2001). The occurrence of pollution and eutrophication of lakes within the Corangamite region has been common. Water quality and artificial water levels have been thought to contribute to the decline in the values of lakes and wetlands (Corrick 1982; DCE 1991). This inventory presents baseline data for many wetlands, which will allow future monitoring of change in water chemistry.

Biological characteristics of wetlands were also investigated. The high level of detail of the flora survey provides an excellent resource within the wetland inventory database. Many rare and threatened flora and fauna species were identified during the wetland inventories (Appendices 9 & 10). Additionally, a previously undescribed *Poa* species was identified in the Kooraweera Lakes during the wetland surveys, and is currently being investigated by the National Herbarium of Victoria. It has been given a provisional name – *Poa* aff. *labillardieri* (N. Walsh pers comm. 2004). It is highly likely that this species will be rare or vulnerable both within Victoria, and nationally, as it has been located at only three sites in the Kooraweera Lakes sub-catchment area. This is a significant find and demonstrates the value of the wetland inventory process.

The diversity of flora and fauna, and number of rare and threatened species recorded during wetland inventory surveys highlights the biodiversity values of the Corangamite wetlands and their importance as a refuge for rare and threatened species.

Wetlands surveyed were more commonly under private tenure (79 sites), and land surrounding wetlands were almost entirely privately owned.

Many of the wetlands surveyed were managed for conservation, but grazing by sheep, cattle and horses occurred on approximately one third of wetlands. Over-grazing and trampling of wetlands is one of the most common threatening processes to wetlands on privately owned land (Platt & Corrick 1994). Shallow freshwater meadows and marshes occurring on privately owned land are thought to be the most at risk (Platt & Corrick 1994).

Grazing should be managed to minimise damage by restricting access to wetlands using appropriate fencing (Platt & Corrick 1994). Alternatively, restricting the duration, timing and number of livestock to a level where wetland values are maintained and damage minimised has also been recommended (Hull 1996). Public education and incentive programs to compensate landholders for fencing materials and loss of productive land could be explored.

The management of grazing for the maintenance of ecological values has been addressed by Hull (1993; 1996) who acknowledged the requirement for further research and experimentation with grazing regimes. Grazing exclusion plots and regular monitoring would assist in determining suitable grazing regimes for different wetland types.

It has been noted that the condition of wetlands in the Corangamite region has declined substantially since European settlement (Corrick 1982). However, given the limited amount of information available on wetland condition, it has previously been difficult to identify trends in wetland status and the overall condition of wetlands. Rapid condition assessment was undertaken within the wetland inventory process to provide information on the condition of flora and fauna, and overall condition values of wetlands. Commonly, overall wetland condition was found to be intact. Only two wetlands were found to be in pristine condition, and only five were found to be severely degraded.

There is generally little information on the extent and implications of threatening processes identified for wetlands of the Corangamite region. Therefore, disturbance and management issues at the site were recorded in the wetland inventories. The extent of each disturbance was recorded on a four-point scale from minimum to severe. Any conservation measures, such as fencing, revegetation and pest control were also recorded.

Weeds were the most commonly recorded threat to wetlands across the five sub-catchments surveyed. Pasture weeds were recorded at 57 of 96 sites surveyed, and environmental weeds were surveyed at 41 sites. Stock grazing and altered water regimes also posed a significant threat to many wetlands surveyed.

Threats to wetlands require management to minimise or eliminate further impacts and incentives should be investigated to ensure wetland continuance on private property (Norman & Corrick 1988; Harding 2001). Financial incentive payments, covenants and rate-rebates for land managed for conservation purposes have been investigated (Binning & Young 1999) and could be utilised for encouraging the conservation of wetlands within the Corangamite region.

Water diversion and regulation schemes have altered the natural water regimes of many wetlands within the Corangamite region, and this threat is often beyond the control of local landowners and managers. This highlights the need for widespread community education on the importance of wetlands. In addition, economic incentives to preserve wetlands may need to be considered for landowners other than those directly managing wetlands due to effects downstream, and across the catchment.

Norman and Corrick (1988) state that loss of natural wetlands will continue unless action is taken to protect remaining wetlands. The current rate of drainage and modification is unknown and largely unregulated on private property within the Corangamite region.

Limitations/difficulties encountered

Some limitations and difficulties were encountered during the current study. Potential issues for future studies have also been highlighted.

- The time and resources available limited the extent of research papers and data reviewed within this report. Although this review encompassed sufficient literature to address the aims of this report, it was not exhaustive. Importance was given to more recent research papers when compiling reference material for this review. Earlier research was often referred to in these more recent papers.
- This review has focused on published and unpublished literature on wetlands and lakes in the Corangamite region. Undocumented regional wetland issues may not have been included in this review.
- Difficulty in sourcing some wetland data was encountered. George Appleby collected wetland data from the Colac region in the late 1980's (refer to review reports Appleby 1989; 1991), however data associated with this inventory work could not be located within the Department of Natural Resources and Environment where it was lodged prior the disbandment of the Wetlands Unit (A. Corrick pers. comm.; P. DuGuesclin pers. comm.; G. Hull pers. comm.).
- Field sampling for the Corangamite Wetland Inventory was intended to be complete in spring of 2002. Unseasonably dry conditions throughout 2002 resulted in many of the shallow seasonal wetlands remaining dry over spring impacting on the presence and intactness of aquatic vegetation. Field survey was therefore extended to include spring 2003 for affected regions of the study area.
- Seasonal rainfall should be considered when planning future wetland inventories to ensure wetlands contain sufficient water when surveyed. Some variability in results may result from seasonal or annual rainfall variation. This will be minimised by ensuring wetlands contain water prior to inventory. Seasonal effects must be considered when comparing results from future wetland inventories.
- Wetlands within the Corangamite region have a highly dynamic character. Variability in flooding regimes result in seasonal differences in water salinity and can lead to different characteristics and life forms in the same wetland throughout the year (Costa *et al.* 1996). This inventory therefore provides a "snap shot" of the current situation and has limited ability to account for past characteristics.
- The majority of the regions most threatened wetland types (including shallow freshwater meadows and marshes) occur within, or are bounded by privately owned land. Wetlands surveyed were therefore dependant on the ability to gain access to private land. Access to private property was gained by contacting landholders with wetlands on their properties. Postal notification was used to inform landholders of the wetland inventory prior to field survey. Phone conversation between field teams and landholders were used to arrange site visitation. Contacting landholders and arranging permission for site visitation was time-consuming. Landholders can be cautious in allowing access to their wetlands, particularly if it is seen that restrictions on wetland use may be imposed as a result of wetland inventory.
- Vehicular access to wetland sites may not be possible during wet years, or following heavy rainfall, due to the nature of these sites. This problem was not encountered during the current study, due to the generally dry prevailing conditions.

Future directions

The methods for identifying wetlands through remote sensing described within this report enable mapping of wetlands at a fine scale and over a large area. Such a large spatial data layer is important for wetland managers, decision makers and local communities in the conservation of representative wetland ecosystems. It would therefore be important to

continue the fine-scale mapping of wetlands throughout the remaining sub-catchments for the Corangamite region.

The current drought situation throughout the Corangamite region provides an opportunity to investigate drought refugia for wetland dependant species. Techniques of wetland classification described within this report could be applied to a Landsat image within a drought affected year (suggest early summer 2002) to identify those wetlands which retain water throughout drought periods and those fed by natural springs.

Additionally, it is recommended that further wetland inventory work be carried out within the Corangamite CMA region, as a continuum of this project. The methods and processes developed could easily be applied to and built upon to form a more complete inventory of wetlands throughout the entire region. A document such as this would be invaluable as a resource for managing and protecting some of Corangamite's most endangered ecosystems.

The structure of this Wetland Inventory document has allowed for the easy inclusion of additional sub-catchment analyses in the future, and includes a database suitable for the collection of wetlands inventory data from remaining sub-catchments.

The wetlands identified in this report as "Significant" for each sub-catchment are likely to meet several of the criteria for nominating nationally important wetlands. Including some of these wetlands on the Directory of Important Wetlands in Australia would provide formal recognition of the values of these wetlands, and therefore encourage more directed management efforts and leverage for funding. Shallow seasonal freshwater meadows characteristic of the Volcanic Plain are under-represented in the Directory of Important Wetlands (where most listings are of permanent or semi-permanent lake systems for the Corangamite region – refer to Appendix 2). The CMA should prioritise the development of a comprehensive adequate and representative reserve system which involves these wetland types.

The Corangamite CMA Regional Strategy (CCMA 2003) indicates a number of strategies relevant to wetlands including:

- Draft Corangamite River Health Strategy: identifies and ranks stream reaches requiring management and/ or rehabilitation using the Victorian Index of Stream Condition parameters, and itemises management actions required for each stream reach;
- Corangamite Floodplain Management Strategy: identifies strategic management requirements for floodplains, presents flood management and emergency response plans, guides development and land use practices, and provides an integrated floodplain management information system;
- Strategic Management Plans for Ramsar Sites: provide a management framework for the Region's wetlands of international importance, the primary goal being to maintain their ecological character through conservation and wise use;
- Corangamite Regional Landcare Support Strategy (CCMA 2005) identifies strategic support processes and tools for community Landcare and environmental volunteer groups.

It is recommended that a Wetlands Strategy for the Corangamite be written to provide strategic direction to wetlands conservation efforts within the region which takes into account the findings of this report. Directions currently listed within the Regional Catchment Strategy (Corangamite Catchment Management Authority 2003) are limited for wetlands.

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APPENDIX 1. ANALYSIS OF THE WETLAND DATA SETS FOR THE CORANGAMITE REGION

Contains research and data that specifically includes reference to the Corangamite region.

Attribute	Number of Reports	% of Reports
Scale of Inventory data (if an inventory)		
• Global scale	1	11%
• National scale	1	11%
• Regional scale	7	78%
Type of source material		
• Peer review journals	5	12.5%
• Book	4	10%
• Article in conference proceedings	1	2.5%
• Internal departmental reports	13	32.5%
• Government formal publications	5	12.5%
• Other government material	1	2.5%
• Consultancy reports	2	5%
• Electronic database	4	10%
• World Wide Web article	3	7.5%
• Thesis	2	5%
Format of study		
• Paper	31	77.5%
• Electronic text	4	10%
• Electronic database	1	2.5%
• Web presentation	1	2.5%
• Part of GIS or GIS output	3	7.5%
Circulation of study		
• Published	26	65%
• Interdepartmental (unpublished)	13	32.5%
• Internal (published)	1	2.5%
Data storage media		
• Paper	31	77.5%
• Web (electronic)	3	7.5%
• Other electronic (not web or database)	2	5%
• Electronic database	1	2.5%
• GIS	3	7.5%
Study implementation		
• International NGO	1	2.5%

Attribute	Number of Reports	% of Reports
• National NGO	1	2.5%
• State (Victoria) NGO	12	30%
• Local (Corangamite) GO	15	37.5%
• Private agency/Individual	8	20%
• Academic institution	3	7.5%
Study funding		
• International NGO	1	2.5%
• National NGO	4	10%
• State (DNRE)	21	52.5%
• State (Parks Victoria)	4	10%
• Corangamite CMA	1	2.5%
• Private agency/Individual	4	10%
• Academic institution	5	12.5%
Main objective of study		
• Biodiversity research	5	12.5%
• Review of literature	2	5%
• Management plan/recommendations	9	22.5%
• Biodiversity monitoring	8	20%
• Wetland inventory/classification	7	17.5%
• Academic research	2	5%
• Hydrochemistry analysis	6	15%
• Condition analysis	1	2.5%
Wetland classification definition		
• A. Corrick (1982)	10	25%
• Ramsar wetland types	7	17.5%
• N/A	23	57.5%
Extent of coverage		
• Ramsar lake/s	16	40%
• Lakes and wetlands	12	30%
• Wetlands	7	17.5%
• Temporary wetlands	2	5%
• Estuaries	1	2.5%
• Rivers and streams (relevant to wetlands)	1	2.5%
• Landsystems (relevant to wetlands)	1	2.5%
Data collection method		
• Collation or review	22	55%
• Ground survey	8	20%
• Faunal survey	5	12.5%
• Remote sensing, GIS based	5	12.5%

Attribute	Number of Reports	% of Reports
Extent of survey (if an inventory)		
• All Corangamite region	5	62.5%
• Partial	3	37.5%
Type of remote sensing		
• Satellite imagery	1	12.5%
• Aerial photography	3	37.5%
• Aerial survey	2	25%
• Map Product	2	25%
Area by wetland type		
• Full details on area per wetland type	6	15%
• Partially on area per wetland type	4	10%
• No information on area per wetland type	30	75%
Wetland loss and degradation		
• Sources providing information on loss and/or degradation	24	60%
• Sources not providing information on loss and deg.	16	40%
Wetland status description		
• Overall wetland status description included	18	45%
• Overall wetland status description not included	22	55%
Focus of study		
• Wetlands as waterbird habitat	4	10%
• Salinity/Hydrochemistry	11	27.5%
• Wetland management	7	17.5%
• Faunal diversity (macroinvertebrates)	4	10%
• Wetland biological values/condition	8	20%
• Identification of important wetlands	5	12.5%
• Flora diversity	1	2.5%
Time of study		
• 1965-1969	1	2.5%
• 1970-1974	1	2.5%
• 1975-1979	1	2.5%
• 1980-1984	5	12.5%
• 1985-1989	5	12.5%
• 1990-1994	12	30%
• 1995-1999	5	12.5%
• 2000-2002	10	25%

APPENDIX 2. IMPORTANT WETLANDS OF THE CORANGAMITE REGION

Wetland Name	No. of wetlands	Total area (ha)	Directory Important Wetlands	Ramsar	Wetland Classification																
					A1	A2	A6	A7	A8	A10	A11	B1	B4	B5	B6	B7	B8	B 10	B 12	B 15	C1	C6
Lower Aire River wetlands	3	84	✓							◆	◆											
Aire River	-	-	✓									◆	◆									
Widderin Swamps	3	359	✓															◆				
Princetown Wetlands	3	119	✓						◆	◆	◆											
Stonyford-Bungador wetlands	12	-	✓															◆		◆		
Red Rock Lakes & The Basins	9	223	✓											◆		◆	◆	◆				
Lower Lough Calvert & Lake Thurrumbong	3	878	✓												◆	◆	◆	◆	◆			
Lake Beeac	1	662	✓	☑											◆				◆			
Lake Connewarre State Wildlife Reserve	10	3100	✓	☑			◆		◆			◆	◆					◆				
Middle Lough Calvert	1	578	✓													◆	◆		◆			
Swan Bay & Swan Island	1	2800	✓	☑	◆	◆		◆	◆													
Lake Colongulac	1	1400	✓	☑												◆						
Lake Murdeduke	1	1550	✓	☑												◆			◆			
Lake Cundare	1	395	✓	☑												◆						
Lake Terangpom	1	208	✓	☑												◆						
Upper Lough Calvert	2	824	✓													◆			◆			
Lake Milangil	1	125	✓	☑												◆						
Kooraweera lakes	8	427	✓											◆		◆	◆		◆			
Lake Corangamite	1	23300	✓	☑												◆			◆			
Cundare Pool / Lake Martin	1	3130	✓													◆			◆		◆	
Lake Gnarpurt	1	2350	✓	☑												◆			◆			
Lake Wendouree	1	224	✓											◆								
Werribee – Avalon area	2	5460	✓	☑				◆	◆													◆
Banongil Network	1	59	✓															◆				
Total	68	48255	24	11	1	1	1	2	4	2	2	2	2	3	2	13	4	6	9	1	1	1

Ramsar:

✓ = Port Phillip Bay Ramsar site

☑ = Western District Lakes

Wetland Classification: Directory of Important Wetlands (Environment Australia 2001).

A1 – Marine waters – permanent shallow water less than 6 metres deep.

A2 – Subtidal aquatic beds: includes kelp beds, seagrasses, marine meadows.

A6 – Estuarine waters: permanent waters.

A7 – Intertidal mud, sand or salt flats.

A8 – Intertidal marshes.

A10 – Brackish to saline lagoons and marshes connected to the sea.

A11 – Freshwater lagoons and marshes in the coastal zone.

B1 – Permanent rivers and streams.

B4 – Riverine floodplains.

B5 – Permanent freshwater lakes (> 8 ha).

B6 – Seasonal/intermittent freshwater lakes (> 8 ha).

B7 – Permanent saline/brackish lakes.

B8 – Seasonal/intermittent saline lakes.

B10 – Seasonal/intermittent freshwater ponds and marshes on inorganic soils.

B12 – Seasonal saline marshes.

B13 – Shrub swamps.

B15 – Peatlands.

C1 – Water storage areas (> 8 ha).

C6 – Wastewater treatment.

APPENDIX 3. WETLAND-DEPENDANT BIRD SPECIES RECORDED ON WETLANDS WITHIN THE CORANGAMITE REGION

Species	Common Name	VROT	FFG	TREATY	Records in Wetland Category								No.
					2	3	4	5	6	7	20	21	wetlands
Actitis hypoleucos	Common Sandpiper			C	◆				◆				3
Anas castanea	Chestnut Teal				◆	◆	◆	◆	◆	◆	◆		38
Anas gracilis	Grey Teal				◆	◆	◆	◆	◆	◆	◆	◆	43
Anas platyrhynchos	Mallard							◆		◆			2
Anas rhynchotis	Australasian Shoveler	v			◆	◆	◆	◆	◆	◆	◆	◆	32
Anas superciliosa	Pacific Black Duck				◆	◆	◆	◆	◆	◆	◆	◆	59
Anhinga melanogaster	Darter						◆	◆		◆			4
Anseranas semipalmata	Magpie Goose	e				◆	◆	◆				◆	6
Ardea alba	Great Egret	e	L	C	◆	◆	◆	◆	◆	◆	◆	◆	29
Ardea ibis	Cattle Egret			C		◆		◆		◆		◆	9
Ardea intermedia	Intermediate Egret	c	L				◆					◆	3
Ardea pacifica	White-necked Heron				◆	◆	◆	◆	◆	◆		◆	32
Arenaria interpres	Ruddy Turnstone			C					◆	◆		◆	4
Aythya australis	Hardhead	v			◆	◆	◆	◆	◆	◆	◆	◆	23
Biziura lobata	Musk Duck	v					◆	◆	◆	◆	◆	◆	25
Botaurus poiciloptilus	Australasian Bittern	e				◆	◆		◆				8
Calidris acuminata	Sharp-tailed Sandpiper			C	◆	◆	◆		◆	◆		◆	20
Calidris alba	Sanderling			C		◆			◆			◆	4
Calidris canutus	Red Knot			C					◆	◆		◆	5
Calidris ferruginea	Curlew Sandpiper			C	◆	◆	◆		◆	◆		◆	19
Calidris fuscicollis	White-rumped Sandpiper											◆	1
Calidris melanotos	Pectoral Sandpiper	i		J						◆		◆	3
Calidris paramelanotos	Cox's Sandpiper									◆			1
Calidris ruficollis	Red-necked Stint			C	◆	◆	◆		◆	◆		◆	23
Calidris subminuta	Long-toed Stint	i		C								◆	1
Calidris tenuirostris	Great Knot			C					◆			◆	3
Cereopsis novaehollandiae	Cape Barren Goose	v				◆	◆	◆	◆	◆			8
Charadrius bicinctus	Double-banded Plover					◆		◆	◆	◆		◆	13
Charadrius mongolus	Lesser Sand Plover			C					◆			◆	3
Charadrius ruficapillus	Red-capped Plover				◆	◆	◆		◆	◆	◆		28
Chenonetta jubata	Australian Wood Duck						◆	◆	◆	◆	◆	◆	15
Chlidonias hybridus	Whiskered Tern	l			◆	◆	◆	◆	◆	◆		◆	25
Chlidonias leucopterus	White-winged Black Tern			C			◆			◆		◆	3
Cladorhynchus leucocephalus	Banded Stilt								◆	◆		◆	6
Dendrocygna eytoni	Plumed Whistling-Duck						◆						1
Egretta garzetta	Little Egret	c							◆	◆		◆	10
Egretta novaehollandiae	White-faced Heron				◆	◆	◆	◆	◆	◆	◆	◆	58
Elseyornis melanops	Black-fronted Dotterel					◆		◆		◆		◆	5
Erythrogonys cinctus	Red-kneed Dotterel					◆	◆		◆			◆	7
Fulica atra	Eurasian Coot				◆	◆	◆	◆	◆	◆	◆	◆	43
Gallinago hardwickii	Latham's Snipe			C	◆		◆	◆	◆	◆	◆	◆	14
Gallinula tenebrosa	Dusky Moorhen				◆	◆	◆	◆		◆		◆	14
Gallinula ventralis	Black-tailed Native-hen									◆			1
Gallirallus philippensis	Buff-banded Rail											◆	1
Grus rubicunda	Brolga	v	L		◆	◆	◆	◆	◆	◆			26
Haematopus fuliginosus	Sooty Oystercatcher											◆	1
Haematopus longirostris	Pied Oystercatcher								◆	◆		◆	9
Heteroscelus brevipes	Grey-tailed Tattler			C		◆						◆	2
Himantopus himantopus	Black-winged Stilt				◆	◆	◆	◆	◆	◆		◆	25
Ixobrychus minutus	Little Bittern	e						◆					1
Larus novaehollandiae	Silver Gull				◆	◆	◆	◆	◆	◆	◆	◆	45
Larus pacificus	Pacific Gull	l							◆	◆		◆	12
Limicola falcinellus	Broad-billed Sandpiper			C						◆			1
Limosa lapponica	Bar-tailed Godwit			C					◆			◆	2
Limosa limosa	Black-tailed Godwit			C			◆		◆			◆	3
Malacorhynchus membranaceus	Pink-eared Duck						◆		◆	◆	◆	◆	12
Micropalama himantopus	Stilt Sandpiper											◆	1
Morus serrator	Australasian Gannet	v				◆			◆			◆	4
Numenius madagascariensis	Eastern Curlew	l		C					◆	◆		◆	10
Numenius minutus	Little Curlew			C						◆		◆	2

Species	Common Name	VROT	FFG	TREATY	Records in Wetland Category								No. wetlands
					2	3	4	5	6	7	20	21	
Numenius phaeopus	Whimbrel			C								◆	1
Nycticorax caledonicus	Nankeen Night Heron	v				◆		◆		◆			3
Oxyura australis	Blue-billed Duck	v	L				◆	◆	◆	◆	◆	◆	14
Pachyptila belcheri	Slender-billed Prion					◆							1
Pachyptila turtur	Fairy Prion	I				◆				◆			2
Pelecanus conspicillatus	Australian Pelican					◆	◆	◆	◆	◆	◆	◆	30
Phalacrocorax carbo	Great Cormorant					◆	◆	◆	◆	◆	◆	◆	29
Phalacrocorax melanoleucos	Little Pied Cormorant					◆	◆	◆	◆	◆	◆	◆	38
Phalacrocorax sulcirostris	Little Black Cormorant					◆	◆	◆	◆	◆	◆	◆	31
Phalacrocorax varius	Pied Cormorant	I						◆	◆	◆		◆	19
Phalaropus lobatus	Red-necked Phalarope			C			◆						1
Philomachus pugnax	Ruff			C								◆	1
Platalea flavipes	Yellow-billed Spoonbill				◆	◆	◆	◆	◆	◆	◆	◆	29
Platalea regia	Royal Spoonbill	v				◆	◆	◆	◆	◆		◆	23
Plegadis falcinellus	Glossy Ibis	v		C		◆	◆	◆					5
Pluvialis fulva	Pacific Golden Plover			C					◆	◆		◆	6
Pluvialis squatarola	Grey Plover			C					◆	◆		◆	3
Podiceps cristatus	Great Crested Grebe					◆	◆	◆	◆	◆		◆	19
Poliocephalus poliocephalus	Hoary-headed Grebe				◆	◆	◆	◆	◆	◆	◆	◆	40
Porphyrio porphyrio	Purple Swamphen				◆	◆	◆	◆	◆	◆	◆	◆	33
Porzana fluminea	Australian Spotted Crake						◆	◆				◆	5
Porzana pusilla	Baillon's Crake	v					◆			◆			3
Porzana tabuensis	Spotless Crake							◆		◆			2
Puffinus gavia	Fluttering Shearwater					◆						◆	2
Puffinus tenuirostris	Short-tailed Shearwater			J								◆	1
Rallus pectoralis	Lewin's Rail	e										◆	2
Recurvirostra novaehollandiae	Red-necked Avocet				◆	◆	◆		◆	◆		◆	14
Rostratula benghalensis	Painted Snipe	e		C						◆			1
Stercorarius parasiticus	Arctic Jaeger			J								◆	2
Sterna albifrons	Little Tern	v	L	C					◆	◆		◆	6
Sterna bergii	Crested Tern	I				◆	◆		◆			◆	12
Sterna caspia	Caspian Tern	v		C		◆	◆	◆	◆	◆		◆	17
Sterna hirundo	Common Tern			C								◆	2
Sterna nereis	Fairy Tern	v	L						◆	◆		◆	7
Sterna nilotica	Gull-billed Tern	e			◆					◆			6
Stictonetta naevosa	Freckled Duck	e	L		◆		◆	◆		◆		◆	7
Stiltia isabella	Australian Pratincole									◆			1
Tachybaptus novaehollandiae	Australasian Grebe					◆	◆	◆		◆		◆	17
Tadorna tadornoides	Australian Shelduck				◆	◆	◆	◆	◆	◆	◆	◆	49
Tasmanogobius lasti	Lagoon Goby					◆							1
Thinornis rubricollis	Hooded Plover	e	L			◆			◆				3
Threskiornis molucca	Australian White Ibis				◆	◆	◆	◆	◆	◆	◆	◆	43
Threskiornis spinicollis	Straw-necked Ibis				◆	◆	◆	◆	◆	◆	◆	◆	38
Tringa flavipes	Lesser Yellowlegs											◆	1
Tringa glareola	Wood Sandpiper			C			◆						1
Tringa nebularia	Common Greenshank			C			◆		◆	◆		◆	17
Tringa stagnatilis	Marsh Sandpiper			C		◆		◆				◆	5
Tryngites subruficollis	Buff-breasted Sandpiper									◆			1
Vanellus miles	Masked Lapwing				◆	◆	◆	◆	◆	◆	◆	◆	67
Vanellus tricolor	Banded Lapwing											◆	2
Xenus cinereus	Terek Sandpiper			C						◆		◆	2
Total no. of species recorded for wetland category					30	53	56	48	63	74	26	84	

Victorian Rare and threatened Species (VROT)
v = vulnerable
e = endangered
c = conservation dependant
i = insufficiently known
l = listed

Flora and Fauna Guarantee Act (FFG)
L = Listed

Treaty (species listed under international migratory bird treaties).
C = CAMBA
J = JAMBA

Wetland Categories (Corrick 1982)
2 Freshwater Meadows
3 Shallow Freshwater Marshes
4 Deep Freshwater Marshes
5 Permanent Open Freshwater
6 Semipermanent Saline Wetlands
7 Permanent Saline Wetlands
20 Sewage Ponds
21 Salt Works

Data Sources: Atlas of Victorian Wildlife (DNRE 2002a); Wetlands Database, WETLAND_1994 (DCNR 1995).

APPENDIX 4. RARE AND THREATENED FLORA SPECIES RECORDED ON WETLANDS WITHIN THE CORANGAMITE REGION

Species	Common Name	AROT	VROT	FFG
Acacia retinodes var. *uncifolia*	Coast Wirilda		r	
Agrostis adamsonii	Adamson's Blown-grass	E	v	L
Agrostis aemula var. *setifolia*	Gilgai Blown-grass		v	
Amphibromus sinuatus	Wavy Swamp Wallaby-grass		v	
Atriplex australasica	Native Orache		k	
Atriplex paludosa ssp. *paludosa*	Marsh Saltbush		r	
Austrostipa gibbosa	Spurred Spear-grass		r	
Avicennia marina ssp. *australasica*	White Mangrove		r	
Bracteantha palustris	Swamp Everlasting	V	v	L
Cullen parvum	Small Scurf-pea	E	e	L
Glycine latrobeana	Clover Glycine	V	v	L
Helichrysum aff. *rutidolepis* (Lowland Swamps)	Pale Swamp Everlasting		v	
Juncus revolutus	Creeping Rush		r	
Lemna trisulca	Ivy-leaf Duckweed		k	
Lepidium aschersonii	Spiny Peppercress	V	e	L
Lepidium hyssopifolium	Basalt Peppercress	E	e	L
Lepilaena marina	Sea Water-mat		v	
Limonium australe	Yellow Sea-lavender		r	
Olearia speciosa	Netted Daisy-bush		k	
Poa sallacustris	Salt Tussock-grass	V	v	
Salsola kali aff. ssp. *tragus*	Coast Saltwort		r	
Thelymitra circumsepta	Naked Sun-orchid		v	
Triglochin minutissimum	Tiny Arrowgrass		r	
Triglochin mucronatum	Prickly Arrowgrass		r	

Australian Rare and threatened species (AROT)

E = Endangered

V = Vulnerable

Victorian Rare and threatened species (VROT)

e = endangered

v = vulnerable

r = rare

k = poorly known

Flora and Fauna Guarantee Act (FFG)

L = Listed

Source: Flora Information System (DNRE 2002b); WETLAND_1994 (DCNR 1995).

APPENDIX 5. WETLANDS WITH FLORA AND FAUNA RECORDS WITHIN THE CORANGAMITE REGION

Wetland Category	No. wetlands	No. wetlands with waterbird records	No. wetlands with flora records	% of wetlands with waterbird records	% of wetlands with flora records
2. Freshwater Meadows	374	29	14	7.75%	3.74%
3. Shallow Freshwater Marshes	293	32	6	10.90%	2.05%
4. Deep Freshwater Marshes	25	7	6	28.00%	24.00%
5. Permanent Open Freshwater	585	28	12	4.78%	2.05%
6. Semipermanent Saline Wetlands	136	25	22	18.38%	16.17%
7. Permanent Saline Wetlands	39	9	8	23.07%	20.51%
20. Sewage Ponds	21	3	0	14.28	0.00%
21. Salt Works	3	3	3	100.00%	100.00%
Total	**1476**	**136**	**71**	**9.21%**	**4.81%**

Source: Atlas of Victorian Wildlife (DNRE 2002a); Flora Information System (DNRE 2002b); Wetlands Database (DCNR 1995)

APPENDIX 6. GIS DATA LAYERS FOR WETLAND MAPPING

<table>
<tr><th>Data</th><th>Description/Type*</th><th>Source</th></tr>
<tr><td>Landsat 7 TM imagery
▪ Run 93/87 184 x 200 km 10.10.00
▪ Run 94/87 20 x 30 km 12.11.00</td><td>Spectral resolution: 7 bands
Spatial resolution: 30 x 30m pixels
Rectified: Level 9
Datum: AGD 66, Zone 54
*Raster
<table><tr><th>Band</th><th>Wavelength (micro-m)</th><th>Spectral location</th></tr><tr><td>1</td><td>0.45 - 0.52</td><td>Blue</td></tr><tr><td>2</td><td>0.52 - 0.60</td><td>Green</td></tr><tr><td>3</td><td>0.63 - 0.69</td><td>Red</td></tr><tr><td>4</td><td>0.75 - 0.90</td><td>Near Infrared (NIR)</td></tr><tr><td>5</td><td>1.55 - 1.75</td><td>Middle Infrared</td></tr><tr><td>6</td><td>10.4 - 12.5</td><td>Thermal Infrared (TIR)</td></tr><tr><td>7</td><td>2.08 - 2.35</td><td>Middle Infrared</td></tr></table></td><td>CCMA Library</td></tr>
<tr><td>Wetland_1994</td><td>Digital wetland data from Corrick (1982). Wetlands were delineated and classed using manual interpretation of aerial photographs. Identifies 1, 457 wetlands over 1 ha in size within the Corangamite region. Includes Wetland ID numbers and Category and Sub-category descriptions.
*Vector</td><td>CCMA Library
DCNR (1995)</td></tr>
<tr><td>Wetland_1788</td><td>Digital wetland data (pre-European extent). Wetlands were delineated and classed using manual interpretation of aerial photographs. Includes Wetland ID numbers and Category and Sub-category descriptions.
*Vector</td><td>CCMA
DCNR (1995)</td></tr>
<tr><td>Aerial Photographs</td><td>January 2001 run Aerial photographs 1:25, 000
Digitised and georeferenced to 1:25, 000 topographic maps by CEM for sample areas.
Includes digital index of runs and photo locations.</td><td>CCMA Library</td></tr>
<tr><td>Hydrological Data
▪ Lakes and Dams
▪ Intermittent Lakes
▪ Swamps
▪ Waterholes
▪ Floodplain
▪ Floodway
▪ Sewerage Filter Beds
▪ Rivers
▪ Streams
▪ Drainage Channels</td><td>Hydrological layers individually extracted from 1:25, 000 topographic map sheets.
*Vector</td><td>CEM / CCMA Libraries</td></tr>
<tr><td>Basins</td><td>Basin boundaries of the four major catchments within the Corangamite region.
*Vector</td><td>CCMA Library</td></tr>
<tr><td>Sub-catchments</td><td>Boundaries of 54 sub-catchments identified within the</td><td>CCMA</td></tr>
</table>

Data	Description/Type*	Source
	Corangamite CMA region. *Vector	Library
Roads	Road layer extracted from 1:25, 000 topographic map sheets. *Vector	CEM Library
Contours	Contour layer extracted from 1:25, 000 topographic map sheets. *Vector	CEM Library
Property Boundaries	Boundaries of individual privately and publicly owned property parcels (given by property number). *Vector	CCMA Library
Rainfall	Average rainfall bands. *Vector	CCMA Library
Bioregions	Boundaries of identified bioregions. *Vector	CEM Library
Geology	*Vector	CEM Library
Land Status	Land ownership boundaries. *Vector	CCMA Library
Wetland Flora	Flora records located within identified wetland boundaries were extracted from the Flora Information System. *Point data	(DNRE 2002b)
Wetland Fauna	Fauna records located within identified wetland boundaries were extracted from the Atlas of Victorian Wildlife.	(DNRE 2002a)
Ecological Vegetation Classes (EVC)	*Vector	CEM Library
DEM	Digital Elevation Models created using the contours layer within the raster based GIS Idrisi®. *Raster	CEM Library

APPENDIX 7. SITE DATA SHEET – CORANGAMITE WETLAND INVENTORY

SHEET 1 *(Refer to field instructions document for code descriptions)*

REFERENCE DATA									
Date / Time	/ /02 : am/pm	Wetland ID	L	L	N	N	N	Sector	N
Compiler details		Wetland Name							
Organisation	CCMA / CEM	AMG location Easting							
Location Description		Northing							
		Area	ha		Elevation		m		
		Photo no.							

LAND TENURE & LANDUSE														
Tenure (tick where applicable)	private	public	Landuse (tick where applicable)	GR1	GR2	CRO	CON	REC	FIS	SEW	IRR	FOR	UNU
On-site			On-site										
Surrounding			Surrounding										
Other (specify)			Other (specify)	On-site:						Surrounding:			

BIOPHYSICAL ATTRIBUTES										
Bioregion	VVP		CVU	OP	OR	WP				
Morphology			Origin (Circle appropriate code)							
Inland system	SBA	DBA	OXB	WHO	DEP	PSD	LAV	CRA	VOL	SOL	COL
			TDB	FAU	SIN	MET	CDU	RDU	ODU	DEF	SPR
	FLA		FLP								
	SLO		BAN	HIL							
Human origin	SBA	DBA	IMP	SEW	SEB	PIT					
Marine system	TID		RRE	MUD							
	EST		EST								

Water regime (circle appropriate code)							
	Inland system	PER	SMP	SEA	INT	EPR	DRY
	Marine system	ITF	STF	SFF			

Water Source (circle appropriate code)	LOC	CHA	OFF	STR	IRR	GRW	SPR	MAR

Maximum depth (Inland systems only)	m (when full)	Average depth (Inland systems only)	m (when full)
%Cover (area of water relative to full)	%	Time since inundation	months

Bottom sediment (substrata) (circle where appropriate)	Stoney	Coarse sand	Fine sand	Muddy sand	Sandy mud	Silt or mud	Silty clay	Clay	Peat	Ooze

WETLAND CLASSIFICATION																				
Category (Ramsar system) (circle appropriate code)		Number (circle appropriate number, refer to category descriptions)																		
Marine and Coastal zone	A	1	2	3	4	5	6	7	8	9	10	11	12							
Inland	B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Human-made	C	1	2	3	4	5	6	7	8	9										

THREATENING PROCESSES					Current extent of disturbance (tick where applicable)				Potential (tick where applicable)
Disturbance / Management Issue (circle where applicable)					Minimum	Moderate	High	Severe	
Altered water regime (AW)	Complete drainage (C)	Decreased (D)	Increased (I)	Flooded (F)					
Changed soil character (CS)	Acidification (A)	Pugging (P)	Sodification (S)						
Dumping (D)	Fill (clean) (FC)	Fill (dirty) (FD)	Garden refuse (G)	Household refuse (H)					
Encroachment (EN)	Gardening (G)	Roadway (R)	Structure (S)						
Grazing (G)	Native (N)	Stock (S)							
Nutrient enrichment (NE)	Agricultural (A)	Dairy effluent (D)	Septic tank (S)	Urban runoff (U)					
Vermin (V)	Cats (C)	Foxes (F)	Hares (H)	Rabbits (R)					
Tracks (T)	Bicycle (B)	Motorcycle (M)	Vehicle (V)	Walking (W)					
Weeds (W)	Environmental (E)	Noxious (N)	Pasture (P)						
Vegetation Destruction (VD)	Herbicide (H)	Ploughing (P)	Slashing (S)						
Increased salinity (S)									
Sedimentation (S-W)									
Lead contamination (LC)									
Stormwater discharge (SD)									
Other (specify)									

Conservation measures taken (tick where applicable)	Fencing		Re-vegetation		Pest control (animal)	
	Pest control (plant)		Restoration of water regime		None	
	Other (specify)					

SURFACE WATER CHEMISTRY							
Salinity (circle where appropriate)	Fresh (<500)	Brackish (500-18 000)	Semi-saline (18 000-30 000)	Saline (30 000-40 000)	Hypersaline (40 000-100 000)	Ultrasaline (>100 000)	Salinity reading:
PH (circle)	Acidic (<6)		Neutral (6-8)		Alkaline (>8)		
Secchi depth (circle)	Very clear (>100cm)	Quite clear (50-100cm)		Slightly turbid (20-50cm)		Very turbid (<20cm)	
Water colour (circle)	Green/blue (low turbidity)		Tea coloured (tannin, low turbidity)		Brown (muddy)		

BIOLOGICAL CHARACTERISTICS								
Zone	Zone description (tick)		Area (%)	Layers Present (tick)				
1	buffer			Riparian		Aquatic		
2	bank			Trees		Free floating		
3	shore			Shrubs		Floating attached		
4	emergent			Reeds / rushes / sedges		Submerged attached		
5	Aquatic submerged and emergent <1 m			Herbs / grasses		Emergent		
6	Aquatic >1 m			Buffer zone	m	Cover	%	
7	Open water							
				Attached Algae (circle where appropriate)		Little	Medium	Abundant

Noteworthy flora (list)	Noteworthy fauna (list)	No.	B

Flora diversity (estimate no.)		Fauna present (tick)		Fauna diversity (estimate no.)		
				Total	No. exotic	No. sensitive
Total		Macroinvertebrates				
No. exotic		Fish				
No. sensitive		Reptiles				
Indicate flora species present and abundance on SHEET 2		Amphibians				
		Birds				
		Mammals				

Weediness								
Vegetation zone	Introduced species % cover (tick)				Introduced species % richness (tick)			
	0%	<10%	10-50%	>50%	0%	<10%	10-50%	>50%
1 buffer								
2 bank								
3 shore								
4 emergent								
5 aquatic submerged and emergent								
6 aquatic								
7 open water								

RAPID ASSESSMENT (CONSERVATION VALUES) (circle where appropriate)					
Water dependent fauna	Aquatic invertebrates	Low	Moderate	High	
	Fish	Low	Moderate	High	
	Water dependent birds	Low	Moderate	High	
Aquatic Vegetation		Low	Moderate	High	
Riparian Vegetation (shore)		Degraded	Moderate	Intact	
Riparian Vegetation (bank)		Degraded	Moderate	Intact	
Riparian Vegetation (buffer)		Degraded	Moderate	Intact	
Wetland Condition		Severely Degraded	Degraded	Moderate	Intact	Pristine

COMMENTS

SHEET 2

Native flora species present	Wetland ID	L	L	N	N	N	Sector	N
Z *(indicate zone number)*	**A** *(Braun-Blanquet cover abundance)*	+ (<1%)	1 (<5%)	2 (6-25%)	3 (26-50%)	4 (51-75%)	5(76-100%)	

Species	Z	A	Species	Z	A	Species	Z	A	Species	Z	A
Acacia melanoxylon (136;651)			Crassula sieberiana ssp. tetramera			Juncus revolutus (r)			Pultenaea daphnoides		
Acaena agnipila			Crassula spp.			Juncus sarophorus			Ranunculus amphitrichus		
Acaena echinata			Cullen parvum (EndEeL)			Juncus spp. (125;292)			Ranunculus inundatus (891)		
Acaena novae-zelandiae			Cynodon dactylon			Juncus subsecundus			Ranunculus spp. (125;292)		
Agrostis adamsonii (EndEvL)			Cyperus gunnii ssp. gunnii			Lemna disperma			Rhagodia candolleana ssp. candolleana		
Agrostis aemula var. setifolia (v)			Cyperus gymnocaulos (291;636;682)			Lemna minor s.l. (300)			Rumex bidens		
Agrostis avenacea (125;292;899)			Cyperus lucidus (292)			Lemna trisulca (k)			Rumex brownii		
Agrostis avenacea var. avenacea			Danthonia s.l. spp.			Lepidium hyssopifolium (EndEel)			Rumex dumosus		
Agrostis billardierei (656)			Deyeuxia quadriseta			Lepidosperma longitudinale (136;200)			Ruppia megacarpa (104;682)		
Agrostis billardierei var. billardierei			Dianella tasmanica			Lepilaena cylindrocarpa			Ruppia polycarpa		
Alisma plantago-aquatica (125)			Dichelachne crinita			Lepilaena marina (v)			Ruppia spp. (684)		
Amphibromus macrorhinus			Dichondra repens			Lepilaena spp. (682;683;684)			Salsola kali aff. ssp. Tragus (r)		
Amphibromus neesii			Disphyma crassifolium ssp. clavellatum			Leptinella reptans s.l. (891)			Samolus repens (656)		
Amphibromus nervosus (125)			Distichlis distichophylla (643;648;656)			Leptorhynchos squamatus s.l.			Sarcocornia blackiana		
Amphibromus recurvatus			Drosera peltata ssp. auriculata			Leptorhynchos tenuifolius			Sarcocornia quinqueflora (648;683)		
Amphibromus sinuatus (v) (647)			Eleocharis acuta (104;125;291;636;643;656;891;898;899)			Leptospermum continentale (200;292;651)			Sarcocornia quinqueflora ssp. quinqueflora		
Amphibromus spp. (200;292)			Eleocharis gracilis			Leptospermum lanigerum (53;292)			Schoenoplectus pungens (104;636;643;656;891;898)		
Angianthus preissianus			Eleocharis pusilla			Lepyrodia spp. (136)			Schoenoplectus tabernaemontani (300)		
Apium annuum			Eleocharis sphacelata (300;653)			Leucopogon parviflorus			Schoenus apogon (136)		
Apium prostratum ssp. prostratum			Elymus scaber var. scaber			Lilaeopsis polyantha (125;136;636;656)			Schoenus nitens (636;682)		
Asperula conferta			Epacris impressa			Limonium australe (r)			Schoenus tesquorum (136;200;651)		
Asperula scoparia			Epilobium billardierianum (125;656)			Lobelia anceps (136)			Sclerostegia arbuscula		
Atriplex australasica (k)			Epilobium billardierianum ssp. billardierianum			Lobelia irrigua			Sebaea albidiflora		
Atriplex cinerea			Epilobium billardierianum ssp. cinereum			Lobelia pratioides (125;292)			Selliera radicans (10;643)		
Atriplex paludosa ssp. Paludosa (r)			Epilobium hirtigerum (125)			Lomandra longifolia (136)			Senecio glomeratus		
Austrodanthonia caespitosa			Eragrostis infecunda (v) (125;291;655;682)			Lycopus australis (863)			Senecio pinnatifolius		
Austrodanthonia carphoides			Eryngium ovinum			Lythrum hyssopifolia (125;292)			Senecio quadridentatus		
Austrodanthonia duttoniana (104;125;657)			Eucalyptus camaldulensis (291;292;651)			Marsilea drummondii (104;125)			Sonchus hydrophilus		
Austrodanthonia eriantha			Eucalyptus ovata (53;136;200;651)			Microlaena stipoides var. stipoides			Spergularia media s.l.		
Austrodanthonia pilosa			Euchiton collinus s.s. (292)			Microseris scapigera spp. agg.			Sporobolus virginicus (682)		
Austrodanthonia setacea			Euchiton involucratus s.l. (292)			Microtis unifolia			Stellaria angustifolia (647)		
Austrostipa bigeniculata			Euchiton sphaericus (292)			Mimulus repens (10;643;656;863)			Suaeda australis		
Austrostipa flavescens			Frankenia pauciflora var. gunnii			Muehlenbeckia florulenta (104;648;655;657;898)			Tetragonia implexicoma		
Austrostipa gibbosa (r)			Gahnia filum (10;656)			Myriophyllum crispatum (125;291)			Themeda triandra		
Austrostipa spp.			Gahnia trifida (53;651)			Myriophyllum muelleri (636;682)			Tricoryne elatior		
Austrostipa stipoides			Geranium solanderi s.l.			Myriophyllum salsugineum			Triglochin minutissimum (r)		
Avicennia marina ssp. Australasica(r)			Glossostigma elatinoides			Myriophyllum simulans (125;136)			Triglochin mucronatum (r)		
Azolla filiculoides (125;300)			Glyceria australis (125)			Myriophyllum spp. (125;200;292;647;653)			Triglochin procerum s.l. (125;200;636;647;653;863;899)		
Banksia marginata			Glycine latrobeana (VulVvL)			Myriophyllum verrucosum (291;636;682)			Triglochin striatum (10;125;136;643;655;656)		
Baumea gunnii			Gonocarpus tetragynus			Neopaxia australasica (125;136;647;656)			Typha domingensis		
Baumea rubiginosa s.l. (136;200)			Goodenia lanata			Olearia speciosa (k)			Typha orientalis (300)		
Baumea tetragona (136)			Gratiola peruviana			Ottelia ovalifolia ssp. Ovalifolia (125)			Vallisneria spiralis (682)		
Bolboschoenus caldwellii (10;636;643;656)			Haloragis heterophylla			Oxalis exilis			Veronica gracilis		
Brachyscome basaltica var. gracilis (125)			Halosarcia halocnemoides ssp. halocnemoides			Oxalis perennans			Villarsia reniformis (136;200;653)		
Bracteantha palustris (VulVvL)			Halosarcia pergranulata			Ozothamnus ferrugineus (651)			Viola hederacea s.l.		
Caesia calliantha			Halosarcia pergranulata ssp. pergranulata			Pentapogon quadrifidus			Wahlenbergia gracilis s.l. (125)		
Caladenia carnea s.l.			Helichrysum aff. rutidolepis (Lowland Swamps) (v)			Phragmites australis (10;53;300;863)			Wilsonia backhousei		
Calocephalus lacteus			Hemichroa pentandra			Picris angustifolia ssp. angustifolia			Wilsonia humilis		
Carex appressa (292;647)			Homopholis proluta (125)			Pimelea humilis			Wilsonia rotundifolia (643;655;682)		
Carex fascicularis			Hydrocotyle laxiflora			Pimelea linifolia			Wolffia australiana		
Carex inversa			Hydrocotyle sibthorpioides (292)			Poa labillardieri (125;292;898)					
Carex tereticaulis (125;136;647;651)			Hypericum gramineum			Poa poiformis var. poiformis					
Carpobrotus rossii			Isolepis cernua			Poa sieberiana					
Centella cordifolia (136)			Isolepis fluitans (125;136;647)			Poa spp. (136;651)					
Centipeda cunninghamii (125;292)			Isolepis inundata (200)			Poranthera microphylla (136)					
Characeae spp.			Isolepis marginata			Potamogeton crispus					
Chloris truncata			Isolepis nodosa			Potamogeton ochreatus					
Chorizandra cymbaria s.l.			Isolepis spp. (292;656)			Potamogeton pectinatus					
Clematis microphylla			Juncus amabilis (125;136)			Potamogeton tricarinatus s.l. (125;136;291;653)					
Cotula australis			Juncus bufonius (125)			Pseudognaphalium luteoalbum					
Cotula vulgaris var. australasica			Juncus filicaulis			Pteridium esculentum					
Crassula decumbens var. decumbens			Juncus flavidus (104;125)			Pterostylis nutans					
Crassula helmsii (300;891;899)			Juncus holoschoenus (125;136)			Puccinellia spp.					
Crassula peduncularis			Juncus kraussii ssp. Aust. (10;643;656;863;891)			Puccinellia stricta (656)					
Crassula sieberiana			Juncus pallidus (136)			Puccinellia stricta var. perlaxa (648;683)					
Crassula sieberiana ssp. sieberiana			Juncus procerus (136;200;647)			Puccinellia stricta var. stricta					

Introduced flora species

Z *(indicate zone number)* **A** *(Braun-Blanquet cover abundance)* + (<1%) 1 (<5%) 2 (6-25%) 3 (26-50%) 4 (51-75%) 5(76-100%)

Species	Common Name	Z	A	Species	Common Name	Z	A
Acetosella vulgaris	Sheep Sorrel			Phalaris aquatica (125)	Toowoomba Canary-grass		
Agrostis capillaris (125)	Brown-top Bent			Phalaris minor (125)	Lesser Canary-grass		
Agrostis stolonifera	Creeping Bent			Plantago coronopus (292;656)	Buck's-horn Plantain		
Aira caryophyllea	Silvery Hair-grass			Plantago lanceolata	Ribwort		
Aira cupaniana	Quicksilver Grass			Plantago major	Greater Plantain		
Anagallis arvensis	Pimpernel			Poa annua	Annual Meadow-grass		
Arctotheca calendula	Cape Weed			Polycarpon tetraphyllum	Four-leaved Allseed		
Asparagus asparagoides (EP)	Bridal Creeper			Polypogon monspeliensis	Annual Beard-grass		
Asphodelus fistulosus	Onion Weed			Rapistrum rugosum	Giant Mustard		
Aster subulatus	Aster-weed			Romulea rosea (125)	Onion Grass		
Atriplex prostrata (656)	Hastate Orache			Rumex conglomeratus (125)	Clustered Dock		
Avena barbata	Bearded Oat			Rumex crispus (125;899)	Curled Dock		
Avena fatua	Wild Oat			Sagina apetala	Common Pearlwort		
Avena sterilis ssp. ludoviciana	Sterile Oat			Silybum marianum (RP)	Variegated Thistle		
Berkheya rigida	African Thistle			Sisyrinchium iridifolium	Blue Pigroot		
Briza maxima	Large Quaking-grass			Solanum furcatum	Broad Nightshade		
Briza minor	Lesser Quaking-grass			Solanum nigrum s.l.	Black Nightshade		
Bromus catharticus	Prairie Grass			Sonchus asper s.l.	Rough Sow-thistle		
Bromus diandrus	Great Brome			Sonchus oleraceus	Common Sow-thistle		
Bromus hordeaceus ssp. hordeaceus	Soft Brome			Sporobolus africanus	Rat-tail Grass		
Carpobrotus aequilaterus	Angled Pigface			Suaeda baccifera	Berry Seablite		
Centaurium erythraea	Common Centaury			Tribolium acutiflorum s.l.	Desmazeria		
Centaurium tenuiflorum	Branched Centaury			Trifolium angustifolium var. angustifolium	Narrow-leaf Clover		
Cerastium glomeratum s.l.	Common Mouse-ear Chickweed			Trifolium campestre var. campestre	Hop Clover		
Cicendia filiformis	Slender Cicendia			Trifolium dubium	Suckling Clover		
Cirsium vulgare (125;292) (RP)	Spear Thistle			Trifolium fragiferum var. fragiferum	Strawberry Clover		
Conyza spp.	Fleabane			Trifolium glomeratum	Cluster Clover		
Cotula coronopifolia (10;125;300;656;863)	Water Buttons			Trifolium repens var. repens	White Clover		
Critesion hystrix	Mediterranean Barley-grass			Trifolium spp. (292)	Clover		
Critesion marinum (656)	Sea Barley-grass			Trifolium subterraneum (125)	Subterranean Clover		
Cynosurus echinatus	Rough Dog's-tail			Ulex europaeus (RP)	Gorse		
Cyperus eragrostis (125)	Umbrella Sedge			Vicia sativa	Common Vetch		
Cyperus tenellus	Tiny Flat-sedge			Vulpia bromoides	Squirrel-tail Fescue		
Dactylis glomerata	Cocksfoot			Vulpia myuros	Rat's-tail Fescue		
Echium plantagineum (RP)	Paterson's Curse						
Ehrharta longiflora	Annual Veldt Grass						
Euphorbia peplus	Petty Spurge						
Festuca arundinacea	Tall Fescue						
Foeniculum vulgare	Fennel						
Fumaria bastardii	Bastards Fumitory						
Fumaria officinalis spp. agg.	Fumitory						
Galenia pubescens var. pubescens	Galenia						
Galium murale	Small Bedstraw						
Helminthotheca echioides	Ox-tongue						
Holcus lanatus (125;292)	Yorkshire Fog						
Hypochoeris glabra	Smooth Cat's-ear						
Hypochoeris radicata	Cat's Ear						
Juncus acutus ssp. acutus (656) (RP)	Spiny Rush						
Kickxia spuria ssp. integrifolia	Blunt-leaved Fluellen						
Lactuca saligna	Willow-leaf Lettuce						
Lagurus ovatus	Hare's Tail						
Leontodon taraxacoides ssp. Taraxacoides (125;136)	Hairy Hawkbit						
Lolium perenne	Perennial Rye-grass						
Lolium rigidum	Wimmera Rye-grass						
Lycium ferocissimum (RP)	African Box-thorn						
Malva dendromorpha	Tree Mallow						
Malva parviflora	Small-flower Mallow						
Marrubium vulgare (RP)	Horehound						
Medicago minima	Little Medic						
Medicago polymorpha	Burr Medic						
Melilotus indicus	Sweet Melilot						
Nassella neesiana (EP)	Chilean Needle-grass						
Nassella trichotoma (SP)	Serrated Tussock						
Oxalis pes-caprae	Soursob						
Parapholis incurva (656)	Coast Barb-grass						
Parapholis strigosa	Slender Barb-grass						
Paspalum distichum (125)	Water Couch						

APPENDIX 8. FIELD INSTRUCTIONS FOR DATA SHEETS

General field instructions

- Data collected from the field survey of wetlands for this inventory is baseline data and is not required to be overly comprehensive or time consuming to collect. Try to keep actual time spent surveying a particular wetland (or sector) under 1.5 hours if possible.
- Use lead pencil or other water resistant ink when filling out field survey sheets and annotating field maps.
- Return completed field survey sheets and annotated field maps to:

Centre for Environmental Management
PO Box 663
Mt Helen 3353

Maps provided

Maps provided of each catchment at 1:20 000. Wetlands have been mapped on Landsat TM images and a centroid XY coordinate for each wetland region is shown (AMG location). These can be used to locate wetlands using Global Positioning System (GPS). All roads and property boundaries are included. Property owner contact details also included.

Indicate by marking on the maps any changes to wetland shape, or add any wetlands that do not appear on the map. Indicate the Wetland ID number (as described in section below) on the map for each wetland visited.

Data Sheet 1 Completion Instructions

Reference data

Date/Time	The date of data collection should be stated (day/month/year) including the time of field survey to the nearest half hour.
Compiler details	State the name/s of person/s undertaking data collection.
Organisation	State the organisation that is managing the data collection (note: this has been completed for Corangamite wetland survey CCMA / CEM).
Location description	Provide a general description of the location of the wetland using landscape features or closest roads. If the wetland is being assessed in sectors (see below) provide a description of the location of the sector (eg. Use a bearing descriptor S/SW sector).
Wetland ID	Each wetland must be identified by a code number specific to this survey. Wetlands are to be numbered using two letter (L) sub-catchment prefix followed by three digit number (N) in order of site visits. For example: wetlands in Salt Creek sub-catchment would begin at SC 001, SC 002 etc. (note that the wetland ID number is to be provided on all sheets of the survey form and also indicated on maps).
Sector No.	Where an individual wetland is very large or has differing character, conditions and management, it may be appropriate to assess individual sectors of wetlands separately. In this instance sectors of the wetland should be numbered sequentially (sector 1, 2, 3 etc.). Identify differing sectors by indicating on maps provided which sector is being assessed (eg. Wetland ID would become SC001-1 for sector 1 of wetland SC001). Note that a separate survey form should be completed for each sector. Leave Sector No. box blank if the wetland is not assessed in sectors. (Note: sector numbers are to be recorded alongside Wetland ID numbers on all sheets of the survey form and also indicated on maps).
Wetland Name	The name of the wetland should be stated. Where multiple names exist use them all. Where no name for the wetland exits, use descriptive qualifiers, landmarks, or ask the landowner to provide a name.

AMG location	(Australian Map Grid location). Geographic location of wetlands should be recorded using GPS (AGD 66 UTM 54s projection). In such a system, the coordinates would be expressed as metres of Eastings and Northings. All boxes provided should contain a number if recorded correctly. GPS locations of wetlands should reflect the approximate centre of the wetland. If the wetland is assessed in sectors, the GPS location should reflect the approximate centre of the sector area being assessed. Maps provided will indicate an AMG position for each wetland. This location data can be used on the data sheet if considered accurate enough.
Area	Provide an approximate area of the wetland (or sector of wetland) extent when full in hectares. This can be estimated using maps provided or recorded later by GIS query if uncertain.
Elevation	Record elevation in metres above sea level. This information can be recorded from GPS or obtained from topographic map sheets.
Photo no.	Digital photographs are to be taken where possible of wetlands surveyed. Record number/s of photo/s on data sheet to identify wetlands when downloading. Rename downloaded photos using respective Wetland ID numbers and sector numbers where appropriate.

Land tenure and land use

Tenure	Indicate if the wetland (on-site) is privately or publicly owned by ticking the appropriate box. Also indicate the land tenure of the areas directly surrounding the wetland by ticking the appropriate box. Specify other option if private and public are not applicable (e.g. Commonwealth land).
Land use	Indicate the on-site use and surrounding use of the wetland by ticking appropriate land use codes. Specify other land use if codes are not applicable. (Note: more than one land use code can be indicated).

Land use codes		
	GRA1	Grazing (sheep)
	GRA2	Grazing (cattle, horses)
	CRO	Cropping (cereals or legumes) includes raised bed crops.
	CON	Conservation (wetland managed for conservation purposes)
	REC	Recreational activity (e.g. boating, fishing, duck hunting)
	FISH	Fishery (wetland used for aquaculture purposes)
	SEW	Sewage treatment
	IRR	Irrigation (wetland used as a source of water for irrigation)
	FOR	Forestry (wetland used as source of timber)
	UNU	Unused (no land use activity identifiable)

Biophysical attributes

Bioregion	Indicate the bioregion the wetland occurs within by circling the appropriate code. Bioregions can be identified on maps provided or by GIS query.

Bioregion codes		
	VVP	Victorian Volcanic Plain
	CVU	Central Victorian Uplands
	OP	Otway Plain
	OR	Otway Ranges
	WP	Warrnambool Plain

Morphology

Describe the morphology of the wetland using codes provided. Morphology is separated into those of inland, human origin, and marine systems. Circle only one of the corresponding codes provided for morphology.

Morphology codes

Inland System – wetlands which do not receive any marine waters (including human origin wetlands)		**Marine system** – wetlands which are influenced by tidal marine water.	
SBA Shallow basin	Concave landform, generally < 2 m deep	**TID** Tidal flat	Intertidal zones of coastal or inlet shorelines exposed to marine tidal water and subject to inundation at least once a year, and not associated with a river mouth.
DBA Deep basin	Concave landform , generally > 2 m deep.	**EST** Estuary	Intertidal zones of coastal areas associated with open river mouths, influenced by both tidal marine water and river flow.
FLA Flat	Flat areas of floodplains with varying frequency and duration of flooding.		
SLO Slope	Sloping plains with wetland characteristics wither due to flooding (eg riverbanks) or the presence of a spring or groundwater seepage.		

Origin

Describe the geomorphic origin of the wetland using the codes provided. Wetland origin is separated into categories within different wetland morphologies as described above.

Origin codes

Shallow or Deep Basin	
OXB Oxbow	Billabong (cut-off anabranch) in floodplain.
WHO Waterhole	Depressions within river or creek channels which retain water when the channel is otherwise dry.
DEP Depositional basin	Broad depressions which have formed by deposition in old deflation basins, may be linked or discrete.
PSD Prior stream depression	Generally long, sinuous depression marking an old stream bed.
LAV Lava flow	Basins formed on the edge of or within lava flows.
CRA Crater	Roughly circular basins with deep margins formed in the vent of a volcano.
VOL Other volcanic basins	Basins associated with volcanic activity which are neither basins formed by lava flows or craters.
SOL Solution	Depression formed by the solution of limestone (karst landscape).
COL Collapse	Depression formed in karst landscape by collapse caused by solution underground. Unlike Solution depressions, collapse depressions are likely to have blocks of rock in their basins.
TDB Terminal drainage basin	Basin which is the lowest point in an internal drainage basin.
FAU Fault	Basin formed from tectonic movement of the earth to block water flow.
SIN Sinkhole	Basin formed from tectonic movement of the earth causing an area to fall relative to its surroundings.
MET Meteor impact	Crater formed by the impact of an extra terrestrial object.
CDU Coastal interdunal	Typically linear or crescent-shaped basins formed between coastal dunes or barrier ridges.
RDU Riverine interdunal	Typically crescent-shaped basins formed between riverine dunes.
ODU Other interdunal	Typically linear or crescent-shaped basins formed between dunes not associated with the coast or a river.
DEF Deflation basin	Small to very large rounded basins formed by the movement of sediment through wind action. Large deflation basins typically have a crescentic dune (lunette) on their down-wind margin.
SPR Spring	Basin fed by groundwater discharge (spring).
Flat	
FLP Floodplain	Alluvial plain subjected to flooding; usually also containing wetland basins e.g. oxbow.
Slope	
BAN Riverine bank	Slope of river bank
HIL Hillside	Hillside supporting a wetland due to seepage from hill slopes.
Basins of human origin	
IMP Impoundment	Basin formed by damming of a river or creek.
SEW Sewage pond	Basin constructed as a sewage oxidation basin.
SEB Salt evaporation basin	Normally dry basin flooded with saline water as part of saline water removal.
PIT Pit	Excavated basin or trench. (e.g. road gutter)
Tidal	
RRE Rocky reef	
MUD Mudflat	
Estuary	
EST Estuary	

Water regime

Indicate using codes provided the water regime for the wetland. These are divided into Inland and Marine systems.

Water regime codes		
	Inland System	
	PER Permanent	Contains water throughout the year, although the level may vary.
	SMP Semi-permanent	Contains water throughout the year but dries out in dry years (eg. 1 year in 10)
	SEA Seasonal	Floods and dries in most years.
	INT Intermittent	Floods irregularly but can be expected to have water at least once per decade and possibly even for several years more or less continuously. This frequency is high enough to influence the type of vegetation present.
	EPI Episodic	Only contains water at infrequent and irregular intervals (less than 1 year in 10). Such episodic events hardly influence the type of vegetation (except when water is present).
	DRY Artificially dry	Water source cut off or wetland drained.
	Marine System	
	ITF Intertidal flat	Inundated by most if not all high tides.
	STF Supratidal flat	Covered only at spring tides or less frequently.
	SFF Supratidal flat and flooding	Relatively rare tidal coverage is combined with seasonal freshwater flooding.

Water source

The source of water inflow should be recorded. Indicate using codes provided the water source of the wetland.

Water source codes		
	LOC Local runoff	Fed by runoff and infiltration generated by precipitation in the vicinity plus rainfall on the wetland surface; no defined stream.
	CHA Channel fed	Fed by local runoff entering wetland in artificial channel.
	OFF Off-stream	Fed by the river only during floods.
	STR Stream-fed	Fed by river/stream with a continuous connection.
	IRR Irrigation runoff	Fed by runoff generated from irrigation isolated from its natural source. Irrigation runoff will be through a channel so this is a subset of Channel-fed.
	GRW Groundwater	Fed by groundwater from underground aquifer.
	SPR Spring	Fed by groundwater coming to surface at a spring beyond the wetland boundary.
	MAR Marine	Fed by inflows from the sea, including tides.

Maximum depth

Provide an estimation of the maximum depth of the wetland when full in metres. This applies to inland systems only.

Average depth

Provide an estimation of the average depth of the entire wetland when full in metres. This applies to inland systems only.

% Cover

Indicate the area of water present relative to full at the time of survey.

Time since inundation

If the wetland is dry, indicate the number of months since the last inundation (if known).

Bottom sediment (substrate)

Simple visual / textural method of classifying the substrata should be applied using categories defined below.

Substrate definitions

Textural class	Texture / general appearance	Percentage composition	
		% clay	% sand
Stony	Rough or gritty texture, evidence of small stones and pebbles.	N/A	N/A
Coarse sand	Disintegrates readily, individual sand grains can be readily seen and felt. Shell fragments are common.	N/A	80
Fine sand	Well packed, clean, disintegrates readily and individual sand grains hard to distinguish.	10	90
Muddy sand	Sandy material noticeable discoloured by mud.	20	80
Sandy mud	Muddy material with equal quantities of sand and mud.	50	50
Silt or mud	Silty or muddy material, loose when moist, with traces of sand.	70	30
Silty clay	Sand hardly evident. Usually grey, sometimes containing iron concretions.	90	10
Clay	Sand not evident. Stiff and tenacious material, greasy when moist. Solid grey to blue grey in colour.	100	N/A
Peat	Organically laden substrata containing partly decomposed plant remains. Spongy when wet.	N/A	N/A
Ooze	Fine black, organically laden sludge, generally smelling of hydrogen sulphide.	N/A	N/A

Wetland classification

Category

Wetland classification is based on that used by Ramsar Convention in describing Wetlands of International Importance and Directory of Important Wetlands in Australia. Indicate which broad category the wetland belongs to (**A** – marine and coastal zone; **B** – inland; **C** – human made).

Number

Indicate which sub-category the wetland belongs to using definitions provided below.

Definition of wetland classification

	A – Marine and Coastal Zone Wetlands
1	Marine waters – permanent shallow waters less than six metres deep at low tide; includes sea bays, straits.
2	Subtidal aquatic beds; includes kelp beds, seagrasses, tropical marine meadows.
3	Coral reefs.
4	Rocky marine shores; includes rocky offshore islands, sea cliffs.
5	Sand, shingle or pebble beaches; includes sand bars, spits, sandy islets.
6	Estuarine waters; permanent waters of estuaries and estuarine systems of deltas.
7	Intertidal mud, sand or salt flats.
8	Intertidal marshes; includes saltmarshes, salt meadows, saltings, raised salt marshes, tidal brackish and freshwater marshes.
9	Intertidal forested wetlands; includes mangrove swamps, nipa swamps, tidal freshwater swamp forests.
10	Brackish to saline lagoons and marshes with one or more relatively narrow connections with the sea.
11	Freshwater lagoons and marshes in the coastal zone.
12	Non-tidal freshwater forested wetlands.
	B – Inland Wetlands
1	Permanent rivers and streams; includes waterfalls.
2	Seasonal and irregular rivers and streams.
3	Inland deltas (permanent).
4	Riverine floodplains; includes river flats, flooded river basins, seasonally flooded grassland, savanna and palm savanna.
5	Permanent freshwater lakes (>8 ha); includes large oxbow lakes.
6	Seasonal/intermittent freshwater lakes (>8 ha), floodplain lakes.
7	Permanent saline/brackish lakes.
8	Seasonal/intermittent saline lakes.
9	Permanent freshwater ponds (<8 ha), marshes and swamps on inorganic soils; with emergent vegetation waterlogged for at least most of the growing season.
10	Seasonal/intermittent freshwater ponds and marshes on inorganic soils; including sloughs, potholes; seasonally flooded meadows, sedge marshes.
11	Permanent saline/brackish marshes
12	Seasonal saline marshes.
13	Shrub swamps; shrub dominated freshwater marsh, shrub carr, alder thicket on inorganic soils.
14	Freshwater swamp forest; seasonally flooded forest, wooded swamps; on inorganic soils.
15	Peatlands; forest, shrub or open bogs.
16	Alpine and tundra wetlands; includes alpine meadows, tundra pools, temporary water from snow melt.
17	Freshwater springs, oases and rock pools.
18	Geothermal wetlands.
19	Inland, subterranean karst wetlands.

	C – Human-made Wetlands
1	Water storage areas; reservoirs, barrages, hydro-electric dams, impoundments (generally >8 ha).
2	Ponds, including farm ponds, stock ponds, small tanks (generally <8 ha).
3	Aquaculture ponds, fish ponds, shrimp ponds.
4	Salt exploitation; salt pans, salines.
5	Excavations; gravel pits, borrow pits, mining pools.
6	Wastewater treatment; sewage farms; settling ponds, oxidation basins.
7	Irrigated land and irrigation channels; rice fields, canals, ditches.
8	Seasonally flooded arable land, farm land.
9	Canals.

Threatening Processes

Disturbance / Management issues

Disturbances and management issues are listed on Sheet 1. A number of these have been divided into sub-categories of a particular disturbance. Circle the particular type of disturbance present at the site (Note: letters in brackets are codes used for database entry and can be ignored). More than one disturbance sub-category can be indicated where necessary. Leave blank where no disturbance exists.
Specify threatening processes that are not included on the data sheet in the "other" row.

Current extent of disturbance

Indicate the extent of disturbance caused by respective threatening process at the time of survey by indicating the level of disturbance (minimum – severe). Leave boxes blank where no disturbance was evident.

Level of disturbance descriptions	**Minimum**	Minimal evidence of the disturbance factor. Disturbance has little impact on wetland values, easily rectifiable.
	Moderate	Moderate evidence of disturbance. Disturbance has noticeable effect on wetland values although is rectifiable.
	High	Significant disturbance to wetland values. Verging on unrectifiable damage, although some of original wetland values evident.
	Severe	Disturbance at such a level that wetland values are destroyed (e.g. wetland completely drained, completely dominated by exotic species, biologically dead etc.)

Potential — Indicate where it is considered that the wetland could potentially be threatened by a disturbance factor in the future, however is currently not effected.

Conservation measures taken — Conservation measures are listed on Sheet 1. Indicate where known conservation efforts have occurred. Also indicate in the "None" category if no conservation measures have been implemented. Specify other conservation measures if not listed.

Weediness — Indicate the presence and abundance of exotic species by ticking appropriate % cover and % richness values for the site for each growth-form. *Introduced species % cover* refers to the percentage of total wetland area covered by any number of exotic species. *Introduced species % richness* refers to the percentage of the total number of flora species present that are exotic.

Growth-form descriptions	**Free-floating**	Includes those species that normally are unattached but float on the surface.
	Floating attached	Includes those species that are rooted in the substrate but normally have at least the mature leaves floating on the water surface.
	Submerged attached	Includes species rooted in the substrate and whose leaves are normally fully submerged. These species may produce flowers that either float on the water surface or are held above it.
	Emergent	Includes those species rooted in the substrate and whose stems, flowers and most of the mature leaves project above the water surface.
	Tree / shrub	Includes those emergent species that have woody stems. Plants in this group tend to grow in seasonally or infrequently wet habitats.

Surface Water Chemistry

Salinity — Measure salinity (total dissolved salts) in parts per thousand. Indicate using the scale provided the broad salinity category. (Note: salinity levels may fluctuate greatly between years).

pH — Indicate the water pH by circling the appropriate level.

Secchi depth — Indicate Secchi depth category. In shallow wetlands, the Secchi disk may not disappear from sight.

Water colour — Indicate the water colour using categories provided.

Biological Characteristics

Zones — Vegetation zones present within the wetland should be indicated. Tick where vegetation zone is present. Corresponding zone numbers provided are to be used on Sheet 2 of the survey form to indicate the presence and abundance of individual species within vegetation zones.

Zone descriptions	**1 buffer**	Fringing native vegetation from the top of the bank and extending between 10-100 m.
	2 bank	High water mark to buffer.
	3 shore	Low water to high water.
	4 emergent	
	5 aquatic submerged and emergent <1 m	Emergent zone to 1 meter water depth.
	6 aquatic >1 m	Mostly submerged at water depth 1 meter and greater.
	7 open water	

Layers present — Indicate the presence of flora growth-forms in both the riparian and aquatic habitats.

Buffer zone — Indicate the average width of fringing native vegetation based on visual estimates (record in meters).

Cover — The cover of aquatic vegetation as a percentage of the water surface that is covered with aquatic vegetation should be estimated by eye.

Attached algae	An indication of the amount of macroalgae present should be recorded as little, medium or abundant.

Attached algae descriptions		
	Little	No obvious macroalgae present.
	Medium	Clumps of significant macroalgae present.
	Abundant	Macroalgae present over at least one-third of water area.

Noteworthy flora	List any rare and threatened flora species that occur at the site. (Note: See Sheet 2 of the survey form for species lists including rare and threatened status.)
Noteworthy fauna	List any rare and threatened fauna species that are present at the site, including species listed under JAMBA and CAMBA. Also include any species that occur in notable numbers or that are regionally significant. Provide approximate numbers of individuals of each species observed at the time of survey in the No. column. Indicate evidence of breeding (B) by ticking.
Flora diversity	Estimate the total number of flora species present at the site. Indicate the number of these that are exotic and the number that are sensitive species (generally uncommon species that only occur where little disturbance is present).
Fauna present	Indicate which fauna groups are present at the site (by direct observation or tracks and signs).
Fauna diversity	Estimate the total number of species that are present in each faunal group at the site. Indicate the approximate number of these that are exotic and the number that are sensitive species (generally uncommon species that only occur where little disturbance is present). Note: numbers given are approximates only and is not expected to be accurate.
Weediness	Indicate the presence and abundance of exotic species by ticking appropriate %cover and %richness values for the site within each vegetation zone identified. *Introduced species % cover* refers to the percentage of wetland zone covered by any number of exotic species. *Introduced species % richness* refers to the percentage of the total number of flora species present that are exotic within each zone.

Rapid Assessment (Conservation values)

The rapid assessment component of the survey provides a snap shot of the vegetation association and condition within different riparian habitats. Scores are subjective and should provide an indication of the condition of wetlands at time of survey as determined by the surveyor. Subjective scores will be compared with condition index scores generated from data collected above and should provide an indication of the accuracy of condition index scores following data analysis.

Water dependent fauna	Subjective score according to the abundance and diversity and relative condition of macroinvertebrates, fish and birds located within or on the water body determined by observation.

Water dependent fauna descriptions		
	Low	Very few or no species present.
	Moderate	Moderate species diversity and abundance, usually more common species.
	High	High species diversity and abundance, presence of more sensitive species.

Aquatic vegetation	Subjective score according to the abundance and diversity and relative condition of aquatic vegetation determined by observation.

Aquatic vegetation descriptions		
	Low	Indicates no or very little aquatic vegetation present, notable presence of exotic species, with low species diversity.
	Moderate	Indicates some aquatic vegetation cover, most vegetation layers present, some exotic species present.
	High	High diversity of aquatic vegetation with few exotics. Most or all aquatic vegetation layers represented.

Riparian vegetation	Riparian vegetation is to be assessed at three zones: • Toe of bank (low water – high water). • Bank (high water mark to buffer). • Buffer (top of bank to the buffer which can extend between 10-100 meters). The vegetation of each zone is subjectively scored considering the level of disturbance and vegetation cover within each zone.

Riparian vegetation descriptions		
	Degraded	< 30% native vegetation cover with an abundance or exotic species and evidence of a high level of disturbance.
	Moderate	Between 30-75% native vegetation cover, few exotics with little evidence of disturbance.
	Intact	>75% native vegetation cover with little or no evidence of disturbance.

Wetland condition	The overall wetland condition score should reflect the previous rapid assessment scores. The combination of these values and the interpretation of other parameters recorded during the survey (such as land degradation and water chemistry) form the basis of the wetland condition score.	
Wetland condition descriptions	**Severely degraded**	Very high level of disturbance evident to the extent that wetland values are destroyed or irreversibly modified (e.g. wetland drained, eutrophication). Received low rapid assessment scores.
	Degraded	High level of disturbance evident. Verging on unrectifiable damage. Received mostly low rapid assessment scores.
	Moderate	Significant level of disturbance evident although some natural values present. Most damage rectifiable. Received mostly moderate rapid assessment scores.
	Intact	Small amounts of disturbance evident, with high native species diversity. Damage easily rectifiable. Received mostly moderate - intact rapid assessment scores.
	Pristine	No obvious disturbance, with high native species diversity. Scored mostly intact rapid assessment scores. Usually formally conserved within the reserve system.

Comments

Provide any comments that clarify the assessment of the wetland where required.

Data Sheet 2 Completion Instructions.

Flora species present at the site are to be identified on Sheet 2 of the survey form. Sheet 2 provides a list of commonly recorded species on wetlands within the Corangamite region compiled from quadrat data from the Flora Information System (DNRE 2002b). Limited quadrat data exists for many wetlands within the study area and so the list provided may not be comprehensive. Additional species should be listed in the spaces provided. Note that detailed quadrats are **not** to be completed for this wetland inventory. However, the most dominant species should be identified in each vegetation zone, including incidentals and any rare and threatened species noted.

Native species and introduced species have been divided on either side of Sheet 2.

Wetland ID	Insert the same Wetland ID number for the site as shown on Sheet 1 of the survey form.	
Sector	Insert the sector number if the wetland is being assessed in sectors as shown on Sheet 1 of the survey form. If the wetland is not being assessed in sectors leave this box blank.	
Native flora species present	Indicate species present at the site by underlining. Species rare and threatened status is shown in brackets. Ecological Vegetation Classes (EVCs), which the species is known to be characteristic of, are also listed in brackets (see EVC descriptions below). The EVC descriptions are given as a **guide only** and have not been extensively mapped for wetlands within the Corangamite and may not be the best classification system possible.	
Z (zone number)	Where a species is identified at a site, indicate which vegetation zone the species occurs in.	
Zone descriptions	**1**	Buffer: Top of the bank to the buffer which can extend between 10-100 meters.
	2	Bank: High water mark to buffer.
	3	Toe of bank: Low water to high water.
	4	Emergent
	5	Aquatic submerged and emergent <1 m: Emergent zone to 1meter water depth.
	6	Aquatic >1 m: Mostly submerged at water depth 1 meter and greater.
	7	Open water
A (Braun-Blanquet cover abundance)	Indicate cover abundance for each species present using the Braun-Blanquet cover abundance scale. (Note that an abbreviated version of the Braun-Blanquet scale is included on the survey form).	
Braun-Blanquet cover abundance descriptions	**+**	Few individuals, less than 1% cover.
	1	Any number of individuals, less than 5% cover.
	2	Any number of individuals, 6-25% cover.
	3	Any number of individuals, 26-50% cover.
	4	Any number of individuals, 51-75% cover.
	5	Any number of individuals, 76-100% cover.

Introduced flora species	The same method for recording native flora species is applied to the introduced species section, using both the zone numbers and cover abundance methods listed above. Exotic species that have been noted as serious weeds of particular EVC are indicated (see EVC descriptions below). Those species that are listed as regional and state priority weeds are noted below.	
Priority weed codes	**RP**	Regional Priority weeds: those that have been assessed to have a detrimental economic, environmental and social impact. Includes declared Regionally Prohibited weeds.
	EP	Emerging Priority weeds: those that are new to the Corangamite catchment or are of a size allowing eradication.
	SP	State Priority weeds: include all weeds declared as State Prohibited Weeds.

Ecological Vegetation Classes (EVCs) identified for wetlands in the Corangamite region – descriptions

10 Estuarine Wetland

Otways Region: Estuarine Wetland is limited in occurrence within the Otways region being confined to lower reaches of streams near the coast. This EVC receives saline water from tidal movements and fresh water flows from inland. The inundating waters are usually salty, sometimes brackish and occasionally fresh over the period of a year depending upon river flooding regimes. Soils are anaerobic peat-rich muds. Rainfall is between 800-1000 mm per annum. Elevation is 0-2 m asl. An example of Estuarine Wetland can be found adjacent to Lake Craven and Lake Hordern around the lower reaches of the Aire River.

Warrnambool Region: Treeless sedge-dominated wetland vegetation in estuaries. Vegetation is determined by fluctuating salinity, which varies in time from occasionally fresh to brackish or occasionally saline according to river flood and marine tide events. Soils are heavy silts and clays. Quadrats are recorded from the Warrnambool Plain within the study area but this EVC occurs or originally occurred in all estuaries within the study area (Glenelg Plain, Victorian Volcanic Plain at Portland, Warrnambool Plain).

***Lower Estuary* Estuarine Wetland**

Floristics: Dominated by sedge *Gahnia filum*, comprising a small number of salt-tolerant (halophytic) herbs.

Structure: Sedgeland 1.5 m tall.

Habitat: Outer (landward) zones of large estuaries, subject to fluctuating salinity including occasional freshwater/brackish floods and tidal inundation.

Nearest relative: Coastal Salt Marsh.

Comments: The stand at Curdies Inlet is one of the largest in south-east Australia (J. Yugovic pers. obs.) and requires detailed survey. Small stands of *Estuarine Flats* Coastal Tussock Grassland occur within this area but are below mapping threshold.

***Upper Estuary* Estuarine Wetland**

Floristics: Dominated by *Juncus kraussii*, comprising a range of moderately salt-tolerant and some typically freshwater species. *Phragmites australis* is scattered throughout the community.

Structure: Rushland 1.0 m tall.

Habitat: Upper reaches of estuary, less saline than for Estuarine Wetland (Community 1).

Nearest relative: Estuarine Wetland (Community 1).

Comments: Estuarine vegetation within the study area requires further survey.

53 Swamp Scrub

Swamp Scrub occurs close to the coast in the study area and has affinities with Shallow Freshwater Marsh. Both occupy similar swamp habitats, however the Swamp Scrub occurs on slight rises where the soil is deeper and better drained.

This EVC lacks an overstorey and is dominated by tall Woolly Tea-tree *Leptospermum lanigerum* that forms dense impenetrable thickets, out-competing other species. Coast Saw-sedge *Gahnia trifida* and Common Reed *Phragmites australis* are also common

104 Lignum Wetland

Lignum Wetland is common across the arid areas of north-western Victoria, however within the Midlands and Otways study areas it is restricted to tiny areas scattered across the plains from Bacchus Marsh to Melton to south of Geelong. Rainfall in this area is very low (500-550mm per annum). Lignum Wetland generally occurs within areas of Plains Grassland, on swamp and lagoonal deposits and quaternary stream alluviums deposited in minor depressions on the basalt volcanic plains. Soils are very heavy grey clays, waterlogged for much of the year but also experience periods of extreme dryness. Species diversity is very low as few plants can thrive in these conditions.

Lignum Wetland is a shrubland dominated Tangled Lignum *Muehlenbeckia florulenta*. Ground species include Common Spike-sedge *Eleocharis acuta,* Sharp Club-sedge *Schoenoplectus pungens*, Brown-back Wallaby-grass *Austrodanthonia duttoniana*, Yellow Rush *Juncus flavidus*, Large-fruit Tassel *Ruppia megacarpa* and Common Nardoo *Marsilea drummondii*.

Wetlands are complex by nature, with distinct zonation patterning dependent on water depth and period of inundation. Most have been severely disturbed by drainage and dam building works in addition to heavy grazing and weed invasion. As a result they are difficult to classify. It is likely that Lignum Wetland is a complex of a number of different entities. Of the wetlands mapped as Lignum Wetland in the Midlands and Otways study area, some are freshwater, some are slightly brackish and some, with less extreme soil conditions and hence more species, have close affinities with Plains Grassy Wetland.

125 Plains Grassy Wetland

Primarily grassy (to sedgy-herbaceous) vegetation of ephemeral to seasonal wetlands on fertile soils of volcanic and sedimentary plains, sometimes with scattered or fringing eucalypts or lignum shrubs. The grassy/sedgy-herbaceous ground-layer comprises various balances of true aquatics and species tolerant of intermittent to seasonal inundation. The vegetation ranges from extremely species-poor to species-rich on some verges or shallower more ephemeral sites. Occurs in seasonally wet depressions on plains, typically associated with heavy paludal soils. Previously widespread and common in suitable habitat but now largely cleared and remnants mostly under threat. Recorded from two bioregions within study area (Victorian Volcanic Plain, Wimmera).

***Victorian Volcanic Plain 1* Plains Grassy Wetland**

Floristics: Dominated by grasses (principally *Glyceria australis*, *Austrodanthonia duttoniana*, *Poa labillardieri*, *Amphibromus nervosus*), with sedges and herbs (notably *Eleocharis acuta*, *Juncus holoschoenus*, *Eryngium vesiculosum*, *Lobelia pratioides*) often conspicuous. Sites range from low to high species-richness. Outer fringes and more ephemeral sites can support a wide range of graminoid and herbaceous species tolerant of intermittent inundation. The relationship between mapping and classification is complicated by the linking of quadrats from the wet cores of drier systems with sites from drier margins of wetter systems.

Structure: Open-grassland, mostly 0.5–1.0 m in height.

Habitat: Shallow seasonally wet depressions and poorly defined drainage systems, on heavy grey-black clay soils.

Nearest relative: Red Gum Wetland

***Victorian Volcanic Plain 2* Plains Grassy Wetland**

Floristics: Dominated by *Glyceria australis*, often with *Eleocharis acuta*, consistently very species-poor. Most of the few associated species are typically aquatic or very inundation-tolerant herbs. Some sites appear to be always species-poor, others reveal increased floristic diversity following seasonal retreat of wetland inundation.

Structure: Open-grassland.

Habitat: Seasonally wet depressions and poorly defined drainage systems, with very heavy grey-black clay soils, prone to turbidity during inundation.

Nearest relative: Other Plains Grassy Wetland communities, Plains Sedgy Wetland.

Comments: The more floristically diverse outer verges of most remnants are degraded by loss of species and weed invasion.

136	Sedge Wetland

Sedge-dominated seasonal wetland, usually of low diversity in central areas, but richer on verges and in some more ephemeral forms of the EVC. Frequently on soils of high organic content, in depressions within sandy terrain. Scattered distribution within higher rainfall areas. While reduced by draining and clearing, this is to a far less extent than in the case of seasonal wetlands on more fertile soils. Several communities are likely to be present within this EVC according to degree and duration of inundation. Recorded from three bioregions within the study area (Dundas Tablelands, Glenelg Plain, Victorian Volcanic Plain).

***Group 1* Sedge Wetland**

Floristics: Dominated by *Chorizandra australis* and *Baumea articulata*, with aquatic herbs including *Myriophyllum* spp. and *Villarsia reniformis*; drier verges dominated by *Lepidosperma longitudinale* with a wider range of small sedges and herbs.

Structure: Sedgeland 1–3 m tall, with aquatic herbs sometimes providing substantial cover in wetter versions of the EVC.

Habitat: Organic soils, in wetland basins on or adjacent to edges of lower fertility sandy soils, with higher sand content around verges. Central areas remain wet on a semi-continuous basis, fringes are typically intermittently wet.

Nearest relatives: Aquatic Herbland, Plains Sedgy Wetland.

***Group 2* Sedge Wetland**

Floristics: Dominated by *Lepidosperma longitudinale*, with fringing verge of *Melaleuca squarrosa* and *Restio tetraphyllus*.

Structure: Sedgeland, 1–2 m tall, with taller scrub verge.

Habitat: Seasonal wetland within highest rainfall forest areas on south-west verge of the volcanic plain, on organic soils.

Nearest relatives: Plains Sedgy Wetland, Aquatic Herbland.

Comments: Remnants minimal, inadequately known.

200	Shallow Freshwater Marsh

Wetlands which, while still shallow, are more deeply inundated and for longer periods than Freshwater Meadow (EVC 680). While this hydrological regime delimits a range of possible wetland EVCs, only on a very local scale does it imply a particular EVC with any certainty. On the volcanic plains and more fertile Tertiary soils, shallow freshwater marsh is usually indicative of Plains Sedgy Wetland, or poorly characterised species-poor variants of Plains Grassy Wetland in drier areas. It can also refer to sites supporting Swamp Scrub along impeded drainage lines in higher rainfall areas of plains. In relevant sections of the Wimmera Plains, Shallow Freshwater Marsh is usually indicative of Red Gum Wetland. In drier areas of the plains (both sedimentary and volcanic), Shallow Freshwater Marsh includes small areas of a range of restricted wetland types, including Cane-grass Wetland, Lignum – Cane-grass Wetland, Lignum Swamp, Brackish Wetland or Brackish Sedgeland. On less fertile sandy country, it typically indicates Sedge Wetland, or, rarely, Brackish Sedgeland (e.g. Casterton area). On floodplains, Shallow Freshwater Marsh has typically been treated as part of Floodplain Riparian Woodland (Floodplain Wetland).

291	Cane Grass Wetland

Open-grassland, typically very species-poor except on outer verges, often with monospecific (or virtually so) cane-grass dominated centres. On very heavy grey clay soils, prone to turbidity when inundated and extreme cracking when dry. Previously rare and localised within the study area, few relatively intact remnants persist. Recorded from one bioregion within study area (Wimmera), although it does occur on the Victorian Volcanic Plain near but outside the study area boundary, and prior restricted occurrences within the study area are possible.

Floristics: Dominated by *Eragrostis infecunda*, typically very species-poor except around outer verges. Where present in more central areas, associated species are often annuals such as *Agrostis avenacea* var. *avenacea* or herbaceous aquatics such as *Potamogeton tricarinatus*. Often fringed by *Muehlenbeckia florulenta*, occasionally with scattered eucalypts.

Structure: Open-grassland.

Habitat: Seasonally to intermittently (mostly) shallowly inundated depressions, typically with heavy grey clay soils.

Nearest relative: Lignum Cane Grass Swamp (in relation to more species-rich outer fringes only) and some variants of Plains Grassy Wetland.

292	Red Gum Wetland

Red Gum Wetland occurs in seasonally inundated drainage lines, swamps or depressions on heavy clay soil plains. It is very uncommon within the Victorian Volcanic Plain Biogeographic Region as most sites have been drained and/or the timber removed. The overstorey is dominated by Red Gum *Eucalyptus camaldulensis* with the occasional Blackwood *Acacia melanoxylon*. Shrubs, usually Tea-Trees, may be scattered or in small thickets. The ground layer is dominated by large clumps of sedges such as Tall Sedge *Carex appressa*. Between these clumps are various herbs, grasses and small sedges, though in the height of summer the ground can appear bare.

300	Reed Swamp

Reed Swamp has only been mapped in one location in the Midlands and Otways study areas, in the Lake Connewarre State Game Reserve, south of Geelong, where it covers much of Reedy Lake. It occurs on Quaternary sedimentary geology of mainly estuarine sands. The soils are peaty, silty clays and average annual rainfall is approximately 600mm. Reed Swamp requires shallow water (to 1 m deep) and low current-scour. It can only tolerate very low levels of salinity. It occupies approximately 5 square kilometres of the centre of Reedy Lake. The more saline margins of the lake support Coastal Saltmarsh Complex and Cane Grass-Lignum Halophytic Herbland.

Reed Swamp is a closed to open grassland/sedgeland dominated by Common Reed *Phragmites australis* to 2-3 m tall. Amongst the Common Reed are more open areas of tall sedges to 2 m including Cumbungi *Typha orientalis*, River Club-sedge *Schoenoplectus validus* and Tall Spike-sedge *Eleocharis sphacelata*. Also growing in these less shaded areas are small species such as Swamp Crassula *Crassula helmsii*, Water Buttons **Cotula coronopifolia* and the floating species Pacific Azolla *Azolla filiculoides* and Common Duckweed *Lemna minor*.

636	Brackish Lake Mosaic

Mosaic of wetland EVCs in which deeper central areas support Brackish Aquatic Herbland (see table below). Verges support a more species-rich herbland or sedgeland in which *Bolboschoenus caldwellii*, *Schoenus nitens*, *Schoenoplectus pungens*, *Cyperus gymnocaulos* and *Eleocharis* spp. are prominent. Brackish Wetland 656 sometimes occurs in this mosaic, but other poorly understood EVCs are also present. Typically fringed by *Eucalyptus camaldulensis*-dominated woodland. The floristic composition of the verge is influenced by factors such as salinity, exposure, aspect and steepness (see Permanent Open Freshwater 682). Always rare in study area, current examples mostly with increased salinity due to hydrological alteration. Recorded from one bioregion (Victorian Volcanic Plain).

Brackish Lake Mosaic (Brackish Aquatic Herbland component)

Floristics: This component dominated by *Myriophyllum verrucosum*, with *M. muelleri*, sometimes with *Triglochin procerum* and *Lilaeopsis polyantha*.

Structure: Herbland (aquatic) to sedgeland, submergent to weakly emergent.

Habitat: Inundated depressions, including along poorly defined drainage lines. Floristic composition indicates the presence of salinity, but not at levels which greatly restrict species-richness.

Nearest relatives: Brackish Wetland, Estuarine Wetland, Grey Clay Drainage Line Herbland/Sedgeland.

643	Brackish Drainage Line Herbland/Sedgeland

Usually sedgeland or herbland, structurally variable, with a range of variously salt-tolerant herbs, but samphires only minor component if present, occurs on heavy clay and organic/alluvial soils along salinised minor drainage lines. Previously rare and localised within study area, now mostly cleared. Recorded from two bioregions within study area (Dundas Tablelands, Victorian Volcanic Plain).

Floristics: Potentially co-dominated by a wide range of somewhat salt-tolerant species, including sedges and rushes/reeds (*Eleocharis acuta*, *Bolboschoenus caldwellii*, *Schoenoplectus pungens*, *Juncus kraussii*, *Phragmites australis*), smaller grasses (*Distichlis distichophylla*) and herbs (e.g. *Selliera radicans*, *Triglochin striatum*, *Pratia irrigua*, *Mimulus repens*, *Wilsonia rotundifolia*).

Structure: Sedgeland or herbland, sometimes reed-bed, mostly 0.2–1 m in height.

Habitat: Frequently saturated heavy clay and organic/alluvial soils along salinised minor drainage lines, mostly on basaltic or fertile Tertiary terrain.

Nearest relative: Estuarine Wetland, Inland Saltmarsh, Brackish Wetland.

647	Plains Sedgy Wetland

Primarily sedgy-herbaceous vegetation of ephemeral to seasonal wetlands on fertile soils of volcanic and sedimentary plains, sometimes with scattered or fringing eucalypts or Tea-tree/Paperbark shrubs in higher rainfall areas. A range of aquatic herbs can be present, and species-richness is mostly relatively low to moderate, but higher towards drier margins. Occurs in seasonally wet depressions on plains, typically associated with silty peaty or heavy clay paludal soils. Plains Sedgy Wetland typically occurs in sites of most sustained and deeper inundation than Plains Grassy Wetland. Previously widespread and relatively common in restricted suitable habitat, but now largely cleared and remnants mostly under threat. Recorded from two bioregions within study area (Dundas Tablelands, Victorian Volcanic Plain).

Victorian Volcanic Plain **Plains Sedgy Wetland**
Floristics: Variously dominated by *Carex tereticaulis*, *Amphibromus sinuatus* and aquatic herbs (notably *Stellaria angustifolia*, *Isolepis fluitans*, *Myriophyllum* spp., *Triglochin procerum*, *Neopaxia australasica*). In higher rainfall versions such as Annya Forest, *Juncus procerus* and *Carex appressa* may be the largest graminoids present. These variants, with a somewhat similar but less-rich aquatic flora, are presumed to represent an undescribed additional community.
Structure: Open-sedgeland (to 1.5 m) to mat-forming or weakly emergent aquatic herbland.
Habitat: Occurs in seasonally wet depressions on plains, typically associated with silty peaty paludal soils over heavy clays.
Nearest relative: Plains Grassy Wetland, Aquatic Herbland.

648	Saline Lake Verge Herbland/Sedgeland

Variously sedgeland, herbland or grassland vegetation occurring on the fringes of saline semi-permanent to permanent wetlands. On lower rainfall volcanic plains and fertile Tertiary or Quaternary soils of sedimentary origin, these wetland types are typically fringed by low vegetation dominated by salt-tolerant grasses and herbs, or succulent chenopods. Central wet areas usually support a herbland dominated by fine-stemmed submerged aquatic monocots. These EVCs have generally been combined and mapped as Saline Lake Mosaic. Soils are generally heavy grey clays, sometimes with a shallow sandy covering, and are intermittently inundated to moist for most of the year. Scattered within the study area but now largely modified by grazing and hydrological alteration. Recorded from two bioregions within the study area (Wimmera, Victorian Volcanic Plain).
Saline Lake Verge Herbland/Sedgeland
Floristics: Dominated by *Puccinellia stricta* var. *perlaxa*, *Sarcocornia quinqueflora* and/or *Distichlis distichophylla*. A range of salt tolerant herbs, sedges and small grasses can also be present on the upper edges of this zone or in less saline examples. *Muehlenbeckia florulenta* was sometimes also present in this zone.
Structure: Grassland or herbland, sometimes (partially) open-shrubland, mostly (0.05–) 0.2–0.6 m in height.
Habitat: Verges of salinised water bodies, associated with heavy soils or superficial sandy overlays.
Nearest relative: Inland Saltmarsh, Brackish Wetland.

651	Plains Swampy Woodland

Eucalypt woodland with ground-layer dominated by tussock grasses and/or sedges, rich in herbs when relatively intact. Occurs on poorly drained, seasonally waterlogged heavy soils, primarily on paludal deposits on the volcanic plains but extending to suitable substrates within landscapes of sedimentary origin. Previously of scattered distribution, mainly in higher rainfall areas. Almost entirely cleared. Recorded from two bioregions (Glenelg Plain, Victorian Volcanic Plain).
Floristics: Dominated by *Eucalyptus ovata*, occasionally *E. camaldulensis. Acacia melanoxylon* also frequently present. Shrubs, if present, include *Ozothamnus ferrugineus*, *Leptospermum continentale*, *Allocasuarina paludosa* (in highest rainfall areas). Sedges are frequently conspicuous, most commonly *Carex* spp., but also including *Gahnia trifida* and *Schoenus tesquorum* at Annya. Grasses (notably *Poa* spp.) tolerant of waterlogging and a range of herbs occur in relatively intact sites.
Structure: Woodland (6–)10–20 m tall, stunted in most waterlogged sites, with sedgy-grassy understorey, shrubbier in highest rainfall situations.
Habitat: Seasonally waterlogged flats, mainly on heavy soils of paludal origin.
Nearest relative: Plains Grassy Wetland, Plains Grassy Woodland.

653	Aquatic Herbland

Herbland of permanent to semi-permanent wetlands, dominated by sedges (especially on shallower verges) and/or aquatic herbs. Occurs on fertile paludal soils, typically heavy clays beneath organic accumulations. Previously widespread within restricted areas of suitable habitat across the study area but now greatly reduced through draining and use for agriculture. Recorded from five bioregions (Dundas Tablelands, Glenelg Plain, Victorian Volcanic Plain, Warrnambool Plain, Wimmera).
Floristics: Dominated by *Eleocharis sphacelata*, *Triglochin procerum* and *Myriophyllum* spp., sometimes with other aquatics such as *Potamogeton tricarinatus* and *Villarsia reniformis* also conspicuous.
Structure: Sedgeland or herbland, with submerged and floating to (mostly less than 0.5 m) emergent aquatic species.
Habitat: Deeper, more continuously inundated wetlands, with heavy clay soils beneath organic layers.
Nearest relatives: Plains Sedgy Wetland, wetlands within Floodplain Riparian Woodland and Riparian Woodland.
Comments: Reasonably resilient flora capable of invading suitable artificial waterbodies.

655	Lignum Cane Grass Swamp

Lignum-dominated shrubland with Cane-grass dominated predominantly grassy-herbaceous associated flora of low to medium species-richness. Most associated species are to some extent halophytic. Occurs on brackish heavy soils. Previously extremely localised within study area, substantially further reduced by agricultural activities. Recorded from one bioregion (Victorian Volcanic Plain) within study area, but likely to have included at least minor occurrences in suitable habitat in low rainfall parts of the Wimmera.
Floristics: Dominated by *Muehlenbeckia florulenta* in association with *Eragrostis infecunda*, low to moderate species-richness, including herbs indicative of salinity (e.g. *Pratia irrigua*, *Wilsonia rotundifolia*, *Triglochin striatum*, *Agrostis* spp.).
Structure: Shrubland to open-shrubland 1.5–2.5 m in height.
Habitat: Intermittently to seasonally inundated, on salinised heavy grey clay soils on flats in wetland basins, isolated occurrences within lower rainfall basaltic terrain.
Nearest relative: Cane Grass Wetland, Brackish Wetland.

656	Brackish Wetland

Sedgeland or herbland, occasionally grassland, dominated by salt-tolerant species, but samphires typically with low cover, if present. Typically occurs on heavy, at least seasonally shallowly inundated to waterlogged soils, on a range of geologies. Previously rare and localised within study area, now mostly degraded by grazing, nutrient run-off and other disturbances. Recorded from two bioregions within study area (Victorian Volcanic Plains, Wimmera).
Victorian Volcanic Plains **Brackish Wetland**
Floristics: Variously dominated or co-dominated by a wide range of sedges or rushes including *Bolboschoenus caldwellii*, *Gahnia filum*, *Juncus kraussii*, *Schoenoplectus pungens*, and/or herbs including *Mimulus repens*, *Triglochin striatum*, *Lilaeopsis polyantha*, sometimes also *Triglochin procerum*.
Structure: Sedgeland mostly to 1–2 m height, or herbland to 0.2 m height.
Habitat: Inundated depressions, including along poorly defined drainage lines. Floristic composition indicates the presence of salinity, but not at levels which greatly restrict species-richness.
Nearest relative: Brackish Lake, Estuarine Wetland, Grey Clay Drainage Line Herbland/Sedgeland.

657	Freshwater Lignum Shrubland

Lignum-dominated shrubland with predominantly grassy-herbaceous associated flora. Occurs on fertile heavy soils, mostly on the fringe of other wetland types. Recorded from two bioregions within study area (Wimmera, Victorian Volcanic Plain).
Floristics: Dominated by *Muehlenbeckia florulenta*, with *Austrodanthonia duttoniana* common at the least degraded remnant examined.
Structure: Shrubland 1.5–3 m in height.
Habitat: Non-saline wetland verges in lowest rainfall areas, sometimes in association with low stony exposures and possible ground-water seepage.
Nearest relative: Plains Grassy Wetland.

680	Freshwater Meadow

Wetlands shallowly inundated for only a few months each year. While this hydrological regime delimits a range of possible wetland EVCs, only on a very local scale does it imply a particular EVC with any certainty. On the volcanics and more fertile Tertiary soils, Freshwater Meadow is usually indicative of Plains Grassy Wetland. In relevant sections of the Wimmera Plains, it is usually indicative of Red Gum Wetland on more fertile soils, or Seasonally Inundated Shrubby Woodland / Sedge-rich Woodland on shallow sand sheets, with Dune Soak Woodland of very restricted occurrence south of Goroke. In the Casterton area, it can indicate Damp Heath, Wet Heath and/or Sedge Wetland.

681	Deep Freshwater Marsh
Semi-permanent wetlands, where at least central areas are inundated for in excess of 6 months each year and soils remain virtually continuously wet. Centres of wetlands in this category of wetland typically support Aquatic Herbland. Fringes are variously dominated by sedges, reeds or rushes, or shrubs, varying according to habitat type in which wetland is occurring. Each wetland description refers to the deepest or wettest area of the respective wetland, hence Deep Freshwater Marsh typically represents mosaics of different vegetation types reflecting the inundation regime. The main EVCs occurring within Deep Freshwater Marsh are mosaics with Aquatic Herbland, variously including Red Gum Wetland, Plains Sedgy Wetland, Sedge Wetland, Swamp Scrub, Floodplain Riparian Woodland and rarely small areas of Brackish Wetland.	
682	**Permanent Open Freshwater**
Permanent waterbodies often mapped as Freshwater Lake or Brackish Lake. Centres of this category of wetland can support Aquatic Herbland or open water apparently lacking macrophytic vegetation. A submerged herbland of *Vallisneria americana* is sometimes present. Character of verges varies with ecological position around respective waterbody. North to western sides can include a beach or steep bank associated with a levee, while on south to eastern banks, patches of sheltered shallows with Aquatic Herbland and sedges or reed beds can be present. An additional fringing community, usually with *Eucalyptus camaldulensis*, typically occurs in the zone between the shoreline and adjacent dryland vegetation types. Brackish lakes (i.e. slightly saline) can support a different flora, including a herbland of aquatics dominated by *Myriophyllum muelleri*, *M. verrucosum*, *Lepilaena* spp. and *Ruppia* spp. In sites considered 'saline', macrophyte diversity is greatly reduced, often to only a single species of *Lepilaena* or *Ruppia*. The verges of brackish lakes also floristically differ from those of freshwater lakes, including species indicative of some salinity, notably herbs (e.g. *Pratia irrigua*, *Wilsonia rotundifolia*, *Cressa cretica*, *Schoenus nitens*, *Sporobolus* spp.), often with *Cyperus gymnocaulos* and *Eragrostis infecunda*.	
683	**Semi-permanent Saline**
Saline wetlands where inundation is prolonged, and soil mostly remains continually wet, at least in central portion. On lower rainfall volcanic plains and fertile Tertiary soils, these wetland types are typically fringed by saltmarsh vegetation dominated by either *Puccinellia stricta* var. *perlaxa* or *Sarcocornia quinqueflora*. Central wet areas usually support a herbland dominated by *Lepilaena* spp. (Aquatic Meadow). In a localised section of the Wimmera, Salt Paperbark Woodland and/or Inland Saltmarsh can occupy flats around saltmarsh fringed salt pans. This category has often been mapped as Saline Lake.	
684	**Permanent Saline**
Description denotes saline waterbodies where inundation, at least in their central portion, is continual. Peripheral vegetation is typically similar to that of semi-permanent saline wetlands in same area. Permanent water areas support a species-poor herbland dominated by *Ruppia* spp. or *Lepilaena* spp. (Aquatic Meadow). Both semi-permanent saline and permanent saline wetlands have mostly been treated as the same EVC (Saline Lake) during mapping, except where it was reasonable to attempt to distinguish drier verges or more seasonal wetland communities such as Brackish Wetland, Inland Saltmarsh / Salt Paperbark Woodland or Lignum Swamp.	
863	**Floodplain Reedbed**
Floodplain Reedbed was identified in only one location in the Midlands and Otways study areas, in Craven, Costin and Hordern Lakes that are on the broad swampy flats of the lower reaches of the Aire River. It occurs in the slightly deeper areas of inundation on these flats. The remainder of the flats was mapped as Swamp Scrub. Soils are Quaternary swamp and lagoonal deposits of clays, silts and peat. Altitude is just above sea level (less than 5 m). Rainfall is greater than 1000mm per annum. A dense sward of Common Reed Phragmites australis to 2 m tall dominates this EVC. Other species recorded include Sea Rush *Juncus kraussii*, Creeping monkey-*flower Mimulus repens*, Water Buttons **Cotula coronopifolia,* Australian Gipsywort *Lycopus australis* and Water-ribbons *Triglochin procerum*.	
891	**Plains Brackish Sedge Wetland**
Within the Midlands and Otways study areas Plains Brackish Sedge Wetland was only identified in the Lake Connewarre area south of Geelong. It occurs on flat to very gently sloping terrain in a strip around the southern edge of Reedy Lake. The width of this strip varies from a few meters to over 100m and is dependent on the degree of slope into the lake. This EVC appears to be very site-specific as it does not occur around the slightly more saline shores of nearby Lake Connewarre. The Quaternary aeolian geology mainly consists of estuarine sands. Annual rainfall is approximately 600mm. Plains Brackish Sedge Wetland is grows in association with Reed Swamp, Plains Freshwater Sedge Wetland and Coastal Saltmarsh Complex. It is a closed sedgeland to 80 cm tall dominant by Sharp Club-sedge *Schoenoplectus pungens*, Creeping Cotula *Leptinella reptans* and River Buttercup *Ranunculus rivularis*. Swamp Crassula *Crassula helmsii* and Common Spike-sedge *Eleocharis acuta* are less common.	
898	**Cane Grass – Lignum Halophytic Herbland**
Within the Midlands and Otways study area, this EVC is restricted to the Lake Connewarre area south of Geelong. It occurs within shallow depressions on otherwise flat terrain, surrounded by Coastal Saltmarsh Complex and Plains Grassland. The geology is Quaternary sedimentary estuarine sands. The soils are silty clays, subject to periodic freshwater flooding from the nearby Barwon river. Annual rainfall is approximately 600mm. This EVC has been identified in two small areas, to the south of Reedy Lake in the Lake Connewarre State Game Reserve and on the west bank of the Barwon River, south east of Geelong Cane Grass – Lignum Halophytic Herbland is a shrubland dominated by Tangled Lignum *Muehlenbeckia florulenta,* though in slightly better drained areas the Lignum is sparse and Common Tussock Grass *Poa labillardieri* dominates. The ground layer is dominated by sedges, with Common Spike-sedge *Eleocharis acuta* prominent at the wetter sites and Sharp Club-sedge *Schoenoplectus pungens* in more brackish situations.	
899	**Plains Freshwater Sedge Wetland**
Within the Midlands and Otways study area this EVC is confined to the Lake Connewarre area south of Geelong. It is grows in association with Plains Grassland, Plains Brackish Sedge Wetland and Coastal Saltmarsh Complex. It occurs on quaternary sedimentary geology, consisting mainly of estuarine sands, the soils are peaty silty clays. Annual rainfall is approximately 600mm. Plains freshwater sedge wetland is an open to closed sedgeland, reaching heights to 1 m. The dominant species are Common Spike-sedge *Eleocharis acuta,* Common Blown Grass *Agrostis avenacea* and the weed, Curled Dock **Rumex crispus* with Swamp Crassula *Crassula helmsii* and Water-ribbons *Triglochin procerum* sub dominant.	

Source: Commonwealth and Victorian Regional Forest Agreement (1999); DNRE 2002.

APPENDIX 9. RARE AND THREATENED FLORA SURVEYED DURING WETLAND INVENTORY

Species Name	Common Name	No. sites	VROT	FFG Act	EPBC Act
Amphibromus fluitans	River Swamp Wallaby-grass	7	k	X	VU
Amphibromus sinuatus	Wavy Swamp Wallaby-grass	2	v		
Atriplex australasica	Native Orache	11	k		
Atriplex paludosa ssp. *paludosa*	Marsh Saltbush	4	r		
Austrostipa setacea	Corkscrew Spear-grass	1	r		
Avicennia marina ssp. *australasica*	White Mangrove	4	r		
Berula erecta	Water Parsnip	1	k		
Chorizandra australis	Southern Bristle-sedge	1	k		
Craspedia paludicola	Swamp Billy-buttons	1	v		
Cullen parvum	Small Scurf-pea	2	e	L	EN
Cuscuta tasmanica	Golden Dodder	3	k		
Elymus multiflorus	Short-awned Wheat-grass	1	k		
Eucalyptus leucoxylon ssp. *bellarinensis*	Yellow Gum	1	e	L	
Helichrysum aff. *rutidolepis* (Lowland Swamps)	Pale Swamp Everlasting	2	v		
Juncus revolutus	Creeping Rush	12	r		
Lawrencia spicata	Salt Lawrencia	5	r		
Limonium australe	Yellow Sea-lavender	1	r		
Lotus australis	Austral Trefoil	1	k		
Melaleuca armillaris ssp. armillaris	Giant Honey-myrtle	2	r		
Microseris sp. 1	Plains Yam-daisy	3	v		
Persicaria attenuata	Velvet Knotweed	1	k		
Pimelea spinescens ssp. *spinescens*	Spiny Rice-flower	1	e		VU
Poa sallacustris	Salt-lake Tussock-grass	10	v		VU
Ranunculus aff. *inundatus* (South-west)	South-west River Buttercup	1	k		
Ranunculus diminutus	Lesser River Buttercup	20	k		
Schoenus nanus	Tiny Bog-sedge	1	k		
Schoenus sculptus	Gimlet Bog-sedge	1	r		

APPENDIX 10. RARE AND THREATENED FAUNA RECORDED DURING WETLAND INVENTORY

COMMON NAME	Number of sites	VROT	FFG Act	EPBC Act
Brown Quail	1	i		
Black-faced Cormorant	1	v		
Pied Cormorant	1	l		
Whiskered Tern	18	l		
Caspian Tern	3	v		
Little Tern	1	v	L	
Brolga	12	v	L	
Glossy Ibis	7	v		
Royal Spoonbill	5	v		
Little Egret	3	c		
Great Egret	7	e	L	
Australasian Bittern	3	e		
Cape Barren Goose	1	v		
Magpie Goose	3	e		
Australasian Shoveler	5	v		
Hardhead	4	v		
Blue-billed Duck	1	v	L	
Pectoral Sandpiper	2	i		
Fat-tailed Dunnart	2	i		
Striped Legless Lizard	1	e	L	VU
Corangamite Water Skink	1	c		
Warty Bell Frog	4	v		VU
Yarra Pigmy Perch	3	l	L	
Damselfly	1	v	L	

APPENDIX 11. SUB-CATCHMENT SUMMARIES

The following pages summarise the data collected for each sub-catchment during the Corangamite Wetland Inventory field surveys.

Abbreviations and terminology used in the following pages are detailed in the methods section of this report.

Corangamite Wetland Inventory - Subcatchment Summary

Summary of sites surveyed within Salt Creek — Number of sites surveyed: 23

SUMMARY OF WETLAND CHARACTER

Table 1. Number of sites surveyed in each morphology class

Inland system	
Deep basin	3
Shallow basin	20

Table 2. Water source of wetland sites surveyed #

Water Source	No. Sites
Groundwater	1
Local runoff	12
Spring	6
Stream fed	5

Figure 1. Frequency of wetland types surveyed in the sub-catchment (Ramsar classification)

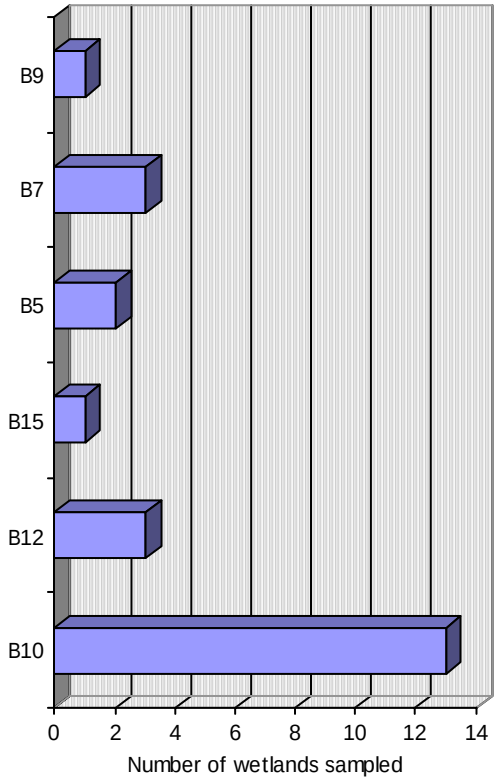


Figure 2. Salinity of wetlands surveyed in the sub-catchment

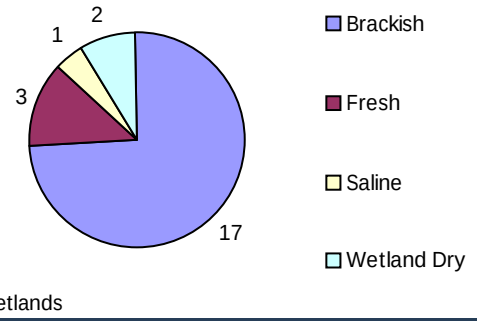


Table 3. Summary of land tenure - number of sites on private and public land within the sub-catchment #

WETLAND		SURROUNDING LAND	
Private	Public	Private	Public
20	3	23	0

Table 4. Land uses recorded on wetland sites and surrounding areas #

Wetland Landuse		Surrounding Landuse	
Conservation	4	Cropping - cereals/legumes	2
Fishery	3	Grazing - sheep	15
Grazing - sheep	8	Grazing - cattle/horses	16
Grazing - cattle/horses	12		
Recreational activity	3		
Stock water supply	1		
Unused	3		

Table 5. Average, minimum and maximum wetland depth

Average:	1.26 m
Minimum:	0.1 m
Maximum:	15.00 m

Table 6. Rare or threatened fauna observed during wetland surveys of the sub-catchment †

Common Name	Status (Vic)	No. wetlands
Whiskered Tern	l	3
Brolga	v	8
Glossy Ibis	v	1
Great Egret	e	1
Australasian Shoveler	v	4
Hardhead	v	1
Blue-billed Duck	v	1
Pectoral Sandpiper	i	1
Corangamite Water Skink	c	1
Warty Bell Frog	v	1
Damselfly	v	1

Table 7. Rare or threatened flora recorded during wetland surveys within the sub-catchment †

Scientific Name	Status (Vic)	No. wetlands
Amphibromus fluitans	k	2
Austrostipa setacea	r	1
Berula erecta	k	1
Elymus multiflorus	k	1
Helichrysum aff. rutidolepis (Lowland Swamps	v	1
Juncus revolutus	r	4
Microseris sp. 1	v	1
Persicaria attenuata	k	1
Pimelea spinescens ssp. spinescens	e	1
Poa sallacustris	v	3
Ranunculus aff. inundatus (South-west)	k	1
Ranunculus diminutus	k	7

Table 8. Summary of flora recorded during surveys of wetlands within the sub-catchment

No. native species	No. exotic species	Vic. rare or threatened
162	72	12

#Sum of frequency values may be greater than number of sites surveyed in the sub-catchment as multiple categories are possible at each site. *Denotes exotic species. †status shown in methods section of report.

Summary of sites surveyed within Salt Creek — Number of sites surveyed: 23

Table 9. Most frequently occurring flora species in each wetland zone across the sub-catchment

Zone 1:Buffer — No. Sites: 8

Frequency		Scientific Name
0.63		*Hymenanthera dentata s.l.*
0.50		*Bursaria spinosa ssp. lasiophylla*
0.38		*Elymus scaber var. scaber*
0.38		*Austrodanthonia caespitosa*
0.38		*Austrodanthonia racemosa var. racemosa*
0.38		*Acaena echinata*
0.25		*Rumex brownii*
0.25		*Themeda triandra*
0.25		*Oxalis perennans*
0.25		*Juncus flavidus*
0.25		*Geranium solanderi s.l.*
0.25		*Wahlenbergia luteola*

Zone 2:Bank — No. Sites: 14

Frequency		Scientific Name
0.36		*Agrostis avenacea*
0.36		*Oxalis perennans*
0.36	*	*Phalaris aquatica*
0.29	*	*Holcus lanatus*
0.29		*Hymenanthera dentata s.l.*
0.29	*	*Trifolium fragiferum var. fragiferum*

Zone 3:Shore — No. Sites: 17

Frequency		Scientific Name
0.53	*	*Cotula coronopifolia*
0.53		*Agrostis avenacea*
0.47		*Eleocharis acuta*
0.41	*	*Holcus lanatus*
0.41	*	*Cirsium vulgare*
0.41		*Epilobium billardierianum*
0.35	*	*Lolium rigidum*
0.29		*Ranunculus diminutus*
0.29		*Glyceria australis*
0.29	*	*Critesion marinum*
0.29		*Juncus flavidus*
0.29	*	*Leontodon taraxacoides ssp. taraxacoides*
0.29		*Lilaeopsis polyantha*
0.29	*	*Phalaris aquatica*

Zone 4:Emergent — No. Sites: 15

Frequency		Scientific Name
0.33	*	*Cirsium vulgare*
0.33	*	*Cotula coronopifolia*
0.27		*Glyceria australis*
0.27		*Juncus bufonius*
0.27	*	*Polypogon monspeliensis*
0.27		*Triglochin striatum*

Zone 5:Aquatic submerged — No. Sites: 11

Frequency		Scientific Name
0.45		*Potamogeton pectinatus*
0.27		*Agrostis avenacea*
0.27	*	*Cotula coronopifolia*
0.27		*Glyceria australis*
0.27		*Myriophyllum verrucosum*

Zone 6:Aquatic >1m — No. Sites: 1

Frequency	Scientific Name
1.00	*Potamogeton pectinatus*

SUMMARY OF WETLAND CONDITION

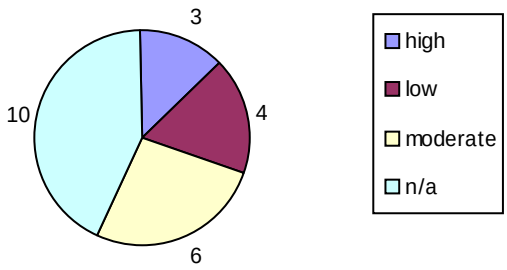
Table 10. Number of sites in each flora and fauna condition category

Fauna	Invertebrates	Fish	Birds
Low	5	11	6
Moderate	7	4	4
High	7		9
Riparian vegetation	**Buffer**	**Shore**	**Bank**
Degraded	16	7	11
Moderate	2	9	6
Intact	1	3	1
Aquatic vegetation			
Low	4		
Moderate	7		
High	8		

Table 11. Summary of subjective wetland condition values

Subjective condition assessment	No. Sites
Intact	8
Moderate	10
Degraded	3

Figure 3. Summary of total rapid assessment scores (number of sites)



SUMMARY OF THREATS

Table 12. Frequency of management issues identified in the sub-catchment #

Management Issue	No. Sites
Weeds	18
Changed soil character	13
Grazing	12
Altered water regime	10

#Sum of frequency values may be greater than number of sites surveyed in the sub-catchment as multiple categories are possible at each site. *Denotes exotic species. †status shown in methods section of report.

Summary of sites surveyed within Salt Creek

Number of sites surveyed: 23

Management Issue	No. Sites
Pest animals	4
Nutrient enrichment	3
Vegetation destruction	2
Encroachment	2
Dumping	1

#Sum of frequency values may be greater than number of sites surveyed in the sub-catchment as multiple categories are possible at each site. *Denotes exotic species. †status shown in methods section of report.

Summary of sites surveyed within Kooraweera Lakes — Number of sites surveyed: 26

SUMMARY OF WETLAND CHARACTER

Table 1. Number of sites surveyed in each morphology class

Human origin	
Shallow basin	1
Inland system	
Deep basin	1
Shallow basin	24

Table 2. Water source of wetland sites surveyed #

Water Source	No. Sites
	0
Local runoff	14
Spring	1
Stream fed	5

Figure 1. Frequency of wetland types surveyed in the sub-catchment (Ramsar classification)

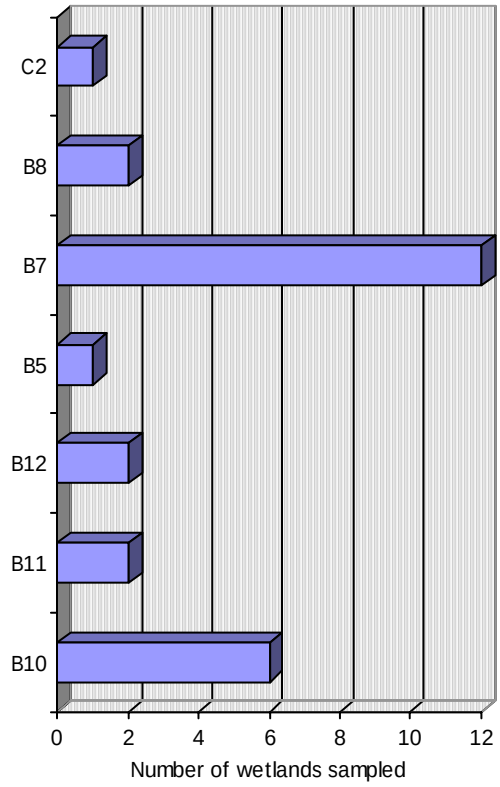


Table 3. Summary of land tenure - number of sites on private and public land within the sub-catchment #

WETLAND		SURROUNDING LAND	
Private	Public	Private	Public
22	5	25	1

Table 4. Land uses recorded on wetland sites and surrounding areas #

Wetland Landuse		Surrounding Landuse	
Conservation	13	Cropping - cereals/legumes	8
Cropping - cereals/legum	1	Grazing - sheep	17
Grazing - sheep	6	Grazing - cattle/horses	7
Grazing - cattle/horses	3		
Unused	10		

Figure 2. Salinity of wetlands surveyed in the sub-catchment

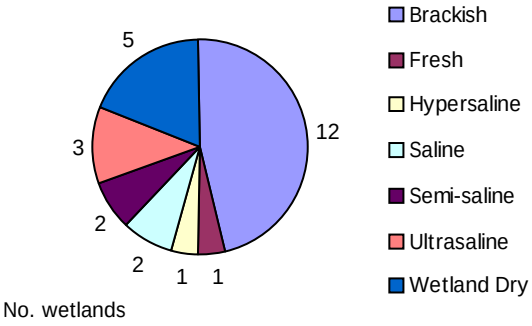


Table 5. Average, minimum and maximum wetland depth

Average:	0.42 m
Minimum:	0.05 m
Maximum:	1.50 m

Table 6. Rare or threatened fauna observed during wetland surveys of the sub-catchment †

Common Name	Status (Vic)	No. wetlands
Whiskered Tern	l	3
Caspian Tern	v	2
Brolga	v	2
Royal Spoonbill	v	1
Cape Barren Goose	v	1
Magpie Goose	e	1
Fat-tailed Dunnart	i	2
Striped Legless Lizard	e	1
Warty Bell Frog	v	1

Table 7. Rare or threatened flora recorded during wetland surveys within the sub-catchment †

Scientific Name	Status (Vic)	No. wetlands
Craspedia paludicola	v	1
Cuscuta tasmanica	k	3
Juncus revolutus	r	5
Lawrencia spicata	r	5
Lotus australis	k	1
Microseris sp. 1	v	2
Poa sallacustris	v	7
Ranunculus diminutus	k	13

Table 8. Summary of flora recorded during surveys of wetlands within the sub-catchment

No. native species	No. exotic species	Vic. rare or threatened
132	72	8

Table 9. Most frequently occurring flora species in each wetland zone across the sub-catchment

Zone 1:Buffer — **No. Sites:** 18

Frequency		Scientific Name
0.67	*	*Phalaris aquatica*
0.61		*Distichlis distichophylla*
0.39	*	*Cirsium vulgare*
0.39	*	*Lolium rigidum*
0.39	*	*Plantago coronopus*
0.39		*Poa labillardierei*

#Sum of frequency values may be greater than number of sites surveyed in the sub-catchment as multiple categories are possible at each site. *Denotes exotic species. †status shown in methods section of report.

Summary of sites surveyed within Kooraweera Lakes — Number of sites surveyed: 26

0.33		*Selliera radicans*
0.33	*	*Bromus hordeaceus ssp. hordeaceus*
0.33		*Agrostis avenacea*
0.28	*	*Trifolium fragiferum var. fragiferum*
0.28		*Samolus repens*
0.28	*	*Melilotus indicus*
0.28		*Austrodanthonia racemosa var. racemosa*
0.28	*	*Sonchus oleraceus*

Zone 2:Bank — **No. Sites:** 23

Frequency		Scientific Name
0.48	*	*Plantago coronopus*
0.43		*Lobelia irrigua*
0.43		*Agrostis avenacea*
0.39	*	*Critesion marinum*
0.39		*Schoenus nitens*
0.35	*	*Bromus hordeaceus ssp. hordeaceus*
0.35	*	*Lolium rigidum*
0.30	*	*Melilotus indicus*
0.30		*Puccinellia stricta*
0.30		*Wilsonia rotundifolia*
0.30		*Spergularia sp. 1*
0.30		*Samolus repens*

Zone 3:Shore — **No. Sites:** 23

Frequency	Scientific Name
0.35	*Lilaeopsis polyantha*
0.30	*Lobelia irrigua*
0.30	*Sarcocornia quinqueflora*
0.26	*Triglochin striatum*
0.26	*Puccinellia stricta var. perlaxa*
0.26	*Puccinellia stricta*
0.26	*Isolepis cernua*

Zone 4:Emergent — **No. Sites:** 12

Frequency	Scientific Name
0.50	*Eleocharis acuta*
0.33	*Glyceria australis*
0.33	*Lilaeopsis polyantha*
0.33	*Agrostis avenacea*
0.25	*Crassula helmsii*
0.25	*Lobelia irrigua*
0.25	*Triglochin striatum*

Zone 5:Aquatic submerged — **No. Sites:** 9

Frequency	Scientific Name
0.67	*Lepilaena preissii*
0.44	*Potamogeton pectinatus*
0.33	*Myriophyllum muelleri*

SUMMARY OF WETLAND CONDITION

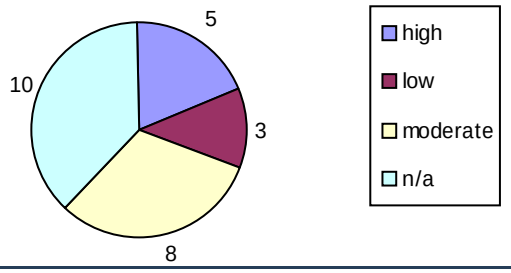
Table 10. Number of sites in each flora and fauna condition category

Fauna	Invertebrates	Fish	Birds
Low	5	15	4
Moderate	11	2	11
High	3		5
Riparian vegetation	**Buffer**	**Shore**	**Bank**
Degraded	22	2	8
Moderate		11	12
Intact		9	2
Aquatic vegetation			
Low	2		
Moderate	7		
High	13		

Table 11. Summary of subjective wetland condition values

Subjective condition assessment	No. Sites
Pristine	1
Intact	15
Moderate	5
Degraded	5

Figure 3. Summary of total rapid assessment scores (number of sites)



SUMMARY OF THREATS

Table 12. Frequency of management issues identified in the sub-catchment #

Management Issue	No. Sites
Weeds	15
Grazing	7
Altered water regime	5
Vegetation destruction	3
Changed soil character	3
Pest animals	1
Nutrient enrichment	1
Encroachment	1
Contamination	1

#Sum of frequency values may be greater than number of sites surveyed in the sub-catchment as multiple categories are possible at each site. *Denotes exotic species. †status shown in methods section of report.

Summary of sites surveyed within Dereel

Number of sites surveyed: 10

SUMMARY OF WETLAND CHARACTER

Table 1. Number of sites surveyed in each morphology class

Inland system	
Flat	3
Shallow basin	7

Table 2. Water source of wetland sites surveyed #

Water Source	No. Sites
Local runoff	6
Off-stream	1
Stream fed	3

Figure 1. Frequency of wetland types surveyed in the sub-catchment (Ramsar classification)

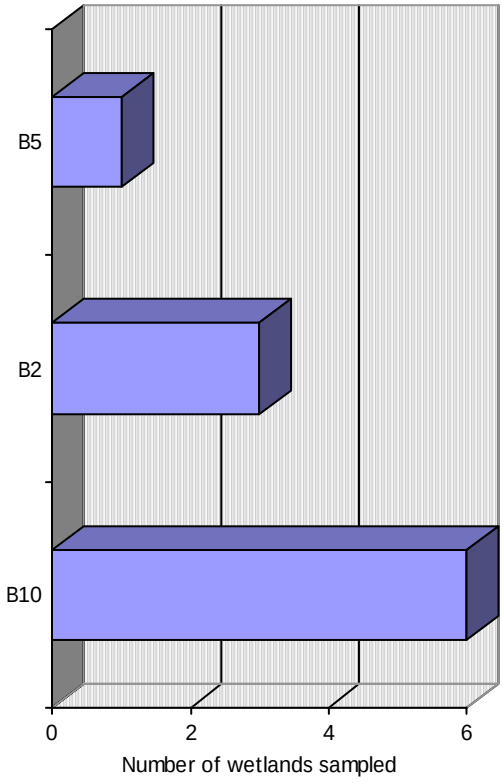


Table 3. Summary of land tenure - number of sites on private and public land within the sub-catchment #

WETLAND		SURROUNDING LAND	
Private	Public	Private	Public
9	1	10	0

Table 4. Land uses recorded on wetland sites and surrounding areas #

Wetland Landuse		Surrounding Landuse	
Conservation	2	Cropping - cereals/legumes	1
Grazing - sheep	5	Forestry	2
Grazing - cattle/horses	3	Grazing - sheep	5
Unused	2	Grazing - cattle/horses	3
		Residential	1

Figure 2. Salinity of wetlands surveyed in the sub-catchment

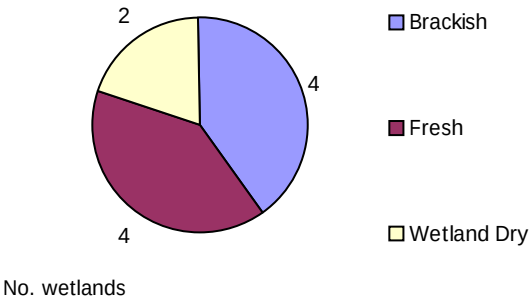


Table 5. Average, minimum and maximum wetland depth

Average:	0.29 m
Minimum:	0.1 m
Maximum:	0.50 m

Table 6. Rare or threatened fauna observed during wetland surveys of the sub-catchment †

Common Name	Status (Vic)	No. wetlands
Brown Quail	i	1
Whiskered Tern	l	1
Brolga	v	2

Table 7. Rare or threatened flora recorded during wetland surveys within the sub-catchment †

Scientific Name	Status (Vic)	No. wetlands
Amphibromus fluitans	k	5
Chorizandra australis	k	1
Helichrysum aff. rutidolepis (Lowland Swamps	v	1
Juncus revolutus	r	2
Schoenus nanus	k	1
Schoenus sculptus	r	1

Table 8. Summary of flora recorded during surveys of wetlands within the sub-catchment

No. native species	No. exotic species	Vic. rare or threatened
145	32	6

Table 9. Most frequently occurring flora species in each wetland zone across the sub-catchment

Zone 1:Buffer **No. Sites:** 8

Frequency		Scientific Name
0.38		*Acaena novae-zelandiae*
0.25		*Haloragis aspera*
0.25		*Themeda triandra*
0.25		*Austrostipa bigeniculata*
0.25		*Microlaena stipoides var. stipoides*
0.25		*Eucalyptus viminalis*
0.25		*Eragrostis brownii*
0.25		*Austrodanthonia setacea*
0.25		*Austrodanthonia geniculata*
0.25		*Austrodanthonia duttoniana*
0.25	*	*Anthoxanthum odoratum*
0.25		*Elymus scaber var. scaber*
0.25		*Schoenus apogon*

#Sum of frequency values may be greater than number of sites surveyed in the sub-catchment as multiple categories are possible at each site. *Denotes exotic species. †status shown in methods section of report.

Summary of sites surveyed within Dereel — Number of sites surveyed: 10

Zone 2:Bank — No. Sites: 10

Frequency		Scientific Name
0.50		*Austrodanthonia duttoniana*
0.50	*	*Holcus lanatus*
0.40	*	*Cirsium vulgare*
0.30	*	*Leontodon taraxacoides ssp. taraxacoides*
0.30		*Veronica gracilis*
0.30		*Senecio glomeratus*
0.30	*	*Lolium rigidum*
0.30		*Poa labillardierei*

Zone 3:Shore — No. Sites: 10

Frequency		Scientific Name
0.50	*	*Leontodon taraxacoides ssp. taraxacoides*
0.40	*	*Cotula coronopifolia*
0.40		*Eleocharis acuta*
0.40	*	*Holcus lanatus*
0.40		*Juncus flavidus*
0.40		*Amphibromus nervosus*
0.30		*Stellaria angustifolia*
0.30		*Agrostis avenacea*
0.30	*	*Cirsium vulgare*
0.30		*Eryngium vesiculosum*
0.30		*Isolepis cernua*
0.30		*Juncus kraussii ssp. australiensis*
0.30		*Lobelia pratioides*
0.30	*	*Lolium rigidum*
0.30	*	*Trifolium repens var. repens*
0.30	*	*Vulpia bromoides*
0.30	*	*Plantago coronopus*

Zone 4:Emergent — No. Sites: 9

Frequency		Scientific Name
0.78		*Eleocharis acuta*
0.67		*Amphibromus nervosus*
0.67		*Eryngium vesiculosum*
0.67		*Glyceria australis*
0.56		*Myriophyllum simulans*
0.56		*Triglochin procerum s.l.*
0.56		*Amphibromus fluitans*
0.44		*Stellaria angustifolia*
0.44	*	*Cotula coronopifolia*
0.33		*Lobelia pratioides*

Zone 5:Aquatic submerged — No. Sites: 4

Frequency	Scientific Name
0.25	*Bolboschoenus caldwellii*
0.25	*Potamogeton ochreatus*
0.25	*Potamogeton spp.*
0.25	*Myriophyllum simulans*
0.25	*Potamogeton tepperi*
0.25	*Villarsia reniformis*
0.25	*Utricularia dichotoma s.l.*
0.25	*Triglochin procerum s.l.*
0.25	*Ottelia ovalifolia ssp. ovalifolia*
0.25	*Lilaeopsis polyantha*
0.25	*Lepidosperma longitudinale*
0.25	*Isolepis fluitans*
0.25	*Hypericum gramineum*
0.25	*Chorizandra australis*
0.25	*Baumea arthrophylla*
0.25	*Eleocharis sphacelata*

Zone 6:Aquatic >1m — No. Sites: 1

Frequency	Scientific Name
1.00	*Nitella spp.*
1.00	*Ruppia megacarpa*
1.00	*Ruppia polycarpa*

SUMMARY OF WETLAND CONDITION

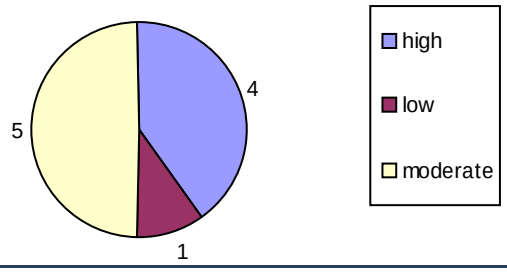
Table 10. Number of sites in each flora and fauna condition category

Fauna	Invertebrates	Fish	Birds
Low	3	9	3
Moderate	4	1	2
High	3		5
Riparian vegetation	**Buffer**	**Shore**	**Bank**
Degraded	7		3
Moderate	2	8	5
Intact	1	2	2
Aquatic vegetation			
Low	1		
Moderate	3		
High	6		

Table 11. Summary of subjective wetland condition values

Subjective condition assessment	No. Sites
Intact	6
Moderate	3
Degraded	1

Figure 3. Summary of total rapid assessment scores (number of sites)



#Sum of frequency values may be greater than number of sites surveyed in the sub-catchment as multiple categories are possible at each site. *Denotes exotic species. †status shown in methods section of report.

Summary of sites surveyed within Dereel

Number of sites surveyed: 10

SUMMARY OF THREATS

Table 12. Frequency of management issues identified in the sub-catchment #

Management Issue	No. Sites
Weeds	8
Grazing	7
Nutrient enrichment	6
Changed soil character	6
Pest animals	5
Altered water regime	4
Tracks	1
Plantation	1
Increased salinity	1
Erosion	1

#Sum of frequency values may be greater than number of sites surveyed in the sub-catchment as multiple categories are possible at each site. *Denotes exotic species. †status shown in methods section of report.

Summary of sites surveyed within Warrambine Creek — Number of sites surveyed: 9

SUMMARY OF WETLAND CHARACTER

Table 1. Number of sites surveyed in each morphology class

Human origin	
Deep basin	2
Shallow basin	1
Inland system	
Deep basin	1
Flat	2
Shallow basin	3

Table 2. Water source of wetland sites surveyed #

Water Source	No. Sites
Local runoff	4
Stream fed	6

Figure 1. Frequency of wetland types surveyed in the sub-catchment (Ramsar classification)

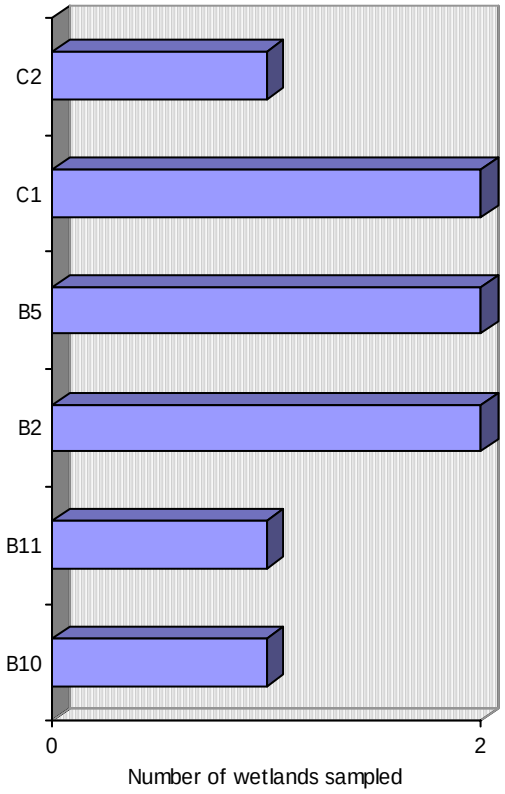


Table 3. Summary of land tenure - number of sites on private and public land within the sub-catchment #

WETLAND		SURROUNDING LAND	
Private	Public	Private	Public
9	1	9	1

Table 4. Land uses recorded on wetland sites and surrounding areas #

Wetland Landuse		Surrounding Landuse	
Conservation	1	Cropping - cereals/legumes	2
Grazing - sheep	4	Forestry	1
Grazing - cattle/horses	2	Grazing - sheep	7
Irrigation	2	Grazing - cattle/horses	2
Recreational activity	2	Road reserve	1
Road reserve	1		
Unused	3		

Figure 2. Salinity of wetlands surveyed in the sub-catchment

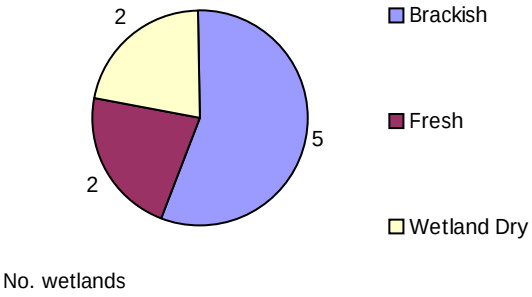


Table 5. Average, minimum and maximum wetland depth

Average:	0.89 m
Minimum:	0.1 m
Maximum:	2.00 m

Table 6. Rare or threatened fauna observed during wetland surveys of the sub-catchment †

Common Name	Status (Vic)	No. wetlands
Australasian Shoveler	v	1
Hardhead	v	1
Warty Bell Frog	v	2

Table 7. Rare or threatened flora recorded during wetland surveys within the sub-catchment †

Scientific Name	Status (Vic)	No. wetlands
Amphibromus sinuatus	v	2
Cullen parvum	e	2
Juncus revolutus	r	1

Table 8. Summary of flora recorded during surveys of wetlands within the sub-catchment

No. native species	No. exotic species	Vic. rare or threatened
92	39	3

Table 9. Most frequently occurring flora species in each wetland zone across the sub-catchment

Zone 1:Buffer — **No. Sites:** 6

Frequency		Scientific Name
0.83		*Poa labillardierei*
0.33	*	*Phalaris aquatica*
0.33		*Cullen parvum*
0.33		*Hymenanthera dentata s.l.*

Zone 2:Bank — **No. Sites:** 8

Frequency		Scientific Name
0.63		*Agrostis avenacea*
0.50		*Persicaria prostrata*
0.50		*Juncus flavidus*
0.50		*Lythrum hyssopifolia*
0.38		*Haloragis aspera*
0.25	*	*Helminthotheca echioides*
0.25		*Juncus gregiflorus*
0.25		*Juncus usitatus*
0.25		*Lobelia pratioides*

#Sum of frequency values may be greater than number of sites surveyed in the sub-catchment as multiple categories are possible at each site. *Denotes exotic species. †status shown in methods section of report.

Summary of sites surveyed within Warrambine Creek — Number of sites surveyed: 9

0.25	*	*Phalaris aquatica*
0.25		*Pseudognaphalium luteoalbum*
0.25	*	*Paspalum distichum*
0.25	*	*Holcus lanatus*
0.25	*	*Rumex crispus*
0.25		*Eucalyptus camaldulensis*
0.25		*Epilobium hirtigerum*
0.25		*Austrodanthonia duttoniana*
0.25	*	*Cirsium vulgare*
0.25		*Centipeda cunninghamii*
0.25		*Carex tereticaulis*
0.25		*Alternanthera denticulata s.l.*
0.25		*Hydrocotyle sibthorpioides*

Zone 3:Shore — **No. Sites:** 8

Frequency		Scientific Name
0.50		*Eleocharis acuta*
0.38	*	*Paspalum distichum*
0.38		*Rumex bidens*
0.38		*Agrostis avenacea*
0.25	*	*Aster subulatus*
0.25		*Eleocharis pusilla*
0.25		*Glyceria australis*
0.25		*Juncus subsecundus*
0.25	*	*Lolium rigidum*
0.25		*Triglochin striatum*
0.25		*Amphibromus nervosus*

Zone 4:Emergent — **No. Sites:** 7

Frequency		Scientific Name
0.57		*Eleocharis acuta*
0.43	*	*Paspalum distichum*
0.43	*	*Cotula coronopifolia*
0.29		*Agrostis avenacea*
0.29		*Rumex bidens*
0.29		*Amphibromus nervosus*
0.29		*Juncus holoschoenus*

Zone 5:Aquatic submerged — **No. Sites:** 5

Frequency	Scientific Name
0.60	*Triglochin procerum s.l.*
0.40	*Eleocharis sphacelata*
0.40	*Potamogeton pectinatus*

Zone 6:Aquatic >1m — **No. Sites:** 4

Frequency	Scientific Name
0.50	*Azolla filiculoides*
0.50	*Myriophyllum salsugineum*
0.50	*Potamogeton ochreatus*
0.50	*Potamogeton pectinatus*
0.25	*Ottelia ovalifolia ssp. ovalifolia*
0.25	*Triglochin procerum s.l.*

Zone 7:Open water — **No. Sites:** 1

Frequency	Scientific Name
1.00	*Azolla filiculoides*

SUMMARY OF WETLAND CONDITION

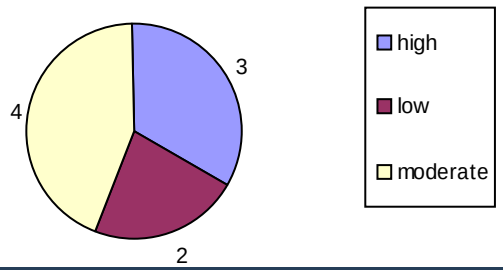
Table 10. Number of sites in each flora and fauna condition category

Fauna	Invertebrates	Fish	Birds
Low	3	7	2
Moderate	3	2	3
High	3		4
Riparian vegetation	**Buffer**	**Shore**	**Bank**
Degraded	9	3	3
Moderate		2	6
Intact		4	
Aquatic vegetation			
Low	3		
Moderate	2		
High	4		

Table 11. Summary of subjective wetland condition values

Subjective condition assessment	No. Sites
Intact	4
Moderate	2
Degraded	1
Severely Degraded	2

Figure 3. Summary of total rapid assessment scores (number of sites)



SUMMARY OF THREATS

Table 12. Frequency of management issues identified in the sub-catchment #

Management Issue	No. Sites
Weeds	9
Nutrient enrichment	4
Grazing	4
Pest animals	2
Increased salinity	2
Changed soil character	2
Vegetation destruction	1
Erosion	1
Encroachment	1
Altered water regime	1

#Sum of frequency values may be greater than number of sites surveyed in the sub-catchment as multiple categories are possible at each site. *Denotes exotic species. †status shown in methods section of report.

Summary of sites surveyed within Connewarre — Number of sites surveyed: 28

SUMMARY OF WETLAND CHARACTER

Table 1. Number of sites surveyed in each morphology class

Human origin	
Deep basin	1
Shallow basin	2
Inland system	
Flat	3
Shallow basin	8
Marine system	
Estuary	3
Shallow basin	1
Tidal flat	10

Table 2. Water source of wetland sites surveyed #

Water Source	No. Sites
Channel fed	6
Groundwater	1
Local runoff	24
Marine	9
Off-stream	11
Spring	1
Stream fed	2

Figure 1. Frequency of wetland types surveyed in the sub-catchment (Ramsar classification)

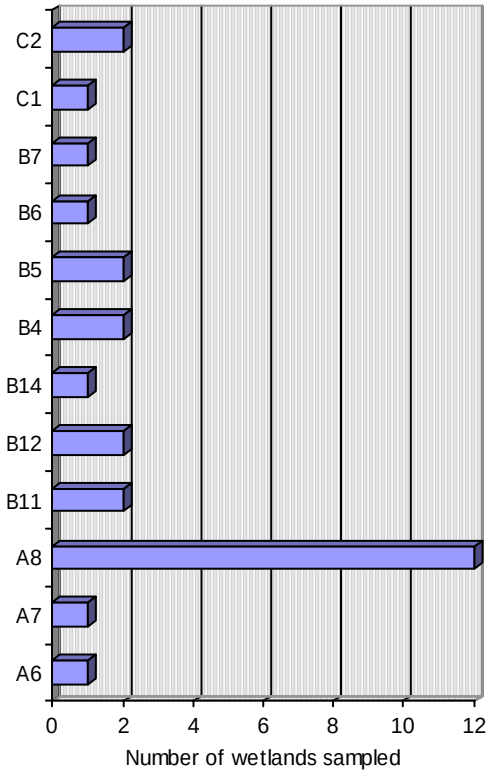


Table 3. Summary of land tenure - number of sites on private and public land within the sub-catchment #

WETLAND		SURROUNDING LAND	
Private	Public	Private	Public
13	16	27	5

Table 4. Land uses recorded on wetland sites and surrounding areas #

Wetland Landuse		Surrounding Landuse	
Conservation	20	Conservation	8
Cropping - cereals/legum	1	Cropping - cereals/legumes	1
Fishery	2	Grazing - sheep	11
Grazing - sheep	4	Grazing - cattle/horses	17
Grazing - cattle/horses	13	Recreational activity	7
Recreational activity	20	Residential	4
		Rubbish tip	1

Figure 2. Salinity of wetlands surveyed in the sub-catchment

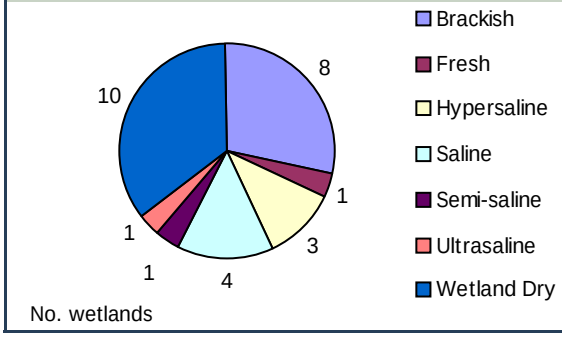


Table 5. Average, minimum and maximum wetland depth

Average:	0.38 m
Minimum:	0.05 m
Maximum:	2.00 m

Table 6. Rare or threatened fauna observed during wetland surveys of the sub-catchment †

Common Name	Status (Vic)	No. wetlands
Black-faced Cormorant	v	1
Pied Cormorant	l	1
Whiskered Tern	l	11
Caspian Tern	v	1
Little Tern	v	1
Glossy Ibis	v	6
Royal Spoonbill	v	4
Little Egret	c	3
Great Egret	e	6
Australasian Bittern	e	3
Magpie Goose	e	2
Hardhead	v	2
Pectoral Sandpiper	i	1
Yarra Pigmy Perch	l	3

Table 7. Rare or threatened flora recorded during wetland surveys within the sub-catchment †

Scientific Name	Status (Vic)	No. wetlands
Atriplex australasica	k	11
Atriplex paludosa ssp. paludosa	r	4
Avicennia marina ssp. australasica	r	4
Eucalyptus leucoxylon ssp. bellarinensis	e	1
Limonium australe	r	1
Melaleuca armillaris ssp. armillaris	r	2

Table 8. Summary of flora recorded during surveys of wetlands within the sub-catchment

No. native species	No. exotic species	Vic. rare or threatened
123	60	6

Table 9. Most frequently occurring flora species in each wetland zone across the sub-catchment

Zone 1:Buffer — **No. Sites:** 14

Frequency	Scientific Name
0.43	* *Plantago lanceolata*

#Sum of frequency values may be greater than number of sites surveyed in the sub-catchment as multiple categories are possible at each site. *Denotes exotic species. †status shown in methods section of report.

Summary of sites surveyed within Connewarre — Number of sites surveyed: 28

0.36	*	*Plantago coronopus*
0.36	*	*Lolium perenne*
0.29		*Rhagodia candolleana ssp. candolleana*

Zone 2:Bank — **No. Sites:** 16

Frequency		Scientific Name
0.44		*Gahnia filum*
0.31		*Distichlis distichophylla*
0.25		*Puccinellia stricta*
0.25		*Sarcocornia quinqueflora*
0.25	*	*Plantago lanceolata*
0.25	*	*Plantago coronopus*
0.25		*Juncus kraussii ssp. australiensis*
0.25	*	*Cirsium vulgare*
0.25		*Bolboschoenus caldwellii*
0.25	*	*Lolium perenne*

Zone 3:Shore — **No. Sites:** 27

Frequency		Scientific Name
0.48		*Distichlis distichophylla*
0.44		*Sarcocornia quinqueflora*
0.37		*Suaeda australis*
0.37		*Samolus repens*
0.30	*	*Cotula coronopifolia*
0.30		*Agrostis spp.*
0.30		*Selliera radicans*
0.30		*Senecio pinnatifolius*
0.30		*Gahnia filum*
0.30	*	*Parapholis incurva*
0.26		*Disphyma crassifolium ssp. clavellatum*
0.26		*Bolboschoenus caldwellii*
0.26		*Juncus kraussii ssp. australiensis*
0.26		*Muehlenbeckia florulenta*
0.26		*Mimulus repens*
0.26		*Sclerostegia arbuscula*
0.26		*Atriplex australasica*
0.26		*Eleocharis acuta*

Zone 4:Emergent — **No. Sites:** 18

Frequency	Scientific Name
0.33	*Sarcocornia quinqueflora*
0.33	*Phragmites australis*
0.28	*Samolus repens*

Zone 5:Aquatic submerged — **No. Sites:** 13

Frequency	Scientific Name
0.46	*Azolla filiculoides*
0.31	*Eleocharis acuta*

Zone 6:Aquatic >1m — **No. Sites:** 1

Frequency		Scientific Name
1.00		*Bolboschoenus caldwellii*
1.00	*	*Cotula coronopifolia*
1.00		*Mimulus repens*
1.00		*Samolus repens*
1.00		*Selliera radicans*
1.00		*Triglochin striatum*
1.00		*Atriplex australasica*

Zone 7:Open water — **No. Sites:** 1

Frequency	Scientific Name
1.00	*Ruppia spp.*

SUMMARY OF WETLAND CONDITION

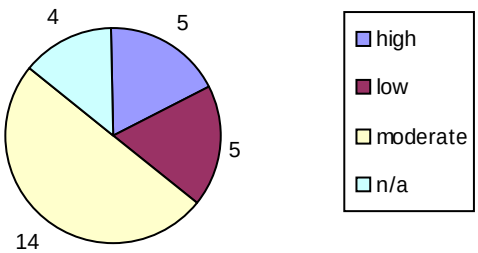
Table 10. Number of sites in each flora and fauna condition category

Fauna	Invertebrates	Fish	Birds
Low	16	18	4
Moderate	5	4	14
High	4	3	7
Riparian vegetation	**Buffer**	**Shore**	**Bank**
Degraded	16	8	9
Moderate	9	14	12
Intact		6	5
Aquatic vegetation			
Low	7		
Moderate	13		
High	7		

Table 11. Summary of subjective wetland condition values

Subjective condition assessment	No. Sites
Pristine	1
Intact	8
Moderate	8
Degraded	8
Severely Degraded	3

Figure 3. Summary of total rapid assessment scores (number of sites)



SUMMARY OF THREATS

Table 12. Frequency of management issues identified in the sub-catchment #

Management Issue	No. Sites
Weeds	25
Pest animals	25
Altered water regime	19
Nutrient enrichment	14

#Sum of frequency values may be greater than number of sites surveyed in the sub-catchment as multiple categories are possible at each site. *Denotes exotic species. †status shown in methods section of report.

Summary of sites surveyed within Connewarre

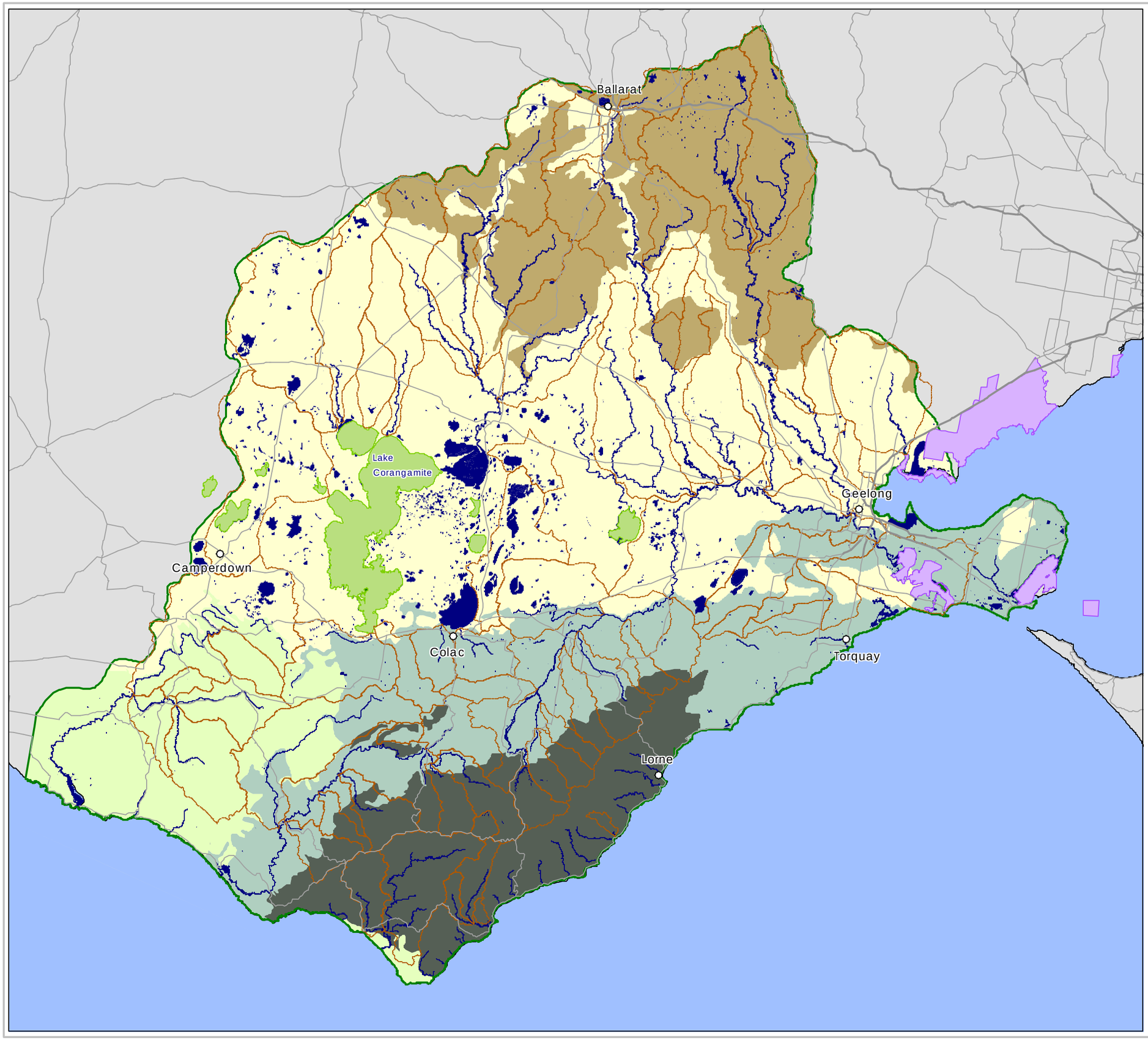
Number of sites surveyed: 28

Management Issue	No. Sites
Grazing	14
Encroachment	14
Dumping	10
Contamination	10
Changed soil character	10
Tracks	8
Vegetation destruction	1
Mining	1
Increased salinity	1
Erosion	1

#Sum of frequency values may be greater than number of sites surveyed in the sub-catchment as multiple categories are possible at each site. *Denotes exotic species. †status shown in methods section of report.

MAP 1

Study Area - Corangamite Catchment Management Authority Boundary.



LEGEND

NORTH

- CCMA Boundary
- Sub-catchment boudaries
- Rivers
- Major roads and highways

Bioregions

- Central Victorian Uplands
- Otway Plain
- Otway Ranges
- Victorian Volcanic Plain
- Warrnambool Plain

Wetlands

- Wetlands Database (DCNR 1995)

Ramsar Wetlands

- Western District Lakes
- Port Phillip Bay (Western Shoreline)

0 20 40

kilometres

University of Ballarat Australia

Centre for Environmental Management

MAP 2

Salt Creek Catchment - Wetland mapping
Corangamite Wetland Inventory

SC007
SC008
SC018
SC002
SC017
SC001
SC003
SC020
SC022
SC021
SC025
SC010
SC026
SC024
SC011
SC004
SC023
Derrinallum
SC016
Skipton
SC015
SC014
SC028
SC027
SC012

LEGEND

- Sub-catchment boudaries
- Creeks
- Major roads and highways

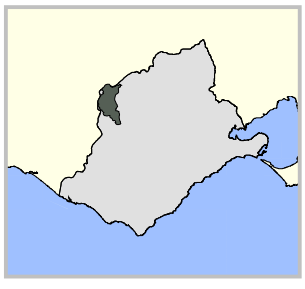
Wetland Type

- Impoundment or farm dam
- Deep marsh
- Floodplain wetland
- Freshwater open water
- Shallow freshwater marsh
- Shallow freshwater meadow
- Wetland inventory site

AAOOO — Inventory identification number (wetland included in survey)

NORTH

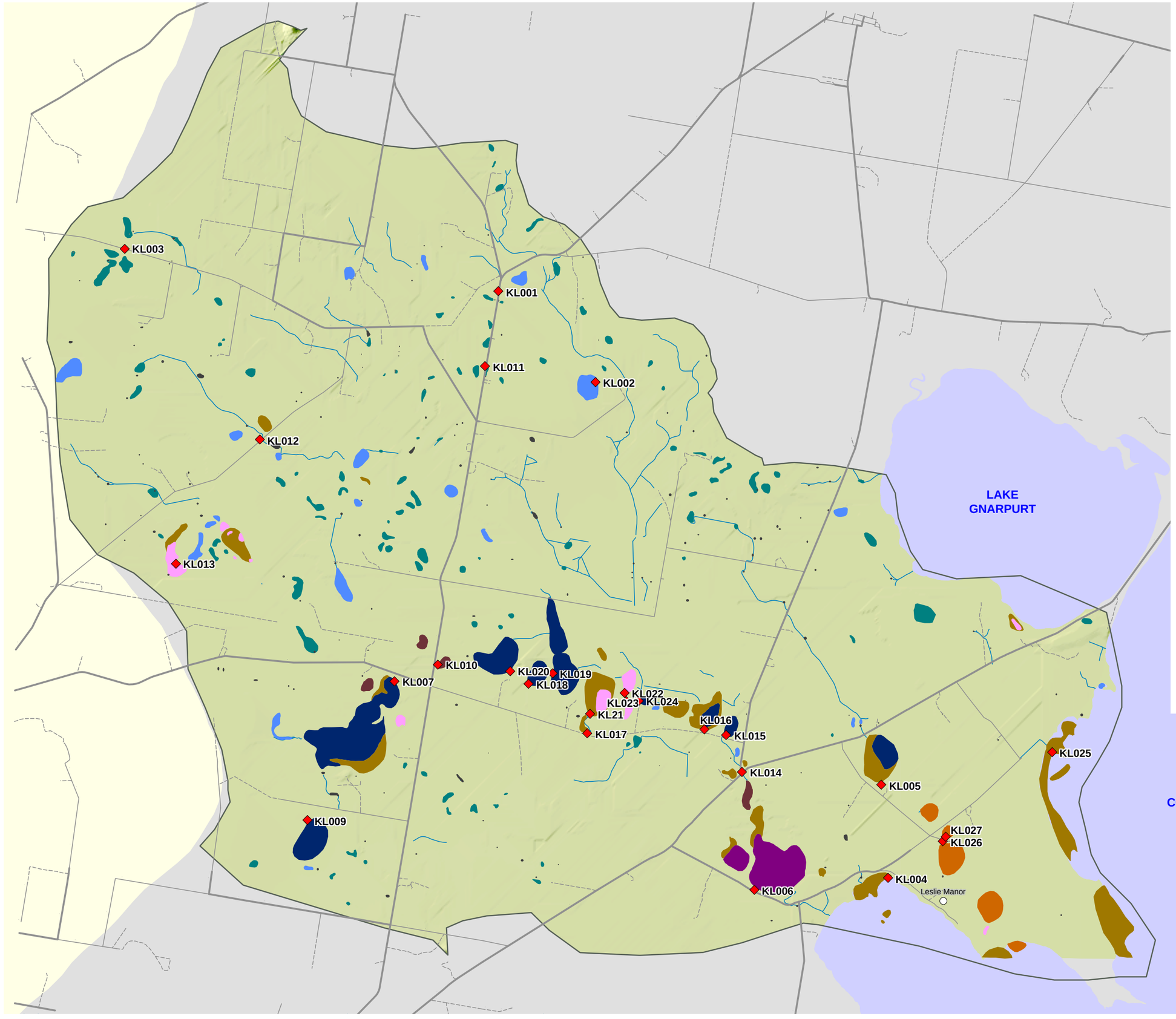
0 2.5 5
kilometres



Centre for Environmental Management

MAP 3

Kooraweera Lakes Catchment - Wetland mapping Corangamite Wetland Inventory



LEGEND

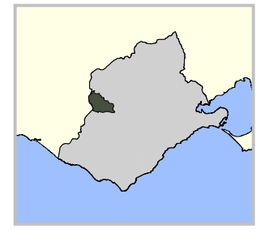
- Sub-catchment boudaries
- Creeks
- Roads

Wetland Type

- Impoundment or farm dam
- Freshwater open water
- Shallow freshwater marsh
- Shallow freshwater meadow
- Salt meadow
- Shallow saline marsh
- Salt marsh
- Saline open water
- Hypersaline open water
- Wetland inventory sites
- AAOOO — Inventory identification number (wetland included in survey)

NORTH

0 2.5 5
kilometres



MAP 4

Dereel Catchment - Wetland mapping
Corangamite Wetland Inventory

Cape Clear
Dereel
Rokewood
DE001
DE002
DE003
DE004
DE005
DE006
DE007
DE008
DE009
DE010

LEGEND

- Sub-catchment boudaries
- Creeks
- Major roads and highways

Wetland Type

- Impoundment or farm dam
- Deep marsh
- Floodplain
- Shallow freshwater marsh
- Shallow freshwater meadow
- Wetland inventory site
- AAOOO — Inventory identification number (wetland included in survey)

NORTH

0 2.5 5
kilometres

MAP 5

Warrambine Creek Catchment - Wetland mapping Corangamite Wetland Inventory

WA003
WA001
WA012
WA011
WA002
WA010
WA007
WA008
WA009

SHELFORD
TEASDALE
INVERLEIGH

LEGEND

- Sub-catchment boudaries
- Creeks
- Major roads and highways

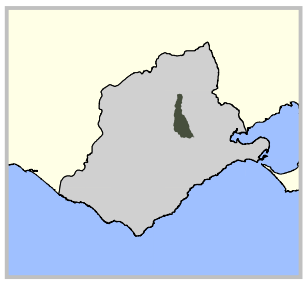
Wetland Type

- Impoundment or farm dam
- Shallow brackish
- Permanent shallow brackish
- Floodplain
- Shallow freshwater marsh
- Shallow freshwater meadow
- Wetland inventory site
- AAOOO Inventory identification number (wetland included in survey)

NORTH

0 2.5 5

kilometres



MAP 6

Connewarre Catchment - Wetland mapping
Corangamite Wetland Inventory

Belmont
Leopold
Lake Connewarre
Barwon River
Ocean Grove
Barwon Heads

CO007
CO006
CO018
CO006
CO006
CO021
CO019
CO020
CO017
CO017
CO016
CO015
CO001
CO024
CO023
CO014
CO002
CO012
CO013
CO009
CO008
CO004
CO005
CO011
CO022
CO010
CO025
CO003

LEGEND

- Sub-catchment boudaries
- Creeks
- Roads

Wetland Type

- Impoundment or farm dam
- Saline open water
- Shallow freshwater marsh
- Shallow freshwater meadow
- Salt meadow
- Shallow saline marsh
- Salt marsh
- Tidal mudflat
- Salt flat
- Floodplain
- Deep marsh
- Mangroves

Wetland inventory site

AAOOO Inventory identification number (wetland included in survey)

0 2.5 5
kilometres

NORTH