WETLAND RECOVERY PRIORITISATION

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Summary

This short report outlines a scoping study undertaken to develop a prioritisation framework that could be used to rank the wetlands of the River Murray floodplain in South Australia, for their value in conserving regional freshwater biodiversity, and to assign them an order of priority for restoration activities.

1. Introduction

A framework for prioritising River Murray floodplain wetlands for the conservation of regional biodiversity and restoration is required, to complement existing community driven priorities. Currently the main driver for wetland restoration works in the Murray River Valley is community involvement, and whilst this is likely to continue there is a need for a more detailed understanding of the basic ecological character of wetlands, on which to base management decisions. Considering the key drivers of wetland ecosystems — hydrology, geomorphology and the resultant ecological values they support (in addition to community priorities) — will better allow restoration goals to be established for these wetlands.

SKM (2004a) identified the River Murray and the Lower Lakes, Murray Mouth, Coorong and the coastal zone as the most highly valued ecological assets for South Australia. Habitat for flora and fauna was identified as the highest valued service provided by these assets, and the greatest threat was the lack of knowledge, including lack of knowledge transfer and acquisition as well as inadequate decision making processes.

Without a standard approach to prioritising the selection of wetlands for management, it becomes difficult to effectively apply policy initiatives aimed at improving wetland condition at the local scale. Added to this, conservation and or restoration efforts are usually hampered by a lack of funds, meaning that all sites cannot be treated equally; thus the need to prioritise sites in order to maximise the ecological function conserved or restored (Leibowitz, 2002).

Prioritisation frameworks are decision processes that, in this case, would allow consistent, and scientifically sound, judgements to be made when allocating limited resources towards wetland conservation and restoration. Simple rules and criteria are needed to guide the decision process.

The current study is concerned with making decisions on where to direct efforts for wetland conservation and restoration along the River Murray valley: in short, which wetlands in which region should be targeted? It will also ensure that:

- the decision on which wetland to manage is made primarily on an ecological basis,
- restoration efforts are undertaken on a representative coverage of wetland types found within the study area, and
- restoration promotes diversity at the landscape scale.

The objectives for this project were developed after considering the goals of the Wetland Strategy for South Australia and its guiding principles. The objectives were then further refined and focused through discussions with the South Australian Department of Water, Land and Biodiversity Conservation (DWLBC) and other stakeholders (e.g. members of the River Murray Catchment Water Management Board).

The objective for this project is to develop a prioritisation framework that will:

1. Aid in the identification of wetlands that are considered to be of conservation value based on sound ecological considerations. This is to be done at a regional scale.
2. Identify wetlands that are amenable to restoration activities based on an ecological basis.

It should be noted that this project is based on a review of existing, published information and that no data were analysed or new data collected. This project is the first step towards achieving these goals; however, it is acknowledged that additional work beyond the scope of the present project will be required to refine the approach suggested here.

Terminology

There are a number of different terminologies used in wetland restoration projects: enhancement, restoration, rehabilitation, and re-creation. Often many of these are used interchangeably or are afforded different definitions by different authors. In the context of this report the term restoration is used to describe actions which will restore as much of the natural ecological values as possible.

Wetland condition is taken as the state or ecological condition of a wetland. This general term is used rather than health or integrity as these terms imply comparison with more pristine wetlands. Ecological character can be used as a measure of wetland condition, and is defined in the Ramsar convention (see http://www.deh.gov.au/water/wetlands/ramsar/index.html) as:

> *the sum of the biological, physical, and chemical components of the wetland ecosystem, and their interactions, which maintain the wetland and its products, functions, and attributes. Change in ecological character is the impairment or imbalance in any biological, physical or chemical components of the wetland ecosystem, or in their interactions, which maintain the wetland and its products, functions and attributes.*

2. River Murray wetlands — an overview

Wetlands are a unique part of the River Murray landscape, supporting distinctive communities of plants and animals. They range widely in character including such diverse areas as floodplain billabongs, River Red Gum Forest, large open lakes, shallow seasonal swamps, and saline lakes. There are 1100 wetlands along the Murray Valley (Thomson, 1986), which constitute a significant proportion of the remaining wetlands in South Australia. It has been estimated that approximately 70% of the State's wetlands have been lost (DEH & DWLBC, 2003).

River regulation has resulted in significant changes in the hydrological regime of floodplain wetlands. A general increase in permanency and a loss of temporary wetlands has occurred, with wetlands which lie below pool levels becoming permanently inundated (Walker, 1992) and with reduced river flows (approximately 42% less; Walker, 1992) leading to reduced flooding of temporary systems. This has had a significant impact on the productivity and ecological character of the wetlands of the region.

For the purpose of this study the River Murray floodplain refers to the areas inundated by the 1956 flood, as shown in Jensen *et al*. (1996) between the Victorian border and the barrages.

2.1 Wetland classification

There is no single definition of a wetland. However, in general there is agreement that they are typically identified by the presence of water at or near the land surface long enough to support mainly aquatic life by the presence of hydric soils and plants adapted to living in such conditions (Wolfson *et al.* 2002).

Most States in Australia recognise the Ramsar convention definition of wetlands listed under Article 1.1:

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

Wetlands in South Australia have been subject to a number of classifications. The Wetland Strategy of South Australia (DEH & DWLBC, 2003) adopts the classification system used in the Directory of Important Wetlands of Australia (DIWA; Environment Australia, 2001) which groups 40 types into three categories, of which only the inland wetlands are of relevance here (see Table 1). Thomson (1986) classified the wetlands of the River Murray based on connectivity to the river and eight subclasses based on hydrological regime, vegetation and slope of banks. The Wetland Atlas of the South Australian Murray Valley (Jensen *et al*., 1996) did not include a classification scheme, only a basic hydrological regime. The Wetlands Management Study (Wetland Care Australia, 1998), undertaken for the riverine Local Action Planning Associations, used Pressey's (1986) geomorphic and hydrological classification system.

Regional aquatic biodiversity is supported by all types of aquatic habitats with each type potentially contributing species and communities to the regional pool (e.g. Williams *et al*., 2003; Butcher, 2003). Work in this field has shown that the smaller temporary aquatic systems can often be overlooked when considering biodiversity or ecological values, when in fact they are significant contributors to regional biodiversity. There is often the assumption that permanent water supports higher biodiversity and this may not be the case (Butcher, 2003). Thomson (1986) recognised the high productivity which occurs in temporary wetlands and suggested that these systems were often undervalued. Having a method of prioritisation which considers all wetland types equally is therefore essential in order to maintain regional biodiversity values of aquatic ecosystems in the Murray Valley. Applying the national classification system to the wetlands of the Murray valley in order to promote a more consistent classification is highly recommended.

It should be noted that, for the purposes of developing the framework, only natural wetlands are considered in this project. Artificial wetlands such as water storage areas, salt evaporation sites, wastewater treatment areas and bore drains are not considered.

Table 1: Inland wetland types as described in the Directory of Important Wetlands in Australia (Environment Australia, 2001). (Note: Marine and Coastal zone wetlands and human-made wetlands are not shown here.)

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; includes sloughs, potholes; seasonally flooded meadows, sedge marshes
11. Permanent saline/brackish marshes
12. Seasonal saline marshes
13. Shrub swamps; shrub-dominated freshwater marsh, shrub carr, alder thicket on inorganic 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 waters from snow melt
17. Freshwater springs, oases and rock pools
18. Geothermal wetlands
19. Inland, subterranean karst wetlands

2.2 Wetland inventory and assessment — existing data

Lloyd and Balla (1986) provided a state-wide review of wetlands, identifying approximately 1500 wetlands and complexes. Other significant inventories undertaken at this time included Pressey (1986) and Thomson (1986). As in other states, each inventory collected different data for each project with limited overlap. Jensen *et al*. (1996) is particularly useful as it combines the findings of Thomson (1986) and Lloyd and Balla (1986) for the atlas of the South Australian Murray valley wetlands, which also initiates attempts to spatially capture data through use of a geographic information system (GIS) (Seaman, 2002d). Since then several GIS databases have been created within the SA Dept for Environment and Heritage (DEH) to capture regional wetland inventory data.

Table 2 shows the type of information that exists for the Murray River valley wetlands. This is not a comprehensive list, but does include the major studies, which are briefly discussed below.

Pressey 1986
Pressey classified floodplain wetlands into 17 geomorphic categories, 12 of which are natural and 5 resulting from the development of the river valley. A separate geomorphic classification was used for the lower lakes and Coorong. In addition to the geomorphic classification Pressey placed the floodplain wetlands into four hydrological categories depending on their relationship to the regulated flows, effluent and drainage waters. The hydrological categories were used to discuss management options and constraints (Pressey, 1986).

Thomson 1986
Thomson assessed 250 wetlands and wetland complexes along the Murray valley and provided one of the first assessments of conservation value for the wetlands. He grouped wetlands into one of five conservation categories based on ten attributes of the ecology and other features observed in the field. Sites within each category were not ranked.

Thomson (1986) listed 84 in the high conservation value category (excluded already protected sites), eight sites worthy of rehabilitation and 20 requiring additional ecological investigation.

Jensen *et al*., 1996: Wetland Atlas of the South Australian Murray Valley
This report is considered to be a key document as it incorporates several studies, combining the information into an atlas, with the core data being entered onto a GIS system held by DEH. It should form the basis for the development of the prioritisation framework.

Wetland Care Australia 1998: Riverine Local Action Planning Associations — Wetland Management Study
This report collected information that was used to score wetlands according to the following eight criteria:

- the existing degree of disturbance,
- urgency of action,
- representativeness of the wetland,
- ease of management,
- public value,
- value for money,
- whether it enhances other land and water programs,
- the diversity of the wetland.

The criteria were adapted from 'similar work in NSW' (but not referenced) suggesting they allow integration of environmental and cultural issues to determine:

- the health of a wetland,
- if the wetland's health is in danger of declining,
- if actions to improve its health will affect wetland users, and
- whether it is feasible for a community group to become involved in a wetland and undertake wetland rehabilitation.

There is limited information on the scoring system and some apparent assumptions that are not fully explained; for example, wholly permanent wetlands receive a score of 0 under the representative wetland criteria, without any explanation as to why. There are few ecological values considered in this scoring system, and overall this ranking is aimed at addressing community concerns first.

River Murray Baseline Survey — 2003–2005
The first part of the baseline survey included 39 wetlands and was completed in December 2004. The second round of the program is currently surveying an additional 22 wetlands. The baseline survey is to form the basis of ongoing community monitoring and, as such, sites were selected based on potential for community involvement. Methods employed in the first round of survey work are detailed in SKM (2004c) and should be referred to along with Tucker (2004).

Ecological Associates (2003) classified wetlands into six types based on four broad hydrological and hydrogeological parameters. This classification system was adopted in the River Murray Baseline Survey.

Part of the original objectives of this program was to (SKM, 2004b):
- Apply the wetland assessment framework (Ecological Associates, 2003), to the wetlands included in the survey to assist in prioritising wetland management according to the ecological values of wetlands.

The wetland assessment framework aimed to combine the use of conceptual models for the 'functions of ideal wetlands' and reference sites to place wetlands along a condition gradient. Wetland condition was taken to equate to ecological integrity which was defined as:

> *the capacity of wetlands to sustain populations of species which potentially depend on them and to contribute to the diversity of habitats and species in the landscape*.

Condition measures were chosen to assess habitat and ecological responses. The results from the initial trial of this wetland assessment framework were inconclusive as the data requirements of the framework were greater than the information collected in the baseline survey. The trial of the framework had to rely on anecdotal and synthesised data to fill the knowledge gaps. The resultant ranking of sites appeared to be reasonable, but was not considered definitive nor defendable. Further work on this aspect of the project is continuing (P. Waanders, SA MDB NRM Board, pers. comm.).

South Australia DEH regional wetland inventory programs
Whilst not covering the River Murray floodplains directly, the regional wetland inventory program (e.g. Seaman, 2002 a–d; 2003) undertaken by SA DEH is the other major wetland inventory program in South Australia. This program adopts the national classification of wetland types and the Ramsar definition of wetlands. Broad wetland condition ratings have been used, often based on inventory and rapid assessment data (includes vegetation, fauna, riparian vegetation values, land degradation and water quality), which provide a rating along a condition gradient. For example the Mt Lofty wetland inventory assigned the following ratings to wetlands (from Seaman, 2002d):

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

State GIS databases

SA DEH has some of the information produced by Jensen *et al*. (1996) on GIS, but not all text was included and only some of the core fields presented in the Atlas were transferred to a stand-alone Microsoft Access database (Felicity Smith, SA DEH, pers. comm.).

Table 2: Examples of data available on wetlands from the River Murray valley.

	Pressey (1986)	**Thomson (1986)**	**Jensen *et al*. (1996)**	**Wetland Care Australia (1998)**	**River Murray Baseline Survey 2003–2005.**
Number of wetlands covered	1100	250 single and wetland complexes	250 single and wetland complexes (includes 26 wetlands not surveyed by Thomson)	156 complexes	39 plus 22 current
Classification system used	Geomorphology and hydrology	Water regime and 8 subclasses based on vegetation, permanency, and bank slope	Water regime — based on Pressey (1986)	Geomorphic and hydrological — based on Pressey (1986)	Hydrological and hydrogeological parameters – including permanency
Conservation value assigned and or ranking of sites for management interventions	Management options based on hydrology	Yes — assigned to one of five conservation categories — not ranked within each category	Lists Thomson (1986), Lloyd and Balla (1986) and makes recommendation to reassess sites.	Yes — for management intervention	No
Location	Yes	Grid ref	Australian Map Grid	Wetland Atlas number	AGM54 datum
Size	Yes	Variable estimate only	Yes	Yes	Yes
Land tenure	No	Notes	No	Yes	Yes
Landuse - impacts	No — but discussion of management options	Yes		Yes	Yes

	Pressey (1986)	**Thomson (1986)**	**Jensen *et al*. (1996)**	**Wetland Care Australia (1998)**	**River Murray Baseline Survey 2003–2005.**
Significant species and or communities	None other than waterbird breeding colony sites	Yes	Lists Thomson key species	None other than vegetation surrogates	Yes
Chemical data	None	Spot measures of pH, Conductivity, Dissolved oxygen, Water temperature, Turbidity, Secchi disc	No additional information collected	None	Standard water quality at 4 locations per wetland — 4 sampling events.
Physical data	Geomorphic features	Extent of reclamation in the region. Diversity of habitat type. Submerged logs. Length of shoreline. Water depth	No additional information collected	Water depth, presence of barriers to flow and evidence of salt issues. Description of inlets and outlets.	Digital Terrain Models for each wetland (1–2 cm accuracy) were produced and used to provide areal and volume estimates for different capacity levels. Groundwater monitoring. Bird habitat variables — shoreline complexity, mud banks, trees for perching and nesting, fringing vegetation.

	Pressey (1986)	**Thomson (1986)**	**Jensen *et al*. (1996)**	**Wetland Care Australia (1998)**	**River Murray Baseline Survey 2003–2005.**
Biological data	Waterbird breeding colony sites	Waterbird counts – variable quality single site visit. Vegetation – dominant species and structure – waters edge, submerged and riparian. Sweep net sample of common macroinvertebrates for each wetland identified to lowest practicable level. 10 sites with invertebrate data sampled using artificial substrate samplers. Mammal trapping at three areas: Coorong, Monteith and Murtho Forest Reserve.	No additional information collected – repeats Thomson's key species.	Pest species. Vegetation structure, diversity and degradation. Assessment of wetland health by use of surrogate plant taxa.	Fish, Vegetation, Macroinvertebrates, Frogs, and Water birds as per SKM (2004c) and Tucker (2004).

3. Designing prioritisation frameworks — considerations

The first step in developing a prioritisation framework is to clearly articulate the questions which will drive the framework and determine the relative importance of various criteria. For example, decisions on the degree of importance or weighting of values (ecological, social, and cultural), risks, threats, data types, scale of consideration, and method options are all important.

The following considerations have been taken into account in developing the prioritisation framework (from Heron *et al*., 2004; DEH & DWLBC, 2003):

- Existing policies and strategies relating to wetlands relevant to the study area. In particular the prioritisation framework will be aligned with the major goals of the SA Murray-Darling Basin Natural Resources Management Investment Strategy.
- Existing information and datasets on wetlands.
- The framework is aimed at providing a process and not the answers.
- The consideration of scale, and in particular the development of landscape variables that can be incorporated into the framework.
- Incorporating environmental, social & economic issues in the priority setting approach.
- Prioritising which wetlands need management plans: currently based on water licensing requirements (i.e. which wetlands have structures and so need water licences).
- Ensuring that the proposed method is based on up-to-date techniques and is scientifically robust.
- Providing a framework that is able to deliver outcomes that are objectively derived and hold up to broader stakeholder scrutiny.
- Framework should be able to be applied in a consistent, transparent and transferable manner.

Some of these are elaborated on in the sections below.

3.1 Issues of scale

In applying any prioritisation framework the scale or spatial unit at which the ranking is undertaken will obviously have an impact on the results (Schweiger *et al.,* 2002). In developing this framework the study area was designated as the Murray River valley, focusing on floodplain wetlands (natural) only, which includes 1100 wetlands from the border to the barrages. Different rankings of sites may be achieved by reducing the spatial unit to say regional areas such as those governed by local action planning units (jurisdictional boundaries) or natural watersheds. The framework will need to be able to be applied at different scales.

3.2 Data limitations

Data limitations are one of the most challenging aspects of developing and implementing prioritisation frameworks. In almost all cases there will be a lack of baseline data for the majority of sites in the study area, in addition to significant limitations in our understanding of how specific wetland ecosystems function or are impaired. Thus prioritisation frameworks need to consider the type and quality of data available, but also be flexible enough to produce guidance based on limited information.

3.3 Data requirements

Prior to actually attempting a prioritisation there are a number of activities that are necessary in order to provide data in an appropriate format. The available data need to be interrogated to identify overlaps and common measures used in the key projects identified above. The data from each of the key projects should be consolidated into a single database with GIS capacity and data sorted by wetland and regions. A GAP analysis should then be undertaken in order to highlight areas in which strategic data collection will improve the overall coverage and quality of data. For example in some regions, certain types of wetlands may not be well represented in previous studies.

In particular the following are required:

- Wetland type: adopt use of national wetland classification system — align Pressey, Thomson and DIWA.
- Data from rapid assessment projects such as the River Murray Baseline Wetland Survey need to be transformed into a condition rating, building on earlier attempts of Ecological Associates (2003) and giving consideration to the methods employed by DEH.
- Re-evaluate conservation ratings of Thomson (1986), Lloyd and Balla (1986) using broadened criteria.
- GAP analysis: Identify which wetlands have limited information and investigate potential to collect additional key data for under represented wetland types.

4. Approaches to wetland prioritisation

4.1 Conservation purposes

The need to further conserve wetland areas for the maintenance of biodiversity and ecological functioning is becoming more widely accepted. In the past, selection of wetlands for protection of ecological values has focused on sites with species listed (usually waterbirds) under State or Federal legislation or international treaties such as CAMBA* and JAMBA*[*]. This method of site selection (not limited to wetlands) has drawn some criticism in recent years, with the recognition that it can result in unrepresentative reserve networks (Wilson *et al*., 2005 and references therein). In many cases, sites selected for icon species such as migratory water birds are assumed to be representative of broader biodiversity values; however, the criteria on which they are based are often restrictive. For example, listing sites which support large numbers of individuals (e.g. Ramsar Criteria use the figure of 20,000 individuals) will bias the selection of sites towards those that support colonial or aggregative species, and may not capture other species that do not occur in large numbers. The success or otherwise of management actions aimed at

[*] China Australia Migratory Birds Agreement
Japan Australia Migratory Birds Agreement

maintaining biodiversity will be dependent on the site selection process (Jackson *et al*., 2004) — are the best sites included in the network to begin with?

Determining sites worthy of conservation is data dependent. The use of listed or threatened species or communities has become common practice in ranking sites; however, as mentioned above there is a danger that sites that have not had inventory work undertaken will be under-represented in the final selection of sites. Also the geographic scope at which a prioritisation of listed species is developed and applied will also affect the rankings. Mehlman *et al*. (2004) compared three priority setting systems for listed North American bird species. They showed that differences in prioritisations of listed species resulted from differences in the biological and geographical scopes (global, continental, regional). For example, the number of species considered differed according to the geographic scope, with global systems listing the least and regional the most. To reconcile differences in lists Mehlman *et al*. (2004) recommend a hierarchical approach that considers species listed under global systems first, then continental.

The principles and research into conservation reserve selection are relevant for natural resource managers interested in prioritising investment for wetland management, as the central issue is site selection. Wetlands in the Murray River valley in South Australia were mapped and classified by Pressey (1986), predominantly on geomorphology. Regional natural resource managers feel that the Pressey classification system has a relatively limited scope for providing landscape-scale management decisions; because it does not incorporate other important drivers of wetland ecology. Concern exists that site selection based on this system may not capture the wetland diversity characteristic of the region.

Subsequent inventories of floodplain wetlands along the Murray valley (Thomson, 1986; Jensen *et al*., 1996; Wetland Care Australia, 1998; SKM 2004b) have attempted to include other aspects of wetland ecosystems, predominantly hydrology and vegetation associations.

An often stated goal for the conservation of wetland ecosystems is to maintain and enhance aquatic biodiversity associated with wetlands. To achieve this goal it is necessary to identify the value of wetland assets, combining the consideration of listed species, selection of representative wetland types, and threats to wetlands. This approach goes beyond considering sites based solely on the presence of listed species.

4.2 Threat and risk assessment

Conservation value is often applied to species, communities and habitat which are considered to be under threat of extinction or loss and in order to focus conservation management actions (Possingham *et al*., 2002). Threats to a wetland ecosystem can be physical, chemical, or biological disturbances (Table 3) and can also be natural or due to human activities; they may cause significant changes in the ecological components, patterns, and processes in natural systems.

Table 3: Disturbance activities, stressors and impacts commonly affecting wetland ecosystems (adapted from Water's Edge Consulting, 2005).

Disturbance activity	Type of threat	Type of impact
Hydrological alteration	Physical	Physical, chemical and biological
Sedimentation	Physical	Physical and biological
Water quality – Salinity	Chemical	Chemical and biological
Physical alteration	Physical	Physical, chemical and biological
Biotic – invasive species	Biological	Physical and biological
Mixture	All	All

An impact can be broken into four components: the disturbance activity, the type of threat, the nature of change and the impact of the change. The nature of change in the ecological character of a wetland as a result of a threatening process can be physical, chemical or biological, or more usually a combination of the three (Water's Edge Consulting, 2005).

- **Physical impacts** can include loss of habitat, changed water regimes – duration, frequency, timing of flooding.
- **Chemical impacts** can include altered chemical composition by dilution/concentration of water, addition of contaminants such as excess nutrients which could lead to toxicity or eutrophication.
- **Biological impacts** can include reduction and or removal of biota, altering the community composition that may affect food web dynamics, potentially increasing competition, or opening other opportunities to selected taxa.

The impact on a wetland will rarely be simple, and our ability to identify causality is limited. Physical alterations such as changing hydrological regimes are the dominant and most obvious causes of impact on wetlands. Geomorphic setting determines runoff and storage of water in wetlands and therefore influences the potential for chemical stressors to be transported, stored, and cycled in wetlands (Lemly, 1997). Chemical and physical stressors interact to influence biotic responses. The fact that multiple stressors often operate at the same time also makes it difficult to determine causality.

4.3 Restoration potential

Effective prioritisation of wetland restoration requires information that integrates both conservation and ecological status of wetlands with the effort to restore an individual wetland (Palik *et al*., 2000).

For many wetlands along the Murray River valley it will not be possible to restore them to pre-regulation condition. Instead the focus is on achieving the best possible outcome in terms of wetland condition, and achieving this for a range of wetland types at the regional or landscape scale.

4.4 Social and economic prioritisation

Mysz *et al*. (2000) identified areas of highest quality and ecological significance using a method that incorporated the following:

- presence of an indigenous ecosystem and biological community types — used as an indicator of relative ecological diversity;
- levels of stressors and the proximity and connectivity to similar high quality biological communities — used as an indicator of long term self-sufficiency;
- numbers and rarity of native species and natural features — used as an indicator of surviving relict native ecosystems.

Their rating system is iterative, in that it is modified as new data become available. Once critical ecosystems are identified they are then prioritised according to socio-economic and political considerations. Mysz *et al*. (2000) linked the rating system above to information on stakeholder views on critical ecosystems. Stakeholders generally equated critical ecosystems with high quality or ecological diversity. Overlap analysis using GIS was used to identify areas of importance to regional stakeholders, thus recognising the increased chance of success of management activities in areas with strong overlap in interest between stakeholder groups.

The Wetlands Management Study (Wetland Care Australia, 1998) provided a prioritisation of wetlands in each of the riverine Local Action Planning (LAP) Associations, based on eight criteria. It was suggested that each local action planning region undertake a prioritisation of objectives, strategies, programs and actions, including identifying priority wetlands, with the process of the prioritisation to be defined. However, it is understood that the outcomes of the Wetlands Management Study were the only attempt by LAP regions to prioritise their wetlands.

Most if not all LAPs did not proceed any further than to develop management plans for some of the wetlands identified in the report. One or two LAPs applied extra criteria (e.g. social) to the Wetland Care Australia rankings, to re-prioritise 'their' wetlands. Comparisons between rankings of sites along the length of the Murray valley to that produced for each LAP region would identify areas which have significant overlap.

5. Framework details

5.1 Step 1: State the objectives and scope of the study

This step is important for the application of the framework. Stating the question or hypotheses to be tested, and setting the scale at which the framework will be applied and the type of data to be used will determine the output. The framework can be applied at different scales, for example at the regional watershed or catchment level, or at the jurisdictional level of the Local Action Planning Authorities. In each case the objectives may vary depending on the type of wetlands and resource management requirements.

5.2 Step 2: Applying the criteria

This framework adopts a hierarchical approach with three levels of ranking. Wetlands are ranked first on their conservation value, then on the degree of threat, and then on their restoration potential. Similar approaches have been used in a number of other prioritisation frameworks such as that developed for the Salinity Investment Framework in Western Australia (Department of Environment, 2003), and Catchment Management Authorities in Victoria (Lyon *et al*., 2002; Heron *et al*., 2004).

Rankings are given as broad categories (high, medium, low) rather than numeric scores. Sites may meet more than one of the criteria.

5.2.1 Conservation value

Asset types and criteria
The following are the criteria against which conservation value is assigned to wetlands. The DIWA criteria (Environment Australia, 2001) are included where appropriate. There are four asset types that can be used to rank wetland conservation value.

1. Existing high value sites
Protect existing high quality wetlands by ranking wetlands which are listed either at the international, national or regional level, acknowledging that listed sites may not be the best representatives of high value sites as defined in this project. Finlayson and Rea (1999) point out that the sites included in the DIWA are based on limited and incomplete data and subjective interpretation of the criteria.

- Listed wetlands to be ranked as follows:
    1. Internationally identified — according to Ramsar convention,
    2. Nationally important — see DIWA,
    3. State level — wetlands considered bioregionally significant,
    4. All other wetlands.

2. Significant taxon and biodiversity value
This asset type is based on the principle of conserving the species and communities that are at most risk, and or sites which support a significant amount of regional biodiversity. This ensures that sites that support listed species or communities, but that are not listed as significant wetlands, are considered.

- The wetland supports native plant or animal taxa or communities that are considered endangered or vulnerable at the national level (by DIWA). Sites with internationally listed species receive top ranking, then national and then state.
- The wetland supports a significant amount of regional biodiversity:
    - Supports significant remnant vegetation,
    - Supports significant waterbird breeding events,
    - Retains a high degree of natural hydrological integrity, thus providing a high degree of habitat complexity.
- The wetland is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail (DIWA).

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

3. Representative wetland types
Representativeness refers to capturing the diversity of a biogeographical region (Bryan, 2002). As discussed above all waterbodies will contribute to regional biodiversity, and this asset type will ensure regional diversity is captured by considering all wetland types. This will require a uniform classification system be applied to wetlands along the Murray valley. It is recommended that the national classification system be applied (see Table 1) as this is the system which other regional wetland inventories have used (e.g. Seaman, 2002d). Some of the criteria used for determining important wetlands at the national level, quoted below, can be applied here.

- *Sites are considered important if they are a rare or unique type of wetland for the region (scale to be determined).*
- *It is a good example of a wetland type occurring within a biogeographic region in Australia (DIWA).*
- *It is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex* (Environment Australia, 2001).

4. Condition assessment results
The final way of valuing sites for priority setting is to consider data collected by baseline assessments such as the River Murray Baseline Survey and inventory projects undertaken by DEH (e.g. Seaman, 2000a-d).

Two of the main characteristics of rapid assessment techniques are:
(i) they measure existing condition, they do not assess the site relative to past conditions, or relative to planned or future conditions; and
(ii) the methods are site-based on field conditions, not inferred from surrounding landscape characteristics, expert opinion or existing reports (Collins *et al*., 2004; Fennessy *et al*., 2004). Assessment of trend data is done in monitoring programs which are targeted at particular problems, usually based on the findings of rapid assessment methods.

Condition ratings based on the findings of rapid assessment methods could potentially be useful in directing management actions. However, at this point in time (2005) the condition rating system trialled by Ecological Associates (2003) for application to data collected by the River Murray Baseline Wetland Survey is being refined, and so its usefulness is limited.

5.2.2 Evaluating threats

The second stage of ranking can be based on threats to wetland condition. Four main categories of threats have been identified for use in assessment and prioritisation programs for wetland maintenance and management (e.g. Lyon *et al*., 2002):

- Altered Hydrology: incorporates any change to the water regime including changes to the amount, delivery, timing and frequency of inundation.
- Water Quality: includes point and non-point source pollution including nutrients, increased salinity, sedimentation and turbidity changes.

- Physical alteration: includes degradation and fragmentation of wetland habitat, loss of connectivity between floodplain wetlands and the river, removal of woody debris, and impacts from land use activities such as agriculture, forestry and urbanisation.
- Biotic threat: includes the impact of invasive species, pest and diseases, and the translocation of aquatic plants and animals.

The potential impact on a wetland's ecological character will rarely be simple, and identifying causality is often very difficult.

Risk assessment is a broad term used to describe a multitude of methods aimed at estimating the likelihood and consequences of undesired events (Hart *et al*., 2003). Ecological risk assessment (ERA) assesses the level of risk to the health of aquatic ecosystems, (mainly rivers so far) posed by multiple threats or stressors. Ecological risk is defined as (Hart *et al*., 2003):

> **Ecological risk** = *likelihood* of ecological effect x *consequence* of that effect.

Risk assessment in wetland ecosystems requires an understanding of the drivers of wetland ecology, and an ability to identify key linkages between stressors and wetland responses. This understanding is then used to identify where, when, how, and to what extent stressors are, or could be, causing an impact on a wetland (Lemly, 1997). Most wetlands have been altered from their natural state. Therefore, the condition that is considered normal for a wetland now may actually be different to the original condition of the wetland.

The timing of an impact, or lag effects, and the ability to be able to control the impact through management activities should also be considered. Risk assessment for evaluating threats to wetlands therefore incorporates degree of impact, timing of impact and the ability to effect control of the threat through management activities (see Table 4).

Table 4: Components of ecosystem risk assessment (adapted from Draft Management Plan for Lake Macleod, in preparation)

Component of risk assessment	**Guideline/Likelihood**	**Risk**
Degree of impact	Variable across wetland type and threat type	
Timing of impact	Immediate/short term	High
	Medium term (5 years)	Medium
	Long term (decades)	Low
Ability to control threat or impact — scale of influence	Local — within individual sites	High
	Regional/surrounding catchments	Medium
	Global/national — uncontrollable	Low

5.2.3 Restoration feasibility

The third stage of ranking for wetlands involves assessing the feasibility of undertaking restoration works and achieving the desired outcome. Determining the feasibility of restoration options requires an appreciation of what the cost will be, the technical difficulties, the likelihood of success and how long it will take to reach the desired outcome, and the degree of stakeholder support for undertaking the work (Department of Environment, 2003).

Restoration usually involves (i) identifying the ecosystem functions and processes thought to be impaired and which are considered important to the condition of a wetland, and (ii) attempting to repair or restore them. This will involve having an understanding of historic and current condition, determining the degree to which a wetland and its valued functions have changed over time, and understanding what has caused those changes and if the functions and processes can be replaced or restored. Wetland restoration usually needs to consider landscape characteristics and key drivers, as opposed to site specific characteristics. This process is a further risk analysis, with the benefit being maintenance or improvement in ecological function (or other stipulated value such as bird habitat), and the cost being the most limiting management resource (this can also vary) (Leibowitz, 2002).

Criteria for determining the restoration feasibility could include:

- Can the current geomorphology, hydrology or connectivity be managed in such a way as to restore the original condition? If yes, what is the likelihood of success — high, medium or low?
- What is the current ecological condition and are there options for improvement?
- What are the key ecosystem processes that support the values and functions of the wetland? Can they be restored?
- What catchment or landscape changes have occurred — land management use, urbanisation, etc.? This may provide a useful indication of degree of change.

5.3 Step 3: Prioritising options

It is possible to rank sites based solely on the conservation value or threat to a particular wetland type, or the feasibility of restoration. However, consideration of all the rankings will provide the most robust output (Figure 1).

Different regional NRM priorities can be allowed for by considering various combinations of rankings as shown in Figure 2, where only the conservation value and threats to wetlands are considered in the prioritisation process.

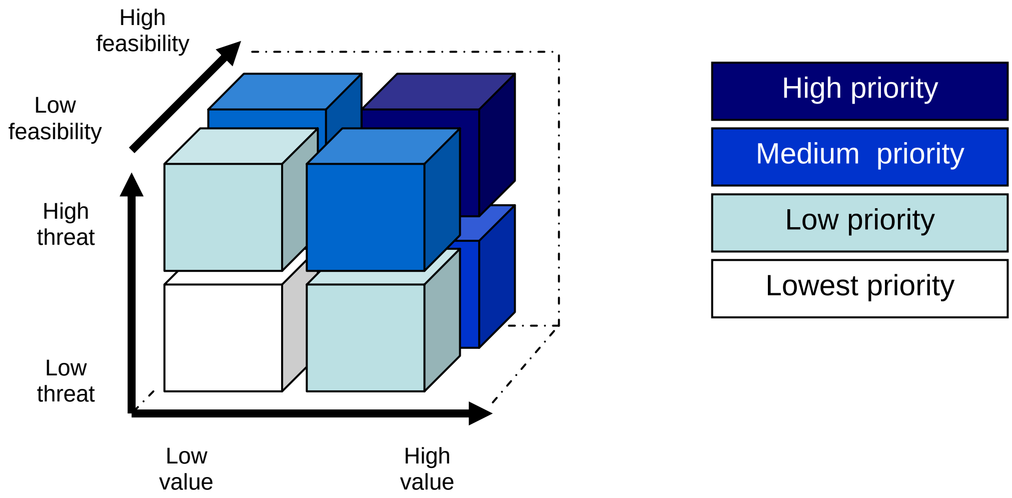

Figure 1: Schematic of prioritisation framework (adapted from Department of Environment, 2003)

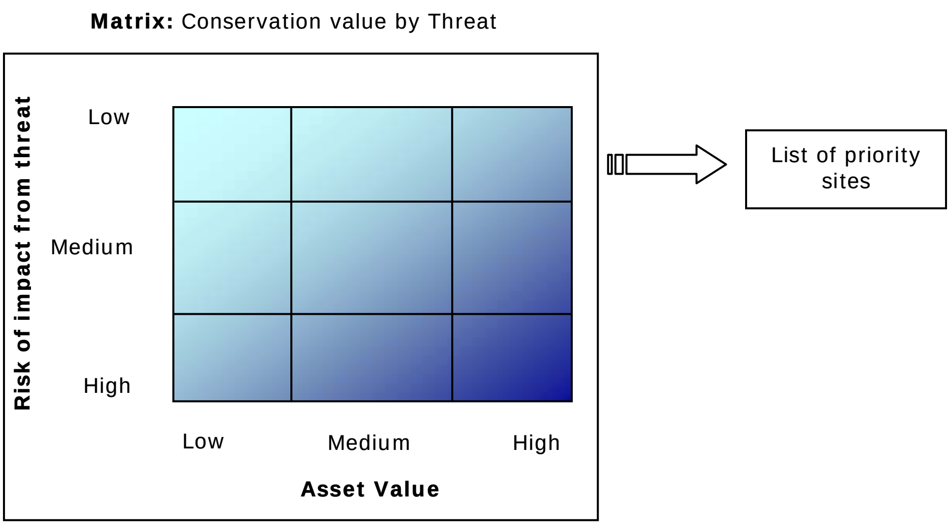

Figure 2: Prioritisation matrix using conservation value and threat.

6. Moving forward

This report has attempted to provide some guidance on how to prioritise wetlands for conservation and restoration along the River Murray valley. In order to actually apply such a prioritisation framework there are a number of things which need to happen in a particular order.

Work required prior to implementing the framework

- The following data requirements need to be addressed.
  - *Wetland typology*: Adopt use of national wetland classification system – align the typologies of Pressey, Thomson, and the River Murray

Wetland Baseline Survey system with that of the national classification system used in the DIWA.
- *Condition ratings*: Data from rapid assessment projects such as the River Murray Baseline Wetland Survey need to be transformed to provide a condition rating, building on the work undertaken by Ecological Associates (2003) and giving consideration to methods used by DEH.
- *Conservation value*: Re-evaluate conservation ratings of Thomson (1986) and Lloyd and Balla (1986), using broadened criteria such as those suggested for this framework.

Formalise and validate the framework

- The framework should be tested with a small set of data and then be refined. In particular, the criteria for assigning conservation, threat, and restoration potential could benefit from further refinement, possibly through consultation with relevant stakeholders (e.g. workshop with DWLBC, RMCWMB, others).
- The testing phase should be done at a minimum of two geographical scales in order to assess the possibility of applying the framework at different scales.
- A method of rating wetland condition needs to be developed. It should give consideration to the measures assessed in the River Murray Baseline Wetland Survey, and also those used to rate condition used by DEH.

Future work

- Identify which wetlands have limited information and investigate potential to collect additional key data for under-represented wetland types.
- Salinity and altered hydrology are considered the dominant threats to wetlands along the Murray valley and, as such, these should form the focus of future works.
- Any future development of a prioritisation method should consider the need for capturing information on an appropriate database — this should include spatial information. The work of Jensen *et al*. (1996) has been entered onto a GIS database and the possibilities of expanding this system should be considered. DEH are currently investigating a major ORACLE-driven wetlands database for the whole of South Australia (J. Vanaarhoven, DWLBC, pers. comm.) and discussions with DEH are highly recommended.

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