MONITORING THE ECOLOGICAL CHARACTER OF AUSTRALIA'S WETLANDS OF INTERNATIONAL IMPORTANCE (RAMSAR CONVENTION)

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Front Cover photograph: False Mouths of the Ord (photo – Jim Lane, CALM, July 1996)

Contents

Tables

Figures

Plates

EXECUTIVE SUMMARY

Australia and 99 other nations are Contracting Parties to the "Ramsar" Convention on Wetlands, an intergovernmental agreement aimed at the conservation of designated wetlands of international importance and the wise use of wetlands generally.

Contracting Parties to the Convention give a number of undertakings. Prominent among these are commitments to designate suitable wetlands for inclusion in a List of Wetlands of International Importance; to formulate and implement planning so as to promote their conservation; and to arrange to be informed at the earliest possible time if the ecological character of any listed wetland has changed, is changing, or is likely to change as a result of human activity.

Australia has nominated 49 Wetlands of International Importance since signing the Ramsar Convention in 1971. These sites are widely distributed across the continent and include a broad range of wetland types from subalpine bogs to marine embayments. They range in size from <1 ha to 1,980,000 ha and have many values related to their biodiversity, productivity and hydrology.

Collectively, Australia's Ramsar sites face many threats. These include on-site threats such as weed and feral pest invasion, plant diseases, inappropriate fire regimes, overgrazing, encroaching development and inadequately managed visitor access and catchment-based threats such as salinisation, eutrophication, chemical pollution and altered water supply. In order to conserve Australian Ramsar sites in the face of these threats, informative and affordable monitoring programs, interactive with management, are needed.

This report recommends a protocol that may be used to establish site-specific monitoring programs for Australian Ramsar sites where suitable programs do not already exist. The nature, complexity and intensity of programs will vary between sites depending upon issues such as wetland type, significance of ecological values to be protected and type and severity of threats to those values.

Under the protocol it is recommended that responsibility for monitoring at specific sites be delegated to the regional managers of the agencies responsible for those sites. This is to ensure that monitoring is interactive with management. It is also recommended that scientific management committees, that include the scientific expertise necessary to adequately address ecological values and threats, be established for at least the most important and severely threatened sites. These committees should be chaired by the regional managers.

A scientific management committee's initial task will be to prioritise identified threats to the ecological character of a site and prepare a draft environmental monitoring program that addresses those threats. It is recommended that community input be sought both prior to and following the drafting of the program. Possible advantages and disadvantages of combining the process of preparation of environmental monitoring programs with the process of preparing formal site management plans should be considered on a case by case basis.

When finalised, the environmental monitoring program should be implemented interactively with management. The scientific management committee will have an ongoing role in evaluating feedback from the monitoring program and periodically advising on management.

In addition to the recommended protocol, this report includes discussion of several fundamental considerations in the design of rigorous monitoring programs, such as parameters to measure and how to measure them, setting acceptance criteria against which the effects of threats and remediation work can be assessed, correct statistical design and appropriate methods for data analysis, the establishment of a database and involvement of community groups. Ramsar definitions of ecological character and change and examples of operation of the Montreux Record and Ramsar management guidance procedure are also presented.

As a demonstration of how the protocol might be applied, three theoretical case studies involving the Toolibin Lake, Lower Ord River Floodplain and Eighty Mile Beach Ramsar sites are presented. In each instance the relevant management agency and site manager are identified, wetland values and threats to these values are listed, expertise needed on the scientific management committee is identified, likely representation at public meetings is indicated, current management and monitoring activities at the site are identified, and possible future monitoring and management activities are outlined.

The report includes a list of sixteen principal recommendations for consideration by Commonwealth, State and Territory Ramsar implementation agencies. These are aimed at assisting efforts to promote the conservation of Australia's Ramsar Wetlands of International Importance.

PRINCIPAL RECOMMENDATIONS

The principal recommendations of this report are listed below. Many secondary recommendations, proposals and suggestions are contained in the body of the report, particularly in Part C "Ecological Character under Ramsar", Part D "Monitoring the Character of Australia's Ramsar Sites" and Part E "Designing an Environmental Monitoring Program".

BACKGROUND

The Convention on Wetlands of International Importance especially as Waterfowl Habitat - commonly referred to as the Ramsar Convention from its place of adoption in Iran in 1971 - is the first of the modern global intergovernmental treaties on conservation and wise use of natural resources (Davis 1994).

For the purposes of the Convention, Article 1.1 defines wetlands as "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".

Article 2.1 of the Convention states that: "Each Contracting Party shall designate suitable wetlands within its territory for inclusion in a List of Wetlands of International Importance, hereinafter referred to as "the List" which is maintained by the Bureau...." and that: "The boundaries of each (listed) wetland shall be precisely described and also delimited on a map and they may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands, especially where these have importance as waterfowl habitat".

The remainder of Article 2 states, in general terms, the bases upon which wetlands may be selected for the List, and imposes upon Contracting Parties the condition of including at least one wetland when signing the Convention, with the right to add further wetlands to the List, to extend, delete or restrict (due to urgent national interests) the boundaries of listed wetlands and an obligation to inform the Ramsar Bureau immediately of any such changes. Article 2 also affirms that inclusion of a wetland in the List does not prejudice the sovereign rights of the Contracting Party in whose territory the wetland is situated.

As at 25 February 1997 there were 100 Contracting Parties to the Convention and 872 wetlands on the List of Wetlands of International Importance, covering an area of 62,439,840 ha (approximately the size of France).

Australia was the first nation to deposit an instrument of accession to the Convention and to date has nominated 49 wetlands (5,039,121 ha) to the Ramsar List. Nomination of these wetlands acknowledges that they are among the most ecologically valuable wetlands on the continent. These wetlands warrant special attention to maintain their internationally recognised values and status. This is particularly pertinent given that Australia's wetlands are a diminishing resource and those remaining are under increasing pressure from a wide range of land and water use practices.

Ratification of the Ramsar Convention by the Australian Government imposed a number of obligations additional to those of Article 2. Most relevant to this document is Article 3.2 which states that: "Each Contracting Party shall arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference. Information on such changes shall be passed without delay to .. (the Ramsar Bureau)".

The terms "ecological character" and "change in ecological character" are general in nature and the Contracting Parties have acknowledged that further elaboration is required. To this end, the issue was debated and interim working definitions of the two terms were adopted at the 6th Conference of Contracting Parties, held in Brisbane in March 1996. While clear definitions of these terms have yet to be finalised, Contracting Parties remain obliged under Article 3.2 to monitor the ecological character of listed wetlands and to inform the bureau of adverse human-induced changes, either recent, current or impending.

In Australia, responsibility for managing Ramsar sites rests with the Commonwealth, State and Territory Governments in their respective areas of jurisdiction. Responsibility to institute arrangements for detection and initial reporting of adverse human-induced change, and threatened change, therefore rests with the respective Commonwealth, State and Territory "Ramsar implementation" (nature conservation) agencies. Under the provisions of the Inter-Governmental Agreement on the Environment (IGAE) the respective State and Territory Government agencies are expected (by the Commonwealth) "to play a pivotal role in

implementing the Convention due to their legislative responsibilities for land and water management" (EABG 1997; p.A2/1).

AIMS OF THIS REPORT

This document has been prepared to assist Commonwealth, State and Territory government agencies in meeting Article 3.2 obligations, and has the following principal aims.

1. To describe the obligations imposed upon the Commonwealth, State and Territory governments of Australia by Australia's ratification of the Ramsar Convention (*Convention on Wetlands of International Importance Especially as Waterfowl Habitat*).

2. To recommend procedures for the development and implementation of monitoring programs for assessing whether the ecological character of any Australian Ramsar site "has changed, is changing, or is likely to change as the result of technological developments, pollution or other human interference" (Article 3.2 of the Convention).

3. To propose administrative arrangements for reporting of adverse human-induced changes to the ecological character of Ramsar sites by the relevant State and Territory agencies to the Commonwealth Government, for referral to the Ramsar Bureau as required under the Convention.

In many instances throughout this report, Western Australian wetlands are cited to provide examples of sites, values, threats etc. This merely reflects the knowledge and background of the authors. It is intended that this report is applicable to all Australian Ramsar Sites.

The document does not provide a detailed review of the burgeoning literature on biological monitoring in aquatic systems. Excellent reviews and texts may be found in Hart (1980), Hellawell (1978), Jones & Walker (1979), and Spellerberg (1991). Of particular relevance are the proceedings of two overseas workshops which addressed the issue of monitoring of ecological change in Ramsar listed wetlands, Moser *et al.* (1993) and Aubrecht *et al.* (1994), and specifically articles by Finlayson (1994a & b).

PART A: THE RAMSAR CONVENTION

A working knowledge of the Ramsar Convention is necessary to understand the process by which wetlands are listed and the associated obligations of Contracting Parties.

The Montreux Criteria (Criteria for Identifying Wetlands of International Importance)

Prior to its adoption at Ramsar in 1971, the principal aim of the Convention was intended to be the conservation of migratory waterfowl populations through the creation of a network of refuges. However, by the time the Convention was agreed and adopted, the emphasis had moved more to the conservation of the wetland habitats of waterfowl (including all species of waterbirds), rather than the birds themselves.

Since its adoption the Convention itself has been modified on two occasions (The Paris Protocol and the Regina Amendments).

The original criteria (adopted in Cagliari, Italy, in 1980) upon which wetlands could be nominated have also been revised (at Regina in 1987; Montreux in 1990 and Brisbane in 1996). The following "Criteria for Identifying Wetlands of International Importance" are current - at least until the next Conference of Contracting Parties in May 1999. They are specified in Annexes of Recommendation C.4.2. and Resolution C.6.2. Note that the criteria now recognise a far wider range of wetland values and functions than waterfowl habitat alone.

"A wetland is identified as being of international importance if it meets at least one of the criteria set out below:

(1) Criteria for representative or unique wetlands.
A wetland should be considered internationally important if:
(a) it is a particularly good representative example of a natural or near-natural wetland, characteristic of the appropriate biogeographical region;
or (b) it is a particularly good representative example of a natural or near-natural wetland, common to more than one biogeographical region;
or (c) it is a particularly good representative example of a wetland, which plays a substantial hydrological, biological or ecological role in the natural functioning of a major river basin or coastal system, especially when it is located in a trans-border position;
or (d) it is an example of a specific type of wetland, rare or unusual in the appropriate biogeographical region.

2. General criteria based on plants or animals.
A wetland should be considered internationally important if:
(a) it supports an appreciable assemblage of rare, vulnerable or endangered species or sub-species of plant or animal, or an appreciable number of individuals of any one or more of these species;
or (b) it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna;
or (c) it is of special value as the habitat of plants or animals at a critical stage of their biological cycle;
or (d) it is of special value for one or more endemic plant or animal species or communities.

3. Specific criteria based on waterfowl.
A wetland should be considered internationally important if:
(a) it regularly supports 20,000 waterfowl;
or (b) it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity;
or (c) where data on populations are available, it regularly supports 1% of the individuals in a population of one species or sub-species of waterfowl".

4. Specific criteria based on fish
A wetland shall be considered internationally important if:
(a) it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity;
or (b) it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.

Formal guidelines (Annexes to Rec. C.4.2 and Res. C.6.2) have been developed to assist in the application of the above Criteria.

The Brisbane Conference of Contracting Parties also resolved (Res. C.6.3) that a further review of the criteria and a revision of the guidelines, taking into account *inter alia* cultural values and/or benefits derived from wetlands, be undertaken by the Ramsar Convention's Scientific and Technical Review Panel (STRP) for consideration by the 7th Conference of Contracting Parties in Costa Rica in May 1999.

Obligations and expectations of Contracting Parties to the Ramsar Convention

The broad objectives of the Ramsar Convention are to ensure the conservation and wise use of wetlands because of their abundant richness in flora and fauna and their economically important functions and values (Davis 1994). To these may be added their ecological, hydrological and cultural values.

Specific obligations of Contracting Parties are:

1. To designate suitable wetlands for inclusion in the List of Wetlands of International Importance (Article 1). Wetlands are to be selected on the basis of international significance in terms of ecology, botany, zoology, limnology or hydrology. In the first instance, wetlands of international significance to waterfowl are to be selected (hence the preponderance of waterfowl habitats listed in Australia and many other countries).
2. To formulate and implement planning so as to promote the conservation of wetlands included in the List and the wise use of wetlands generally (Article 3.1).
3. To arrange to be informed at the earliest possible time if the ecological character of any listed wetland has changed (since listing), is changing or is likely to change as a result of human activity or interference, and to pass such information on to the Ramsar Bureau without delay (Article 3.2). The Bureau's role is to forward this information to all Contracting Parties for discussion at the next Conference, and to subsequently advise the relevant Contracting Party of the recommendations of that Conference with respect to the change in character (Article 8). In practice, many issues are satisfactorily resolved by discussions between the Bureau and the Party involved, without the need for referral to the next Conference.
4. To promote the conservation of wetlands and waterfowl by establishing nature reserves on wetlands (whether listed or not) and providing for their "wardening"; to encourage research; to endeavour through management to increase waterfowl populations on appropriate wetlands; to promote training in wetland research, management and wardening (Article 4).
5. To ensure that those responsible at all levels for wetlands management shall be informed of, and take into consideration, recommendations of Conferences of Contracting Parties concerning the conservation, management and wise use of wetlands and their flora and fauna (Article 6.3).

RECOMMENDATION 1. That the Commonwealth, State and Territory government agencies responsible for implementation of the *(Ramsar) Convention on Wetlands of International Importance* in their respective areas of jurisdiction[1] note the obligations of Contracting Parties, including Australia, to "arrange to be informed at the earliest possible time if the ecological character of any listed wetland has changed, is changing or is likely to change as a result of technological developments, pollution or other human interference", and to pass information on such changes "without delay" to the Ramsar Bureau for discussion at the next Conference of Contracting Parties and for possible follow-up action.

In addition to the specific obligations undertaken by nations when they become Contracting Parties to the Convention there are a number of expectations. These arise from Resolutions and Recommendations of triennial Conferences of Contracting Parties. All Conference Resolutions and Recommendations are recorded in published proceedings of the Conferences, of which there have now been six (the most recent being the March 1996 Conference of Contracting Parties in Brisbane). A compendium of all Resolutions and Recommendations is currently being prepared, by the Ramsar Bureau.

Expectations most relevant to this document are those rising from Conference Resolution C.6.1, which calls upon Contracting Parties "to support the development, by the relevant authorities within their territories, of Early Warning Systems for detecting and initiating action in response to change in ecological character".

RECOMMENDATION 2. That Australia's Ramsar implementation agencies also note Resolution C.6.1 of the 1996 Ramsar Conference in Brisbane, calling upon Contracting Parties "to support the development, by the relevant authorities within their territories, of Early Warning Systems for detecting and initiating action in response to change in ecological character".

Wise use of wetlands

"Wise use" of wetlands (as opposed to total protection) is a central theme of the Ramsar Convention. As mentioned above, Article 3.1 of the Convention obliges Contracting Parties to "formulate and implement

[1] Also referred to in this document as Australia's "Ramsar implementation agencies".

their planning so as to promote the conservation of the wetlands included in the List, and as far as possible the wise use of wetlands in their territory".

The Convention considers the conservation of listed sites, and the "wise use" of wetlands generally, to constitute realistic goals.

"Wise use" has been defined by the Contracting Parties as "their sustainable utilisation for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem". "Sustainable utilisation" has, in turn, been defined as "human use of a wetland so that it may yield the greatest continuous benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations", while the "natural properties of the ecosystem" are defined as "those physical, chemical and biological components, such as soil, water, plants, animals and nutrients, and the interactions between them" (Davis 1993).

The Ramsar wise use provisions apply to all wetlands and their support systems within the territories of Contracting Parties, both those wetlands designated for the List, and all other wetlands. The concept of wise use seeks both the formulation and implementation of general wetland policies, and wise use management of all wetlands. These activities are seen as integral parts of ecologically sustainable development. In order to apply the wise use concept it has been recommended that all Parties formulate national wetland policies addressing all problems and activities related to wetlands within a national context.

The Ramsar Database

Contracting Parties are requested to present information on wetlands designated for the List of Wetlands of International Importance by means of an approved Information Sheet (as adopted by Conference Recommendation C.4.7), at the time of designation.

The required information is arranged under 32 headings as follows: 1-11 = site location and other basic parameters, 12 = a two or three sentence overview of the site, 13-15 = physical and ecological features and ownership of the site and surrounding areas, 16 & 17 = conservation measures taken and proposed, 18 & 19 = land use and possible changes, 20 = disturbances and threats, 21 = hydrological and biophysical values, 22 = social and cultural values, 23 & 24 = noteworthy flora and fauna, 25 = scientific research and facilities, 26 & 27 = conservation education, recreation and tourism, 28 & 29 = management authority and jurisdiction, 30 = scientific references, 31 = reasons for inclusion on the List, and, 32 = outline map of the site.

This information is added to the Ramsar Database. This database is the means by which the List of Wetlands of International Importance is kept up to date. It was established on computer in 1990 and is maintained by the Ramsar Bureau at IUCN Headquarters in Gland, Switzerland.

At the 1996 Conference in Brisbane, Contracting Parties were advised by the Ramsar Bureau that improvements to the Guidelines for completing the Information Sheet were proposed, in order to increase its value for describing and assessing the ecological character of listed sites. New headings in the Guidelines are proposed to emphasise the importance of:

- establishing a baseline by describing the full range of wetland benefits and values which should be considered when assessing the possible impact of changes at a site;
- providing information on human-induced factors that have affected or could significantly affect the benefits and values of international importance;
- providing information on monitoring and survey methods in place or planned at the site; and
- providing information on the variability and amplitude of natural changes that have or could affect the ecological character of the site.

These changes were endorsed by the Contracting Parties by means of Resolution C.6.1 (Annex).

The Ramsar Database is used to facilitate frequent updated publication of the List and periodic publication of a Directory of Wetlands of International Importance. This Directory, which provides a comprehensive overview of the latest information on every site on the List, has been published in four volumes covering

(I) Africa, (II) Asia & Oceania, (III) Europe and (IV) Neotropics and North America (Jones 1993 a,b,c &d). An update (Ramsar 1996), tabled at the 1996 Conference of Contracting Parties, includes information provided at the time of nomination for the Moreton Bay and Bowling Green Bay Sites in Queensland (and newly-listed Sites of other Contracting Parties).

The Database also enables the Bureau to:

- respond to reports of changes in ecological character at listed sites;
- prepare briefs for Bureau staff and consultants engaged in application of the Management Guidance Procedure (see later section of this document);
- provide information for Bureau technical staff working on wise use and management plan projects;
- process enquiries and data requests from Contracting Parties, partner organisations and researchers;
- prepare site-based texts and illustrations for Ramsar publications; and
- provide essential data to those developing global, regional and national inventories of wetlands (Davis 1994).

The use of the database in recording and responding to reports of changes in ecological character at listed sites is noteworthy in the context of the present document.

The Ramsar "Management Guidance Procedure"

The Management Guidance Procedure is a mechanism aimed at assisting Contracting Parties in the management and conservation of Listed sites whose ecological character is threatened. The Procedure (originally referred to as the Monitoring Procedure) was established by the Ramsar Standing Committee in 1988 in response to Regina Recommendation C.3.9, which called for Contracting Parties to take swift and effective action to prevent further degradation of listed sites and to restore, as much as possible, the ecological value of impacted sites. The Procedure was formally adopted by Recommendation C.4.7 of the 1990 Montreux Conference and is described in the Annex to that Recommendation. Its name has since been changed to the Management Guidance Procedure to clearly distinguish it from the scientific process of monitoring.

Although the Management Guidance Procedure does not involve scientific monitoring, it may result in the initiation of a program of scientific monitoring (of ecological character or related parameters) as a consequence of its recommendations. It is therefore useful to understand how it operates.

Under the Management Guidance Procedure, the Convention Bureau and its recruited experts work with individual Contracting Parties to find solutions to the problems facing internationally important wetland areas. The Procedure normally takes the form of one or more visits to the site by Bureau staff members and/or consultants, and the subsequent report generally includes detailed analysis of the situation and makes recommendations about future action at the site. For example, it may be recommended that more detailed studies are undertaken, boundaries of protected areas be extended, waterfowl hunting activities be moderated, an environmental impact assessment be carried out prior to a proposed development, water be drawn from aquifers to help maintain surface waters, or that existing regulations be better enforced.

The kinds of problems which may prompt a Contracting Party to consult the Bureau, and possibly to initiate the Management Guidance Procedure, may include any one or combination of the following:

- impacts on water (on its source, its course, its quantity, its quality, or its seasonality)
- impacts on the ecological character of the site by actions that affect:
    a) physical characteristics of the wetland (e.g. by drainage or landfill);
    b) chemical characteristics (e.g. by industrial or agricultural contaminants);
    c) biological characteristics (e.g. through inappropriate management of species, habitats or other natural resources).

The Management Guidance Procedure is conducted as follows:

1. It comes to the attention of the Bureau that the ecological character of a listed wetland is changing or is likely to change as a result of technological development, pollution or human interference.

2. Where appropriate, the Bureau shall ask the Contracting Party or Parties concerned to provide further information concerning the situation.
3. Where, as a result of this procedure and other information available to the Bureau, the Bureau is of the opinion that there is evidence of significant change or likely change in the ecological character of a listed wetland, the Bureau shall collaborate with the Contracting Party or Parties concerned to arrive at an acceptable solution and the Bureau may offer advice and assistance to that Party or those Parties, if required. The Bureau shall inform the Standing Committee of any action it has taken in this connection.
4. If it does not appear that an acceptable solution can be readily achieved, the Bureau shall immediately bring the matter to the attention of the Standing Committee. The Standing Committee, acting through the Chairman and Secretary, provided by the Bureau, may pursue the matter, in direct contact with the Contracting Party or Parties concerned and, where appropriate, with other responsible agencies or bodies, with a view to helping to find a solution.
5. In the event of alterations to the List or changes in ecological character in wetlands included therein, the Standing Committee shall arrange for the information to be circulated for discussion at the next Meeting of the Conference of the Contracting Parties in accordance with Article 8 paragraph 2 (d) of the Convention.
6. The Bureau shall periodically review and report progress on the conservation status of sites to which its attention has been drawn under this procedure. To facilitate follow-up, the Bureau shall maintain a register of activities undertaken in this connection. (Rec. C.4.7 Annex).

The Montreux Record

In addition to adoption of the Management Guidance Procedure, a separate recommendation (C.4.8 of the 1990 Montreux Conference) instructed the Bureau to keep a record of Ramsar sites where change in ecological character had occurred, was occurring or was likely to occur. This was to be referred to as the Montreux Record ("Record of Ramsar sites where changes in ecological character have occurred, are occurring, or are likely to occur").

Montreux Record procedures

The Montreux Record (Table 1) was initially compiled on the basis of Site information contained in the National Reports submitted to the Montreux Conference (1990). Additional sites were subsequently added to the Record following a set of procedures (Annex to Resolution C.5.4) adopted at the Kushiro Conference in 1993. At the Brisbane Conference these procedures were revised in the light of further experience. An abbreviated version of the revised procedures (Annex to Resolution C.6.1) is as follows. References to ecological character or monitoring have been italicised due to their significance in the context of this report.

Procedure for inclusion.

- A Contracting Party may request inclusion of a site in the Montreux Record, *because of potential or actual adverse change in its ecological character,* in order to draw attention to the need for action or support. ...A site can only be included in the Record with the approval of the Contracting Party concerned.
- The Bureau will pass ...to the Contracting Party ...a concise, voluntary questionnaire (specified in the Annex) normally to be returned to the Bureau within three months...
- The completed questionnaire will .. be forwarded by the Bureau to the Scientific and Technical Review Panel (STRP) *for advice in line with the Working Definitions and Guidelines for Describing and Maintaining the Ecological Character of Listed Sites* (also specified in the Annex).
- Any technical comment or advice provided by the STRP will be forwarded by the Bureau to the Contracting Party ....
- The Bureau will discuss the STRP's comments and advice with the Contracting Party concerned, with the aim of determining what steps might be taken, including a decision as to whether the site should be included in the Montreux Record...
- Within the framework of their triennial National Reports, Contracting Parties shall provide a report .. on the conservation status of any sites included in the Montreux Record...

Table 1. The Montreux Record as of 25 February 1997

Country	Site Name	Date
Algeria	Lake Oubeïra	04/07/90
	Lake Tonga	16/06/93
Austria	Donau-March-Auen	04/07/90
Belgium	Schorren van de Beneden Schelde	04/07/90
Bulgaria	Durankalak Lake	16/06/93
	Srebarna	16/06/93
Costa Rica	Palo Verde	16/06/93
Croatia	Kopacki Rit	16/06/93
Czech Republic	Novozámecký a Brehyñský rybník (fishponds)	16/09/94
	Treboñské rybníky (fishponds)	16/09/94
Denmark	Ringkøbing Fjord[1]	04/07/90
Egypt	Lake Bardawil	04/07/90
	Lake Burullus	04/07/90
Germany	Unterer Niederrhein	16/06/93
	Wattenmeer, Ostfriesisches Wattenmeer & Dollart[2]	04/07/90
Greece	Amvrakikos Gulf	04/07/90
	Artificial lake Kerkini	04/07/90
	Axios, Loudias, Aliakmon Delta	04/07/90
	Evros Delta	04/07/90
	Kotychi Lagoons	04/07/90
	Lake Mikri Prespa	04/07/90
	Lake Vistonis, Porto Lagos, Lake Ismaris & lagoons	04/07/90
	Lakes Volvi & Koronia	04/07/90
	Messolonghi Lagoons	04/07/90
	Nestos Delta * & adjoining lagoons	04/07/90
Guatemala	Laguna del Tigre	16/06/93
India	Chilka Lake	16/06/93
	Keoladeo National Park	04/07/90
	Loktak Lake	16/06/93
Iran (Islamic Republic of)	Alagol, Ulmagol & Ajigol Lakes	16/06/93
	Anzali Mordab (Talab) complex	31/12/93
	Hamun-e-Puzak, south end	04/07/90
	Hamun-e-Saberi & Hamun-e-Helmand	04/07/90
	Neyriz Lakes & Kamjan Marshes	04/07/90
	Shadegan Marshes, Khor-al Amaya & Khor Musa flats	16/06/93
	Shurgol, Yadegarlu & Dorgeh Sangi Lakes	
Italy	Laguna di Orbetello	31/12/93
	Palude della Diaccia Botrona	31/12/93
	Stagno di Cagliari	04/07/90
	Stagno di Molentargius	04/07/90
	Torre Guaceto	31/12/93
Jordan	Azraq Oasis	04/07/90
Poland	Jezioro Siedmiu Wysp	04/07/90
	Slonsk Reserve	16/06/93
Senegal	Djoudj	16/06/93
	Bassin de la Réserve Spéciale de Faune du N'diaël	04/07/90
South Africa	Blesbokspruit	
	Orange River Mouth	
Spain	Doñana	04/07/90
	Las Tablas de Daimiel National Park	04/07/90
Trinidad & Tobago	Nariva Swamp	16/06/93
Tunisia	Lake Ichkeul	04/07/90
Uganda	Lake George	04/07/90
Ukraine	Karkinitski Bay	04/07/90
	Yagorlits & Tendrov Bays	
United Kingdom	Dee Estuary	04/07/90
United States of America	Everglades	16/06/93
Uruguay	Bañados del Este y Franja Costera	04/07/90
ex-USSR, Azerbaijan	Kirov Bays	04/07/90
ex-USSR, Kazakhstan	Lakes of lower Turgay and Irgiz	16/06/93
ex-USSR, Kyrgyzstan	Issyk-kul Lake	04/07/90

[1] The Danish authorities have indicated that this site should be removed from the Montreux Record. The Bureau is currently awaiting receipt of documentation "detailing the remedial measures implemented successfully" as required by Kushiro Resolution C.5.4.

[2] The German authorities have indicated that this site should be removed from the Montreux Record. The Bureau is currently awaiting receipt of documentation "detailing the remedial measures implemented successfully" as required by Kushiro Resolution C.5.4.

Procedure for removal.

- The Bureau may ...receive information *...suggesting that there is no longer a risk of change in the ecological character of the listed site.*
- The Bureau will submit the concise questionnaire (referred to above) to the Contracting Party and forward the completed questionnaire to the STRP *for advice in line with the Working Definitions and Guidelines for Describing and Maintaining the Ecological Character of Listed Sites.*
- At the request of the Contracting Party, the Bureau may organise a site visit ....
- A wetland will be removed from the Montreux Record based on the request of the Contracting Party and after consideration of advice and/or comment from the STRP. The final decision will be made by the Contracting Party ...

As of 25 February 1997 there were 61 listed sites on the Montreux Record (Table 1).

Montreux Record questionnaire

The questionnaire referred to in the above procedures seeks information under the following headings (also abbreviated and with direct references to ecological character or monitoring italicised).

Information for assessing possible inclusion.

- Name of Site.
- Ramsar Criteria for listing the Site as internationally important.
- Nature of the change in *ecological character* / potential for adverse change.
- Reason(s) for adverse change, or potential adverse change, in *ecological character.*
- Benefits and values derived from the Site
- Extent to which values and benefits .. have decreased or changed.
- *Monitoring program* in place at the Site .. (techniques, objectives, nature of .. information gathered).
- Assessment procedures in place .. (how is information obtained from the *monitoring program* used).
- Ameliorative and restoration measures in place or planned (if any) so far.

Information for assessing possible removal.

- Success of ameliorative, restoration or maintenance measures.
- Proposed *monitoring* and assessment procedures.
- Extent to which the *ecological character*, benefits and values of the Site have been restored or maintained.
- Rationale for removing the Site from the Montreux Record..

Examples of operation of Management Guidance Procedure and Montreux Record

Currently (1 March 1997), the Management Guidance Procedure has not been applied at any Australian Ramsar site and there are no Australian sites on the Montreux Record. The Commonwealth Government has indicated its preference of not listing Sites on the Montreux Record, preferring instead to cooperate with the relevant State or Territory Government to resolve management problems where they exist (EABG 1997; p.37). To illustrate the application of the Procedure and the function of the Record, several overseas examples are presented.

The St Lucia (South Africa) experience

A detailed example of the application of the Management Guidance Procedure is provided by the St Lucia System, South Africa. St Lucia is one of Africa's oldest nature reserves, established in 1895. The St Lucia System was designated to the Ramsar List in 1986. It consists of an area of 150,000 ha, largely comprised of flat to undulating sandy country surrounding a lagoon-estuary system lying behind steep coastal dunes. Lake St Lucia covers 30,000 ha and is separated from the sea by a strip of land 2-11 km in width. St Lucia is the largest estuarine system on the African continent and it is important for its flora and wildlife, including bushbirds and waterfowl.

In 1989 an application was made to mine mineral sands within the St Lucia System, on the coastal dunes which form the interface between Lake St Lucia and the Indian Ocean. Following submission of an inadequate environmental appraisal (by consultants) of the effects of the proposed dredge mining, South Africa notified the Ramsar Bureau (via its triennial National Report and in accordance with Article 3.2 of

the Convention) that change in the ecological character of the system was likely to occur due to human interference. At the same time, the South African Government directed relevant government departments to coordinate the preparation of a new environmental impact study for the proposed mining operation.

Following notification of the Bureau, the Management Guidance Procedure was initiated. The Bureau and the Minister of Environment Affairs corresponded and a Management Guidance Mission was invited to visit the site in 1992 with the following terms of reference.

(1) To apply the Management Guidance Procedure to the St Lucia System Ramsar site.
(2) To visit other wetlands in South Africa which are included on the List or are considered candidates for inclusion.
(3) To collaborate with local authorities in activities to publicise the value of wetlands and the need for their conservation and wise-use in the spirit of the Ramsar Convention.
(4) To disseminate the aims and objectives of the Ramsar Convention at a wider regional level in southern Africa, particularly in Botswana, Lesotho and Namibia which are (were) not Contracting Parties (Botswana and Namibia have since become Parties).
(5) To attend the forthcoming meeting of the South African Ramsar Working Group.

The mission, with ecologists and mining experts, viewed the existing mining operations south of St Lucia and the proposed mining lease area within the System. They also held discussions with scientists involved in the environmental impact assessment and collected additional literature on the assessment and the System. This allowed the Management Guidance Mission to place the proposed mining operation in perspective, with an appreciation of the international importance of St Lucia.

In the subsequent report to the South African authorities, the Mission suggested that the authorities should consider whether, in view of the importance of the site, the mining application be refused on principle. The mission also recommended consideration be given to such issues as: looking for an alternative sources of ore; conducting an environmental cost/benefit analysis; assessing critical impacts on the St Lucia System and examining the difficulties of dune restoration after mining. Both the Mission report and the environmental impact assessment were subjected to close public scrutiny. An independent review panel subsequently recommended that mining should not be allowed and that special measures should be taken to improve the living standard of the local people (Smart 1994).

The March-Auen (Austria) and Myvatn (Iceland) experiences

The Management Guidance Procedure has also been applied at March-Auen, Austria and Myvatn, Iceland. At March-Auen, on the Austrian banks of the River March, the Management Guidance Mission investigated reports of increasingly intensive agricultural use and of transformation of flood meadows and woodland into arable land. Recommendations from the Mission included: that federal and provincial authorities develop an overall concept for management of the site; necessary administrative and financial means be provided for application of the concept; cross frontier initiatives be pursued, and a proposed canal linking the Danube and Oder go ahead only on the basis of the precautionary principal[1]. Following the report, federal and provincial authorities cooperated with local non-government organisations to produce a document that was to be submitted to the Austrian Federal Minister in 1994 (Smart 1994). The site is still on the Montreux Record.

At Myvatn the Management Guidance Procedure was applied more informally. The site had been exploited by local people for many years, with farming of surrounding land, mining of diatomite and harvesting of fish and waterfowl. Expansion of diatomite dredging activity was proposed and there was concern that this may have a negative effect on the lake's productivity. A Management Guidance Mission visited the site in mid-1992 and reported to the Icelandic Minister of the Environment. Following the report, the Icelandic National Assembly introduced a bill (proposed legislation) confining dredging to a restricted area of the

[1] The United nations Conference on the Environment and Development, held in Rio de Janeiro in 1992 adopted Principle 15 (the "Precautionary Principle") as follows: "In order to protect the environment, the precautionary approach shall be widely applied by the States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation"

lake's northern basin, with dredging to cease by 2010. Following announcement of this bill to the Kushiro Conference of Contracting Parties in 1993, it was agreed that the site be removed from the Record.

Conclusion

The Montreux Record was established, in consultation with the Contracting Parties, to identify priority sites for positive national and international conservation attention. The value of the Record and the Management Guidance Procedure is illustrated above. It is important to note that, as in the case of Myvatn, a site may be removed from the Record when it is considered that the ecological character of the wetland is no longer threatened.

Implementation of the Management Guidance Procedure and placement of sites on the Montreux Record are both dependent on Parties identifying that the *ecological character* of a listed site has undergone, is undergoing, or is likely to undergo change as a result of technological development, pollution, or other human interference. Detection of change, or threatened change, in a timely and reliable manner, is largely dependent on the existence of effective monitoring mechanisms. The development and implementation of such mechanisms is addressed in Parts D and E of this document.

PART B: AUSTRALIA'S RAMSAR SITES

Implementation of the Ramsar Convention in Australia

The Australian Commonwealth, State and Territory Governments each play a major role in implementation of the Ramsar Convention in Australia.

The Australian Commonwealth Government is the Contracting Party to the Convention (only *national governments* can be Contracting Parties to Ramsar). However, under the Australian Constitution, responsibility for land and water management is vested in the States and Territories within their respective areas of jurisdiction. For this reason, responsibility for selection of sites for Ramsar listing - other than sites on Commonwealth Government land - has been delegated by the Commonwealth to the States and Territories. The States and Territories also retain responsibility for the management of sites within their jurisdiction following listing and therefore have a major responsibility for meeting Ramsar obligations and expectations with respect to the conservation of those sites and the detection and reporting of adverse changes, and threats of adverse change, in their ecological character.

The Australian and New Zealand Environment and Conservation Council (ANZECC) is the council of environment and nature conservation ministers of the Commonwealth, State and Territory governments of Australia and the national government of New Zealand. ANZECC provides a forum for the discussion and formulation of coordinated nature conservation and environment programs throughout both countries. A working group of ANZECC, comprising officers from each Australian State and Territory ANZECC conservation agency (e.g. Department of Conservation and Land Management in Western Australia) advises on implementation of the Ramsar Convention and on other wetland issues within Australia and New Zealand. The Biodiversity Group of Environment Australia (EABG) is the principal adviser to the Australian Commonwealth Government on nature conservation issues. EABG provides the convenor for the working group (known as the ANZECC Wetlands Network) and coordinates the implementation of the Ramsar Convention in Australia.

Australia's Ramsar Sites

Currently (25 February 1997), Australia has 49 Ramsar sites (Figure 1; Table 2) with a total area of 5,039,121 ha.

Criteria of Site listings

Many Australian sites have been nominated primarily on the basis of use by waterfowl (Montreux Criterion 3). This is because there is a specific obligation under Ramsar (Article 2.2 of the Convention) for Contracting Parties to list important waterfowl sites "in the first instance". All sites also meet other Montreux Criteria (see Table 2), some of which were adopted by Conferences of Contracting Parties *after*

sites were nominated (listings are updated periodically and where sites already on the List meet new criteria these can be added).

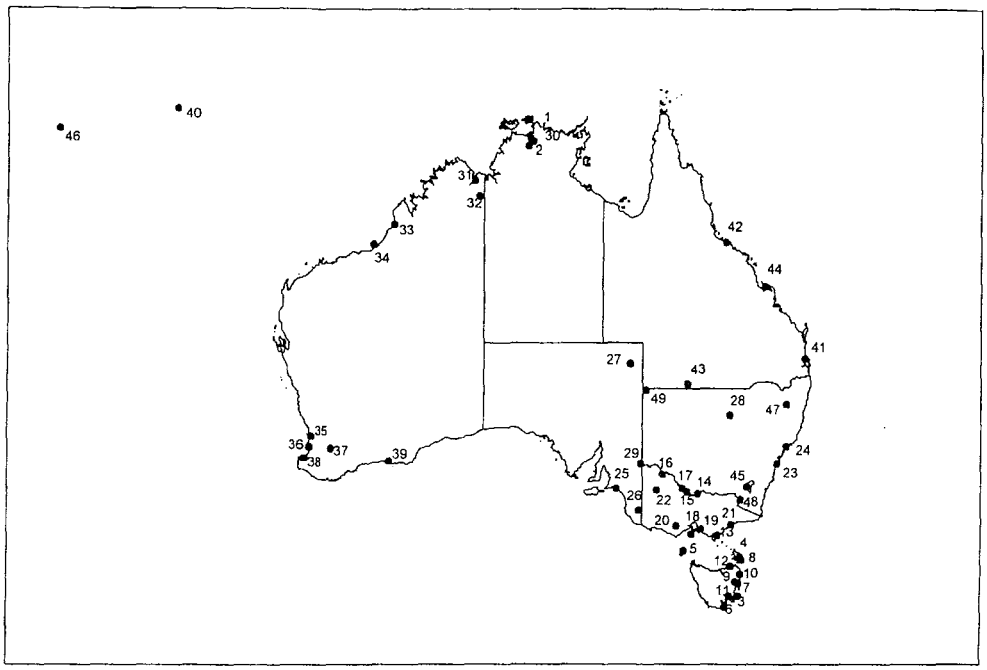

Figure 1. Distribution of the 49 Ramsar wetlands in Australia (sites numbered and cross-referenced to Table 2).

Designation, tenure and management responsibility

Most of the 49 Ramsar sites in Australia are within conservation reserves (national parks, nature reserves, marine parks, game reserves, etc.) (Table 3) and are managed by State and Territory nature conservation agencies or, in the case of the Coburg, Kakadu and Hosnies Spring Ramsar sites, the Biodiversity Group of Environment Australia.

Some sites, however, are on vacant Crown land or unprotected marine waters (e.g. major parts of Roebuck Bay and Eighty Mile Beach), on Crown land leased for other purposes (e.g. pastoralism), on reserves managed by other government agencies for other purposes (e.g. water supply), on privately owned land or on combinations of these.

In Western Australia, the only freehold land within a Ramsar site is a portion of Lake Meelup, within the Peel-Yalgorup Ramsar site. This was included at the request of the Lake Meelup Preservation Society, whose members own the eastern portion of the lake. Two sites (Roebuck Bay and Eighty Mile Beach) are partly covered by pastoral leases.

The ability of State and Territory nature conservation agencies to have Crown lands - particularly vacant Crown land and pastoral leases - designated as conservation reserves has been complicated by the passing, in December 1994, of the Commonwealth Government's *Land (Traditional Titles and Usage) Act.* As a consequence of the Act, if a State or Territory nature conservation agency (or other body) purchases or otherwise acquires a pastoral lease (e.g. for addition to the conservation estate) this must be made known to the Office of Traditional Usage. A land claim or claims may result. Where a claim is made, this has the effect of stalling, or at least greatly delaying, any moves by authorities to have such land reserved for conservation (or other purposes). Efforts to have the nature conservation values of significant areas - including Ramsar sites such as Roebuck Bay and Eighty Mile Beach - provided with a greater level of legal and administrative protection, and to institute protective management and monitoring arrangements, are thereby frustrated. It is to be hoped that improvements will be made to processes of resolving traditional usage issues, preferably to the benefit of all.

Table 2. Australia's Wetlands of International Importance, listed in the order in which they were nominated, with the Criteria under which each site is currently listed (after Jones 1993b). Information for sites 41-49 was taken directly from the respective nomination documents (QDEH 1991a & b, and others supplied by EABG)(see Figure 1 for locations).

	Site	State/ Territory	Area (ha)	Criteria
1	Coburg Peninsula	NT*	220,700	1a, 2a, 3a, 3b
2	Kakadu National Park Stage 1	NT*	683, 000	1a, 1c, 2b, 2c, 3a, 3b, 3c
3	Moulting Lagoon	TAS	4,760	1a, 2c, 3b
4	Logan Lagoon Conservation Area	TAS	2,320	1a, 2c, 3b
5	Lavinia Nature Reserve	TAS	1,730	2a, 2c, 2d
6	Pittwater-Orielton Lagoon	TAS	2,920	2a, 2b, 2d, 3b
7	Apsley Marshes	TAS	940	2a, 2b
8	East-Coast Cape Barren Island Lagoons	TAS	4,230	2b, 2d
9	Flood Plain Lower Ringarooma River	TAS	4,160	2a, 2b
10	Jocks Lagoon	TAS	70	2b
11	Lake Crescent	TAS	470	2a, 2b
12	Little Waterhouse Lake	TAS	90	1b, 2b
13	Corner Inlet	VIC	51,500	1a, 1b, 1c, 2b, 3a, 3b, 3c
14	Barmah Forest	VIC	28,500	1a, 2b, 3b
15	Gunbower Forest	VIC	19,450	2b, 3b
16	Hattah-Kulkyne Lakes	VIC	1,018	2b, 3b
17	Kerang Wetlands	VIC	9,172	1a, 2c, 3b
18	Port Phillip Bay & Bellarine Peninsula	VIC	7,000	1a, 1b, 2b, 3a, 3c
19	Western Port	VIC	53,325	1a, 1b, 3a
20	Western District Lakes	VIC	30,182	1a, 3a
21	Gippsland Lakes	VIC	43,046	1a, 3a
22	Lake Albacutya	VIC	10,700	1a, 1b, 3a
23	Towra Point Nature Reserve	NSW	364	1b, 1d, 2a, 2b, 2c, 3b, 3c
24	Kooragang Nature Reserve	NSW	2,206	1a, 1c, 2a, 3b, 3c
25	Coorong and L. Alexandrina and Albert	SA	140,500	1a, 2a, 2b, 2c, 3a, 3c
26	Bool and Hacks Lagoon	SA	3,200	1a, 2a, 2b, 2c, 3a, 3c
27	Macquarie Marshes Nature Reserve	NSW	18,143	1a, 2c, 3a, 3b, 3c
28	Coongie Lakes	SA	1,980,000	1b, 2a, 2b, 2c, 2d, 3b
29	"Riverland"	SA	30,600	1a, 3a, 3c
30	Kakadu National Park Stage II	NT*	692,940	1a, 1c, 2b, 2c, 3a, 3b, 3c
31	Ord River floodplain	WA	130,000	1a, 2a, 2b, 3b
32	Lakes Argyle & Kununurra	WA	150,000	1d, 2a, 3a
33	Roebuck Bay	WA	50,000	1a, 2c, 3a, 3c
34	Eighty Mile Beach	WA	125,000	1a, 2c, 3a, 3c
35	Forrestdale & Thomsons Lakes	WA	754	1a, 2b, 3a, 3c
36	Peel-Yalgorup System	WA	21,000	1a, 2d, 3a, 3c
37	Lake Toolibin	WA	437	1d, 2b, 2c
38	Vasse-Wonnerup System	WA	740	1d, 3a, 3c
39	Lake Warden System	WA	2,300	1a, 3a, 3c
40	Hosnie's Spring (Christmas Island)	Cwlth	<1	1d, 2a, 2d
41	Moreton Bay	QLD	113,314	1a, 1b, 1c, 2a, 2b, 2c, 3a, 3b
42	Bowling Green Bay	QLD	35,500	1a, 1b, 1c, 2a, 2b, 2c, 3a, 3b, 3c
43	Currawinya Lakes	QLD	151,300	1a, 1b, 2a, 2b, 2c, 3a, 3b, 3c
44	Shoalwater & Corio Bays	QLD & Cwlth	239,100	1a, 1c, 2a, 2b, 2c, 2d, 3a, 3b, 3c
45	Ginini Flats Subalpine Bog complex	ACT	125	1a, 2a, 2b, 2c
46	Pulu Keeling National Park	Cwlth	122	1a, 1d, 2a, 2b, 2c
47	Little Llangothlin Nature Reserve	NSW	258	1a, 2a, 2c
48	Blue Lake	NSW	320	1a, 1d, 2b, 2d
49	Lake Pinaroo	NSW	800	1a, 2a, 2c, 2d, 3b
	TOTAL AREA		**5,039,121 ha**	

* Site on Commonwealth Government land

Table 3. Designation/tenure of lands and waters of Australian Ramsar sites (after Jones 1993b). Information for sites 41-49 has been taken directly from the respective nomination documents (QDEH 1991a & b; and others supplied by EABG).

	Site	State	Designation/Tenure
1	Coburg Peninsula	NT*	National Park, with Marine Park adjacent to site
2	Kakadu National Park Stage 1	NT*	National Park
3	Moulting Lagoon	TAS	Game Reserve
4	Logan Lagoon Conservation Area	TAS	Conservation Area
5	Lavinia Nature Reserve	TAS	Nature Reserve
6	Pittwater-Orielton Lagoon	TAS	Crown Land and Nature Reserve
7	Apsley Marshes	TAS	Unprotected private land
8	East-Coast Cape Barren Island Lagoons	TAS	Crown Land unprotected
9	Flood Plain Lower Ringarooma River	TAS	Crown and Private Land - all unprotected
10	Jocks Lagoon	TAS	Private Land & partly State Recreation Area.
11	Lake Crescent	TAS	Partly included in Crown Reserve, remainder private land
12	Little Waterhouse Lake	TAS	Conservation Area
13	Corner Inlet	VIC	Three-quarters of site is in Marine and Wildlife Reserves, the remainder is unprotected Crown Land
14	Barmah Forest	VIC	State Park and State Forest
15	Gunbower Forest	VIC	State Forest, part of which is a Wildlife Sanctuary
16	Hattah-Kulkyne Lakes	VIC	Within a National Park
17	Kerang Wetlands	VIC	22 wetlands consist of 7 State Wildlife Reserves, 8 Water Supply Reserves, 3 Salinity Disposal Reserves and 4 areas of Crown Land.
18	Port Phillip Bay & Bellarine Peninsula	VIC	3 State Wildlife Reserves, 3 Marine Reserves, a Wildlife Sanctuary & a Metropolitan Reserve.
19	Western Port	VIC	Currently unprotected, but nominated for declaration as a Wildlife Management Co-operative Area and a Wildlife Reserve but by different authorities.
20	Western District Lakes	VIC	Parts of the site are State Wildlife Reserves and Lake Reserves
21	Gippsland Lakes	VIC	8 State Wildlife Reserves, 5 Crown Land Reserves, part of 1 Coastal Park and part of 1 National Park
22	Lake Albacutya	VIC	Within a Regional Park
23	Towra Point Nature Reserve	NSW	A Nature Reserve, with an aquatic reserve to protect inter-tidal and sub-tidal areas
24	Kooragang Nature Reserve	NSW	Nature Reserve
25	Coorong and Lakes Alexandrina and Albert	SA	National Park, several Game Reserves and Crown Land
26	Bool and Hacks Lagoon	SA	One Game Reserve and one Conservation Park
27	Macquarie Marshes Nature Reserve	NSW	Nature Reserve
28	Coongie Lakes	SA	Crown Land, part of which is Regional Reserve, the remainder is pastoral lease
29	"Riverland"	SA	Crown Land and National Park
30	Kakadu National Park Stage II	NT*	National Park
31	Ord River floodplain	WA	5 Nature Reserves which are being amalgamated
32	Lakes Argyle & Kununurra	WA	Currently unprotected crown and, but part proposed as a Nature Reserve and the remainder as a water management reserve
33	Roebuck Bay	WA	Currently unprotected Crown Land but proposed for designation as a Marine Park, with 2 additional Nature Reserves
34	Eighty Mile Beach	WA	Unprotected Crown Land, part of which has been recommended for inclusion in a Nature Reserve and part as a Marine Park.
35	Forrestdale & Thomsons Lakes	WA	Two separate Nature Reserves
36	Peel-Yalgorup System	WA	Partly in Nature Reserves and National Parks, and partly unprotected
37	Lake Toolibin	WA	Nature Reserve
38	Vasse-Wonnerup System	WA	Largely unprotected; partly in a Nature Reserve & partly on private land

	Site	State	Designation/Tenure
39	Lake Warden System	WA	Included in three Nature Reserves
40	Hosnie's Spring (Christmas Island)	Cwlth	National Park
41	Moreton Bay	QLD	Combination of National Parks, State Sanctuaries, Fish Habitat Reserves, Queensland Water, Crown Land and private land
42	Bowling Green Bay	QLD	Majority in a National Park, also includes vacant Crown land, leasehold and Special Purpose Reserves, all designated for inclusion in the National Park
43	Currawinya Lakes	QLD	National Park
44	Shoalwater & Corio Bays	QLD & Cwlth	Military training area (terrestrial component of Shoalwater Bay), State and Commonwealth Marine Parks (marine areas), State Fish Habitat Reserve (Corio Bay only)
45	Ginini Flats Subalpine Bog complex	ACT	National Park
46	Pulu Keeling National Park	Cwlth	National Park (owned by Shire Council and leased to Commonwealth Government)
47	Little Llangothlin Nature Reserve	NSW	Nature Reserve
48	Blue Lake	NSW	National Park
49	Lake Pinaroo	NSW	National Park

* Site on Commonwealth Government land

Threats to the Sites

The State, Territory and Commonwealth agencies responsible for nominating Australia's Ramsar sites have identified various threats, disturbances and other conservation issues at each. These have been registered on the Ramsar database (and published - sites 1-40 only - in Jones 1993b) and are summarised under broad categories in Table 4.

Table 4. Conservation issues/threats at Australian Ramsar-listed sites as listed in Jones (1993b). Information for sites 41-49 has been taken directly from the respective nomination documents (QDEH 1991a & b; and others supplied by EABG).

Conservation Issue/Threat	Wetlands where issues identified
Recreation (tourism, visitor access, trails, 4WD use, angling access)	Coburg Peninsula, Moulting Lagoon, Jocks Lagoon, Lake Crescent, Port Phillip Bay & Bellarine Peninsula, Western Port, Gippsland Lakes, Towra Point, Kooragang, Lake Warden system, Ginini Flats, Pulu Keeling, Blue Lake, Lake Pinaroo
Feral/exotic/noxious animals (cats, foxes, buffalo, cattle, horses, pigs, goats, rabbits, rats, trout etc)	Coburg Peninsula, Kakadu Stage (I), Sea Elephant Nature Reserve, Port Phillip Bay & Bellarine Peninsula, Western District Lakes, Towra Point, Kooragang, Macquarie Marshes Nature Reserve, Coongie Lakes, Kakadu Stage (II), Currawinya Lakes, Shoalwater & Corio Bays, Ginini Flats, Pulu Keeling, Little Llangothlin, Lake Pinaroo
Invasive exotic/noxious plants	Kakadu Stage (I), Moulting Lagoon, Apsley Marshes, Lake Crescent, Little Waterhouse Lake, Corner Inlet, Port Phillip Bay & Bellarine Peninsula, Western Port, Towra Point, Kooragang, Kakadu Stage (II), Ord River floodplain, Forrestdale & Thomsons Lakes, Shoalwater & Corio Bays, Ginini Flats, Little Llangothlin, Lake Pinaroo
Plant pathogens ("dieback")	Little Llangothlin
Inappropriate fire regime	Shoalwater & Corio Bays, Ginini Flats
Mineral exploration/extraction	Kakadu Stage (I), Sea Elephant Nature Reserve, Lower Ringarooma River, Kakadu Stage (II), Ord River floodplain, Lakes Argyle & Kununurra, Roebuck Bay, Eighty Mile Beach, Hosnie's Spring, Moreton Bay
Shooting/lead shot	Moulting Lagoon, Apsley Marshes, Lake Crescent, Bool & Hacks Lagoons

Conservation Issue/Threat	Wetlands where issues identified
Illegal fishing/hunting	Shoalwater & Corio Bays, Pulu Keeling
Military training	Shoalwater & Corio Bays
Livestock grazing/access	Moulting Lagoon, Apsley Marshes, East Coast Cape Barren Island Lagoons, Lower Ringarooma River, Barmah Forest, Gunbower Forest, Port Phillip Bay & Bellarine Peninsula, Western Port, Western District Lakes, Gippsland Lakes, Ord River floodplain, Eighty Mile Beach, Currawinya Lakes
Overgrazing due to excessive increases in native animal populations	Gunbower Forest, Hattah-Kulkyne Lakes, Currawinya Lakes, Lake Pinaroo
Water catchment reservoir/regulation changing natural hydrologic cycle	Moulting Lagoon, Barmah Forest, Gunbower Forest, Hattah-Kulkyne Lakes, Kerang Wetlands, Western District Lakes, 'The Coorong, Lake Alexandria and Lake Albert', Macquarie Marshes Nature Reserve, Riverland, Lakes Argyle & Kununurra, Forrestdale & Thomsons Lakes, Peel-Yalgorup system
Reduced water inundation, extraction, draining	Logan Lagoon, Little Waterhouse Lagoon, Gippsland Lakes, Lake Albacutya
Urban/residential/resort developments	Sea Elephant Nature Reserve, Lake Crescent, Port Phillip Bay & Bellarine Peninsula, Gippsland Lakes, Towra Point, Forrestdale & Thomsons Lakes, Peel-Yalgorup system, Vasse-Wonnerup system, Hosnie's Spring, Bowling Green Bay, Moreton Bay
Industrial Developments	Corner Inlet, Port Phillip Bay & Bellarine Peninsula, Western Port, Towra Point, Bowling Green Bay, Moreton Bay
Dredging, drainage modifications	Pittwater-Orielton Lagoon, Port Phillip Bay & Bellarine Peninsula, Western Port
Infilling/dumping refuse	Pittwater-Orielton Lagoon, Western Port, Kooragang, Moreton Bay
Agricultural development, land clearance, logging	Jocks Lagoon, Barmah Forest, Gunbower Forest, 'The Coorong, Lake Alexandria and Lake Albert', Macquarie Marshes Nature Reserve, Riverland, Forrestdale & Thomsons Lakes, Peel-Yalgorup system, Lake Toolibin, Bowling Green Bay
Nutrient/effluent/chemical/pesticide inputs (drainage into wetland)	Lake Crescent, Kerang Wetlands, Port Phillip Bay & Bellarine Peninsula, Western Port, Western District Lakes, Gippsland Lakes, Bool & Hacks Lagoons, Forrestdale & Thomsons Lakes, Peel-Yalgorup system, Bowling Green Bay, Moreton Bay, Blue Lake
Salinisation	Barmah Forest, Kerang Wetlands, Western District Lakes, Gippsland Lakes, 'The Coorong, Lake Alexandria and Lake Albert', Bool & Hacks Lagoons, Macquarie Marshes Nature Reserve, Riverland, Lake Toolibin
Nitrification	Little Llangothlin
Sedimentation/siltation	Barmah Forest, Gippsland Lakes, Macquarie Marshes Nature Reserve, Currawinya Lakes, Little Llangothlin, Blue Lake
Erosion	Barmah Forest, Port Phillip Bay & Bellarine Peninsula, Gippsland Lakes, Macquarie Marshes Nature Reserve, Currawinya Lakes, Little Llangothlin, Blue Lake

A second summary of conservation issues/threats at Australian Ramsar sites may be derived from *A Directory of Important Wetlands in Australia, 2nd Edition* (ANCA 1996).

This Directory, compiled by State, Territory and Commonwealth nature conservation agencies, identifies 698 wetlands and wetland complexes, covering an area of 24.2 million hectares, as being of national importance (Table 5). Forty five of Australia's 49 Ramsar sites are included in the Directory (four were Ramsar-listed after its publication) - either wholly or divided into component parts. Lakes Argyle and

Kununurra, for example, are listed as a single, *internationally* important site under Ramsar, but are listed as separate, *nationally* important sites in the Directory.

Table 5. The number and area of nationally important wetlands in each State and Territory. (ANCA 1996).

State/Territory	No. Sites	Area (ha)
ACT	13	667
NSW*	94	2 171 737
NT*	30	2 912 790
QLD*	165	11 453 556
SA	68	4 100 287
TAS	91	20 828
VIC*	121	395 104
WA*	110	2 056 246
External Territories*	6	1 090 582
TOTAL	698	24 201 797

* Includes sites on lands of the Australian Commonwealth Government.

A comparison of the *Directory of Important Wetlands in Australia 2nd Edition* with the Ramsar Database (as reported in Jones 1993b) shows that while for some Ramsar sites the identified issues/threats are the same, for others there are significant differences. For each of the nine Western Australian Ramsar sites, for example, the Directory lists a number of threats not recorded in the Database (Table 6). These differences are due primarily to increasing knowledge of the threats which sites face.

Without exception, all Australian Ramsar sites have acknowledged threats to their ecological character. No doubt some sites have additional threats that have yet to be formally recognised or even detected (see, for example, the case studies in Part F of this document). Given Australia's obligations under Article 3.2 of the Ramsar Convention, these threats, and any significant adverse changes resulting from them, need to be identified and dealt with, on a site by site basis.

RECOMMENDATION 3. That Australia's Ramsar implementation agencies give priority to the development and implementation, at each Australian Ramsar site, of site-specific environmental monitoring programs that will enable Australia to fulfill its obligations to promote the conservation of listed wetlands and to detect and report adverse changes, including likely changes, in a timely manner.

The Wetlands Unit of the Biodiversity Group of Environment Australia has indicated that it proposes to undertake a detailed analysis of information contained in the Second Edition of *A Directory of Important Wetlands in Australia*, including threats to the ecological character of all sites listed in it (ANCA 1996; p.5). This analysis can be expected to provide a useful summary of the threats faced by, and any adverse changes occurring at, Australia's Ramsar sites, as at the time of compilation of the Second Edition (1995).

Wetlands International presented an analysis of data from the Ramsar Database to the 6th Conference of Contracting Parties. As part of this analysis (entitled *An Overview of the World's Ramsar Sites*), the five most frequently recorded "change factors" occurring inside Ramsar sites in each Ramsar Region (Africa, Asia, Oceania, etc.) were reported. The most frequently reported factors in Oceania (48 sites, of which 42 were in Australia) were "water regulation", "agricultural impacts (including agricultural pollution)", "faunal effects", "pollution" and "habitat effects". The analysis was noted by the Conference and Wetlands International was requested to develop it further, "in particular with a view to presenting a

summary of the frequency and distribution of different categories of threat ... and drawing conclusions on the success or otherwise of Ramsar listing in reducing such threats" (Conference Resolution C.6.13).

Table 6. Conservation issues, disturbances and threats identified at Western Australian Ramsar sites in the Ramsar Asia and Oceania Directory (Jones 1993b) and *A Directory of Important Wetlands in Australia* (ANCA 1996).

Ramsar Site	Threats identified in the Ramsar Directory	Additional threats listed in the Directory of Important Wetlands in Australia
Ord River floodplain	Tourism, cattle grazing, exotic plants, mining.	Upstream flow regulation, aquaculture, pesticides from upstream irrigation, fire regime.
Lakes Argyle & Kununurra	Water level management, eutrophication, mining.	Siltation, exotic plants, water pollution from urban/agricultural activities.
Roebuck Bay	Petroleum exploration.	Mining, unsustainable hunting of Dugong, disturbance of shorebirds, oil spill.
Eighty Mile Beach	Cattle grazing, petroleum exploration.	4WD use, disturbance of shorebirds.
Forrestdale & Thomsons Lakes	Nutrient inputs, pesticide use, exotic plants, agricultural & urban development, altered water regime.	Human disturbance of lake when drying-out, botulism.
Peel-Yalgorup System	Eutrophication, algal blooms, urban development, agricultural run-off.	Siltation, mosquito control measures, some recreational activities, dredging and spoil dumping, possible adverse impacts of Dawesville Channel, groundwater extraction.
Lake Toolibin	Salinisation, vegetation clearing.	Eutrophication from agricultural run-off, increased inundation,
Vasse-Wonnerup System	Urban development, agricultural run-off.	Exotic plants, livestock grazing, mining, altered water regime, landfill of floodplain, seawater intrusion, mining, pollution, disturbance of waterbirds.
Lake Warden System	4WD access, human disturbance.	Eutrophication from agricultural run-off, salinisation.

Resolution C.6.13 also called upon Contracting Parties to revise the data provided for the Ramsar database at least every six years (i.e. every second Conference) "for monitoring purposes". The revised Information Sheet (see Resolution C.6.1) is to be used for this purpose. A revision of data for Australia's sites is currently being undertaken by the Commonwealth, State and Territory Ramsar implementation agencies within their respective areas of jurisdiction and is due for completion in 1997. This will provide the most up-to-date statement available of threats and adverse changes at Australia's sites.

PART C: ECOLOGICAL CHARACTER AND CHANGE UNDER RAMSAR

In order to properly address threats to the ecological character of Ramsar Sites, as required under Article 3.2 of the Convention, it is necessary to firstly consider the twin issues of what is ecological character and what constitutes significant adverse change.

What is Ecological Character and What Constitutes Change

Dugan & Jones (1993) defined the 'ecological nature' of a wetland to be '*the sum of the functions, products and attributes which give the wetland value, these in turn being the product of the interchange between the biological and physical components of the ecosystem.*' They then defined ecological change as the '*alteration of the biological and/or physical components of the ecosystem, and/or the interaction between them, in a manner which results in a reduction in the quality of those functions, products and attributes which give the wetland value to society*'.

Finlayson (1995a) modified the Dugan & Jones definition of ecological character to become '*the sum of the wetland's functions, products, and attributes that are derived from the individual biological, chemical, and physical components of the ecosystem and their interactions*'. Using this definition, Finlayson then defined a change in ecological character of a wetland as occurring '*as the result of technological developments, pollution, or other human interferences with the biological, chemical and/or physical components of the ecosystem and/or the interactions between them to such an extent that a reduction and/or an ongoing imbalance occurs in any of those functions, products, and attributes which give the wetland benefits and values*'.

Ramsar Definitions of Ecological Character and Change

The 6th Conference of Contracting Parties to Ramsar, following consideration of work undertaken by the Scientific and Technical Review Panel (STRP) on this issue during the previous triennium, and the outcomes of a technical session held at the Conference, adopted a resolution (Res. C.6.1) to "accept working definitions, to be assessed further during the 1997-99 triennium, of 'ecological character' and 'change in ecological character', together with .. guidelines (contained in an Annex) for describing and maintaining ecological character of listed sites ..".

The interim Working Definitions adopted by the Conference are as follows.

> *The **"ecological character"** is the structure and inter-relationships between the biological, chemical and physical components of the wetland. These derive from the interactions of individual processes, functions, attributes and values of the ecosystem(s).*
>
> ***"Change in ecological character"** of a wetland is the impairment or imbalance in any of those processes and functions which maintain the wetland and its products, attributes and values.*

"Change" is interpreted (in the Annex) as meaning adverse change caused by human activities and excludes natural evolutionary changes that occur in wetlands.

The Annex suggests possible interpretations of the terms "processes", "functions", "products" and "attributes". However, several Contracting Parties, including Australia, have expressed some concern about these interpretations and they are to be reviewed. (EABG 1997, pp 15, 27).

RECOMMENDATION 4. That, for the purpose of monitoring ecological change and threats of ecological change in Australia's wetlands of international importance, relevant Australian government authorities[1] make use of the interim working definitions of "ecological character" and "change in ecological character" accepted by the 6th Conference of Contracting Parties to the Ramsar Convention (Brisbane 1996). That in doing so, authorities take into account both the interim nature of those definitions and the concerns expressed by Australia and other countries about some aspects of possible interpretation.

[1] "Relevant Australian government authorities" includes both "Ramsar implementation agencies" and any other government agencies responsibile for on-ground management of Australian Ramsar sites (see Table 3).

Ramsar Guidelines for Monitoring Ecological Character

The guidelines referred to above (Annex to Res. C.6.1.) for "describing and maintaining" the ecological character of Ramsar Sites are summarised below. Due to their significance in the context of this report, they are also reproduced in full at Appendix 1.

- The ecological character of a site is to be described by the Contracting Party at the time of designation for the Ramsar List, by completion of an Information Sheet (as adopted by Recommendation 4.7; modifications are proposed - refer to the full text of this Annex).

- Contracting Parties are requested to verify the Information Sheet data every six years (this is also called for under Resolution C.6.13) and provide the Bureau with updated sheets if necessary. During the intervening period, urgent information on changes at listed sites should be conveyed to the Bureau forthwith.

- Change in ecological character should be assessed against the status presented in the Information Sheet at the time of designation for the List (or at the time the Information Sheet was first provided to the Bureau), together with any information which has been received subsequently.

- Assessment should be linked to the Ramsar criteria fulfilled by the site at the time of designation. However, this forms only part of the assessment needed, since significant degradation of wetland functions and values might occur without any of the designated Ramsar criteria being contravened.

- An effective monitoring and survey programme is a prerequisite for assessing whether or not a wetland has undergone a change in its ecological character.

- Monitoring should establish the range of natural variation in ecological parameters at each site, within a given time frame. Change in ecological character occurs when these parameters fall outside their normal range.

- A Contracting Party may decide to restore a wetland to re-establish the ecological character that existed prior to the date of designation. In the case of such restoration programmes, a new Information Sheet should be provided, to establish a new baseline for assessing any future change. Information should also be given concerning the target state that any restoration is aiming at.

- Monitoring differs from general surveillance in that there is a specific reason and method for collecting particular data or information.

- Monitoring does not automatically require sophisticated technology or high investment and can be carried out at different levels of intensity. It is emphasised that there are many different monitoring techniques available, and that each Contracting Party should select the technique(s) most appropriate to its priorities and available resources.

- A monitoring programme should, ideally, be an integral part of a site-specific wetland management plan. However, where a management plan does not yet exist, it is still possible to implement a monitoring programme (though without the framework of a management plan, it will be difficult to implement the results of monitoring effectively).

RECOMMENDATION 5. That relevant Australian government authorities note the set of guidelines accepted by the 6th Conference of Contracting Parties for "describing and maintaining" the ecological character of Ramsar-listed wetlands.

The guidelines also suggest a "framework" which "might be of assistance to Contracting Parties in designing effective wetland monitoring programmes". This framework (see Appendix 1) is based on a text (Finlayson 1995b) prepared for the MedWet Methodological Guide for Monitoring Programmes in Mediterranean Wetlands and is relevant to "PART E: Designing an Environmental Monitoring Program" of this report.

PART D: MONITORING THE CHARACTER OF AUSTRALIA'S RAMSAR SITES

In order to address the many threats faced by Australia's 49 Ramsar Sites, it is necessary for site-specific monitoring programs to be developed and implemented as a matter of urgency. The approach taken could be determined independently at each Australian Site, however this would be likely to result in much "re-inventing of the wheel" (which would be wasteful of resources) and may not produce satisfactory results (at least at some Sites), in terms of monitoring program design, implementation, and integration with Site management. Reporting of results, at both State/Territory and national levels, as necessary under Ramsar, is also likely to be hampered by such an approach. For these reasons it is recommended that a standardised procedure, as described below, be adopted for developing and implementing monitoring programs for Australia's Ramsar wetlands.

The recommended procedure

The recommended procedure involves a series of steps, the extent of which will vary from one wetland to another depending on the type of wetland, land tenure, conservation threats and the degree of ecological change that has occurred, is occurring or is believed likely to occur. The procedure is summarised in Table 7 and each stage is discussed in detail in the following sections. It is recommended that the procedure be followed at all Australian Ramsar sites. At those sites where environmental monitoring and management is already occurring it is recommended that the procedure be implemented to verify the adequacy of those programs. Central to the procedure is the development and implementation of an *Environmental Monitoring Program (EMP)* for each site. The design of EMPs is discussed in Part E of this report.

RECOMMENDATION 6. That a standardised procedure, as described in Part D and summarised in Table 7 of this document, be applied by relevant Australian government authorities for the purpose of developing and implementing programs for monitoring the ecological character (and threats to this) of Australia's Ramsar-listed wetlands.

Identification of management responsibility

Where Ramsar sites are designated as conservation reserves and managed by State, Territory or Commonwealth nature conservation (ANZECC) agencies, arrangements for environmental monitoring, management and reporting to meet Ramsar obligations should be relatively straightforward, as the management agency is also the State, Territory or Commonwealth Agency responsible for Ramsar implementation (i.e. the "Ramsar implementation agency").

In those instances where Ramsar sites are *not* on land (or water) managed by ANZECC nature conservation agencies, those agencies will need to consult with the site manager(s) to ensure that environmental monitoring, management and reporting arrangements, via the relevant Ramsar implementation agency, fulfill Australia's obligations under Ramsar.

RECOMMENDATION 7. That where a Ramsar site is managed by an organisation (or individuals) other than a Ramsar implementation agency, the relevant implementation agency consult with the managing body to arrange the monitoring necessary to fulfill Australia's obligations to promote the conservation of Ramsar-listed wetlands and to report adverse changes, including likely changes.

Where Sites are currently unvested and unmanaged (e.g. Roebuck Bay and Eighty Mile Beach), Ramsar implementation agencies may need to develop, in consultation with other stakeholders, interim arrangements to meet Ramsar monitoring and reporting requirements. This may also apply in situations where current vesting or ownership is considered inappropriate given a site's international significance under Ramsar, and changes in ownership or vesting are proposed.

RECOMMENDATION 8. That where management responsibility for a Ramsar site is undecided, uncertain or a change is proposed, and where early resolution appears improbable, the relevant State, Territory or Commonwealth Ramsar implementation agency consider organising interim monitoring arrangements in order to fulfill Ramsar obligations and expectations.

Table 7. Procedure for initiating and conducting environmental monitoring and management of individual Ramsar sites.

State/Territory to nominate lead agency to implement and administer the Ramsar Convention at the State/Territory level (e.g. Department of Conservation & Land Management in Western Australia)

↓

Lead agency to identify agency responsible for management of the site (either self or other agency)

↓

Management agency to delegate responsibility for implementing environmental monitoring and management of the site to the relevant site (or regional) manager

↓

Management agency to list values for which wetland was originally nominated and make preliminary assessment of conservation threats and disturbances

↓

Management agency to draft interim list of members of a site-specific Scientific Monitoring & Management Committee (SMMC), with relevant expertise to address the identified values and threats

↓

SMMC meets at the site to discuss the EMP process, the values and threats, to identify additional areas of expertise required on the committee and to plan overview presentations to be given at a public meeting on the wetland

↓

Management agency to convene public meeting to explain the Ramsar Convention, State obligations for monitoring and management of sites, the EMP process, the wetland values, threats to those values, and to invite input and involvement from the public in the process

↓

Additional wetland values and threats identified in public meeting incorporated if appropriate in the process. Membership of SMMC reviewed to address new and relevant issues raised in public meeting

↓

SMMC to prioritise conservation threats and disturbances for management action

↓

SMMC to draft an environmental monitoring program that addresses threats to wetland values

↓

Draft Environmental Monitoring Program for the wetland is released for public comment

↓

Draft Environmental Monitoring Program is revised by SMMC following public comment and then submitted for approval by State Management Agency and State Implementation Agency

↓

Monitoring program implemented, and is interactive with management

⇩ ⇩ ⇩

Revision ongoing. Management agency periodically to inform the public of progress and solicit feedback

Role of the Site Manager in Monitoring

Once the management agency has been decided (or interim arrangements have been put in place) then the environmental monitoring process may be initiated. For the process to be effective it must have an ongoing interactive relationship with management of the site. Little is gained from having an extensive

environmental monitoring program collecting quality data if the information it produces is not quickly acted upon.

In its simplest form, the process will involve the following.

1. Management initiates environmental monitoring.
2. Environmental monitoring detects a substantial adverse change.
3. Management is informed of the change.
4. Action needed to correct or mitigate change is determined
5. Agreed action is undertaken.
6. Continued environmental monitoring assesses effectiveness of management action.
7. Results of continued monitoring are reported to management.
8. Management action is judged effective and no additional management action is required - or - management action is judged ineffective and additional action and directed (targetted) monitoring are undertaken.

To ensure that the process is interactive, and closely aligned to the capabilities and information needs of management, it is recommended that it be driven by the Regional Manager (or equivalent officer) with delegated (by the Site management agency) responsibility for management of the Site, in consultation with the relevant ANZECC Wetlands Network officer (State, Territory or Commonwealth).

An example of this arrangement working very successfully is provided by the Toolibin Lake Ramsar Site in Western Australia, where the Manager of the WA Department of Conservation and Land Management's Wheatbelt Region is responsible for management of the Site and chairs both the Toolibin Lake Recovery Team and its Technical Advisory Committee. The work of these two committees, which has included the design and implementation of a Site monitoring program (Froend & Storey 1996a & b), involves a great deal of interaction and productive cooperation between Site management personnel, scientists, technical experts and catchment landholders.

RECOMMENDATION 9. That, in order to ensure that monitoring programs are relevant, realistic and interactive with management, the preparation and implementation of individual environmental monitoring programs for detecting change and threats of change to the ecological character of each of Australia's Ramsar sites be driven by the Regional Managers (or equivalent) with delegated responsibility for the management of those Sites.

Management plans and monitoring

Resolution C.5.7 of the Kushiro Conference (1993) calls upon Contracting Parties to develop management plans for each wetland designated for the Ramsar List. The Resolution (Annex) recognises that management planning is a process subject to constant review and revision, and that management plans should therefore be regarded as flexible, dynamic documents. The importance of monitoring in order to provide a basis for periodic reviews of management plans is indicated. Monitoring is referred to as an "all-important" activity to be undertaken.

The Ramsar "Guidelines for describing and maintaining the ecological character of listed Sites" (Annex to Resolution C.6.1) suggest that ideally, a monitoring program should be an integral part of a site-specific wetland management plan. Lack of a management plan does not, however, prevent a monitoring program from being implemented.

In recent years, preparation of management plans for Australia's Ramsar Sites has been a high priority of the National Wetland Program (NWP), administered by ANCA (now Environment Australia Biodiversity Group). Funding has been provided through NWP to State and Territory Ramsar implementation agencies to prepare plans for many Sites. Most Australian Sites now have formal management plans in place or under preparation (or review).

Given the critical importance of ongoing monitoring in assessing:

- the effectiveness of individual Site management plans and their implementation in maintaining the ecological character of those Sites, and
- the nature and direction of changes that will, at times, be needed for those plans,

it is recommended that the development and implementation of Site-specific monitoring programs be given similar, high priority in the allocation of funding and other resources to the preparation and implementation of Site-specific management plans. Where plans are being prepared, environmental monitoring programs should be developed at the same time and ideally should form part of those plans. Where plans already exist, monitoring programmes should be developed and implemented as a matter of urgency to provide a basis for periodic review of those plans and their effectiveness.

RECOMMENDATION 10. That the development and implementation of substantial, Site-specific, environmental monitoring programs be recognised as essential to the preparation, implementation and periodic review of Ramsar Site management plans and that this be reflected in the timing and relative allocation of funding and other resources by Australia's Ramsar implementation agencies.

Coordination of Ramsar Site monitoring and reporting

Ramsar implementation agencies may find it beneficial to designate or establish specialist units to coordinate, and where appropriate undertake, monitoring of Ramsar-listed (and possibly other important) wetlands. This would facilitate the development of a coherent and concerted approach to monitoring and management of Sites within each jurisdiction and nationally. This is particularly pertinent in jurisdictions where one or more Sites are managed by bodies other than the relevant Ramsar implementation agency. The formation of dedicated units would also facilitate the development of program design criteria; data collection, processing and analysis methodologies; program quality assurance and quality control, and national cooperation. Preparation of reports and other advice, as necessary to meet Ramsar obligations and expectations, on adverse changes or threats of change, could also be coordinated and undertaken by these units.

RECOMMENDATION 11. That Commonwealth, State and Territory Ramsar implementation agencies designate or appoint suitably qualified personnel to coordinate, and where appropriate undertake, site-specific monitoring of the ecological character of Ramsar sites within their respective areas of jurisdiction and the preparation of reports and other advice, as necessary to meet Ramsar obligations, on adverse changes and threats of change.

Identification of wetland values and threats to those values

The first task of the management agency in the environmental monitoring process will be to review the values (particularly those specified as meeting Ramsar criteria) identified at the time the wetland was nominated for listing under the Convention. This maybe achieved by reference to Part Two (Asia and Oceania) of the Directory of Wetlands of International Importance (Jones 1993b), to the recent Directory Update (Ramsar 1996) and to original site nomination documents.

Revised criteria for identifying wetlands of international importance were adopted at the 5th Conference of Contracting Parties in Kushiro in 1993 (see earlier section on "The Montreux Criteria") and a fourth criterion relating specifically to fishes was added at the 6th Conference in Brisbane in 1996. Consequently, wetlands nominated prior to either of these dates may now satisfy additional criteria not in force at the time of nomination. In the context of Ramsar, this may influence the determination of "ecological character" at particular sites.

Recent research or surveys may also have revealed that some sites that were previously thought not to meet particular criteria, now do so (either because a positive change has occurred at the site or, more commonly, previous knowledge of values of the Site was incomplete). Site descriptions in *ADirectory of Important Wetlands in Australia* (ANCA 1996) include a number of such recently discovered values.

All of the values identified by the processes referred to above need to be listed so that a determination of ecological character may be made.

After listing the values, the management agency needs to identify and determine the extent and severity of any disturbances or threats to the site. This process will firstly involve reviewing disturbances and threats recognised in the Asia & Oceania Directory (Jones 1993b), the Update (Ramsar 1996), *A Directory of Important Wetlands in Australia* (*op. cit.*), and any scientific, management or other literature (published and unpublished) concerning the Site and its catchment.

It is important to identify potential threats as early as possible in order that these may be prevented, deflected or minimised and (if the threat cannot be prevented or deflected) in order that monitoring programs may be put in place or modified so as to ensure that adverse changes (either in the wetland itself or in its catchment) are detected in a timely manner. Early warning of impending change will, in many instances, allow remedial action to be taken before serious damage to ecological character occurs.

Early indications of potential threats may include changes in land tenure (where this is likely to affect land or water use), applications to change zonings (e.g. from rural to urban), mineral exploration or mining lease applications, applications for increased water allocations (e.g. for horticultural developments), drainage proposals, and applications for environmental approval for these and a host of other developments (powerlines, roads, heavy industries etc.).

Site managers need to be constantly aware, at least in general terms, of activities and developments on, adjacent to, and within the catchments of the Ramsar sites they are responsible for managing. They also need to be aware of any changes in parameters (e.g. regional trends in water table levels, ground and surface water salinities and other water quality attributes) which may eventually impact on their Ramsar site. Effective government environmental policies, programs and procedures will assist in this process, especially where whole of catchment considerations are recognised, however it would be unwise for managers to rely totally on such arrangements. Periodic inspections of the catchment and networking with local communities is also recommended and has other benefits. Knowledge gained of current and potential threats may be fed into the environmental monitoring program process, as described in following sections.

Some ongoing activities (e.g. use of fertilisers in catchments) may not pose an immediate, severe threat but may lead to a gradual change in ecological character. The relevant parameters (in this case nutrients) need to be identified and routine monitoring implemented to detect temporal changes which indicate a developing problem (in this case eutrophication)

Managers also need to be aware that the ecological character of a listed site may be influenced by factors external to the site and its catchment. These factors may be natural or human-induced.

For example, poor breeding seasons of migratory shorebirds in arctic or subarctic breeding grounds, or human interference (e.g. habitat destruction or excessive hunting) along a flyway, may result in much reduced numbers arriving at a southern Ramsar site. If the site was listed on the basis of use by these shorebirds, then a change in ecological character of the site results. Note that if the change is not human-induced, no action is necessary. If, however, the decline in numbers is due to human interference, the change in ecological character should, under Article 3.2 of the Convention, be reported without delay for possible follow up with the country or countries concerned.

Acid rain generated by industries provides another example of an activity that may impact on a wetland even though it may be far distant from the site and its catchment.

Once the current values and threats to those values have been identified, the management agency is in a position to draft a provisional list of relevant expertise for a Scientific Monitoring and Management Committee (SMMC) for the particular Site.

Scientific Monitoring & Management Committee

Members of the SMMC should include the best relevant expertise available to comment and advise on identified values, sustaining processes, threats and monitoring methodologies. It is recognised that the management agency may not employ all the relevant expertise necessary to conduct an effective environmental monitoring program. Agencies may need to source this expertise externally (e.g. from other government departments, tertiary institutions, industry, private consultants or public interest groups or

individuals). Based on prior experience in wetland management and monitoring it is possible to compile a generic list of desirable expertise (Table 8). Because Australian Ramsar sites include several estuarine and coastal habitats, marine expertise may at times be required. In some instances, one individual may provide expertise on more than one aspect. Generally, most members of the committee will be sourced from local (intra-State/Territory) organisations. It may be necessary to approach inter-State/Territory resources in a few instances and international expertise on rare occasions. The committee must include expertise on the values for which the wetland was nominated for listing under the Ramsar Convention (and any other substantial relevant values subsequently identified), as well as on the major processes that are crucial to the maintenance of those values. The relevant ANZECC Wetlands Network officer (see above) must also be included to ensure that Ramsar requirements (which are continuing to evolve) are met. In addition, the committee should ideally include an environmental economist/natural resource manager who is skilled in assessing the achievability of desired end-points/outcomes given the available funding.

Table 8. Summary of general categories of expertise that may be required on a Scientific Monitoring & Management Committee (SMMC)

Regional Manager (or equivalent senior officer) responsible for management of the Site
Hydrologist/hydrogeologist for issues involving surface and groundwater flows
Expert on values for which wetland was nominated (e.g. stromatolites, mangroves, coral reefs)
Botanist (algae; aquatic macrophytes; emergent & fringing, wetland-associated plant species)
Zoologist (aquatic invertebrates, fish, frogs, reptiles, mammals or birds)
Environmental chemist, toxicologist
Expert on food chains / trophic interactions and wetland processes
Scientists/authorities with direct experience/expertise on the specific wetland
Relevant ANZECC Wetlands Network member (Ramsar expertise)
Environmental economist to assess achievability of desired outcomes given available funding.
Geographic Information System (GIS) specialist for catchment-level work
Remote sensing specialist (satellite or aerial photography) for very large or remote wetlands

Once selected, the SMMC would meet, preferably at or near the wetland, to be briefed by the management agency and to view the values and threats. The Regional Manager would chair the committee and drive the process. During this first meeting the committee would review the identified values and threats. Membership of the committee might change following this first meeting as some areas of expertise may turn out to be superfluous (e.g. due to a perceived value or threat not existing). Conversely, the committee might identify additional values or threats, not initially listed by the management agency, for which additional expertise needs to be sourced and included on the committee.

The next stage in the process would be the convening of a public meeting (see next section). In preparation for the meeting, the SMMC would delegate members to make brief overview presentations about the Ramsar Convention, site management and reporting obligations under Ramsar, the values of the wetland, threats to those values, the environmental monitoring and management process, and other issues. Selected invitees would also be approached to make brief presentations concerning local interests and possibly other issues of particular significance.

Public meeting

The management agency will convene a public meeting, preferably in the vicinity of the wetland so that local people, particularly those with a direct interest (i.e "stakeholders") can readily attend. The main purpose of the meeting will be to:

1. inform local people about Ramsar, the wetland values and current management aims;
2. collect additional information on values and threats (actual & perceived) to the wetland;
3. provide a forum for interested parties to express their views and to become involved in the environmental monitoring and management process;

To achieve these aims the meeting needs to be well advertised, with specific invitations being sent to individuals or organisations with a direct and/or significant interest. It may be prohibitively expensive for some relevant people to attend a meeting relating to a very remote wetland (e.g. Ord River floodplain, Roebuck Bay or Eighty Mile Beach in the far north of WA) and in these circumstances special arrangements or funding may be needed.

The Regional or District manager from the site management agency would chair the public meeting, ensuring a functional link between the SMMC and the public meeting. Other attendees would or could include:

- Other members of the SMMC (i.e. in addition to those making presentations).
- Other members of the management agency (with Site-related knowledge, responsibilities or functions; also to assist in running the meeting).
- Expert scientists/institutions who currently, or in the past have conducted research on the wetland (may or may not already be on the SMMC).
- Local industry that may be utilising the wetland (e.g. fishing industry).
- Land holders (e.g. pastoralists, farmers, catchment groups).
- Local recreational users of the site (fishers, shooters, water skiers, divers, windsurfers, four wheel drive club etc).
- Local naturalist or other interest groups (e.g. Frog Watch, Royal Australasian Ornithologists Union, Ribbons of Blue, Naturalist Club, Wildflower Society).
- Representatives of government agencies (local/State) who are knowledgeable about and/or influence land and water use in the catchment (e.g. agriculture department extension officers, water authority personnel, environmental protection officers).
- Commonwealth Ramsar implementation agency observer (where the Site is within State or Territory jurisdiction).

Presentations would be made by members of the SMMC and by other selected attendees and the views of all attendees would be sought. A formal record of the proceedings would be prepared, distributed to invitees and attendees and made more widely available on request.

Following the public meeting, membership of the SMMC may be revised to include additional expertise to address threats newly identified in the public meeting. This may entail involving people from the catchment, identified at the public meeting, who can bring special knowledge to bear on particular threats or values. In any case, it may be considered desirable to include representation of the local community and possibly other interest groups on the SMMC in order to facilitate communication. Other benefits may also arise from doing so. Such an approach would also be consistent with Recommendation C.6.3 of the 1996 Brisbane Conference. This Recommendation calls upon Contracting Parties to make specific efforts to encourage active and informed participation of local and indigenous people in the management of Ramsar Sites and other wetlands and their catchments.

It is important throughout the whole process to remember that the wetland is part of a catchment and monitoring must consider the whole catchment and not treat the wetland in isolation.

If additional specific threats to the Site are raised at the public meeting, they should be investigated and confirmed or rejected by the SMMC, prior to the monitoring program being designed.

The SMMC will utilise its expertise to assess the extent and degree of each threat. Once all threats to the values of the wetland have been identified, the committee will need to prioritise them according to the severity of the expected impact and the urgency with which preventative and/or remedial action is required. By including expertise on issues such as food chains and trophic interactions (i.e. interactions between different levels of the food chain) the committee will be able to consider possible flow-on effects of disturbances that do not directly affect wetland values but which may ultimately do so (e.g. introduction of so-called "mosquito fish" (*Gambusia holbrooki*) may cause, due to predation by the fish, a reduction in numbers of algae-eating aquatic invertebrates and this in turn may lead to an increase in the frequency and severity of toxic algal blooms, causing mass mortality of other fauna (e.g. waterbirds) for which the wetland is particularly valuable.

Designing a program to monitor ecological change

Once threats have been identified and prioritised then it is the task of the SMMC to design an appropriate, statistically rigorous and cost-effective environmental monitoring program to address those threats.

A situation may arise where there are no apparent threats to a wetland (other than general threats such as import into a country or region of invasive plants or exotic diseases, or global threats such as climate or sea level change). Where such situations exist then the management agency should collect "baseline" data (see below) to augment information presented to the Ramsar Bureau at the time of site nomination. This is important since unforeseen changes may occur at these sites in the future. In addition, relatively undisturbed wetlands may be used as valuable reference sites against which change at other wetlands may be assessed.

Some sites may already have established monitoring programs. These should be reviewed by the SMMC to verify their adequacy with respect to Ramsar site monitoring and reporting obligations. For example, from a technical point of view it is important to ascertain whether or not the most appropriate variables are being measured with sufficient frequency and replication to provide acceptable statistical power to detect significant change.

Monitoring may be separated into strategic and reactive.

Strategic monitoring will include, for example, routine measuring of basic water quantity and quality parameters either to provide a baseline data set against which future changes may be judged or to monitor slow, incipient changes already occurring. Basic parameters for many Australian wetlands include water level, salinity (or conductivity), acidity/alkalinity (pH), dissolved oxygen (DO), total phosphorous concentration (total-P) and total nitrogen (total-N).

Note that strategic monitoring in the broadest sense will also include making arrangements to ensure that proposed developments that may ultimately impact on wetland sites, either directly or indirectly, are detected well in advance of necessary approvals (e.g. environmental or planning) being given, so that adverse impacts may be prevented, deflected or minimised and appropriate monitoring instituted.

Reactive monitoring entails more detailed and directed investigations to address specific issues or problems. For example, proposed or actual discharge of industrial waste may result in a need to monitor heavy metal (e.g. lead, mercury, cadmium) concentrations in the water column, sediments and biota of a wetland site. Because of the cost of heavy metal analyses, such monitoring would not usually be undertaken unless heavy metal pollution was a definite and significant threat.

Another consideration for the SMMC is the formulation of "target" and "close-out" criteria. Target criteria are the targets that management is attempting to achieve; for example a reduction in salinity of a permanent wetland to <2000 mg/l. Close-out criteria indicate the stage at which management is deemed successful and monitoring can be scaled-down or, if it is not strategic monitoring, can be terminated; for example salinity maintained at <2000 mg/l for three years.

Once the environmental monitoring program has been designed (this will be discussed in detail in a later section), the revised list of wetland values, the prioritised threats to these values, and the proposed environmental monitoring program would then be assembled into one document, referred to as the Draft Environmental Monitoring Program (DEMP).

Following completion by the SMMC, the DEMP would be assessed by the Site management agency (and by the relevant State, Territory or Commonwealth Ramsar implementation agency where this is different). This assessment is necessary in order to obtain formal agency support for the document. The assessment should be quite straightforward as agency personnel will have been closely involved or consulted during the processes leading up to completion of the DEMP.

Following this assessment, and incorporation of any minor changes should these be required, the DEMP would be released for a public comment period of 1-2 months, with copies being sent in particular to invitees to the public meeting earlier in the process. Comments would also be sought from the

Commonwealth Ramsar implementation agency (EABG) at this stage (noting that an observer from EABG may also have been invited to the public meeting.)

The SMMC would revise the DEMP in the light of comments received during the public submission period and the document would then be submitted for final approval by the Site management agency (and Ramsar implementation agency if different) before adoption and release as the Environmental Monitoring Program (EMP) for the Ramsar site.

Following approval of the EMP, and assuming the required funding has been obtained, the monitoring program would be implemented. As noted in a previous section, the program should be driven at the Regional level and must be interactive with site management (Table 9).

Table 9. Environmental monitoring and interactive management of a Ramsar Site.

Results of environmental monitoring reported to operations manager
↓
Need for and nature of appropriate remedial action decided by operations manager on advice of SMMC
↓
Operations manager arranges implementation of remediation if needed
↓
Monitoring detects and reports results of remediation action
↓
Management action deemed successful and threat averted or continued/new remediation required
↓
Continued strategic & reactive environmental monitoring with appropriate management

Often there is a range of issues threatening wetlands and it may not be possible for one monitoring procedure to address all the different issues. Therefore, it may be necessary to implement, as part of an overall program, a variety of monitoring procedures involving different individuals or organisations measuring different parameters at different frequencies and in different locations. Each monitoring procedure would need to be reported to the operations manager. Similarly, each threat or disturbance may require separate remedial action. In some situations this action may impact on other disturbances and on other monitoring programs.

The SMMC will need to meet periodically to discuss progress. It should be a "standing" (on-going) committee, so that the operations manager can approach the whole committee or individual members to discuss matters as they arise. These matters could include the possible impacts of a proposed activity or development - either on the Site or elsewhere in its catchment - and any implications for the monitoring program; the implications of a reported change in a specific parameter being monitored, and the need for and appropriate nature of remedial works.

Although there is an obligation to monitor the ecological character, and threats to this, of all Ramsar sites, implementation agencies will need to adopt a strategic approach to the establishment of SMMCs and the development and implementation of monitoring programs. Available expertise in relevant fields is limited and may soon be exhausted if too many monitoring programs are attempted at the same time. The guidelines for "describing and maintaining" the ecological character of listed sites accepted by the 1996 Conference of Contracting Parties (Annex to Resolution C.6.1) propose that, in gathering new data or assembling existing data, emphasis be given to Ramsar-listed wetlands where there appears to be a "high-medium risk of human-induced change with a high-medium ecological impact, likely to result in permanent, long or medium term degradation of values and benefits". We support this view.

RECOMMENDATION 12. That in view of the limited resources available to undertake the task in Australia, a strategic approach be adopted by Commonwealth, State and Territory Ramsar implementation agencies to the development and implementation of site-specific environmental monitoring programs. Emphasis should be given to Ramsar-listed wetlands where there appears to be a "high-medium risk of human-induced change with a high-medium ecological impact, likely to result in permanent, long or medium term degradation of values and benefits".

Environmental monitoring should be on-going. Strategic monitoring will have a set frequency, however it must also include the flexibility to respond to episodic events (e.g. flood, drought, fire, cyclone) as often these events have a profound "shaping" effect, strongly influencing wetland attributes and processes such as survival and regeneration of fringing and emergent vegetation. Reactive monitoring, as discussed earlier, will be reactive to issues as they arise. If remedial action is successful, and the desired end-point is achieved, then reactive monitoring may be suspended. Alternatively, new environmental monitoring programs may be initiated to address new threats.

It will be necessary to convene public meetings periodically to report progress and obtain feedback. If resources permit, there may also be considerable value in the management agency periodically issuing monitoring update newsletters to inform the local community of progress in site management and monitoring.

Databases and Data Accessibility

The main purpose of environmental monitoring is to collect data that may be used to detect impacts, assess the success of remedial action and determine when a desired end-point is achieved. Data collected at currently unimpacted sites are particularly useful as they not only establish a baseline against which future change can be measured, they also enable natural variations to be determined, and provide "reference" data against which changes at other comparable sites may be assessed.

For data to be useful, they must be accessible. In the case of Ramsar site monitoring, it is important that the data are readily available to the relevant Ramsar implementation agencies as well as the site management agencies (where these differ). To this end, it is suggested that each implementation agency establish a single database and reference collection (literature, maps, photographs etc.) for all of the Ramsar sites within its area of jurisdiction (State, Territory or Commonwealth), drawing as necessary on information provided by other sources. In the few instances where the implementation agency is not the management agency the use of common software will simplify the process but is by no means a necessity as current technology facilitates relatively easy data transfers between different software packages and computer systems. State and Territory implementation agencies can then make use of these databases to provide information or advice, as necessary, to the Biodiversity Group of Environment Australia and the Ramsar Bureau. In some circumstances it may be desirable for data to be stored in a Geographic Information System (GIS).

Arrangements are needed whereby data and reports on Ramsar sites collected by organisations other than site management agencies are automatically provided to, or at least brought to the attention of, the management agency and are entered or recorded appropriately in the centralised database and reference collection. For example, a Ramsar wetland close to a major population centre may regularly attract researchers from a tertiary institute, or members of Waterwatch, Frogwatch or the Royal Australasian Ornithologists Union (RAOU) who collect useful data. Information obtained from these sources may be of substantial value in monitoring (particularly where formal monitoring programs have yet to be established), but if not added to the site database as it is produced, such information may be lost.

Any organisation or individual wishing to work (take samples, place markers, trap fauna etc.) on a Ramsar Site must first obtain a permit or other approval from the Site manager (usually a government agency). As well as informing the Regional office of the application so that they are aware of the work proposed, the agency could make it a requirement (if it is not already) of approval that any reports or publications and a copy or summary of the data arising from the study be lodged with the Regional office of the agency.

In Western Australia, organisations wishing to collect or disturb fauna, flora and any other material on conservation reserves; collect protected fauna on any land; collect protected flora on non-private land, or

collect Declared Rare Flora on any land are required to obtain a permit or permits from the State's Ramsar implementation agency (in its role as the State's nature conservation agency). Other States and Territories have similar requirements and administrative arrangements. We suggest that it be made a requirement of such permits that, if work is undertaken on a Ramsar Site, any reports or publications and a copy or summary of the data arising from the study be lodged not only with the permit issuing (Ramsar implementation) agency, but also with the relevant Regional office of the Site management agency (where this is not the same). The Ramsar implementation agency should routinely bring such reports to the attention of its ANZECC Wetlands Network officer.

The situation is not so clear-cut where a Ramsar site is on private land and the research is not dealing with protected fauna or (in Western Australia) declared rare flora. Under these circumstances permits may not be required, and the only authority needed may be the permission of the land owner. In these situations it would be desirable for the Ramsar implementation agency to have an arrangement with the landowner concerning research activity and the provision of data, data summaries, reports and publications to the agency.

Funding of Environmental Monitoring Programs

Additional funds will be required to develop and implement environmental monitoring programs for Ramsar sites. Management agencies can reasonably be expected to provide "in kind" support for Ramsar site monitoring, as monitoring is an integral part of management and performance assessment. However, given the international profile of Ramsar listed wetlands, and the predominant role of the Commonwealth Government in ensuring that Australia's obligations under Ramsar are met, it is considered appropriate that the Commonwealth Government, through EABG, should provide most of the funding needed to develop the environmental monitoring programs needed for Australia's Ramsar sites, and should also provide ongoing support for the implementation of those programs.

During the development phase, management agencies' tasks will include establishing the SMMC, convening the public meeting and, with SMMC input, preparing and reviewing the environmental monitoring program. To do so, they will probably need to contract an additional officer for a period of six months or thereabouts. Funding provided by the Commonwealth would need to be sufficient for this to be possible.

SMMC members may be prepared to supply their time without charge, as has been the case in similar situations in the past. Increasingly, however, agencies can expect to be charged for expert advice and will therefore need funds to pay for non-government expertise at least. Additional funding to cover the travel and accommodation expenses of most SMMC members whilst attending committee meetings will also be required.

Once the environmental monitoring program is established, it is expected that the site management agency would maintain it, with ongoing funding support from EABG. Where a monitoring program is particularly expensive, "top up" funding may be needed. This will most commonly apply to reactive (and therefore relatively short-lived) monitoring, rather than strategic monitoring, and may involve obtaining funds from industry.

RECOMMENDATION 13. That the Australian Commonwealth Government, through the Biodiversity Group of Environment Australia (EABG), provide the funds necessary for Commonwealth, State and Territory Ramsar implementation agencies to develop environmental monitoring programs for the Ramsar sites within their respective areas of jurisdiction. That the Commonwealth Government provide ongoing funding support to Commonwealth, State and Territory Ramsar implementation agencies for the implementation of those programs.

Procedure for advising the Australian Commonwealth Government of threats and changes to listed wetlands.

As discussed in preceding sections of this report, Article 3.2 of the Ramsar Convention requires that:

> "Each Contracting Party shall arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the List (of wetlands of international importance) has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference. Information on such changes shall be passed without delay to (the Ramsar Bureau)".

The Bureau's role is to forward this information to all Contracting Parties for discussion at the next Conference, and to subsequently advise the relevant Contracting Party of the recommendations of that Conference with respect to the change in character (Article 8 of the Convention). The Bureau may also propose to the Contracting Party that the Management Guidance Procedure be invoked, and/or that the site be added to the Montreux Record (so that it may receive positive national and international conservation attention (see Part A of this report).

In the context of obligations of Contracting Parties under the Convention it is important to note the Australian Commonwealth Government, not the State or Territory Governments, is the Contracting Party to Ramsar. It is therefore the Australian Commonwealth Government that is obliged to "arrange to be informed" (of adverse changes or threats) and to pass information on changes or threats to the Bureau without delay.

Given that 44 of Australia's 49 Ramsar sites are within the jurisdiction of the States and Territories and managed by State and Territory agencies (one jointly with the Commonwealth), it is necessary to consider *how* the Commonwealth Government should "arrange to be informed" as per Article 3.2 and the process by which information should be passed to the Bureau.

Our recommendation is that the Commonwealth, State and Territory Governments arrange as follows.

- the Commonwealth seek to meet Article 3.2 obligations by supporting the States and Territories, through EABG and the State/Territory Ramsar implementation agencies, in the development and implementation of appropriate Ramsar site monitoring programs;

- results and conclusions of these programs be reported by State/Territory Ramsar implementation agencies to EABG, at three year intervals, at least in the form of a brief statement, as part of the established process of preparing National Reports for Meetings of Conferences of Contracting Parties to the Ramsar Convention. [Note that Resolution C.6.1 Annex 1 requests Contracting Parties "to verify the data which they have provided on Information Sheets on Ramsar Wetlands every six years (ie. every second meeting of the Conference) and to provide the Bureau with updated sheets if necessary" (see Appendix 1)]

- urgent information on significant threats or adverse changes in the ecological character of Ramsar sites be reported by State/Territory Ramsar implementation agencies to EABG using existing mechanisms of formal contact (refer again to Appendix 1).

RECOMMENDATION 14. That results and conclusions that may be confidently drawn from formal Ramsar site monitoring programs be reported by State and Territory Ramsar implementation agencies to the Biodiversity Group of Environment Australia (EABG) at three year intervals, at least in the form of a brief statement, as part of the established process of preparing National Reports for Conferences of Contracting Parties to the Ramsar Convention. That EABG report similarly on the Ramsar sites within the Australian Commonwealth Government's jurisdiction.

RECOMMENDATION 15. That urgent information on significant threats or significant adverse changes in the ecological character of Ramsar sites be reported by State/Territory Ramsar implementation agencies to the Biodiversity Group of Environment Australia (EABG) using existing formal contact mechanisms. That such information received from State/Territory Ramsar implementation agencies be passed without delay by EABG to the Ramsar Bureau, as required under the Convention.

PART E: DESIGNING AN ENVIRONMENTAL MONITORING PROGRAM

There is a very extensive and detailed literature on biological monitoring in aquatic systems (see texts by Hart 1980; Hellawell 1978; Jones & Walker 1979; Spellerberg 1991). Of particular relevance to this document are the proceedings of recent workshops which addressed the issue of monitoring of ecological change in Ramsar wetlands (Moser *et al.* 1993; Aubrecht *et al.* 1994) and the guidelines for monitoring contained in the Annex to Resolution C.6.1 (Appendix 1 of this document). Because of the extensive nature of the literature on monitoring, the following section is not intended as a review, but presents some general background, outlines some general procedures and highlights some of the more salient issues for managers to be aware of when initiating an environmental monitoring program. In practice, the operations manager responsible for coordinating and implementing environmental monitoring at a Ramsar wetland will be able to rely upon the expertise of the SMMC to provide the correct advice.

Before commencing to "monitor" it is necessary to understand what is intended and why do it. As defined by Hart (1980) "monitoring essentially means the keeping of a continual record of certain parameters, advising whether they are being maintained within prescribed limits and warning if undesirable changes occur". In addition, the 'certain parameters' need to be carefully selected so that they are relevant to the objectives of the study. In the majority of situations this means monitoring a range of different parameters (some of which may be external to the wetland but within the catchment) that indicate changes in key processes and attributes. Change may be good or bad and monitoring may detect positive change that indicates improved conditions and enhanced wetland values.

When monitoring to maintain the ecological character of a Ramsar site, it must be remembered that in this context the ecological character is, in essence, the values for which the site is listed. Under Article 3.2 of the Convention, Contracting Parties are obliged to notify the Bureau if the ecological character of any wetland has changed, is changing or is likely to change as a result of technological developments, pollution or other human interference. This may appear as a rapid change in character due to a severe "pulse" impact (e.g. oil/chemical spills, infilling, drainage or mining extractions), or a slow, incipient change due to a gradual "press" impact (i.e. salinisation due to land clearing, eutrophication due to agricultural run-off, heavy metal pollution due to industrial discharge, loss of vegetation due to stock grazing). Also, there may be natural changes in ecological character, not related to technological developments, pollution or other human interference (e.g. change in water regime due to changing land levels, impacts due to seismological activity (earth quakes and volcanoes), siltation or erosion following a storm event, or the gradual infilling of wetlands due to natural eutrophication). It will be necessary to differentiate between natural changes and those due to human interference (e.g. human-induced changes in global climate) because, without differentiating between these effects it will not be possible to report the cause of the change and whether management action is required. For instance, if a natural event adversely changes the ecological character of a Ramsar wetland there is no obligation for the State to inform the Bureau, although the member State may wish to invoke management to recover the site to maintain cultural heritage.

The MedWet Inventory and Monitoring meeting, Portugal 1993 (Anon 1993) identified five objectives for monitoring ecological change in Mediterranean wetlands. These are applicable to wetlands in general:

1. To identify changes that have occurred, are occurring or are likely to occur.
2. To determine the extent of these changes.
3. To identify measures to stop or reverse the adverse changes.
4. To assess the success of management actions and restoration projects.
5. To assess the effects of policies affecting wetlands.

Although it is possible to generalise about wetland attributes, processes and conservation threats, when designing and implementing a monitoring program it is not possible to produce a single point-by-point set of rules that is applicable to each and every wetland. A number of possible approaches may, however, be considered. The following section presents broad outlines of some of these.

Monitoring approaches

Kvêt (1994), in the conclusions to a workshop on monitoring ecological change in wetlands of Middle Europe, acknowledged that 'approaches to monitoring can vary widely', but recommended they follow three phases:

1. The policy planning phase (including financial policy); this is accomplished by monitoring of policy planning processes and early adoption of counter-measures should these be necessary to avoid adverse impacts on wetlands.
2. The implementation phase; this is accomplished by on-site monitoring of causes and spatial and temporal patterns of ecological (in this case "key parameter") changes, and by an evaluation of the data obtained.
3. The post-implementation phase; this is accomplished by monitoring the effects of changes in the ecological character (key parameters) of the wetland(s) concerned as well as of the effectiveness of monitoring and counter-measures taken in phases 1 or 2. The effectiveness of rehabilitation measures undertaken to mitigate undesirable ecological changes should also be monitored in this phase.

An integral part of the monitoring process recommended by Kvêt (*op. cit.*) is that ecological character be determined by employing a small number of carefully selected parameters, comprising the basic hydrological, water-quality and other abiotic attributes, the wetland's biological characteristics, and information on both present and anticipated uses and management. The significance of any ecological change is then evaluated by comparing the baseline characteristics of the wetland with data obtained from subsequent monitoring. Kvêt (*op. cit.*) identified two problems likely to be encountered when implementing stage 1:

- lack of available qualified personnel to monitor policy planning, and,
- incomplete access to the information needed.

In phase 2, Kvêt recommended that on-site monitoring should link up with routine wetland surveys, should augment the information from these surveys, and the evaluation of all information obtained should be transmitted without delay to the decision-makers and managers. Kvêt also reported that in the workshop referred to above, three broadly conceived wetland types were identified:
- lentic wetlands (shallow lakes, ponds and lake littorals),
- mires (bogs and fens) and
- lotic (riverine) wetlands (floodplains).

The openness and connectivity of these three wetland types increases from mires, through the lentic to the lotic wetlands. For meaningful results to be obtained from monitoring programs, the range of ecological parameters and interactions monitored must also be increased in this order. Managers can therefore expect the complexity of monitoring programs to increase from mires, to lentic, to lotic wetlands.

Another approach is to separate monitoring programs into three periods:

1. before an event, to predict a future change (early warning) and provide a baseline,
2. during an event to assess magnitude of spatial/temporal change, and,
3. after an event to assess resilience or success of rehabilitation/mitigation

In many instances monitoring during period 1 is omitted, usually due to lack of planning and/or commitment of resources to undertake the work. In the absence of adequate baseline data and data from appropriate control (reference) locations, the detection and interpretation of change is either difficult or impossible. Similarly, monitoring during period 3 often wanes once the direction of rehabilitation or mitigation is determined, but before success is proven.

Hart (1980) identified two broad approaches to monitoring:
(1) A sequential approach, which is typically short-term but extensive (collecting information on a wide range of parameters), followed by a more intensive study of identified problem areas, and,
(2) A simultaneous approach, involving a long-term broadly-based study in association with intensive study of potential problem areas.

Both of these approaches require regular data assessment and analyses and feed-back systems to respond to the monitoring results.

Having considered the above approaches, we recommend that, at the majority of Ramsar Sites, monitoring should take the form of approach 2 of Hart (1980), whereby a long term, broadly based program results in collection of data on basic parameters, and intensive studies are implemented to assess and manage specific threats. The intensive studies should commence and cease as threats appear and are resolved. Approach 1 of Hart (1980) may be implemented at sites for which there are few data, so as to quickly establish a baseline database.

In designing monitoring programs, an additional factor that managers need to recognise is the ecological importance of extreme events. Storms, fires, droughts, earthquakes etc. may all have dramatic effects on wetlands, and managers need to ensure that these events and impacts are recorded. Events such as severe summer rain storms may result in huge quantities of nutrients being flushed into wetlands, causing algal blooms, low oxygen levels and death of fish. Similarly, 1 in 100 year storms in coastal areas may dramatically alter coastal wetland morphology and other, ecological, characteristics. Such an event occurred at Mandora Marsh in late 1994, when cyclonic winds damaged the tree canopy in some places, allowing increased light penetration and subsequent domination by bulrush (*Typha* sp.) over ferns (refer to Part F: Eighty Mile Beach case study).

Another aspect of monitoring, of which managers should be aware, is the use of historical information (historical literature, oral histories, aerial photographs, satellite images, sediment cores, etc.) to determine past changes and previous baselines. For instance, a mining company in Papua New Guinea has used aerial photographs taken in the early 1940s (during World War II) to assess rates of migration of river meanders across the floodplain of a lowland river receiving increased sediment loads (A. Storey, pers. comm.). Old aerial photography can also be used to identify historical changes in wetland and catchment vegetation cover. Another example, is the use of sediment cores to assess change. Wyrwoll *et al.* (1986), using ^{14}C dating of cores from Mandora Swamp (part of the Eighty Mile Beach Ramsar site), was able to determine that the swamp (located in the Great Sandy Desert) had existed for at least 7000 years. Similarly, analysis of pollen and/or diatom profiles from cores can provide information on changes in the composition of plant communities over time. Sanders (1991) has also documented change in wetlands (of south-western Australia) by gathering oral histories.

A final consideration for managers in deciding approaches to monitoring is when to start. Given the international importance of Ramsar sites, and the obligations of Contracting Parties under the Ramsar Convention, all sites should be continually monitored. The level and intensity of monitoring will vary, however, depending on the severity of threat.

At relatively threat-free sites, ongoing low level monitoring (i.e. strategic monitoring) programs should be developed and implemented *as soon as possible.* This will enable baselines to be established and will also allow incipient changes, where these are occurring, to be detected. Strategic monitoring will also enable potential threats to the ecological character of these sites to be detected early and this will greatly assist in preventing adverse changes.

Monitoring programs (both strategic and reactive) should be developed and implemented *as a matter of urgency* at sites that are severely and imminently threatened. This will enable baselines to be established at these sites also, and, in addition, will enable changes in key parameters to be detected and preventative action taken before major adverse changes in ecological character occur. Where preventative action is not taken or is not effective, these programs will enable impacts to be measured, will guide the design and implementation of restoration efforts, and will enable these efforts to be assessed and modified as necessary until acceptable outcomes are achieved.

In relation to relatively threat-free sites, the question really is not when to start monitoring (it should start now, if it hasn't started already), but when should intensity be increased. "Triggers" managers need to be aware of are events that indicate that a new threat (or newly recognised threat) exists. Such events will include applications to build factories, discharge wastes, draw water, clear land, change land use zonings, etc. Where potentially impacting developments such as these are approved, or are highly likely to be

approved, despite a strong likelihood of impacting adversely on the ecological character of a Ramsar site, reactive (more-directed and higher intensity) monitoring should be initiated.

Williams & Choo (1994) produced a schedule of phases in an environmental monitoring process designed for a State conservation agency (Table 10). The schedule is comprised of nine distinct stages. For the current application (Ramsar Site monitoring), the actual content and complexity of each stage will depend on the circumstances specific to the wetland being monitored. The authors regarded the final four phases (data collection, analysis, interpretation and implementation) as "an open-ended environmental impact experiment", requiring interactive monitoring and management, involving operations staff, scientific personnel and management (Williams & Choo 1994).

Table 10. Phases in an environmental monitoring program (after Williams & Choo 1994)

Task		Responsibility
Set-up Environmental Monitoring Steering Committee to:- • Define objectives • Allocate staff • Manage program	-	Management
- Define indicator variables and critical values - Set allowable limits for monitoring variables	-	Scientific Staff Management
- Specify sampling regime and replication, timing, controls, covariates, statistical power, etc.	-	Statistician Scientific Staff Operations
- Design information management system	-	Information systems specialist
- Collect & store data	-	Operations
- Analyse data	-	Scientific staff & Operations
- Interpret results	-	Scientific Staff
- Implement findings	-	Management

It was regarded as essential that operations and scientific staff (and perhaps others) were involved in all stages, though the degree of involvement would vary between stages. Williams & Choo (1994) identified four major problem areas in the schedule, each of which require further discussion: defining indicator variables, devising sampling regimes, designing and constructing an information management system and analysing data/results.

The general approach we recommend is to identify potential threats, assess possible ecological changes that may arise from such threats and then design an appropriate, quantitative monitoring program that will detect changes, if they occur.

What to measure

At the outset, a decision must be reached as to what parameters to measure in the environmental monitoring program. The selection of both relevant and specific indicators of the character of the system has been identified as the most difficult stage in devising a monitoring program (Hart 1980). Due to the interactive nature of wetlands (i.e. wetland components), it would be uncommon for a single parameter (or even several) to completely define the status of a system (Hart 1980). However, it is usually impractical

(due to resource limitations) to attempt to monitor a great multitude of parameters. In practice, it is better to monitor a small number of key elements correctly than a greater number of elements with less precision.

Williams & Choo (1994) distinguish between causal and symptomatic variables. Historically, biologists have been good at measuring symptomatic parameters (e.g. numbers of waterbirds, mammals, frogs, fish, dominant plants), but if, as is commonly the case, these parameters are also the values to be protected in the wetland, then by the time a change has been detected, a change in "ecological character" (in the Ramsar sense) has already occurred. What is more, there may be a long lag-period between remedial action and the value recovering, even if remedial action is implemented immediately. It is obviously preferable to be forewarned of impending changes in wetland values, rather than simply discover such changes as they occur. By monitoring the values alone, managers may get an incorrect impression of the state of a wetland. They may conclude that no adverse impacts are occurring, when, in fact, impacts are occurring but have not yet affected high trophic levels.

Although it is necessary to monitor the values for which a wetland is nominated, to ensure the wetland values are intact, it is also necessary to measure causal variables. Monitoring programs must include integrative catchment parameters that drive or shape *processes*, changes in which will lead to changes in the ecological character of wetlands. For instance, effluent from an industrial development may contain heavy metals which accumulate in benthic sediments, having a toxic effect on benthic invertebrates and thereby reducing standing stock biomass, thus significantly reducing the food supply for certain species of fish and causing their decline. In this example, the causal parameter to monitor is heavy metal concentration.

A wetland being used as a sump provides another example. In this case increased water depth and increased period of inundation (from temporary to permanent) may lead to the death and collapse of fringing and emergent vegetation, thus destroying waterbird nesting and roosting habitat and greatly reducing numbers of breeding birds. Increased inundation may also "drown" shallow margins used by migratory waders, and the loss of this habitat may in turn cause the loss of waders from the wetland. In this case the causal parameter to monitor is water depth. A final example concerns increases in salinity, particularly from fresh/brackish to saline. Such increases commonly lead to changes in aquatic invertebrate communities, death of vegetation and associated changes in waterbird usage. Here, salinity is the causal parameter to be monitored.

If the correct causal parameters are monitored, then impacts can be detected at an early stage and, in many instances, there will be an opportunity to take corrective action before wetland values are adversely affected. A question arises, however, and that is how to determine the correct causal parameters to monitor.

There is now a great deal of experience available to indicate the types of problems that various forms of development or other human activity may cause. Armed with this knowledge, and a knowledge of the types of activities that occur or are likely to occur within a wetland or its catchment, it is possible to make informed judgements about which causal parameters should be monitored. For instance, increased nitrogen and phosphorus concentrations often result from point or diffuse-source effluent inputs from developments such as golf courses, piggeries or horticultural farms close to wetlands. Changes in water level may result from re-routing of surface drainage into a wetland, particularly in association with an urban development which causes increased surface run-off. Increased wetland salinity may result from land clearing and consequent water table rise, or reduced seasonal flushing due to reduced freshwater inflows (e.g. as in Western Districts Lakes in Victoria). In each case, the causal parameter(s) is clear.

Early warning of potential threats to the ecological character of Ramsar sites may be provided by advertisement of intention to change land zonings, approve developments, grant exploration or mining leases, divert or extract water etc. Operations managers need to establish early warning systems so that, as far as possible, they are aware of proposed developments before they are approved or occur. Where such developments threaten Ramsar sites, improvements may be suggested or alternatives proposed. Where threats remain, appropriate monitoring may be put in place before the development takes place. Legislation or administrative arrangements may exist whereby site management agencies are automatically informed of proposals that may affect conservation reserves. However, Site managers should also establish their own networks and procedures as those systems may not be fail safe. For example, information on some proposals may not reach the site manager in a timely fashion, or at all. Managers need to establish

networks whereby this information is brought to their attention. This type of "early warning" monitoring needs to be conducted on a whole of catchment basis, since activities anywhere in a wetland's catchment may, depending on the nature of the activity, impact that site.

The possible range of parameters to measure in a wetland and its catchment is large and expanding all the time as research expands our understanding of processes and interactions and technology makes new approaches possible. In a recent workshop on monitoring ecological change in wetlands of Middle Europe (Aubrecht *et al.* 1994), Herzig & Pokorný (1994) summarised the types of variables to consider when monitoring lakes and ponds (Table 11). Ultimately the variables/parameters selected will depend on the specific threats to and values of each wetland, but this listing provides managers with an indication of the types of parameters that may be incorporated in a monitoring program.

Table 11. Summary of possible parameters/variables to be considered in an Environmental Monitoring Program (after Herzig & Pokorný 1994).

Meteorological, physical and chemical parameters

- Precipitation, evaporation, radiation - recorded continuously at one to three localities in a region; retention time (inflow, outflow), water level fluctuations, temperature - recorded continuously; transparency, pH, conductivity, alkalinity, oxygen, BOD, COD, anions, cations, nutrients (if possible, nutrient budget), heavy metals, toxins (in the food chains), blue green toxins, sedimentation rate, sediment stratigraphy.

Biological parameters

- Bacteria - numbers, biovolume, activity (for short and/or characteristic periods of time).
- Phytoplankton - numbers, biovolume, chlorophyll a, dominant algae (group of algae), primary production (for short and/or characteristic periods of time).
- Zooplankton - numbers, biomass, size-classes and/or species distribution, dominant species (or group), grazers, predators, secondary production (for short and/or characteristic periods of time).
- Macrophytes - vegetation structure and cover (remote sensing using aerial photography and satellite imagery), vegetation mapping (biodiversity), biomass (nutrient and toxin content), bioindicators (care required in interpreting results - their presence may mean a lot whilst their absence does not mean anything).
- Fish - species, size, condition, numbers and biomass, if possible growth and production (for distinct periods of time), diseases.
- Birds and/or other animals - species richness, dominant species, indicator species, community structure, population structure, reproduction characteristics and success.

Management practices

- Drainage, littoral cutting of vegetation, shoreline management (swimming, boating), fish stocking, fertilising, liming, external nutrient load, management of the catchment area (e.g. capacity and quality of sewage treatment plants, development of sewerage, land use, degree of industrialisation).

NB. Table 11 is by no means exhaustive and, although general in many respects, is derived from a workshop on Middle European wetlands and therefore is not specific to the Australian situation.

Acceptance criteria/limits

In addition to selecting appropriate variables, an effective environmental monitoring program also must define a.) acceptable limits for the parameters and b.) what action to take should the limits/criteria be exceeded (Williams & Choo *op. cit.*). Without these limits and ensuing actions, a Ramsar site environmental monitoring program will not achieve its purpose. This is particularly relevant to the strategic monitoring component of the program, as a slow, incipient change in a wetland may not be acted upon unless exceedance of a criterion causes alarm bells to sound.

Williams & Choo (1994) note that defining acceptable limits may be difficult in the absence of a detailed knowledge of the desired state of the environment, however, they propose that a site may be deemed as undisturbed if the variable in question is not significantly different from levels recorded in an undisturbed reference site(s). Although this is a useful approach, it can be expensive, requiring routine sampling at additional sites. However, this expense can be minimised by monitoring at a small set of reference sites to be used as comparisons for all monitored sites within a region (Williams & Choo 1994). In reality, it is

becoming more and more difficult to find undisturbed reference sites. This is particularly evident for many Ramsar wetlands which often are nominated because of special qualities or rarity. Alternative approaches are to use a.) published maximum acceptable concentrations of specific elements set for the protection of ecosystems (e.g. as set by the EPA, NHMRC or WHO) or, b.) to use accepted criteria based on quantitative analyses (e.g. greater than a 25% reduction in number of species might be deemed an unacceptable impact).

Devising a sampling regime

The next step is to design an appropriate sampling regime. The adopted regime must be able to reliably detect environmental change (i.e. significant changes above or below accepted criteria) and must also be affordable. This is one of the more complex aspects of designing an environmental monitoring program, often requiring input from statisticians or other specialists with experience in this area, and is referred to as statistical decision theory (Williams & Choo 1994). The process considers issues such as power analysis (i.e. the ability to detect a significant difference, should one exist) and Type I & Type II errors (i.e. the mistake of concluding an impact has occurred when it has not (Type I), and the probability of concluding that no impact has occurred even though one has (Type II)) (see Table 12, after Fairweather 1991). The ultimate aim of an adequate design is to maximise power and therefore minimise the probability of making a Type II error.

Table 12. Statistical outcomes in relation to detecting environmental impacts through a hypothesis-testing approach (after Fairweather 1991).

	Prediction or conclusion of study	
Real state of nature	IMPACT	NONE
IMPACT	Correct	Type II error
NONE	Type I error	Correct

Basically, it would be unfortunate if a manager concluded or was advised that there has been a significant impact, when in fact there has not (Type I), but in most cases this type of mistake will be revealed by further investigation and remedial action will either not be initiated or will be suspended. The situation is more serious if a manager concludes or is advised that there is no impact, when in fact there is (Type II), and no action is taken! The danger of a poorly designed monitoring program is that there will be insufficient replication (that is to say, power) to detect a significant impact, should one occur and that the impact will go unnoticed (see Figure 2). An adequate design will have sufficient power to detect the impact or change required to sound alarm bells.

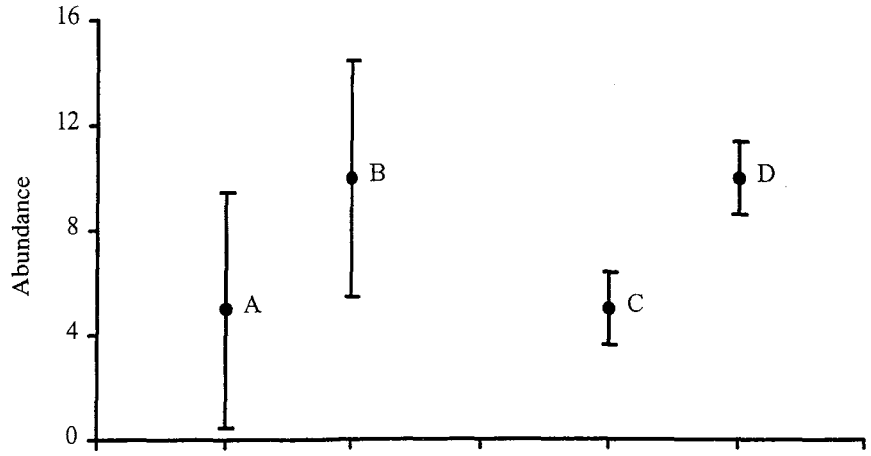

Figure 2. Relationship between sample size, variance and ability to detect a significant difference ($p < 0.05$ & $\beta = 0.95$) for two hypothetical situations, where each data point represents a mean $\pm$ 95% confidence intervals. Significant difference is not detectable between populations A and B because of high variance and low replication. Significant difference is detectable between populations C and D because replication has been increased.

Fairweather (1991) highlights three applications of power analysis in environmental monitoring: a.) for guiding investigators to select the most sensitive statistical tests to apply to the data, b.) to indicate sample size (replication) required to detect an impact, based on a pilot study or existing data with known variance, and c.) to evaluate any non-significant results of completed studies to determine their sensitivity, realised power and detectable effect size (e.g. analysis may demonstrate that the design of a program was inadequate because the program could only detect a 200% (for example) change in a variable).

Traditionally, environmental monitoring and impact studies have had to prove the presence of an impact rather than prove one didn't exist. This is analogous to the situation of the 'burden of proof' in law, whereby the legal system is designed to minimise the probability of convicting an innocent person (a person is considered "innocent until proven guilty"), but at the expense of occasionally releasing a guilty person (since to be convicted, a person must be proven "guilty beyond reasonable doubt") (Williams & Choo 1994). Using a monitoring program based on this principle, change would need to be detected with a high degree of confidence, e.g 99.9% ($p<0.001$), before it would be concluded that change had definitely occurred. Under such a program, there would be an accompanying risk of more moderate (but no less real) impacts not being acted upon because (for the same level of sampling effort) they were not demonstrated with the necessary high degree of confidence (e.g. the level of confidence may have been 96% ("p"=0.04) rather than 99.9%). Thus, Type II errors would be likely to occur.

For the same level of sampling effort, a monitoring program may be designed to be more protective of the environment by changing the "level of doubt" component of the "burden of proof". If changes only need to be detected with a "moderate" level of confidence, e.g. 80% (that is $p<0.20$), before it is concluded that change has occurred (and action is taken), then although more "false alarms" (Type I errors) will occur, there will be a reduced risk of changes going "unnoticed" (Type II errors).

Often the ideal design (i.e. with sufficient power to minimise Type II errors) will be costly to implement because it involves collecting and processing numerous replicates. The use of sequential decision plans should be considered as a means of reducing costs, because it has been shown that using such plans the number of replicates needed to classify a site as impacted or unimpacted may be reduced by an average of 50% (Jackson & Resh 1989). The process involves sequentially processing replicates and examining the data until a decision may be made as to whether the site is impacted or unimpacted (Figure 3). Once a decision is reached, then no more samples need to be processed. For a full description of the history, theory, worked examples and advantages of sequential decision plans over fixed-sample size procedures the reader is referred to Jackson & Resh (1989).

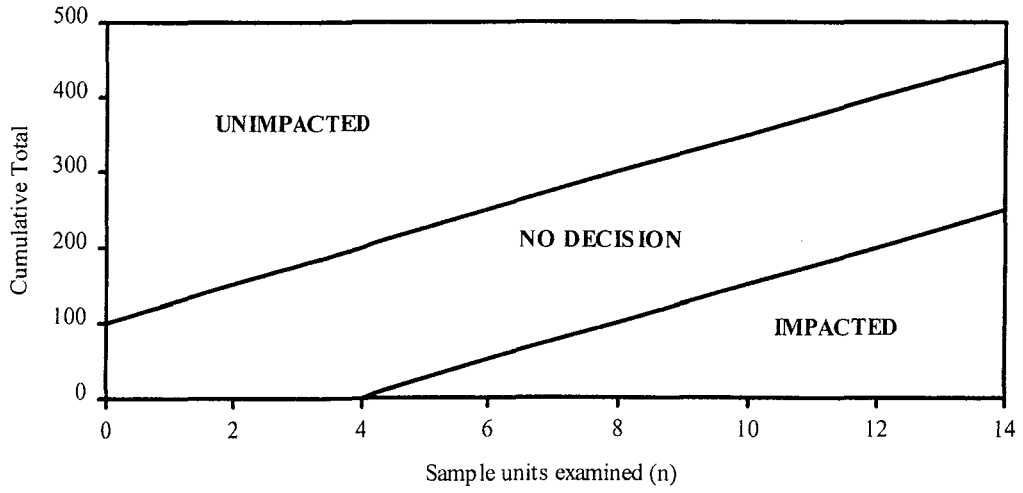

Figure 3. Sequential decision plan for monitoring the density of a hypothetical macroinvertebrate population whose density decreases under impacted conditions (after Jackson & Resh 1989).

The Information Management System

Consideration must be given in the design process to storage of the data that are to be collected and the subsequent access to, and use of, the data from the storage system. There are a number of databases on the market that may be suitable, however hardware and software continue to develop at a fast pace which could result in a system rapidly becoming obsolete. Therefore, consideration must be given to maintaining and updating the system. In the context of Ramsar Site monitoring, where both Site management agencies and Ramsar implementation agencies (where they are not the same) need access to data collected (though not necessarily at the same level or in the same form), the data will be of a corporate nature, with users at different locations accessing the one source (the Site management agency's database). Therefore, availability of the data and the format in which it is available are important issues. Also, different users may have different access rights as some data (e.g. catch details of individual professional fishermen) may have been supplied to the Site management agency on a strictly confidential basis. With the correct expertise, most databases can be configured with different levels of security, restricting access to different parts of the system for individual users. Finally, monitoring programs tend to evolve, with new parameters being incorporated. Therefore, the system also must be capable of evolving and have personnel capable of undertaking ongoing maintenance, enhancements and upgrades. This will require ongoing budgetary commitment from the relevant agency (Williams & Choo 1994).

Data analysis

Williams & Choo (1994) note that the use of different methods of data analysis may result in markedly different conclusions. In most instances, the method of analysis should be determined during the design stage. The program should then be designed to collect data in the format (i.e spatial and temporal array with a given replication) required to test the relevant hypothesis using the specified method of analysis. If a program has not been designed in this way, firm conclusions should only be drawn when a variety of methods indicate the same trends/changes (e.g. analysis of variance, rank correlation and linear regression all indicate a significant changes in the abundance of a taxon at a site over time). In each instance, the assumptions of the specific method must be met before the method is applied (e.g. for one-way analysis of variance, replicates must be independent, data normally distributed and sample variances equal).

The use of a BACIP (before/after, control/impact, pairwise) design is becoming widely accepted as an appropriate design for data collection in biological monitoring programs as it allows rigorous data analysis to detect impacts (Humphrey *et al.* 1995; Faith & Dostine 1995). Under such a design, multi (e.g. community structure) or univariate (e.g. number of taxa) data may be analysed to detect change. Also, the design allows the investigator to differentiate between natural changes and development-related changes (Figure 4).

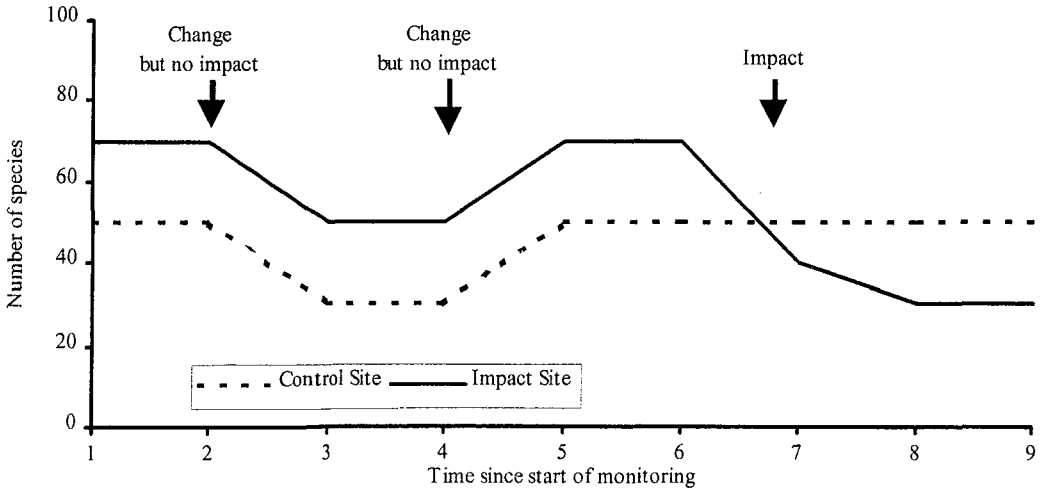

Figure 4. Use of BACIP design to differentiate between natural changes and development-related changes (impacts).

Monitoring programs and wetland complexes

As mentioned previously, monitoring programs must be designed on a site by site basis, since sites differ with respect to wetland type, perceived values and the nature and severity of threats. In several instances, Ramsar sites are composed of a number of connected (e.g. Vasse-Wonnerup) or unconnected wetlands (e.g. Forrestdale & Thomsons Lakes, Peel-Yalgorup, and the Eighty Mile Beach site) (Table 2). Where these site components (wetlands) are very different in terms of type and/or threats, it will be necessary for the environmental monitoring program for the site to include a number of sub-programs addressing each major wetland type and/or combination of threats.

Who should conduct the monitoring

Once the key parameters have been identified and an EMP designed, then a decision must be made as to who conducts the monitoring (e.g. Site management agency researchers, operations staff, tertiary institutes, consultants, or interest groups such as Ribbons of Blue, Waterwatch, Frogwatch, ornithological societies, natural history societies, "friends of the wetland" societies, or landcare groups). In most instances, the program will require a number of parameters covering a range of disciplines to be measured (e.g. hydrology, hydrogeology, botany, zoology and environmental chemistry). Therefore, a number of personnel, with a variety of qualifications, experience or training may be required.

In many instances it will be necessary or most cost effective for the work to be undertaken by paid staff. Volunteers are not cost free. Like paid staff they need to be recruited, trained and managed to produce good results. Monitoring is necessarily repetitive and long term, and may require significant travel and associated expense. In these circumstances, maintenance of volunteer interest and continuity in data collection can be a particular challenge.

Nonetheless some components of a monitoring program (e.g. bird counts, water level and some water quality data collection, invasive plant detection) can be done to a high standard, and most cost-effectively, by volunteers. There may also be very substantial ancillary benefits from involving volunteers, such as support for Site protection and assistance with management. A combination of paid and unpaid personnel may often prove to be the most cost-effective and productive arrangement. The qualified personnel may develop protocols for sample collection and then volunteers from "friends of the wetland" groups may collect the samples which are forwarded for analysis and reporting. This is a particularly cost-effective approach for wetlands remote from the source of the expertise.

Community groups

Where practicable, local communities should be involved in site monitoring. Concerned residents, keen amateurs or retired specialists are often prepared to participate in such activities on a voluntary basis. Involvement of community groups can be very productive. They often have easy access to the site, are aware of relevant issues throughout the catchment and have low or no overheads (e.g. office maintenance and administration costs). Some funding may be required for the purchase and maintenance of scientific equipment (pH meters, salinity meters, etc), for cost of sample processing (e.g. nutrient analyses) or for training (see following section). However, experience shows that these groups can be highly cost efficient.

Local community members are able to regularly visit sites and catchments and may provide early warning of impending changes. For this to happen, community members must have good communications with site management officers. An added benefit arising from community involvement is that local people may develop a sense of site "ownership" (where this does not already exist) and may be very effective in lobbying for site protection and better management.

In recent years, community groups have become much more prevalent, with groups involved in a range of conservation and landcare issues. For instance, the Western Australian Department of Conservation & Land Management has established a volunteer-based program for monitoring populations of endangered flora in the State's wheatbelt. It is intended that this program should enhance the sense of pride and ownership of the rural community for rare and endangered plants present on private land. Similarly, local volunteers, with the assistance of the federally funded Threatened Species Network, have established the Malleefowl Preservation Group to help protect the threatened malleefowl *Leipoa ocellata* in Western Australia, undertaking such activities as surveying for nest mounds.

Numerous landcare groups are involved in monitoring and rehabilitation work to the benefit of wetlands. Members of the Serpentine-Jarrahdale Land Conservation District Committee, for example, undertake revegetation activities, re-route drainage schemes and monitor phosphate levels in drains feeding into the Peel-Harvey Estuary component of the Peel-Yalgorup Ramsar site. "Friends" groups, such as Friends of Forrestdale Lake, work in concert with site management agencies to protect, monitor and manage other important wetlands.

The Royal Australasian Ornithologists Union (RAOU) also has monitoring expertise. The South West Wetlands project of 1981-85 monitored waterbird use of wetland nature reserves in south-western Australia (Jaensch *et al.* 1988) and, together with water depth, salinity, pH and nutrient data collected by management agency staff, established a baseline for more than 150 sites (J. Lane pers. comm.). Similarly, the "Scopewest" waterbird survey in the early 1990's involved regular counts by RAOU-coordinated volunteers of waterbird numbers and breeding activity on over 250 wetlands on the Swan Coastal Plain, north and south of Perth (Storey *et al.* 1993). The RAOU also coordinates regular, volunteer counts of shore and bushbird numbers at a host of monitoring sites across Australia. Other bird study clubs also conduct similar activities at local or regional levels.

An outstanding example of community involvement in water quality monitoring is the national "Waterwatch" program - delivered as "Ribbons of Blue" in Western Australia, "Streamwatch" in New South Wales, and as "Waterwatch Victoria", "Waterwatch Queensland", etc. in the other States and Territories. Waterwatch programs encourage local schools and community groups *inter alia* to adopt river sections and, using standardised procedures, routinely measure basic parameters such as flow rates, nutrients, pH and salinity.

International volunteer organisations may also participate in wetland monitoring. Anon (1993) proposed the use of the International Waterfowl Census network to collect simple, non-quantitative wetland data, on an annual basis, right across Europe. It was argued that for minimum effort, the existing network (which includes many volunteers) could record information on threats and changes in wetlands, as well as waterbird numbers, during winter site visits.

Australia's many landcare and community conservation groups provide a large (though in places, thinly distributed) resource of people willing to invest time and energy (and considerable expertise) into better management of the environment. The potential to involve such groups and individuals in Ramsar site monitoring is substantial. It is therefore recommended that their participation be sought during initial phases of environmental monitoring program development.

Training

Training may be required for staff at different levels in the EMP.

For example, the site manager driving the process may be very experienced in general resource management issues. However, in some cases, he or she may have limited familiarity with wetland values or ecological processes. This situation most commonly arises where operational staff "inherit" (though they may have little or no training in this area) wetland management responsibilities as a result of restructuring of management agencies. This is beyond the control of the personnel concerned. Nonetheless, it is important that Ramsar site managers be knowledgeable about recognising threats to wetlands and about management techniques. We believe, therefore, that there is substantial merit in the proposal (B.Phillips, pers. comm.) that a survey be undertaken to ascertain the training needs of Ramsar and other wetland site (e.g. "Directory" site) managers in Australia, and that appropriate courses and/or other training arrangements, subsequently be provided. Note that Article 4.5 of the Ramsar Convention obliges Contracting Parties to "promote the training of personnel competent in the fields of wetland research, management and wardening".

Similarly, community groups and field staff within site management agencies may require or may greatly benefit from specialist training in many fundamental aspects of site management and site monitoring. Some of the most important skills required are, for example, the ability: to recognise invasive plant species and to detect their presence (and that of feral animals) before they become firmly established; to detect the likely presence of plant-killing diseases such as "dieback" (e.g. *Phytophthora*), to identify the species of flora and fauna which, in many cases, give the site its value; to measure key parameters such as water depth

variation, salinity and pH, and to recognise potentially harmful activities, e.g. even minor changes to wetland outflow levels. There is a pressing need for training courses to be provided so that Ramsar site field personnel, employed or voluntary, can develop and apply these skills. The expertise to conduct this training may be in-house (e.g. botanists and zoologists for native and introduced flora and fauna identification, hydrologists and chemists for water quantity and quality measurements). Alternatively, it may be necessary to source the expertise from private industry, consultants or tertiary institutions. In either case, it will generally be relatively low cost and readily achievable, through field or laboratory workshops, readily available identification guides and the like.

RECOMMENDATION 16. That practical training courses and other guidance or assistance that will enable Ramsar site management personnel and others (particularly community-based Ramsar site support groups) to recognise particular threats to wetlands; to recognise early signs of adverse changes in the character of wetlands, and to take or initiate appropriate action, be developed and implemented by Commonwealth, State and Territory Ramsar implementation agencies as a priority. That the Commonwealth Government, through the Biodiversity Group of Environment Australia, provide funding support to the State and Territory Ramsar implementation agencies for this purpose.

Promoting independent research and surveys at Ramsar Sites

Research is needed to fill gaps in current knowledge of many Ramsar sites (their flora, fauna, etc) and the processes that sustain them. Such research may include, for example, undertaking detailed taxonomic surveys of sites to ensure that species lists of higher taxa (at least) are complete, or it may involve research into ecological or hydrological processes, such as energy cycling or ground water movement, to increase understanding of how these processes operate and the implications for management. While research of this nature may be undertaken in-house, tertiary institutions and keen amateur naturalists can also make substantial, independent (as well as collaborative or participatory) contributions and should be encouraged to do so. It is recommended that State management and implementation agencies should encourage independent research on Ramsar wetlands, by, where possible, facilitating appropriate postgraduate research projects, and surveys or other studies by community groups (e.g. natural history societies) with expert knowledge relating to wetlands.

Independent research activity can be greatly facilitated by quite modest levels of funding or "in kind" support. Funding to cover travel costs to and from a Ramsar site may often be sufficient to attract interested parties. Where the management agency can provide basic accommodation at a site this can be an additional incentive for groups to visit and conduct useful work. The availability of support for research and surveys could be advertised periodically. A stipulation for support should be the submission of raw data (or data summaries) and copies of reports for inclusion on, or appendage to, the management agency's site database.

The role of policy in management

Finlayson (1994a) notes that in addition to addressing the individual causes of ecological change in wetlands, a major consideration is the inadequacy of institutional structures, reflecting economic, political and social constraints under which ecological management must operate. These issues need to be addressed whilst also undertaking valid and scientifically rigorous monitoring programmes (Finlayson, *op. cit.*).

It should be possible to avoid many negative impacts through a combination of good management and effective government policy. The adverse effects of many activities on wetland processes and functions are understood and documented. Identification of these threats at an early stage, combined with active management, will often allow preventative actions to be implemented before damage has occurred. This will usually depend, however, on adequate "policy" (including legislation and administrative arrangements) being in place (e.g. to: restrict land clearing in catchments prone to salinisation; prevent use of high value wetlands as drainage sumps; restrict mining activities that would otherwise lead to habitat degradation; prevent industrial developments from discharging effluents into wetlands; ban the use of lead shot for waterfowl hunting, etc). In some instances this policy may already exist, and it will be up to the site manager to be aware of the policy and to ensure (to the extent he/she is able) that it is implemented and effective. In other cases, adequate policy will not exist and will require active lobbying for it to be written and adopted.

PART F: AUSTRALIAN CASE STUDIES

As a theoretical test of the application of the above guidelines for monitoring ecological change in Ramsar wetlands, three Western Australian sites have been selected as case studies; Toolibin Lake, Eighty Mile Beach and Ord River Floodplain. Each site has different and distinct characteristics, values, conservation threats and history. For each case study the guidelines will be applied. The wetland values, conservation threats, "sustaining processes", existing environmental monitoring programs, existing management arrangements, current relevant research, catchment land use, etc will be identified and summarised. The relevant managers, local interest groups, local authorities, State Government departments and scientific expertise will be identified. Finally, a hypothetical environmental monitoring program will be outlined.

In the first case study, Toolibin Lake, a recovery plan (Bowman et al. 1994) is currently underway, and a monitoring program has been prepared (Froend & Storey 1996a & b) in response to acknowledged changes and threats to the ecological character of the Site. This case study incorporates a detailed historical account of the evolution of the recovery plan and is partly the basis upon which the current guidelines were written.

The sites covered in the subsequent case studies, Eighty Mile Beach and Ord River Floodplain, have had no active management or monitoring programs related to detecting change in ecological character of the Ramsar Site. The monitoring programs for these Sites are therefore entirely theoretical.

Toolibin Lake

Site description

Toolibin Lake is a fresh to brackish water lake located in the Wheatbelt Region of south-west Western Australia, about 200 km south-east of Perth and 45 km east of Narrogin. The 437 hectare Ramsar Site is comprised of one distinct wetland (Toolibin) with a surface area of approx. 226 ha (Casson 1988), contained in a nature reserve of approximately 497 ha, with a catchment area of 43 500 ha (Figure 5 & Plate 1). The majority of the catchment has been cleared for agriculture, predominantly to grow wheat and graze sheep.

Seasonally flooded wetlands with extensive stands of sheoak and melaleuca were once common in agricultural lands east of the Darling Scarp. These wetlands, with their fresh water and excellent breeding habitat, were very important for waterbirds. Toolibin Lake is now the most important remaining representative of a once widespread natural community.

Toolibin Lake is part of a chain of 13 main lakes at the head of the Northern Arthur River, which flows into the Blackwood River. The Dulbining Lakes (Dulbining West, Dulbining Central and Footballer Lakes) are immediately upstream and to the north of the Site. Immediately downstream are Lakes Walbyring (also known as Mud Hut) and Taarblin. Further downstream are Lakes Ibis, Billy, Bokan, Noman's, Lukin, White and Little White. The Site receives inputs from surface flows originating from the north-west, north and north-east parts of the catchment. The lake is not permanently inundated, but holds at least 1 m of water approximately seven out of ten years and fills approximately four years out of ten (Halse 1987). It occasionally dries out and may receive no inflow for several years in succession. When full, the lake is approximately 2 m deep and overflows at the south-west corner into Lake Walbyring.

Toolibin has been described as a macroscale ovoid sumpland, with pronounced undulations or 'gilgai mounds' on its floor (ANCA 1996). It is situated in alluvial and lacustrine valley-fill deposits, surrounded by broadly undulating sandplain. Median and mean annual rainfalls at Wickepin, 17 km to the north-west, are 401 mm and 415 mm respectively, mostly falling between May and August. Annual evaporation is circa 1800 mm.

Prior to clearing, the natural vegetation of the catchment was heath with open woodland of *Eucalyptus wandoo* and *Acacia acuminata* on the gravelly sands, *E. salmonophloia* and *E. oleosa* var. *longicornis* on the heavier valley soils and *E. loxophleba* on the sandier valley soils. The remnant woodland fringing the wetland consists of *Allocasuarina huegeliana*, *Melaleuca uncinata*, *E. rudis* and *Acacia accuminata*.

Eucalyptus loxophleba forms open woodland on higher ground. The outer remnant sand dune to the north-east of the lake is characterised by an open woodland of *Allocasuarina huegeliana*, with an understorey of *Banksia prionotes* and *B. attenuata*. Most of the lake is covered in thickets or woodlands of water-tolerant trees, predominantly *Casuarina obesa*, although *Melaleuca strobophylla* is common and *M. laterifolia*, *M. viminea* and *E. rudis* also occur. There is a large open area on the eastern side of the wetland. The sedge *Chorizandra endodis* occurs in parts of the lake, and two aquatic macrophytes, *Potamogeton* sp. and *Lepilaena* sp. also occur (Casson 1988). Currently, the wetland has a buffer of approx. 500m of native vegetation along the east and north shores, and a narrower buffer of semi-cleared bush and re-planted agricultural land to the south and west.

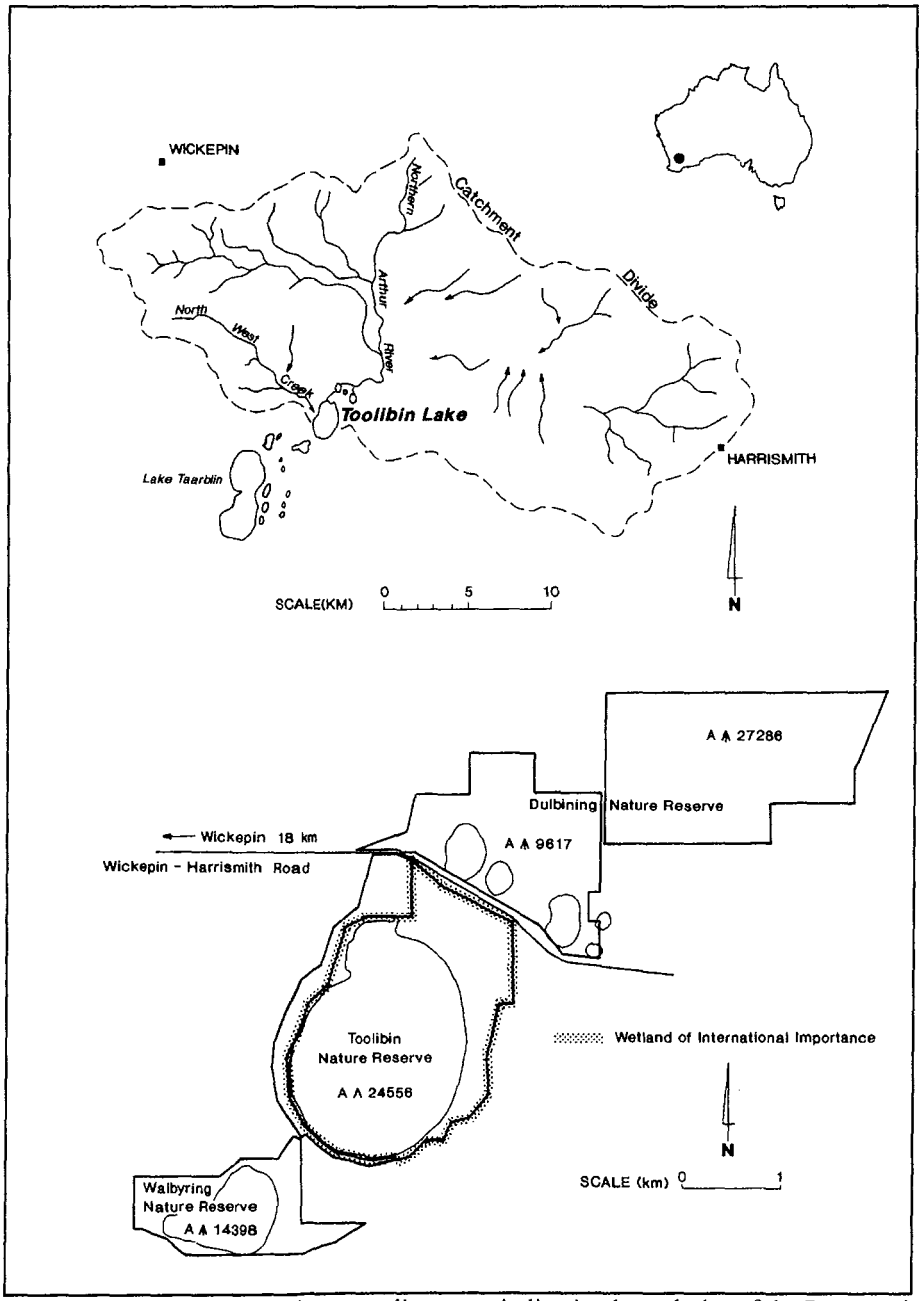

Figure 5. Toolibin Lake and surrounding area, indicating boundaries of the Ramsar site.

Management of the site

At the time of nomination as a Wetland of International Importance (February 1990), the Site was referred to as "Toolibin Nature Reserve (NR↑24556) and that portion of Dulbining Nature Reserve (NR↑9617) to the south of the Wickepin/Harrismith Road" (WADCALM 1990). Both reserves (total area

742 ha) were vested in the National Parks and Nature Conservation Authority of Western Australia as "A" Class Reserves for the Conservation of Flora and Fauna and managed by the WA Department of Conservation and Land Management. Toolibin Nature Reserve included a buffer of remnant vegetation along the east and northern shorelines, however recently acquired farmland adjoining the south and west shorelines had not, at this stage, been added to the reserve.

Shortly after nomination of the Wetland of International Importance, Toolibin Nature Reserve and other reserves in the area were re-gazetted to increase their levels of protection, to include additional land and to rationalise their boundaries. That portion of Dulbining Nature Reserve to the south of the Wickepin/Harrismith Road was added to Toolibin Nature Reserve, along with the land purchases to the west and south of Toolibin Lake itself. As a result, the 437 ha Site is now enclosed within a single reserve of 497 ha (Anon 1991). The boundary of Dulbining Nature Reserve, consisting of reserves ↑9617 (reduced to 245 ha) and ↑27286 (343 ha), was accordingly redefined and vested as an "A" Class reserve for the Conservation of Flora and Fauna (Anon 1991). Around the same time, Walbyring Nature Reserve (NR ↑14398), containing Lake Walbyring, immediately to the south west of Toolibin Lake, was increased in area (to 148 ha) by the addition of some adjoining vacant Crown land. The reserve was made "A" Class and its purpose was amended from the Protection of Flora and Fauna to the Conservation of Flora and Fauna (Anon 1990). Similarly, Lake Taarblin, to the south of Lake Walbyring, consisting of North Taarblin (NR ↑9550 (633 ha)) and South Taarblin reserves (NR↑20962 (362 ha)) initially was a Game Reserve, for duck shooting, but was later amended to an "A" Class Nature Reserve for the Conservation of Flora and Fauna (Anon 1989). Management of these reserves, including the Ramsar Site, remains the responsibility of the State nature conservation agency, WADCALM.

A common issue compromising the management of many Ramsar sites is the inadequate definition (both on paper and on the ground) of their boundaries. This is not a major issue with Toolibin, as the Site is entirely contained within Toolibin Nature Reserve, and the boundary of the reserve is well defined, bordered by fences or roads. The presence of cleared farmland around the reserve provides added definition.

Identifying wetland values

Toolibin Lake was nominated as a Wetland of International Importance on the basis of its use by waterbirds and as a particularly good example of a wetland type formerly widespread in the region (WADCALM 1990).

In the nominating document (WADCALM 1990), the wetland was identified as supporting 24 species of breeding waterbird, which was the greatest number recorded for any wetland in south-western Australia. Altogether, 41 species of waterbird were known to use the Site, which was the highest number of species recorded on any inland wetland in the south-west of the State.

More recent analysis of available data, incorporating historical records collected between the mid-1960s and the mid 1970s (Goodsell *et al.* 1978), and including all other surveys known to have been conducted at the lake up to the present (June 1996), suggests 25 species have bred at the Site and 49 species have been recorded on the wetland (Froend & Storey 1996a). The additional species are Darter *Anhinga melanogaster*, Australasian Bittern *Botaurus poiciloptilus*, Banded Lapwing *Vanellus tricolor*, Common Sandpiper *Actitis hypoleucos*, Glossy Ibis *Plegadis falcinellus*, Red-necked Stint *Calidris ruficollis*, Red-necked Avocet *Recurvirostra novaehollandiae* and Wood Sandpiper *Tringa glareola.* Purple Swamphen *Porphyrio porphyrio* was the additional species recorded breeding on the Site. S.A. Halse (WADCALM, pers. comm.) advises, however, that the majority of these additional species have not been recorded since pre-1980; the Wood Sandpiper was a once-off record from 1988.

The lake is particularly important as a breeding area for Freckled Duck *Stictonetta naevosa*, a species gazetted 'rare and endangered' under the Western Australian Wildlife Conservation Act. Five or more pairs breed when the water is at least 1 m deep through spring, more than 50 birds were present from March 1982 to January 1983, and a count of 600 birds in December 1982 is the highest number recorded from the region, and second highest for the State (ANCA 1996). The lake also is important for breeding by large wading birds: White-necked Heron *Ardea pacifica*, White-faced Heron *Egretta novaehollandiae*, Great Egret *A. alba*, Nankeen Night Heron *Nycticorax caledonicus* and Yellow-billed Spoonbill *Platalea flavipes*. In addition, Toolibin Lake is an important breeding area in south-western Australia for Great

Cormorant *Phalacrocorax carbo*, Little Black Cormorant *P. sulcirostris* and Little Pied Cormorant *P. melanoleucos*. For some of these species, this is the only regularly-used inland colony in the region. Great Crested Grebe *Podiceps cristatus*, Blue-billed Duck *Oxyura australis* and moderate numbers of other ducks also breed at the site. Eight of the species recorded utilising the wetland, Great Egret *Ardea alba*, Glossy Ibis *Plegadis falcinellus*, Common Greenshank *Tringa nebularia,* Wood Sandpiper *T. glareola*, Common Sandpiper *Actitis hypoleucos*, Red-necked Stint *Calidris ruficollis*, Sharp-tailed Sandpiper *Calidris acuminata* and Oriental Plover *Charadrius veredus* are listed under the Japan-Australia (JAMBA) and China-Australia (CAMBA) Migratory Birds Agreements (Glossy Ibis under CAMBA only and Oriental Plover under JAMBA only).

Generally, the lake supports moderate numbers of birds. The highest count was of 1646 birds in January 1982, with Grey Teal *Anas gracilis* being the most abundant species.

In addition to waterbird usage, the wetland is internationally significant for its vegetation. It is the only sizeable, remaining example in south-western Australia of a wetland with extensive thickets of living *Casuarina obesa* across its floor. This used to be one of the main types of inland freshwater wetland in the 'Wheatbelt' region before widespread clearing for agriculture resulted in most inland wetlands becoming saline, with the concomitant death of emergent vegetation (WADCALM 1990). Increased inundation, due to increased runoff, is also believed to be a major factor. The wetland also supports extensive stands of *Melaleuca strobophylla*, which has a restricted distribution in the region.

There are no other components of the flora or fauna that are known to be particularly noteworthy. Because the lake's waters are not permanent and are now rarely fresh, the aquatic invertebrate fauna is characterised by taxa adapted to seasonally dry and brackish habitats. These taxa are common in wetlands throughout the region. Similarly, any fish recorded from the site must reinvade after each dry period and are likely to be common in the south-west. There are a potential seven species of frog that could occur in the lake (they occur in the region), however, current salinities are probably above the thresholds at which most species may successfully breed. There are no records of tortoises from the lake (Sanders 1991).

Identifying threats to wetland values

Long before Toolibin Lake was nominated as a Wetland of International Importance, action was taken by the then management agency, the WA Department of Fisheries and Wildlife, to protect the lake and its values.

Duck shooting

In 1974, in recognition of the presence of a rare species (Freckled Duck) and the importance of the wetland as breeding habitat for this and other species of waterbirds (particularly colonial nesters such as egret), the lake was closed to duck shooting.

Salinisation

A far more serious threat to the ecological character of the lake was salinization as a result of clearing of native vegetation in its catchment. In the mid-1970s duck shooters and local landholders noticed that emergent vegetation along the western shore of the lake was dying, apparently due to rising soil salinity. Out of concern for the future of the wetland, the Western Australian Field and Game Association, together with local citizens, organised a public meeting in Narrogin, on 25th August 1976, to discuss the plight of the lake. Toolibin was recognised as one of the last wetlands in the 'Wheatbelt' Region of Western Australia that was predominantly fresh, had an intact, healthy and extensive cover of *Casuarina obesa* and *Melaleuca* spp. (and some *Eucalyptus rudis*) through the seasonally-inundated area, and supported a diverse range of species of breeding waterbirds. Shooters and local residents did not want to see the wetland deteriorate in the same fashion as other wetlands in the region. For instance, at Lake Taarblin, several kilometres downstream, all vegetation was dead or dying, the water was highly saline and only a restricted suite of waterbirds utilised the system, with few species breeding.

In response to the public meeting, the Northern Arthur River Wetlands Rehabilitation Committee was set up by government (State) to examine ways of reducing the salinity of the lake to ensure the survival of the vegetation and ensure that the lake remained an important breeding area for waterbirds.

The initial task of the committee was to assess the threat to the system posed by land clearing and salinization. Land in the catchment was first taken-up for farming in the 1890s, but widespread clearing did not occur until after the First World War. By the mid-1930s about $^1/_3$ of the native vegetation in the catchment had been cleared. Most of the remainder was cleared in the late 1940s and early 1950s. By 1972, at least 90% had been removed (NARWRC 1978).

A result of clearing has been secondary salinization of wetlands and other, mainly low-lying, parts of the landscape. Deep-rooted native, perennial vegetation intercepts more rainfall and uses more water at greater depths than the shallow-rooted, annual, pastures and cereals that have replaced it. As a consequence, water tables rise bringing stored salt to the surface. This is evident from observations of fifty-seven bores sunk in the catchments of Toolibin and Taarblin between 1907 and 1913. When first drilled, most bores were 25 to 30 m deep and bottomed onto rock. About half were dry and in the others the water tables generally were deep and saline (~ 30 ppt) (NARWRC 1978). Since clearing, water tables have risen, by 12 - 15 m to 1977. At this time about 3% of the catchment was severely salt-affected and a further 2.6% was slightly affected (Watson 1978).

Secondary salinization of Toolibin has occurred due to saline groundwater rising to within 1 - 2 m of the lake bed and into the root zone of the *Casuarina obesa* and *Melaleuca* spp. Some of this salt is brought to the surface by capillary action, resulting in salt crusting on the lake bed. This process has resulted in the death of trees in the wetland, especially along the western shore, where adjacent cleared land is also severely salt-affected. Monitoring of bores in the catchment suggests that the effects of land clearing on the water table have yet to be fully expressed and the situation may deteriorate further in years to come.

Secondary salinization due to flushing of salt from affected land upstream of the lake is also taking place. Increased amounts of salt are being discharged into the wetland, and the higher water table is thought to have reduced leaching of this salt down into the lower soil profile. When the lake partially fills but does not overflow, the problem is exacerbated; salt loads increase with no flow-through flushing.

Reduced vegetation cover in Toolibin's catchment has also resulted in increased runoff. This has contributed to secondary salinization of the lake by causing more waterlogging and flooding in the catchment and increased flushing of surface-salt into the drainage system from salt-affected land.

Increased inundation

Increased runoff due to clearing may also lead to longer periods of inundation in seasonal wetlands and, where excessive, this may lead to the death of emergent species. It is thought that this was the initial reason for the death of vegetation in Lake Taarblin. Vegetation in the southern basin of the lake died after the lake filled "for the first time in living memory" in 1926. Vegetation in the northern basin persisted into the early 1930s but was dead by the mid-1930s, even though the lake was mostly dry during the first half of the decade. Salt, however, was not evident in the lake until after 1955 (Watson 1978). It seems reasonable to conclude that increased duration of inundation has the potential to adversely affect the vegetation of Toolibin Lake also.

Eutrophication

A final consideration with respect to catchment clearing is the potential for eutrophication of the wetland due to the flushing of nutrients applied for agricultural purposes. In the Toolibin catchment, most nutrient mobilised in this way is likely to be in particulate form, bound to suspended sediments. The low rainfall and low gradients of the Toolibin catchment reduce its susceptibility to this process (Ed Hauck, AGWA pers. comm.). However, in March 1993 there was an outbreak of botulism in the lake that killed many waterbirds; this may have reflected a concentration of nutrients towards the end of the summer as the lake was drying.

Deteriorations in the vegetation and fauna of Toolibin Lake due to rising ground water and salinization have been detected by monitoring and indicate a change in ecological character is occurring at the Site.

Vegetation trends

The vegetation of Toolibin Lake has been monitored since 1977, when plots were first established for this purpose (NARWRC 1978). Since then, the status of the lake vegetation has been assessed in 1980, 1982, 1986 and 1992 (see review by Froend & Storey 1996a). Data from these assessments indicate a gradual,

though unevenly distributed, decline in the health of the *Casuarina obesa* - *Melaleuca strobophylla* stands on the bed of the lake (Mattiske 1993). Most of the deaths observed have been in flat, low-lying areas where salt crusting on the soil surface was evident. Healthier trees were restricted to the gilgai mounds. The proportion of dead *Casuarina obesa* trees in plots gradually increased (13-19%, total n=341) since 1977, with the greatest increase occurring since 1986. A similar trend was observed with stressed trees (6-12%). The proportion of dead and stressed *Melaleuca strobophylla* trees was comparatively high and ranged from 24-37% (total n=141) and 4-6% respectively over the monitoring period. The decline in the *Eucalyptus rudis* population had advanced significantly by the time monitoring first started in 1977. In that year, 77% (total n=23) of the trees within plots were already dead. By 1986, all the trees were dead. Although the monitoring plots reflect the key vegetation types on the lake bed, there is insufficient replication over all parts of the lake. Therefore, these data should be considered only as indicators of the trend in total population health (Froend & Storey 1996a).

Additional monitoring (different plots) of the vegetation in 1983 (Froend 1983; Froend *et al.* 1987) and 1988 (Bell & Froend 1990) showed similar trends. The two common lake bed and lake margin species, *Melaleuca strobophylla* and *Eucalyptus rudis,* had relatively high mortality rates, with nearly a quarter of tagged trees dying in the 1983-1988 period. Assessment of *Casuarina obesa* revealed that, in general, most trees tagged in 1983 survived until 1988.

Although there are no quantitative data, there is substantial evidence to suggest that sedges were once common in the wetland, though now they are virtually absent. Circumstantial evidence suggests that the sedges began to decline in the late 1960's. Munro (1975) mentions 'reeds' as occurring over the extensive shallow marginal area of the lake. Casson (1988) collated information on the presence of sedges at Toolibin and surrounding lakes. "Reedbeds" at Toolibin were observed in the early 1970's and grew rapidly in response to water in the lake. At this time a larger type of 'reed' was confined to a thin 0.3 ha strip in the southeast corner of the lake bed. The last of these sedges, which were about 135cm tall, disappeared from under the flood gums of the lake bed in the early 1980's. Casson (unpub. dat.) also identified (in 1989) two tiny patches of sedge on the neighbouring farm of J. Knox as *Juncus pallidus*. The decline of *J. pallidus*, if it was this species on the lake fringe, was probably due to prolonged inundation and increasing salinity, as this species is normally found in freshwater swamps or soaks. Finally, Mattiske (1993) noted the presence in 1992 of the sedge *Chorizandra enodis* on the gilgai mounds in some plots. It varied considerably in cover (stems per unit area) and appeared dependent on the mounds for relief from prolonged inundation and higher soil salinities. This sedge does not correspond with the 'reed' margin noted by Munro (1975) and has not been recorded as present on the lake bed since 1993 (Froend & Storey 1996a).

During the period of monitoring, halophytic species, including species of *Halosarcia* and *Sarcocornia,* have encroached into the vegetation plots. This is consistent with other visual evidence (e.g. salt crusting on the surface) of increasing soil salinity.

Waterbird trends

Coincident with increasing salinity and declining vegetation health, there are trends of decreasing usage by waterbirds. Froend & Storey (1996a) reported that seven species (Australasian Bittern, Banded Lapwing, Common Sandpiper, Darter, Glossy Ibis, Red-necked Stint and Red-necked Avocet) have not been recorded from Toolibin since before 1980, and five species (Chestnut Teal, Pacific Heron, Purple Swamphen, Freckled Duck and Hardhead) have apparently declined in numbers over time. Pacific Heron and Purple Swamphen have not been recorded on the lake since 1987 and in the early 1990s there have only been occasional sightings of Freckled Duck and Hardhead. The only record of Chestnut Teal since 1987 came from dead specimens recovered from the lake (together with dead Freckled Duck) in March 1993 during a botulism outbreak.

Three species (Darter, Purple Swamphen and Hardhead) have not been recorded breeding in Toolibin Lake since pre-1980. Of the remaining 21 species recorded breeding on the lake, only three have been recorded breeding since 1985 (Australian Shelduck, Black Swan & Hoary-headed Grebe) and only the Black Swan has been recorded breeding since 1990. These trends are no doubt at least partly due to inconsistent survey effort and method during the late 1980s and 1990s, however water quality data suggest an increase in lake salinity in springtime (Figure 6.), and this may be adversely affecting breeding as spring is the most critical period.

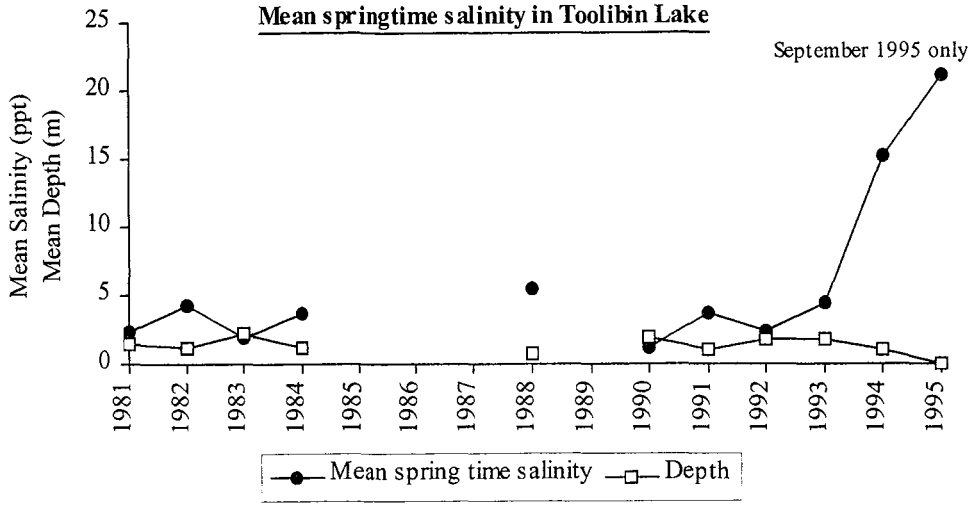

Figure 6. Changes in mean salinity (ppt) and depth (m) in springtime in Toolibin Lake each year (Mean of measurements taken in September and November of each year. Source, J. Lane WADCALM).

Halse (1987) concluded that the high level of breeding activity previously reported on Toolibin Lake was due to:

- extensive, dense thickets of *Casuarina obesa* and *Melaleuca* spp throughout much of the inundated area
- fresh/brackish water of sufficient quality to sustain growth of emergent vegetation and survival of young waterbirds
- occasional drying which facilitates persistence of the emergent vegetation and probably increases wetland productivity, thereby leading to a greater availability of food items.

Reasons for the high number of species of waterbird recorded from the lake include those listed above, but also relate to the diversity of habitats provided, both at any instance in time, and over time as water levels fluctuate (Halse 1987).

Loss of habitat, through death of vegetation as a result of either increased salinity or increased inundation or both, will result in a loss of waterbird species utilising the wetland. Species likely to be most affected include Freckled Duck (which prefer dense tree vegetation), most of the tree-nesting birds (i.e. Cormorants, Herons, Egrets and Spoonbills) and species preferring dense stands of rushes (Halse 1987). This appears to have already happened to a certain extent, with the loss of Australasian Bitterns and Purple Swamphens, both of which favour rushbeds which are no longer found in the wetland (see above). Other species that utilise rushes for nesting will also be affected.

Water potability

Water potability for young birds is also of major concern. For the first week or so after hatching, most young waterbirds must have fresh water to drink. This is because their salt glands are not developed and the birds are unable to regulate salt intake (Halse 1987). This applies to young of salt-tolerant as well as salt-intolerant species. Conversely, adult birds of most species can survive while drinking brackish or even moderately saline water. Therefore, so long as water is fresh (or nearly so) in spring, when most breeding occurs at Toolibin, it is of little consequence, in terms of drinking water, if salinity rises later in the year.

From unpublished data of breeding attempts of waterbird species on various wetlands in different salinity categories in south-western Australia, Halse (1987) determined that, if salinity in Toolibin Lake in September rose to >10 parts per thousand, only Black Swan, Australian Shelduck, Grey Teal, Australasian Shoveler, Pink-eared Duck, Eurasian Coot and Little Pied Cormorant could be expected to attempt to breed in similar numbers. Great Crested Grebe, Australasian Grebe, Pacific Black Duck and

White-faced Heron might also nest, but Halse (1987) predicted that at least 11 other species reported breeding at the lake would stop. Recent water quality data suggest that these critical threshold levels are now being reached.

Selection of a provisional Scientific Monitoring and Management Committee

Following recognition of the threat to Toolibin Lake posed by rising salinity, management of the wetland has evolved through a series of stages as various committees/groups have been established.

In response to the initial concerns of duck shooters and local landowners, the Northern Arthur River Wetlands Rehabilitation Committee (NARWRC) was established, in March 1977, under the authority of the WA Minister of Fisheries and Wildlife. This committee first met on 11 May 1977. The original members of the committee, their affiliations and broad areas of expertise are presented in Table 13.

Table 13. Original membership of the Northern Arthur River Wetlands Rehabilitation Committee

Committee Member	Affiliation	Area of Expertise
Mr K.L. Barrett (Chairman)	Public Works Dept.	Management/surface water
Mr J.T. Goodsell	Dept. Fisheries & Wildlife	Wetlands and waterbirds
Mr A.N. Watson	Dept. Agriculture, Narrogin	Agricultural practises
Mr P.R. George	Dept. Agriculture	Hydrology/drainage
Mr L.N. Furness	Geological Survey of W.A.	Geology/geomorphology
Mr P.D.K. Collins	Public Works Dept.	Water allocation
Dr E.M. Mattiske	Forests Dept.	Flora, especially wetland plants

This membership provided expertise in areas considered most relevant at that time. Management of Toolibin Lake Nature Reserve was then the responsibility of the Department of Fisheries and Wildlife (a role now performed by WADCALM). A representative from this organisation, with expertise in waterbird and wetland ecology, was present on the committee. Additional areas of expertise included: botany, to provide an understanding of the reasons for the demise of the emergent vegetation; agriculture, to provide an understanding of land management issues in relation to catchment clearing and salinization; representatives from the Public Works Department (which became the Water Authority of Western Australia, and is now the Water Corporation), to provide expertise on surface water issues, and a representative from Geological Surveys (Mines Department) to provide an understanding of ground water movements in relation to the geology and geomorphology of the region.

The terms of reference of this committee were to recommend measures to:

- Preserve Lake Toolibin as a freshwater[1] lake, and
- Rehabilitate other lakes and foreshores downstream from Toolibin to improve the carrying capacities, water quality and wildlife values of the system.

[1] For this purpose, a freshwater lake was defined as one which has an overall salinity level low enough to provide the food that will enable water birds to nest and rear young. A salinity of 3000 mg/l TDS was tentatively set as the maximum desirable level of soluble salts (NARWRC 1978).

The NARWRC completed its studies in 1986, with a series of reports being produced on different aspects of the wetland. Its principal recommendations (abbreviated) were as follows (NARWRC 1987).

1. A 100 to 200 m wide strip of farmland adjacent to the full length of the western edge of the lake should be acquired and revegetated promptly.
2. The interceptor banks discharging saline water into the western side of Lake Toolibin should be diverted.
3. Active management of the Lake Toolibin Nature Reserve should be undertaken to promote regeneration and evapotranspiration.
4. Practical actions for control of groundwater levels and saltwater discharges should be actively encouraged across the catchment.

5. Groundwater pumping tests should be undertaken and a borefield designed and costed to assist the vegetation in lowering the watertable to at least 1.5 m beneath the soil surface.
6. The 26 established vegetation plots should be monitored every four years and a sub-set should be monitored annually.
7. Boreholes in and around Lake Toolibin should be monitored annually and consideration should be given to instrumenting key sites for continuous monitoring.
8. Operation of the established gauging stations monitoring lake level and inflow from the Northern Arthur River should be continued and lake water quality should be sampled at intervals following each major inflow event.

Recommendations 1, 2 and 4 were implemented within a few years of being made. The remaining recommendations have since been partly implemented and implementation continues.

In 1985, an independent group of local landholders, who were concerned about the increasing loss of agricultural productivity as a growing percentage of the catchment became salt-affected, formed the Wickepin Land Conservation District Committee (WLCDC). This was one of the first such groups in Western Australia and led a major community effort to rehabilitate salt-affected land. The WLCDC, with support from the Department of Agriculture, Greening Australia, Alcoa, Wickepin Shire Council, local schools, a Commonwealth Employment Scheme project and local farmers, rehabilitated 569 ha of salt-affected land on eight farms in the Toolibin Flats area; 60 000 trees were planted to help draw down the water table and 34 kms of fencing were erected to protect them. This achievement won the WLCDC an Australian Broadcasting Commission National Tree Care Award (Halse 1988). At the same time, WADCALM had planted 9 000 trees in the Dulbining Nature Reserve to help lower the water table to the north of Toolibin Lake. Following this initiative, the Toolibin Lake Catchment Group was formed by local landowners from within the catchment of the Site.

By the beginning of 1992, many initiatives which could benefit landholders as well as the ecological values of Toolibin Lake were underway. Nevertheless, there were a number of issues over which different interest groups had different points of view and there was no clear process for pursuing the implementation of other actions needed if the lake was to be saved from salinisation. In 1992, WADCALM was successful in obtaining funds from the Australian Nature Conservation Agency Endangered Species Program to support preparation of a Recovery Plan for the lake. This would provide the necessary coordinating mechanism (Blyth *et al.* 1996).

As the first step in preparation of the Recovery Plan a technical workshop was convened by the Department of Conservation and Land Management on 3 September 1992, to attempt to develop a common understanding among research and technical practitioners regarding environmental management actions necessary to protect and enhance the lake and surrounding reserves. The participants in the workshop (see next section) included scientists who had been involved in research on Toolibin Lake and its catchment, conservation managers, and members of the local community including farmers from the WLCDC and members of the Wickepin Shire Council (Blyth *et al.* 1996).

The workshop was successful in achieving a broad consensus on the following critical issues pertaining to the management of Toolibin Lake and its surrounding reserves:

- the processes that have given rise to the current hydrological and salinity status of the lake and adjoining lands;
- anticipated future changes in the hydrology of the area that are relevant to the future ecological condition of Lake Toolibin;
- the critical and urgent need for management to save the lake from an otherwise inevitable further decline; and
- proposed management actions and their priority for implementation.

Based upon the consensus from the workshop, a Recovery Plan for Toolibin Lake and its surrounding reserves was prepared. This initial plan was revised and finally endorsed by WADCALM on 13 September 1994, by the NPNCA on 9 September 1994 and launched by the WA Minister for the Environment on 11th October 1994 (Bowman *et al.* 1994). The Plan is current until September 2003, i.e. for a period of ten years.

The objective of the recovery plan is to "ensure the long-term maintenance of Toolibin Lake and its surrounding nature reserves as a healthy and resilient freshwater ecosystem, suitable for continued waterbird usage at current high levels". To assist in determining if and when recovery is achieved, a range of biological and physical criteria were formulated:

Biological Criteria:

1. No further deterioration is observed in the health of the vegetation of the lake or the reserves.
2. Successful tree and shrub regeneration in the lake and reserves is established in all vegetation associations.
3. Based upon available data, the lake supports sufficient species richness and numbers of invertebrates to assure waterbird food resources.
4. The numbers and species of waterbird visitation (41 species) and breeding success (24 species) that currently occurs is maintained or improved.

Physical criteria:

1. The minimum depth to the water table beneath Lake Toolibin and Toolibin Flats in spring, when the lake is dry (i.e. in dry years), should be 1.5m.
2. The maximum salinity of lake water when the lake is full should be 1000 mg/l Total Dissolved Salts (TDS).
3. The maximum salinity of inflow to the lake, measured at the Water Authority gauging station 609 010 on the Northern Arthur River, should be 1000 mg/l TDS during the winter months when the lake is full.
4. The lake bed dries periodically by evaporation, on average once every three years.
5. The levels of nutrients within Lake Toolibin should not cause excessive growths of algae or other aquatic plants, or cause deleterious reductions in dissolved oxygen concentrations in the water. Total phosphorus levels in the water should not exceed 100µg/l unless long-term monitoring indicates that this criterion may be modified.

Many of the recommendations for management of Toolibin Lake made by the NARWRC became significant parts of the recovery plan (Bowman *et al.* 1994) and are currently being implemented (see following section on Current Management and Monitoring Activities). The Recovery Plan involves an integrated strategy of short-term and ongoing measures at a local and catchment scale. The principal elements of the Recovery Plan are as follows:

1. Establishment of a Recovery Team and a Technical Advisory Group to ensure efficient and adaptive implementation of the Recovery Plan.
2. Watertable drawdown by staged groundwater pumping to ensure the drawdown of the saline water table beneath the lake and reserves in the short term.
3. Surface water drainage of the Toolibin Flats to reduce saline inflows to the lake and reduce waterlogging.
4. Lake outlet control to improve flushing efficiency.
5. Enhancement of vegetation in the lake and its adjoining reserves through grazing control, planting, and fire management, to improve regeneration and maintain waterfowl habitats.
6. Revegetation in the catchment to establish and maintain a more favourable hydrological equilibrium for the Lake Toolibin catchment in the long-term. This will be achieved though land management planning, the promotion of fodder crops, the revegetation of salt affected land and the targeted but broadscale revegetation of groundwater recharge and discharge areas.
7. Agronomic manipulation to maximise soil water storage.
8. The development of a computer-based decision support system to enable the Toolibin Lake Recovery Team to consider all available information during the implementation and on-going management of the Recovery Plan.
9. Monitoring and reporting to provide input to the Decision Support System, to determine the effectiveness of the recovery actions and to facilitate ongoing adaptive management.

The Recovery Team and a Technical Advisory Group (TAG) were formed following preparation of the initial draft Recovery Plan (i.e. prior to its revision and final adoption) and met, jointly, for the first time in September 1993. Membership of each team and their affiliations at the end of 1994 are detailed below

(Table 14). The TAG plays a key role in advising on the complex and incompletely understood hydrological and ecological issues of the lake and catchment, whilst the Recovery Team has the responsibility for ensuring that the necessary resources are made available for implementing the recovery plan. Of major significance is the fact that both committees are chaired by WADCALM's Wheatbelt Regional Manager, Mr Ken Wallace. This is seen as pivotal, providing a highly effective link between the committees and with on-ground management.

Table 14 . Membership of the Toolibin Lake Recovery Team and Technical Advisory Group (as of 1 March 1997).

Committee	Name	Affiliation
Recovery Team		
	Mr Ken Wallace	Wheatbelt Regional Manager, CALM (Chair)
	Mr John Blyth	WA Threatened Species & Communities Unit, CALM
	Mr Grant Davenport	Farmer, member of Toolibin Lake Catchment Committee
	Mr Phil Domaschenz	Environment Australia Biodiversity Group
	Mr Richard Pickett	Senior Water Resources Officer, Water & Rivers Commission
	Mr Jim Lane	Principal Research Scientist, CALM
	Mr Gordon McDougall	Farmer, member of Toolibin Lake Catchment Committee
	Mr Doug Sawkins	Agriculture Western Australia, Narrogin
Technical Advisory Group		
	Mr Ken Wallace	Wheatbelt Regional Manager, CALM (Chair)
	Mr David Bicknell	Revegetation Development Officer, Department of Agriculture
	Dr Ray Froend	Research Officer, Water Authority of Western Australia
	Dr Richard George	Research Officer, Department of Agriculture
	Dr Stuart Halse	Senior Research Scientist, CALM

With the new impetus provided by the Recovery Plan, and in response to the success of the Toolibin Lake Catchment Group, additional land conservation groups have evolved representing sub-catchments of Toolibin Lake; the West Toolibin Catchment Group was formed in 1994, and the Scrivener Soak Catchment Group was formed with seven members in January 1995. Wallace (1996) notes that the catchment scale was too broad for effective action by the Toolibin Lake Catchment Committee, the group being too large and the sense of cooperation too diffuse. The sub-catchment groups have proven more effective for implementing management actions.

Likely participants in a public meeting

The proposed guidelines for monitoring change in ecological character of Ramsar wetlands (Part D of this report) recommend holding a public meeting to discuss issues relating to the Site (i.e. highlight conservation values and identify threats to these values and determine community response).

The only public meeting to have been held concerning management of Toolibin Lake (apart from its closure to duck shooting) was in 1976 (fourteen years prior to Ramsar listing) and was initiated by the Western Australian Field and Game Association, together with local citizens. The authors have been unable to source a list of participants at this meeting, but it is known to have involved landholders, Shire representatives, wetland users (predominantly duck shooters), interested local citizens, members of the State nature conservation agency (Department of Fisheries and Wildlife), and possibly local representatives of naturalist groups such as the Royal Australasian Ornithologists Union (RAOU).

Though it was not a public meeting in the true sense, the technical workshop convened by CALM on 3 September 1992 (see section above) did have some representation from the local community and stakeholders. The Workshop was conducted at the WADCALM Headquarters in Perth. Participants are listed in Table 15.

Table 15. List of participants at the Toolibin Lake Recovery Plan Workshop.

Name & affiliation	Name & Affiliation
Dr Libby Mattiske Consultant Botanist	Mr John Blyth WADCALM
Dr Adrian Peck Consulting Hydrologist	Mr Jim Lane Principal Research Scientist, WADCALM
Michael Elliott NSCP Project Officer, Dept. Agriculture	Mr Ken McIntosh Alcoa Australia Ltd
Dr Ray Froend Wetland Botanist, Water Authority	Mr Russell Marks Greenbase Consulting Pty Ltd
Mr Ken Wallace Regional Manager, WADCALM	Dr Nick Schofield Water Resources Council
Dennis Hilder District Manager, WADCALM	Mr Frank Batini Environmental Protection, WADCALM
Lyn Chadwick Toolibin Lake Catchment Group	Dr Ken Atkins Senior Botanist, WADCALM
Keith Parnell (Chair) Toolibin Lake Catchment Group	Kelvin Baldock Surface Water Branch, Water Authority
Mary Taylor Toolibin Lake Catchment Group	Dr Ramsis Salama Division of Water Resources, CSIRO
Dr Don McFarlane Hydrologist, Dept. Agriculture	Dr Jim Davies Consultant Hydrologist
Mr Michael Martin Geological Survey Division, DME	Mr Vivian Read Land Management Consultant
John Bartle Principal Research Scientist, WADCALM	Richard Gorham & Beverley Walker Environmental Management Consultants
Dr Bob Nulsen Senior Hydrologist, Dept Agriculture	Dr Richard Bill School of Environmental Sciences, MU

The specific objectives of the Workshop were to obtain consensus on:

- the processes that have given rise to the current hydrological and salinity status of Lake Toolibin and adjoining lands;
- anticipated future changes in the hydrology of the area relevant to the future ecological condition of Lake Toolibin; and
- proposed management actions and their priority for implementation.

The Workshop was facilitated by Mr Viv Read (Rural Planning) and began with presentations by Mr Jim Davies (Jim Davies & Associates), Mr Michael Elliott (Western Australian Department of Agriculture) and Ms Beverley Walker (Bowman Bishaw Gorham), to describe the physical and biological processes affecting the Toolibin Lake Nature Reserve and particularly the lake itself. The presentations were followed by a group discussion which was aimed towards reaching consensus on the causes of biological deterioration, the extent to which the hydrology of the lake has changed, and "why" and "how" Toolibin Lake has survived as a relatively freshwater lake given the demise of all other large wheatbelt lakes of similar type (Bowman *et al.* 1994).

Following the morning session, the Workshop participants met in specialist groups and were asked to consider and address predefined issues that were relevant to their areas of expertise. These issues related to the development of management options for the lake, its environs, and the Toolibin catchment, in the context of the Recovery Plan objective of retaining the lake as a freshwater waterbird habitat consistent with Ramsar listing. At the end of the group session the Workshop reconvened, and Dr. Don McFarlane and Dr. Elizabeth Mattiske, both of whom have conducted extensive research on lake and catchment hydrology and vegetation respectively, presented their summary views. The Workshop then concluded with a plenary session in which the outcomes of the day were summarised (Bowman *et al.* 1994). The proceedings from the workshop were then published as an appendix to the Recovery Plan, and played a major role in determining the content and purpose of the Plan.

Identifying current management and monitoring activities at the site

Froend & Storey (1996a) have recently reviewed all data collected during past management and monitoring of the Site and its catchment in all disciplines (i.e. surface water flow, groundwater hydrology, land use practices, wetland vegetation, terrestrial vegetation, lake inflows, water levels and quality, waterbird usage, aquatic invertebrate assemblages and all aspects of terrestrial fauna) to assess past and current trends and assess the current status of the values for which the wetland was Ramsar listed. This review was conducted as a first step in designing an ongoing monitoring program for the system (Froend & Storey 1996b; see below). Past management and monitoring activities identified during the review are summarised below.

Since completion of the Recovery Plan (in 1994), numerous management and monitoring activities have been implemented at the Site and within its catchment. Landowners are primarily responsible for the management of freehold farmland within the catchment, whilst WADCALM is responsible for management of the Site itself. Effective action has required the cooperation of all parties. The Toolibin Lake Recovery Team and its Technical Advisory Group have provided advice and guidance to WADCALM in its efforts.

Management

Management actions have concentrated on remedial action to control saline surface water flowing and flooding across the catchment and highly saline groundwater coming up underneath the lake. Monitoring activities have concentrated on assessing the effectiveness of this remedial action and on detecting changes in wetland values (*sensu* criteria for nomination to Ramsar). Management actions have been separated into short and long term. The short term (urgent) actions are mainly temporary (20 - 30 yr) engineering works considered essential to save the lake. They require ongoing effort, mostly in the form of surface water diversion and groundwater pumping. Some revegetation of key areas also has been implemented under short term actions. The long term actions (taking longer to fully implement and to have the desired effects) predominantly involve broadscale replanting of strategically located areas of the catchment in order to lower watertables and reverse land salinization.

Of the short term actions, pumping to lower the watertable under the lake was given the highest priority, as it had risen 10 - 15 m since clearing for agriculture commenced and was 1 - 2 m below the lake bed and within the root zone of the emergent vegetation.

An initial study by Geological Survey concluded that at least nine pumping bores would be required to lower the watertable along the western side of Lake Toolibin by 1.5 m (Stage 1). A further 16 pumping bores would be required to lower the watertable in the other salinized areas of the lake (Stage 2). The Toolibin Lake Recovery Plan (Bowman *et al.* 1994) recommended urgent implementation of Stage 1 of the program, and Stage 2 was given medium priority unless rapid deterioration of the lake vegetation occurred.

To provide a better understanding of the geomorphology and underlying geology of the lake, the Recovery Team commissioned a private company, Tesla 10, to fly an aerial magnetometer survey of the wetland. A map was produced showing where features such as faults and dykes lie in relation to land surface features such as salt patches and wet areas. This information was used to decide on placement of the groundwater bores.

In submissions by WADCALM to the Commissioner of Soil and Land Conservation and the Department of Environmental Protection regarding the groundwater pumping and drainage proposals, modifications were made to Stages 1 and 2 on the basis of subsequent advice that a smaller, strategically placed system might achieve the desired results. It was also proposed that, if the modified system proved sufficient to protect the lake, further implementation of the pumping listed in the Recovery Plan would not be required.

Plate 1. Toolibin Lake has extensive stands of sheoak (*Casuarina obesa*) and melaleuca (*Melaleuca* spp) across its floor (photo – Jim Lane, CALM, October 1978).

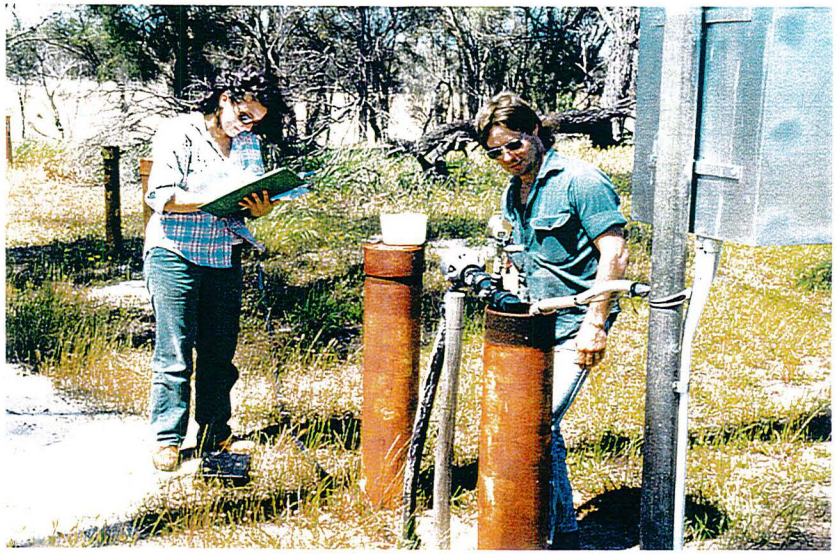

Plate 2. Experimental bore on west side of Toolibin Lake (photo - Andrew Storey, WR&M, October 1995)

Plate 3. Diversion channel around Toolibin Lake (photo - Jim Lane, CALM, September 1995).

Plate 4. Flow separator, Toolibin Lake (photo – Andrew Storey, WR&M, October 1995).

The modified system would consist of:
1. Ten (10) strategically placed groundwater pumping bores on the lake bed. The bores would be sited near the centre of dyke and fault bounded blocks and major faults, either at intersections with other faults or near intersections with dykes (George & Bennett 1995).
2. Storage tanks and pipes to take all groundwater directly to the highly degraded Lake Taarblin, by-passing agricultural land and the fresh waters of Lake Walbyring.
3. Improved monitoring of water depth, salinity, samphire cover and waterbird populations at Taarblin, and monitoring impacts, if any, on adjoining landowners.
4. Continued and improved monitoring of groundwater levels and salinity beneath Lake Toolibin, and monitoring of the quantity and quality of water pumped by the bores.

The system was approved and seven deep and two intermediate depth production wells have since been drilled. In addition, four piezometers have been installed at sites where insufficient flows (to warrant bore installation) were obtained. Pumping has commenced with experimental bores (Plate 2).

George & Bennett (1995) estimated that the maximum load of the modified pumping system would be 6570 tonnes/year. This is higher than that estimated by Martin (1990) for the original Stage 1 proposal. However, they also suggested that the load is likely to reduce (by up to 50%) when pumping rates stabilise.

Revegetation of cleared land adjoining the western side of the lake was proposed as an additional means of lowering the watertable beneath the lake and this has been implemented as a short term (urgent) action in association with the pumping described above. Other revegetation projects identified for immediate implementation included planting areas of major recharge (i.e. deep sands), revegetation of discharge areas, especially along drainage lines, and protection of remnant vegetation to maintain evapotranspiration and other water management capabilities (Wallace 1996).

A second area of high priority in the Toolibin Lake Recovery Plan was improved surface drainage of the Toolibin Flats. The very low gradients and rising groundwaters in this area have resulted in widespread ponding and waterlogging. This, in turn results in increased flushing of salt from the catchment (i.e. increased salt loads to the Site). Therefore, in consultation with relevant landholders, a drainage scheme was designed and implemented with the aim of decreasing waterlogging. Two main drainage channels; the Western Drainage Branch which directs 'fresh' water into the western part of Dulbining Nature Reserve, and the Eastern Drainage Branch which directs 'brackish' flows into the north-eastern part of the reserve, were constructed. A monitoring program has been developed to assess the effects of the work. The program involves the collection of rainfall data to characterise the hydrology of the West Toolibin catchment and to help discriminate drainage effects on the western side of the catchment from those originating on eastern catchment areas. Water depth and velocity are recorded in each drain with an acoustic Doppler meter, capacitance probes, maximum depth indicators (which consist of a perspex tube containing talcum powder) and a propeller velocity meter used at different depths during flow events These data will assist in converting recorded depths to flow rates (m^3 sec^{-1}). Water quality parameters are also monitored using rising stage sampling bottles arranged in a vertical profile to allow water sampling at different depths. Salinities (as electroconductivities (mS/m)), total nitrogen (mg l^{-1}), total phosphorous (mg l^{-1}) and suspended sediment loads all are recorded. Minimal data were collected in the winter following completion of the drainage channels (i.e. in 1995), due to low rainfall. Flows were more substantial in winter 1996 and data have been collected and remain to be analysed.

Management identified the need to control salinities of surface inflows to the lake as a high priority. The only feasible means of achieving this was to construct a diversion channel. This would enable higher salinity flows, particularly the 'first flush' flows at the start of each winter to be diverted past the lake. In the summer of 1994/95, a 5.5 km channel was constructed along the western boundary of Toolibin Lake and around the northern side of Lake Walbyring to Lake Taarblin (Plate 3). This channel takes water from the Northern Arthur River upstream of Toolibin Lake and diverts it around the lake, to rejoin the river downstream of the outflow from Walbyring Lake, thereby protecting both Toolibin and Walbyring lakes. In addition, saline flows into Toolibin Lake from North-West Creek are intercepted by the channel and also diverted to Taarblin.

A steel and wandoo *Eucalyptus wandoo* separator was constructed at the upstream end of the channel (Plate 4). Its gates may be opened to allow saline flows down the diversion channel, or closed to direct fresher flows into Toolibin Lake. The channel was designed to carry a flow of 6.0 m^3 sec^{-1} upstream of the confluence with North West Creek and 7.0 m^3 sec^{-1} downstream of the confluence.

In winter of 1996, the Northern Arthur River flowed for the first time since the channel was constructed, and the diversion channel and separator were successfully tested. A specific criterion for inflows to Toolibin Lake has been designated in the Recovery Plan; the maximum salinity of inflow to the lake, measured at the Water Authority gauging station (609 010) on the Northern Arthur River, was to be 1000 mg/l TDS during winter months when the lake is full. Analysis of streamflow and salinity data from this gauging station indicated that flows greater than 3.0 m^3 sec^{-1} had salinities less than 1500 mg/l TDS. Therefore, flows less than 3.0 m^3 sec^{-1} were diverted around the lake, and the separator was closed to divert flows into the lake once discharge exceeded this threshold. (The criterion of 1000 mg/l was not adhered to in the first year due to concern that this would not allow sufficient water to be diverted into the lake to meet its needs).

Catchment revegetation, by landowners and WADCALM, is the major, long term objective aimed at protecting the Site. Revegetation will reduce groundwater recharge and thereby lower the saline watertable. This will reduce the extent of surface salinisation as salt is gradually flushed back into the lower soil profile by rainfall events (though this may take decades or centuries). Lowering the watertable under the lake will take saline groundwater away from the root zone of the emergent vegetation, reducing stress levels. Revegetation will also reduce catchment runoff which will a.) reduce flushing of surface-salt from the land into water courses, b.) reduce the potential for excessive prolonged inundation of wetland vegetation and c.) lower the potential for nutrient enrichment of the lake by reducing flushing of fertilisers applied for agriculture.

In order to achieve long term revegetation of the catchment, efforts are being made to develop viable farming systems, incorporating deep-rooted perennial plants, that will provide direct economic benefits for landowners. Alley farming is the main means by which this is being achieved and involves planting trees or shrubs in strips with "alleys" between. The alleys are grazed and the strips of trees or shrubs are cropped. Perennial species being promoted are those that are suited to local conditions and will produce fodder for stock, timber for fence posts, wood for craft work, tannins, and eucalyptus oil for industrial grade solvents and for the custom pharmaceutical/cosmetics markets. The planting of tagasaste (tree lucerne) for fodder is also being promoted. This perennial legume forms a shrub, approximately 2 m in height, which may be grazed by sheep.

Other revegetation work includes planting salt-tolerant species in salt-affected areas, wind breaks on flats and vegetation buffers along drainage lines. Fencing-off revegetated areas to prevent damage from grazing is an important component, as is fencing and protection of remnant vegetation.

A revegetation manual has been produced to guide catchment groups and individual farmers in their efforts. Activities and achievements of the catchment groups in 1995 are detailed in Table 16. Examples of revegetation and other land management projects conducted by catchment groups and WADCALM since 1990, along with current (1996) commitments, are listed in Table 17.

Monitoring

Froend & Storey (1996a) have reviewed all monitoring activities in Toolibin Lake and its catchment to identify available data which may be used to assess changes in wetland values and parameters that may affect wetland values. These monitoring programs are summarised below.

Lake volume is monitored indirectly by means of a continuous water level, float operated chart recorder situated in the lake and in operation since December 1977.

Main inflows to the lake are recorded by a continuous water level float operated chart recorder at Station 609 010 on the Northern Arthur River. Also sited at this station are an additional water level recorder monitoring "tailwater" effects (water backup) from the lake and a continuous stream conductivity recorder. Data are complete from April 1981. Daily salt loads to the wetland are derived from the integration of the continuous flow and conductivity data. Station 609 013 records additional inflows to

the wetland from North West Creek, the only other significant surface water drainage feature (natural or artificial) that discharges into the lake. A continuous water level, float operated chart recorder has been in operation at this site since June 1982.

Table 16. Major activities and achievements of catchment groups in 1995.

Catchment Group	Activity/Achievement
Lake Toolibin Catchment Committee (LTCC)	
	Won inaugural Shirley Balla Wetland Conservation Award (State Govt award)
	Produced the Toolibin Catchment Revegetation Manual
	Inaugural Lake Toolibin Catchment Committee newsletter printed (and 2nd issue)
	$30-00 landholder subscription (voluntary) to LTCC introduced
	Visit by Governor General of Western Australia
	Visit by WA Minister for Environment
	Numerous bus tours by visitors to the catchment
West Toolibin Catchment Group	
	West Toolibin Catchment Group formed in 1994
	Catchment revegetation and drainage plan established
	Meetings held to discuss progress and to plan 1996 activities
	Commenced plan for monitoring of catchment drainage
	Undertook upper catchment drainage work, linking banks via the main drain
	Planted 45 000 oil mallees (Eucalyptus spp.)
	Planted 24 000 tagasaste and other seedlings
	Fenced 5 areas of remnant bush (50, 81, 40, 33 & 8 ha)
Scrivener Soak Catchment Group	
	Formed with 7 members in January 1995
	Developed plan to revegetate main creeklines to form bush corridors
	Group expanded to 12 members during the year
	Bus tour of catchment by members in August
	Meeting to plan projects and priorities for 1996
	Extended a 65 ha piece of fenced remnant bush by 2 ha with 3500 seedlings
	Joined 2 areas of remnant bush (119 & 57 ha) with 250 m fenced corridor & 500 seedlings
	Fenced 5 ha of Sheoak (Casuarina)/Mallee woodland with 1.25 km fencing
	Formed bush corridor along creek with 6.25 km fencing and > 5000 seedlings
	1000 seedlings planted as a continuation of an existing corridor
	Approximately 16 000 trees and saltbush planted for various other projects
	88 km of tagasaste planted on deep sands with associated fencing

Catchment rainfall is recorded by means of a pluviograph installation (site 510 254) co-located with the main inflow station (609 010) on the Northern Arthur River, and by rainfall stations reporting to the Bureau of Meteorology. Long term rainfall data are held by the Wickepin Post Office (Bureau of Meteorology site 010654). Evaporation data for the catchment are available from the Bureau of Meteorology station at Narrogin.

Surface outflow from Toolibin Lake currently is not measured for volume or quality, although the elevation of the outflow (i.e. the "invert level") has been measured allowing the estimation (from lake level recordings) of outflow event timing and duration. Also of note is the absence of continuous monitoring of salinity levels in the lake itself. The only salinity data for the lake are values measured during short-duration studies such as Stokes & Sheridan (1985), or longer term monitoring programs with low frequency sampling regimes such as that implemented by WADCALM's Science and Information Division (J. Lane and support staff monitored water depth, salinity and pH every 2 months at all major wetlands in the Toolibin Reserves (Toolibin, Dulbining, Walbyring, Taarblin) from 1978 to 1985. Monitoring frequency was subsequently reduced to September and November each year. This work continues). Periodic sampling of Toolibin Lake is also conducted by the Water & Rivers Commission - though not for salinity. The water samples are analysed for nitrite as N, NO_3+NO_2 as N, Ammonium as

N, Kjeldahl N, Nitrate as N, total nitrogen unfiltered, total phosphorus unfiltered, and reactive phosphorus filtered.

Table 17. Examples of revegetation and other land management projects implemented by catchment groups and WADCALM (*) since 1990, listing commitments for 1996(#).

Project
500 m creekline planted in 1991
200 m windbreak planted in 1991
400 m windbreak planted in 1991/94
5 ha woodlot planted
30 000 oil mallees planted in alley farming trials
90 ha saltpan revegetated
2 km windbreak planted
80 ha remnant bush block fenced
Salt-affected areas fenced off and planted with saltbush, sheoak, eucalypts, tamarisk, etc.
4 km of interceptor banks constructed as part of main drain
500 m of backhoe work conducted to improve flow
1.2 km of windbreak planted on Toolibin Flats
2.5 km of banks constructed in 'salt country' for drainage
Creekline planted with trees and fenced
Tree planting in sandy areas
Windbreak construction
30 ha of tagasaste planted
4 km of creekline planted between 1982 and 1993
8 ha of tagasaste planted in 1992
18 ha of oil mallees planted over 1993/94
44.6 km (60 000 seedlings) of oil mallees planted*
Purchased and rehabilitated 177 ha bush that had been chained*
Purchased and fenced 30 ha of previously grazed bush*
Purchased and revegetated 128 ha of pasture/cleared land*
Revegetated cleared land in the north of the Toolibin Lake Nature Reserve*
Planted 4-5 ha of oil mallees
Established 2-3 km of trees on drainage lines
Planted Tagasaste on sandy ridge with ~ 1 km of fencing for protection
Fenced off remnant bush block with 800 m of fencing
Revegetated 6 ha of West Toolibin Flats between the Western and Eastern drains
Planted 5 ha of oil mallees
Monitored areas prone to salinization
Planted salt-affected areas with saltbush
Fenced off remnant bush blocks (2 & 1.5 km of fencing)
Planted 3 km of creekline
Upgraded 3 km of banks along drainage lines
Planted 3 km of windbreaks with trees (with required fencing for protection)
Planted 2 ha of tagasaste (with required fencing for protection)
Planted 5 ha of oil mallees (with required fencing for protection)
Established 40 ha of alley farming as a research project*
Revegetated 5 ha on conservation reserves*
Finished planting 38 km (50 000 seedlings) of oil mallee hedge on private property*
Establish oil mallee plantings on gravelly ironstone soils#
Plant 2-3 km of trees along drains#
Establish 4 ha of oil mallees#
Continue corridor plantings#
Tree planting on salt-affected land with 1 km of fencing#
Additional 2 km of creekline planting#
Establish additional tagasaste planting with required 2 km of fencing#
Fence off remnant bush block with 2 km of fencing#
Upgrade existing banks on drainage channels (2 km)#
Plant 4 km of windbreak#
Additional creekline planting (3.5 km)#
Establish 40 ha of alley farming project#*
Revegetate 5 ha on conservation reserves#*
Plant 75 km (100 000 seedlings) of oil mallee#*

Extensive, but uncoordinated groundwater monitoring is being conducted by Agriculture WA, the Toolibin Catchment Group (LCD farmers) and WADCALM (Table 18). The Water & Rivers Commission currently is not monitoring the bores under its control. This includes the multiport, pump and monitoring bores installed on the lake floor.

Table 18. Summary of groundwater monitoring activities in Toolibin Lake and its catchment.

Managers	Database	Number of Bores
Agriculture WA	AgWA	34 at 19 sites in the catchment
Toolibin Catchment Group	AgWA, LTCG	50 at 50 sites in the catchment
CALM (alley farming trials)	CALM	114 at 2 farms (Whites, Davenports)
CALM/WRC	CALM/WRC	69 at 56 sites in the lake
Total		**267**

Monitoring of these bores enables catchment-wide changes in groundwater levels and salinities to be assessed. Monitoring of bores will also provide data on the future effects of groundwater abstractions on groundwater levels beneath the lake.

There has been extensive monitoring of waterbird usage of the Site, but with a number of approaches over the years. Data consist of:

- combined observations of wheatbelt farmer, Mr Ray Garstone, from approx. 1965 to approx. 1975 (summarised by Goodsell *et al.* 1978),
- the joint RAOU/CALM database of waterbird counts conducted between 1981 and 1988,
- the WADCALM database of aerial surveys of waterfowl conducted biannually between 1988 and 1992, and,
- occasional surveys conducted over the whole time period (1975 to 1993) by WADCALM field and research staff, RAOU members and the general public, recorded in departmental files in the WADCALM Narrogin Regional Office, and elsewhere (uncompiled).

Currently, there is no systematic monitoring program of waterbirds at the Site.

There have been no systematic surveys of the amphibian fauna of the wetland or adjoining (terrestrial) components of the Toolibin Lake Nature Reserve. Frogs have been sighted, however they have seldom been identified to species level. Two species were caught during a pit-fall trap survey of the reserve for mammals and reptiles in 1978.

Similarly, there have been no systematic surveys of the fish fauna of lakes in the Toolibin System. The only data are occasional sightings of species (native and introduced) documented in WADCALM departmental files in the Narrogin District Office and in oral histories (Sanders 1991).

There are various data on aquatic invertebrates in the wetland, but sampling methodologies have been inconsistent. Some data consist of opportunistic sightings of aquatic invertebrate taxa, however, these have seldom been identified to species level and are of minimal value. General surveys of aquatic invertebrates of Lake Walbyring were conducted by Halse, Pearson & Munro (unpub. dat., summarised by Casson (1988)) in September 1985 and August 1986 when salinities were 7.5 ppt and 3.6 ppt respectively. Toolibin Lake was dry at the time and not sampled. In recent years, S.A. Halse (WADCALM, Wildlife Research, unpub. dat.) has conducted repeated standardised surveys of the Ostracoda (a component of the aquatic invertebrate fauna) of Toolibin Lake and Lake Walbyring. This was part of a survey of 20 wetlands of varying salinities across the south-west of WA. Additional data on Ostracoda were obtained from Toolibin in November 1994, when replicate cores of sediments from the lake bed (to a depth of approximately 30 cm) were collected and analysed for fragments of Ostracoda (Halse, unpub. dat.). The most recent data on the aquatic macroinvertebrate fauna of the system, including Toolibin Lake are from a one-off standardised survey of five locations on 27 September 1992; a shallow marshy area on the Arthur River upstream of Dulbining West Lake, Dulbining West Lake, Arthur River between Dulbining West and Toolibin Lake, Toolibin Lake (two samples, one on east and one on west side), and Lake Walbyring (re-sampled in April 1993) (Doupé & Horwitz 1995). The survey

was intended to provide a preliminary assessment of the macroinvertebrate fauna of the wetlands as the basis for an ongoing monitoring program.

There has been one comprehensive, systematic survey of the mammal and reptile fauna of Toolibin Lake Nature Reserve (Goodsell, *et al.* 1978). In addition, occasional sightings of mammals and reptiles are documented in WADCALM files held in the Narrogin District Office. There have been no surveys of mammals on other nature reserves in the Toolibin System.

There have been no standardised, quantitative, systematic surveys of the terrestrial birds of Toolibin Lake Nature Reserve or other nature reserves in the Toolibin System. However, documented in WADCALM files held in the Narrogin District Office, there are frequent site visit reports with sightings of various species. The most comprehensive list of species of terrestrial birds is that compiled by wheatbelt farmer Ray Garstone during frequent visits to Toolibin Lake Nature Reserve from the mid-1960s to mid-1970s. Eighty five species were recorded from the reserve, with 78 nesting (Goodsell *et al.* 1978). A standard methodology was not adopted and this limits the value of the data from a monitoring perspective, except for assessing gross changes over time.

There have been no standardised, quantitative, systematic surveys of the terrestrial invertebrates of Toolibin Lake Nature Reserve or other nature reserves in the Toolibin System. Also, there are very few records of any sort relating to terrestrial invertebrates documented on departmental files. This reflects the relative difficulties of conducting terrestrial invertebrate surveys and of identifying material to species level.

There has been no formal monitoring of phytoplankton or submerged or floating aquatic plants at Toolibin or surrounding lakes. Mattiske (1986) noted dead Potamogeton sp. in a monitoring plot with salt crusting on the soil surface. Oral histories of the region (Sanders 1991) record the presence of Duckweed (*Lemna* sp.) and Nardoo (*Marsilea* sp.) between 1926-35, and Munro (1975) records the presence of a 'grass-like aquatic weed common to many freshwater lakes in the southwest'.

There has been extensive longterm monitoring of emergent vegetation (predominantly Casuarina, with Melaleuca and some Eucalyptus) by Mattiske (1977 to 1992) and Froend (1983 & 1988) (see earlier section on Threats to Values) using permanent transects and plots. Data identify changes in condition of mature trees and record the incidence and success of seedlings and recruitment events. Changes in the occurrence and distribution of rushes in the lake have been inferred from incidental observations (see earlier section on Threats to Values), as have changes in the incidence of salt-tolerant species (i.e. spread of samphires onto the lake bed). Terrestrial vegetation also has been monitored by Mattiske, using permanent plots to report changes in condition of different vegetation complexes.

Detailed description and analysis of data that have been collected for all the above monitoring elements are presented by Froend & Storey (1996a).

Future monitoring, research and management

Major actions identified for future management of the wetland and its catchment include revegetation of degraded sections of the floor of the lake (and areas disturbed by engineering works); revegetation of cleared and disturbed areas and regeneration of ageing vegetation communities within conservation lands adjoining the lake; adoption of agronomic practices that will maximise water usage, land conservation and farm profitability in the catchment, and revegetation across the catchment with economically viable systems that will reduce recharge to the groundwater (Wallace 1996).

Revegetation commitments by catchment groups and WADCALM within the catchment for 1997 include planting drainage and creek lines, establishing additional oil mallee stands, planting windbreaks and corridors to link remnant vegetation blocks, finish planting tagasaste areas, establish trees on seeps, erect fencing to protect revegetated areas, conduct revegetation on reserves and attain the goal of planting 75 km (100 000 seedlings) of oil mallee. It is anticipated that revegetation work will be ongoing into the future.

Other management will involve continued maintenance of the engineering structures established to protect the Site in the short term (i.e. the drainage channels, separator, diversion channel and groundwater bores, pumps and pipes). Proposed monitoring will assess the effectiveness of these measures, and, depending on the outcome, additional short term measures may be required. The Recovery Plan identified control of the lake outlet as an issue as this would allow some flushing of the wetland to reduce salt load. Management will be assessing this option in the near future.

A comprehensive monitoring program for the wetland and its catchment has been designed by Froend & Storey (1996b). The program identifies management actions and wetland values that require monitoring and provides a design for each component of the monitoring program with precise details of parameters to measure, frequency of measurement, monitoring locations, levels of replication, types of instruments to use, and criteria on which to assess success. The report also indicates levels of funding required and prioritises the components on the basis of perceived urgency and necessity. Monitoring components and recommended priorities are summarised below (Table 19).

Table 19. Monitoring components and their priorities for Toolibin Lake and catchment (after Froend & Storey 1996b).

Priority	Component	Ranking
Existing programs to be continued	Inflow volumes and salinity	1
	Lake level	1
	Pluviometer	1
	West Toolibin Flats drainage	1
	Existing Mattiske lake and terrestrial vegetation transects	1
For immediate implementation	Waterbirds	1
	Aquatic invertebrates	1
	Toolibin Lake separator channel	1
	In-lake salinity and overflow volume and salinity	1
	Additional lake and terrestrial vegetation plots	1
	Aquatic macrophyte survey	2
	Amphibians	2
Desirable, but not critical	Mammals	1
	Reptiles	1
	Seedling recruitment investigations in lake and terrestrial vegetation	1
	Reassessment of Froend vegetation transects	1
	Rhizosphere research	2
	Terrestrial Birds	3
Not necessary	Fish	1
	Terrestrial invertebrates	1
	East Toolibin Flats drainage	1

For the Recovery Plan to be effective in saving Toolibin Lake, the final elements identified by the Recovery Plan are seen as critical. These are:

- The development of a computer-based decision support system to enable the Toolibin Lake Recovery Team to consider all available information during implementation of the Recovery Plan, and
- Monitoring and reporting to provide input to the Decision Support System, to determine the effectiveness of the recovery actions and to facilitate ongoing adaptive management.

Lessons to be learnt from the Toolibin Lake experience

Given that management of Toolibin Lake has evolved over a 20 year period from *ad hoc* management and monitoring to a fully integrated and coordinated project with specific objectives and criteria set down in a Recovery Plan, there are lessons to be learnt, particularly for managing and establishing monitoring programs for other important wetlands (Ramsar and non-Ramsar sites). Wallace (1996) noted that

constant liaison and positive interaction between groups and individuals is essential to develop congruent goals and philosophies. Major points from Wallace (1996) are summarised in Table 20 and are worthy of consideration

Table 20. Major issues for consideration in establishing a successful Recovery Plan for Toolibin Lake (after Wallace 1996).

Relationships between farmers within the catchment
Catchment boundaries are not congruent with social boundaries defined by farming communities within the catchment. This affects interactions between landholders.
The catchment scale is too broad to maximise effective action on the ground. Sub-catchment groups are more effective.
Landholders higher in the catchment are not as affected by landcare problems and are more difficult to involve that those lower in the catchment, who are directly affected by salinity and waterlogging.
The catchment area is fairly "safe" in terms of rainfall and agricultural production, however there is little cash surplus. As a consequence most landholders seem conservative in accepting new ideas and this has influenced the intensity with which they have tackled landcare issues.
Relationships between the management agency (WADCALM) and farmers
At times there has been disagreement over management issues (e.g. drainage proposals) with respect to perceived benefits for farm productivity and impacts on nature conservation values. Improved research, better engineering design and linkage of approvals with commitments to undertake other works (e.g. revegetation) have helped resolved issues.
Changing staff within the management agency make it difficult to maintain a long term relationship of mutual trust and understanding with the community.
The management agency has limited resources to apply to all the conservation issues within its Region; Toolibin Lake is one of many. Time for communication and information exchange is not always adequate.
Interlocking membership of the Toolibin catchment group and the Lake Toolibin recovery team has been important in planning, liaison and maintaining information flow between farmers and the lake manager.

Wallace (1996) also notes that interactions between organisations, both government (e.g. WADCALM, AgWA) and non-government (e.g. Alcoa), are subject to similar considerations to those between farmers and WADCALM. However, Wallace asserts, provided all parties continue to understand the potential problems and work to prevent them detrimentally affecting the current high level of integration, these issues will not become a problem.

Finally, Wallace (1996) notes that of 18 points identified by Blyth *et al.* (1996) as issues to consider in assessing the likelihood of success of Recovery Plans, all were relevant to Toolibin.

Shortcomings in the design and implementation of past monitoring in the catchment have been discussed by Froend & Storey (1996a), and a number of lessons may be learnt. Frequently there were no or inadequate data available on specific issues (e.g. aquatic macrophytes, phytoplankton, aquatic invertebrates, trends in condition of adjoining terrestrial vegetation) on which to assess the effectiveness of management actions. Similarly, there were insufficient data on parameters (e.g. aquatic plant cover, water nutrient status, terrestrial vegetation condition) affecting wetland values (e.g. condition of waterbird habitat and food resources) to assess their current status. This was even though earlier reports on Toolibin had specifically recommended implementation of monitoring programs. In many instances this was due to a lack of specific funding to carry out the required monitoring. In other cases, it has been due to changes in personnel and organisational arrangements (the project has spanned two decades), resulting in the lack of a consistent, standardised approach.

Surveys of waterbirds on the wetland provide an example of the problem. There have been approximately 54 surveys of waterbirds of Toolibin Lake since 1975, however data are of limited usefulness for monitoring purposes, due to inconsistencies. These include:

- differences in survey coverage, in that the whole wetland was not always surveyed,
- some surveys produced counts or estimates of total numbers of each species of waterbird whilst others provided only presence/absence data,
- surveys were not always conducted at the most appropriate time of year to assess breeding activity or other use by waterbirds, giving the impression of decreased usage,
- not all surveys included reporting of breeding activity,
- some surveys were of all waterbird species, whilst others were only of waterfowl (ducks and swans) and coot,
- survey techniques varied considerably, from ground counts of all waterbirds to aerial counts of waterfowl only, and
- surveys were conducted by many people with differing skill levels, interests and training.

It is recognised that Toolibin is a difficult wetland in which to conduct comprehensive waterbird surveys (due to its size and tree cover) and that the surveys conducted were generally not intended for formal monitoring purposes. It is also acknowledged that, in the context of saving the emergent vegetation of the lake, ongoing assessment of use by waterbirds was not the highest monitoring priority. However, the data referred to above do highlight the need for a coordinated, unified approach to monitoring when it is required. This applies to all aspects of monitoring of the Site and its catchment.

Eighty Mile Beach

Site description

This Wetland of International Importance is located in the far North West of Western Australia. Its northern limit is approximately 142 kms south-south-west of Broome and its western limit is 130 km east-north-east of Port Hedland. The Site comprises two unconnected areas of wetland, Eighty Mile Beach (20 000 ha) and Mandora Salt Marsh (105 000 ha) (Figure 7).

Eighty Mile Beach extends in a broad curve from Cape Missiessy in the north to Cape Keraudren in the west and consists of a sloping, white siliceous sand beach about 220 km long (not 130 km as its name would suggest) and 100 m wide, with a 0.5 m drop from the foot of the beach slope to broad tidal mudflats extending 0.5 to 1.0 km offshore at low tide. Sand dunes occur behind the beach and a few small bays have developed in which mud collects and mangroves have become established. The site extends from low water mark to 40 m above high water mark and is bordered by open ocean on the seaward side and pastoral stations inland (Anna Plains, Mandora and Wallal Downs cattle stations). There is a small public recreation reserve (Wallal caravan park) on the coast at Wallal Downs.

Mandora Salt Marsh is directly inland from Eighty Mile Beach and consists of three principal features; a large expanse of seasonally-inundated samphire flats, a number of permanent or almost permanent freshwater swamps supplied by springs, and Salt Creek, an old watercourse 10-20 m wide, about 5 km long, and lined with mangroves. Salt Creek is possibly connected to the sea by an aquifer, and this would account for its salinity. The Mandora Marsh portion of the Ramsar Site is largely in the southern part of Anna Plains Station but also touches onto the eastern boundary of Mandora Station and extends eastwards into vacant Crown land in the Great Sandy Desert.

Management of the site

Future management of the site will depend upon changes to land tenure, purpose and vesting. Currently, those parts of Eighty Mile Beach and Mandora Salt Marsh that are on vacant Crown land come under the jurisdiction of the Department of Land Administration whilst those parts of Mandora Salt Marsh under pastoral lease are the responsibility of the Anna Plains and Mandora station lessees. The boundary of the Shire of Broome extends to low water mark on Eighty Mile Beach, and the Shire, therefore, also has some jurisdiction over the site.

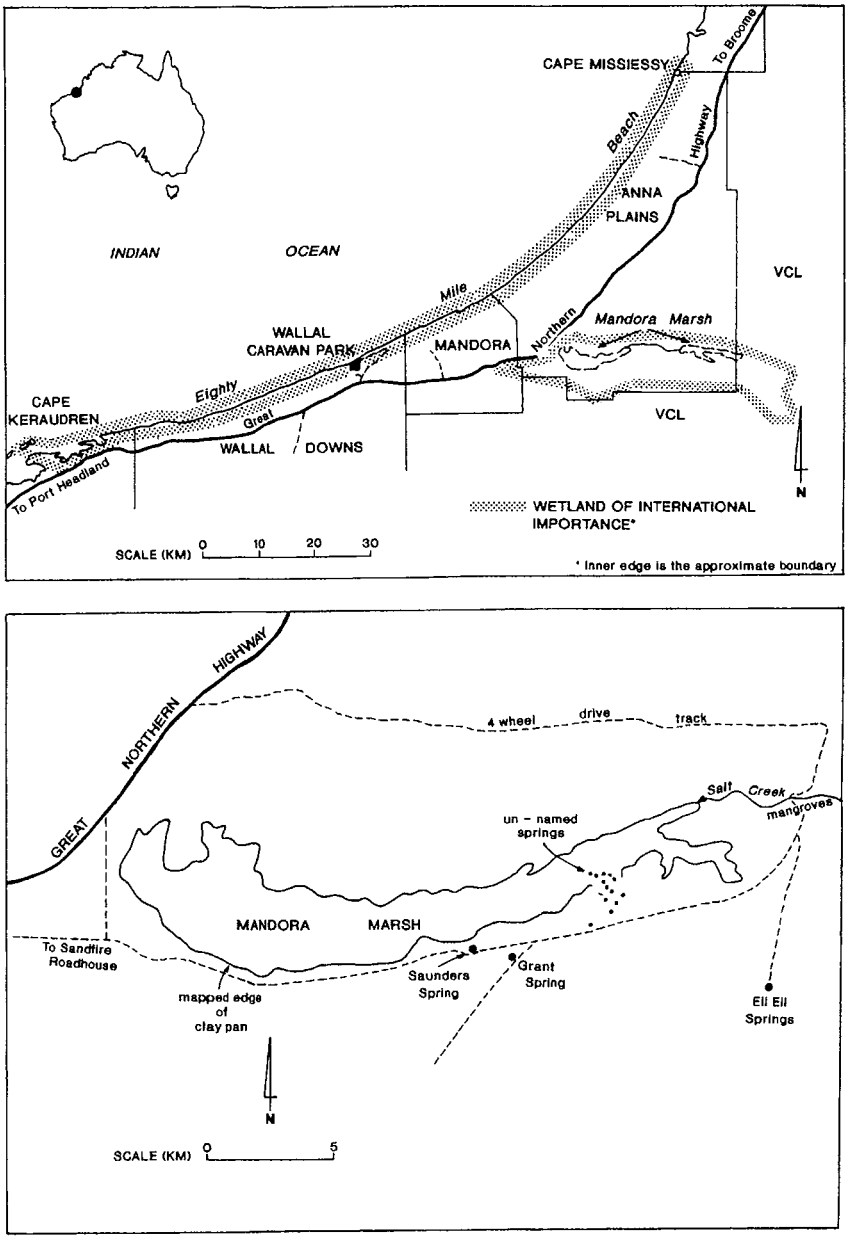

Figure 7. Eighty Mile Beach and Mandora Marsh, indicating boundaries of the Ramsar site.

It has been recommended by a Marine Parks and Reserves Selection Working Group (WADCALM 1994) that a section of Eighty Mile Beach be reserved for the protection of marine flora and fauna and the habitat of migratory shorebirds, and that the area reserved should include the tidal mudflats and the 40 metre strip of vacant Crown land above high tide level. The Working Group also recommended that an area of coastal waters seaward of low tide, preferably to the limit of State waters (3 nautical miles from high water mark) be reserved as a buffer to the beach reserve. The Working Group's final recommendation (WADCALM 1994) was that a decision as to the section of beach to be reserved be deferred until the Royal Australasian Ornithologists Union (RAOU) identifies the area of beach of most importance to migratory shorebirds. Currently, no action has been taken regarding the proposed Marine Park.

The other section of the Site, Mandora Salt Marsh, was recommended for inclusion in a Class A nature reserve (WADCALM 1991). The proposed Mandora Nature Reserve would occupy an area of approximately 400 000 ha and would be vested in the National Parks and Nature Conservation Authority (WADCALM 1991), however, declaration of the Nature Reserve is dependent upon the acquisition of the

land in question from the pastoral lease and this has not yet occurred. The freshwater springs are a valuable asset to the station, providing a low maintenance, permanent water supply for stock (John Stone, Station Manager, Anna Plains Station, pers. comm.). Therefore, it is considered that the sale of the land is unlikely without an arrangement for access to water. Pastoralists currently are lobbying for freehold ownership of pastoral leases. The status of pastoral land is due for review in 2015 and this may bring the issue of Mandora Salt Marsh to a head if it is not resolved beforehand.

If and when both conservation reserves are declared, the entire Eighty Mile Beach Ramsar site including Mandora Marsh will come under the management of WADCALM. Most of the site is within the Department's Kimberley Region and day to day management of the site would be the responsibility of the West Kimberley District Office in Broome. The westernmost 30 km of the site is in the Pilbara Region, and would be the responsibility of staff in the Regional office in Karratha. It is likely that responsibility for the whole site would be nominated to the one office, most likely the Broome Office. Overall responsibility of the site would rest with the Kimberley Regional Manager, who is based in Kununurra.

A general consideration for future management of the site is the adequate definition of boundaries, both for Eighty Mile Beach (i.e. up to 40 m above high tide mark) and the Mandora Salt Marsh system (i.e. the various springs, Salt Creek and the samphire flats).

Until the site is within the conservation reserve system, it has limited protection, except as provided by the State Wildlife Conservation Act and the general protection this affords to all wildlife (flora and fauna) in Western Australia. Prior to completion of any reservation action, both areas will have to be referred to the Office of Traditional Usage for consideration under the Land (Traditional Title and Usage) Act. The parts of Mandora under pastoral lease will be referred to the Office of Traditional Usage if the land is acquired by the State Government for reservation. It is possible that these areas and the areas of vacant Crown land on the Site may be subject to Native Title Land Claims.

Identifying wetland values

Eighty Mile Beach was nominated as a Wetland of International Importance primarily because it is the most important wetland in north-western Australia in terms of numbers of waders; 336 000 birds were recorded on the beach in November 1982 (Jones 1993b). It is one of the most important migration stop-over areas for shorebirds in East Asia - Australasia, surpassed (numbers) only by Roebuck Bay and the South-east Gulf of Carpentaria. The beach is one of the most important sites in the world for migration of Great Knot *Calidris tenuirostris* and supports at least 1% of the national population of 21 species of shorebird (ANCA 1996). Approx. 40 species of waterbird have been recorded from the beach (ANCA 1996) and the wetland has been ranked third in importance in Australia for species of shorebird, supporting 15 species of international and 19 species of national importance (Watkins 1993). Distribution of birds along the beach is not uniform, with approx. 90% of the birds concentrated in the northern section between Cape Missiessy and Wallal. Ground counts have revealed up to 140 000 birds in the 15 km section south of Anna Plains with a sharp decline in numbers south of a small area of mangal near Wallal (WADCALM 1994). Species occurring in especially high numbers include: Red-capped Plover *Charadrius ruficapillus,* Greater Sand Plover *C. leschenaultii,* Oriental Plover *C. veredus,* Bar-tailed Godwit *Limosa lapponica,* Grey-tailed Tattler *Heteroscelis brevipes,* Common Greenshank *Tringa nebularia,* Terek Sandpiper *Xenus cinereus,* Red Knot *Calidris canutus,* Great Knot *C. tenuirostris,* Red-necked Stint *C. ruficollis,* Curlew Sandpiper *C. ferruginea,* Sharp-tailed Sandpiper *C. acuminata* and Grey Plover *Pluvialis squatarola* (Watkins 1993; ANCA 1996). The birds use the exposed sand and mud flats at low tide for feeding and roost in dense flocks on the narrow beach at high tide. Some birds use the supratidal samphire flats directly behind the sand dunes and Mandora Salt Marsh for roosting, loafing and feeding, particularly during the wet season. Adult and juvenile birds of migratory species arrive from northern breeding grounds (central and north-eastern Asian) from August to October and adults generally depart in March and April. Juveniles of migratory species remain until the following autumn. Many birds of resident species are present throughout the year.

The beach itself is an unusual and spectacular geomorphic feature and has also been noted as worthy of protection for that reason alone (WADCALM 1994).

Eighty Mile Beach is regarded as an important breeding rookery for Flatback Turtles, *Chelonia depressa* in Western Australia (R. Prince, WADCALM, pers. comm.). The Flatback Turtle is a long-lived, bottom feeding carnivore, predating on shell fish, prawns etc. It produces the largest eggs and smallest clutches for any sea turtle and it is likely that the young are non-pelagic, remaining on the continental shelf, as opposed to other Australian sea turtles which have pelagic young. Eighty Mile Beach's attractiveness as a rookery is probably due to the ready availability of suitable nesting conditions, including sand of a particle size that provides suitable gas permeability capabilities, correct salinities and moisture content. The feeding range of Flatback Turtles is from Exmouth Gulf northwards, across the top of Australia and south down the east coast towards Moreton Bay. They also occur in the Indonesian Archipelago, Irian Jaya and Papua New Guinea, however, and importantly, they have only been recorded breeding from Australia.

In southern parts of the breeding range Flatback Turtles breed from November to April. This timing appears to be reversed (April to November) in northern parts, possibly due to the effects of high temperatures or rainfall. Breeding on Eighty Mile Beach occurs in the summer months. The density of individuals using the beach is relatively low. However, because the beach is several hundred kilometres long, the total number utilising the site is considerable (up to 1000 adults) and this makes it an important "dispersed rookery" (R. Prince, WADCALM, pers. comm.). Other important rookeries for Flatback Turtles in Western Australian are located at Barrow Island and the Dampier Archipelago. There have been occasional sightings of Green and Loggerhead Turtles at Eighty Mile Beach, but not with sufficient frequency to make it an important site for these species.

Although there have been no systematic studies of the inter-tidal flora and fauna along the shores of Eighty Mile Beach, examination of beach drift and information from local people and shell collectors indicate that the tidal flats and shallows support a rich and abundant community of invertebrates (WADCALM 1994). This partly explains the significance of this area as a feeding ground for waders. Due to a paucity of data it is not possible to place the beach in a regional context in terms of species diversity and representativeness, however the mud flats may also prove worthy of special protection on the basis of the diversity of their invertebrate fauna alone.

The Mandora Salt Marsh is notable for its landform value; being part of a palaeo-drainage system, with associated aquifers, springs, salt water creek and extensive samphire flats. The Marsh includes a series of permanent spring-fed swamps (Saunders, Grant and Eil Eil Springs to the west and Cordong Biddy, Top and Baramith Springs to the east) scattered along the axis of a palaeo-drainage system that extends from the eastern Kimberley, through Lake Gregory, to Eighty Mile Beach (WADCALM 1990; Wyrwoll *et al.* 1986). The springs are recognised for supporting unusual plant assemblages. Eil Eil Spring (also referred to as Mandora Soak (Jones 1993b) and Mandora Swamp (Wyrwoll *et al.* 1986)) is the most spectacular. It takes the form of a 'raised bog' rising two metres above the surrounding country and supports a 20m high forest of *Melaleuca argentia* (Wyrwoll *et al.* 1986) (Plate 5). Its 3.3m thick accumulation of organic sediment overlies a sand substrate and is dated to 7000 yrs B.P. (Wyrwoll *et al.* 1986). The other springs tend to have thin layers of organics (< 40 cm) overlying a stiff plastic clay horizon (WADCALM, 1991). Dragon Flower Trees (*Sesbania formosa*) are established in many swamps with the sedge *Schoenoplectus litoralis*, the native bulrush *Typha domingensis* and clumps of the fern *Acrostichum speciosum* forming an understorey. The sedge *Fimbristylis ferruginea* forms a tussock grassland under the paperbarks in Eil Eil Spring (Plate 5).

On the 18th December 1994, cyclone Annette crossed the coast at Mandora Station and progressed inland over Mandora Salt Marsh and springs. Wind speeds of 217 km hr^{-1} (Bureau of Meteorology) caused substantial damage to Saunders Spring, resulting in a dramatic change in vegetation structure. The tops of the Dragon Flower trees were snapped off, allowing light to penetrate and "burn" off the fern understorey. This permitted *Typha domingensis* to become established as the dominant plant (John Stone, Manager Anna Plains Station, pers. comm.).

It is likely that the aquatic invertebrate fauna of the springs (in both the surface outflows and the subterranean groundwater) is characterised by a high level of endemism, containing species and possibly genera new to science. Mound springs in South Australia (Ponder 1986; Mitchell 1985) and springs in south-west Western Australia (Jasinska & Knott 1994) are notable for their endemic aquatic invertebrate fauna. So far, there has been no survey of this aspect of the fauna of the Site.

Plate 5. Eil Eil Spring (photo – Andrew Storey, WR&M, November 1995)

Plate 6. Salt Creek with relict stands of White Mangrove (*Avicennia marina*) (photo - Andrew Storey, WR&M, November 1995).

Plate 7. Wheel ruts on Eighty Mile Beach (photo - Jim Lane, CALM, July 1996).

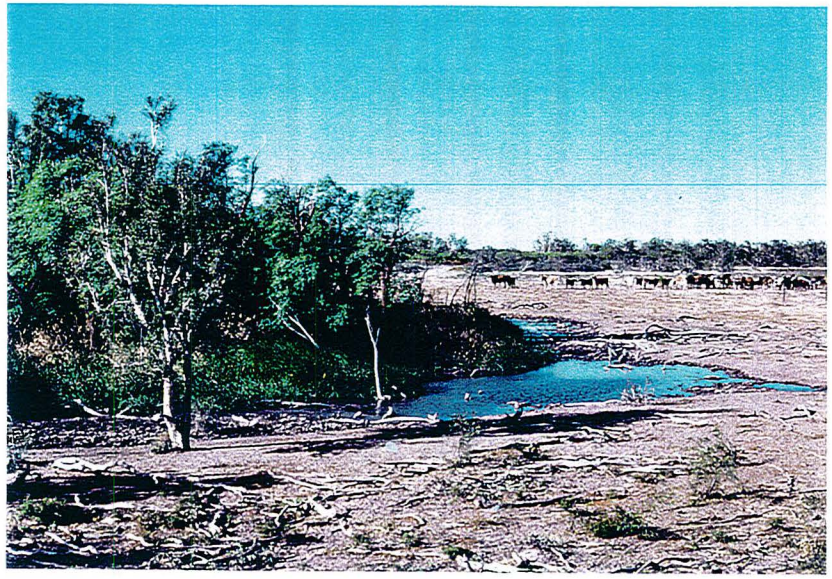

Plate 8. Damage by cattle at Grant's Spring (photo – Jim Lane, CALM, July 1996).

Salt Creek features the most inland occurrences of mangroves in Western Australia. The creek is a deep channel, 10-20 m wide and 5 km long and permanently filled with salt water (34.8 ppt, John Stone, unpub. dat.) which discharges into the eastern end of Mandora Marsh. It is lined by a relict stand of White Mangrove (*Avicennia marina*) (Plate 6), first described by Beard (1967; cited WADCALM 1991) and it is possible that the creek is connected to the sea by an aquifer (WADCALM 1990). The creek contains large numbers of fish, of at least two species (A.W.S. pers. obs.) and presumably there is an abundant invertebrate fauna to support the piscifauna. Because of the remoteness of the creek and the length of time it has been separated from other systems, the aquatic fauna of this relict wetland could be scientifically unique.

The Mandora Salt Marsh contains samphire vegetation (*Halosarcia indica, H. halocnemoides* and *Frankenia* sp.) and *Sporobolus virginicus* grassland and forms a broad (up to 10 km wide), open basin that is seasonally inundated, probably holding shallow water (< 0.5 m) in most years following monsoonal precipitation. Episodic inundation to a depth of 0.5-1m may occur when cyclones pass close to the area (e.g. early 1982). When inundated, the samphire flats are extensively utilised by waders for feeding, particularly prior to departing Australia in autumn. Many pairs of Black-winged Stilt *Himantopus himantopus* and Whiskered Tern *Chlidonias hybridus* (both resident species) were recorded breeding in the inundated marshes in March 1982, following cyclonic rains (ANCA 1996) and a variety of other waterbirds have been recorded from the site, including Plumed Whistling-Duck *Dendrocygna eytoni*, White-necked Heron *Ardea pacifica*, Nankeen Night Heron *Nycticorax caledonicus*, and Straw-necked Ibis *Threskiornis spinicollis*.

Identifying threats to wetland values

One of the most frequently mentioned threats to wetland values at Eighty Mile Beach relates to tourism, It is the disturbance of birds by 4WD vehicles, particularly at high tide when birds are concentrated on the narrow strip of beach between the mudflates and the foredune. For the most part the beach is inaccessible, as most stations have either placed locked gates across access roads (from North-West Highway) or have erected signs denying access to the beach. There are, however, an established caravan park at Wallal, a small camping area on the beach at Anna Plains Station, and a seasonal caravan site at Cape Keraudren.

The camping area at Anna Plains Station currently has space for only 2 caravans and has relatively few visitors. There is only one access road to the camp site and this comes via the station homestead. The current manager of the station is pro-tourism and intends to expand the camp ground to a fee paying caravan site. The existing camp ground is on the seaward side of the sand dunes, within 40 m of high tide and therefore on vacant Crown land (and within the Ramsar site). Prior to any expansion of this camp ground it would be desirable for it to be relocated behind the dunes, onto the pastoral lease.

The possibility of increased tourist numbers at Anna Plains is a concern as this section of Eighty Mile Beach has the highest densities of birds (WADCALM 1994). Although there is only one access point through Anna Plains, once having gained access 4WD vehicles can travel many kilometres along the beach in either direction and can potentially disturb all roost sites. Currently the only other access to this section of Eighty Mile Beach is at Cape Missiessy, at the northern extremity of the beach.

The caravan site at Cape Keraudren is situated on the top of a bluff overlooking the sea. It is promoted by the Port Hedland Shire, which seasonally employs a camp ground host, Mr Dave Fairgrove, to police the site. There is a boat ramp below the bluff, but no direct 4WD access onto the beach. In addition, the southern end of Eighty Mile Beach is predominantly limestone outcrop and is not suitable for 4WD use, therefore this camp ground probably poses little direct threat to wetland values.

The caravan park at Wallal Downs is located directly behind the sand dunes in a small reserve that has been excised from the pastoral lease and gazetted for public recreation. The park is owned by Mr Ken Norton and managed by Col & Jo Lewis. Current management are aware of the beach's Ramsar site status, are environmentally aware and have had contact with various researchers visiting the beach, such as V. Semeniuk (mangroves & coastal processes), R. Prince (turtles) and RAOU/AWSG (D. Watkins, C. Minton) (waders). The camp ground has 132 bays, holding a maximum of approx. 330 people, however the ground is rarely fully occupied. People visit the camp ground all year round, although the majority of

visitors come during winter months (Easter to September). There is one main access to the beach at the caravan site. Other access points to the beach across Wallal Downs, to the south, and Mandora Station, to the north, have been either locked or sign posted and most of the sand dunes have been fenced-off. Approximately 32 kms of beach are accessible from Wallal caravan park, 10 kms south to a rocky headland and 22 kms north to Mandora Creek. The owners at Mandora Station only occasionally saw 4WD tracks north of Mandora Creek, as only keen explorers would venture that far and attempt to cross the creek.

Most visitors to the caravan park come for short day or overnight visits, usually as a stopover during north or south bound journeys (WADCALM 1994). The majority of these visitors are elderly retirees, who tend to be quiet and not make much 4WD use of the beach, except for short trips. The caravan park was formerly heavily used by families from Shay Gap Mine, especially during school holidays, with high usage of 2 and 4 wheel motorbikes. This mine has since closed and is no longer a source of patrons. The park managers realised the damage being caused to sand dunes by motor bikes and, at their own initiative, took remedial action. New visitors were given a leaflet detailing restrictions on the use of motorbikes/4WDs on the sand dunes, a sign at the beach access point informed people to keep vehicles off the sand dunes, and tree loppings were used to restabilise blow-outs at old/fenced-off access points. Currently, there are various signs in the caravan park informing people about restrictions on 4WD use, dune restoration, fishing restrictions and turtle nesting, but no reference to waders, Ramsar or effects of 4WDs disturbing birds. Management are willing to erect signs to inform people about Ramsar, with a wader identification chart, if supplied.

The wide tidal mudflats fronting the beach, the low sand dunes behind and the exposed nature of much of the beach do not make it an attractive place for much fishing, swimming, diving or other traditional beach activities. Therefore the beach does not attract large numbers of patrons. The main reasons people access the beach include: some fishing, shell collecting (recreational & commercial), 4WD use and government patrols.

Fishing

Recreational fishing, both angling and beach seining, principally for Threadfin Salmon, is common in the vicinity of the caravan park. Previously, recreational fishers were allowed to set gill nets along the beach, but this was banned by the Fisheries Department in 1995. Two commercial fishermen, based at Broome and Port Hedland, have licences to net the beach. These operators also target Threadfin Salmon. Trophic relationships between salmon, bait fish, benthic invertebrates and waders are not known, but it is unlikely that the current fishing intensity will deplete salmon stocks to a level at which invertebrate populations on the mud flats are depleted by increased bait fish populations.

Shell collecting

Shell collecting is one of the more common activities. This is principally recreational, although some commercial collecting may occur to supply the tourist market in Broome. Collecting is principally restricted to dead shells deposited in the upper inter-tidal zone. Other vehicle usage comes from government patrols; Fisheries, Customs and WADCALM make infrequent visits to the park (~2 visits per year) and may patrol along the beach.

Disturbance

One of the greatest threats to wetland values would appear to be vehicles (4WD & motorbikes) causing disturbance of waders and nesting turtles.Generally, vehicle access to the beach is partly to facilitate other activities (fishing & beach combing), but is also to experience driving along such a long, open beach.

Disturbance to waders occurs when vehicles are driven along the beach at high tide and roosting birds are repeatedly flushed. Most people visit the beach in winter months when the majority of migratory waders have returned to northern hemisphere breeding grounds and are therefore not subjected to this disturbance. Populations of resident waders and "over-wintering" juveniles of migratory species are, however, disturbed.

Disturbance of nesting turtles by 4WDs occurs by two processes. The first is by sand compaction and crushing of nests. Flatback Turtles nest above the high tide mark, in the fore-dunes and inter-dunes. These areas are used by 4WD vehicles at high tide when the compacted, inter-tidal areas of the beach are

under water. The second process is by rutting. Deep (to 20 cm) wheel ruts running parallel to the waters' edge develop in the soft sand (Plate 7) and these tend to catch and retain hatchlings which then progress along the beach rather than towards the water, resulting in some mortality (R. Prince, WADCALM, pers. comm.). *Direct* disturbance of Flatback Turtles nesting on the beach is limited as most nesting occurs outside the major tourist season.

Human exploitation of Flatback Turtles is potentially an issue as their eggs are eaten by Aborigines and Torres Strait Islanders, though their flesh is generally regarded as inferior to that of other turtles (Dyne & Walton, 1987). To date, however, there have been no reports of local Aboriginal groups utilising Flatback Turtles on Eighty Mile Beach.

Limpus & Parmenter (1986; cited Dyne & Walton 1987) have reported destruction of Flatback Turtle nests by feral pigs on mainland beaches in the Torres Strait Region, however there have been no reports of feral pigs in the Eighty Mile Beach area.

An additional factor at the caravan park that may have long term implications, particularly if patronage increases, is the use of septic systems for showers and latrines. If the existing systems have insufficient capacity the potential exists for localised contamination of the beach directly in front of the caravan park.

"Kimberley Wildlife and Natural History Tours", based in Broome, includes Eighty Mile Beach in its birdwatching tours. The frequency of these tours very much depends on demand. On the current scale, with tour groups restricted to a maximum of four people and an experienced tour guide leading the party, it is unlikely this venture will threaten wetland values.

Pollution

Flotsam and jetsam, such as plastic drums and plastic sheeting, is occasionally washed up on the beach. This may come from the ports at either Broome or Port Hedland or from passing ships and demonstrates the potential for more significant pollution. The EPA recognises Eighty Mile Beach as an area of high conservation value (EPA 1981). However, because there are no petroleum or gas fields in production or under development in the immediate area, there are no specific oil spill contingency plans for the beach. Major damage could occur if an oil spill from coastal shipping affected the site, particularly if it happened when high densities of birds or nesting turtles were present. Impacts (on birds, flora and benthic invertebrate fauna) could include direct effects of the oil and indirect effects of any dispersant chemicals used. An oil spill could have a catastrophic impact on migratory wader numbers as these birds are long-lived, slow breeders and, at times, a large proportion of the total population of some species may be present at this key staging point.

Feral animals

Feral animals do not appear to be a big problem at either Eighty Mile Beach or Mandora Salt Marsh.

Camels, *Camelus dromedarius*, occur in low numbers in the eastern parts of the proposed Mandora Nature Reserve, infiltrating from the Great Sandy Desert, and presumably utilising the most easterly springs. The current managers of Anna Plains Station cull any camels that move further west onto their lease, thereby preventing significant impacts. ANCA (1996) note that camels are damaging the wetland area at Dragon Tree Soak, approximately 150 kms to the east, and this damage is continuing (M. Bamford, pers. com.). If there is an increase in the number of camels at Mandora, then the Ramsar site (eastern parts at least) may be affected.

There is no obvious sign of rabbits. Foxes and cats occur in the area and may have a low level impact on birds, possibly predating on nesting and/or feeding waterbirds both in the samphire marsh and on the beach.

Irrigated agriculture

There is the potential for damage to the Mandora Salt Marsh area through irrigation for cotton farming. In September 1993 a proposal (the Bodequena Cotton Project) was submitted for a 500 000 ha pastoral lease to be made available, within which small areas (total ~ 6000 ha) would be developed for cotton production. The intention was to locate the project on the palaeo-channel and use the freshwater aquifers to supply irrigation water. The original proposal completely covered the vacant Crown land component at

the eastern extremity of the proposed Mandora Nature Reserve, and, therefore, conflicted with the intentions of WADCALM. The general recommendations from WADCALM regarding the project were that alternative land outside the proposed nature reserve be sought, that the project be developed in a way which would not have any detrimental impact on the Ramsar wetland and that there needed to be as large a buffer as possible between the project and the wetland. There have been no further formal developments regarding this proposal since late 1993, although there has been mention of an alternative project to develop irrigated agriculture in the area (G. Graham, WADCALM, pers. comm.).

Mining

Exploration for petroleum and minerals may occur in the future. For example, Petroleum Exploration Permit WA-233-P covers the offshore coastal waters in the southern half of Eighty Mile Beach and in 1992 a proposal for exploratory drilling in the proposed Mandora Nature Reserve, to investigate a geophysical anomaly found by seismic survey, was approved, subject to certain environmental terms and conditions.

Cattle

Cattle grazing occurs extensively on the coastal plain and inland areas managed by Wallal Downs, Mandora and Anna Plains Stations. There is no evidence of cattle transgressing onto the beach, partly because large sections of the beach are fenced. There is also little to attract stock onto the beach (no feed and no fresh water). In Mandora Salt Marsh cattle grazing has probably had little or no detrimental effect on the samphire areas with respect to waterbird usage (ANCA 1996). Similarly, there was no evidence of cattle grazing or other damage to the sections of Salt Creek inspected during a site visit (November 1995), though this was to be expected given the absence of fresh water or suitable fodder in the creek. Several permanent freshwater springs were, however, heavily impacted, as a consequence of both trampling by cattle and human activity (e.g. excavation of sumps for stock watering) (Plate 8).

Several of the smaller springs, isolated on the open claypan, were extensively degraded by cattle. The vegetation had been trampled, the surrounding dry earth compacted and the swamp deposits churned into a muddy bog. In one instance a stock pen (approx. 100m x 100m) had been constructed around a spring to attract and retain stock for mustering. As a result, the spring was heavily utilised and degraded by stock.

Of the larger swamps, Saunders Spring was one of the more degraded (the vegetation had also been recently affected by a cyclone). Some of the surrounding bush had been denuded as a result of cattle trampling, forming well worn stock routes towards the spring. In the spring itself, stock had trampled understorey vegetation and churned the peat deposits. Anna Plains Station had excavated one end of the spring to provide a permanent, open waterhole. The station manager was aware of some of the problems, and was preparing to fence-off part of the spring. For this purpose fence lines had been pushed through the bush by a grader. In contrast, several of the larger swamps (e.g. Eil Eil and Graham Spring) were relatively unaffected by cattle. Either the water was not attractive to the cattle or there were alternative water supplies nearby.

In association with the physical damage caused by stock, there is likely to be a future water quality problem. The high number of stock has resulted in the build-up of large quantities of faecal material in the immediate vicinity. Wet season flushing of this nutrient into the swamps is likely to lead to algal blooms and reduced water potability. Continued cattle grazing may lead to a gradual net import of nutrients to the swamps causing eutrophication and ultimately threatening the viability of the vegetation complexes and potentially unique aquatic invertebrate assemblages in the swamps.

Selection of a provisional Scientific Monitoring and Management Committee

Following listing of known wetland values and threats, it is proposed that the management agency (in this case WADCALM) would draft a provisional list of members for a Scientific Monitoring and Management Committee (SMMC), with the expertise needed to address these issues. This process would be driven by the Regional Manager, who would chair the Committee. On the basis of the values and threats identified in the previous section, the following membership is proposed (Table 21). Members would be selected primarily on basis of expertise rather than affiliation.

Table 21. Proposed membership of a SMMC for the Eighty Mile Beach Ramsar Site.

Person	Area of expertise/role on committee
WADCALM Regional Manager	Chairman of the SMM Committee.
Aboriginal community representative	Native title and sacred site issues.
Botanist	Botanical issues (marine & terrestrial).
Coastal geomorphologist	Coastal processes.
Environmental Economist/Resource manager	Assessment of monitoring program achievability.
Fisheries Department (OIC Broome office)	Recreational & commercial fisheries issues.
Hydrogeologist	Ground water & spring interactions/processes.
Managers of pastoral stations of Ramsar Site	Pastoral lease management and related issues.
Marine biologist	Marine biology issues, particularly intertidal fauna.
RAOU / AWSG ornithologist	Shorebird biology & management issues.
Turtle biologist	Sea turtle biology and management issues.
WA member of ANZECC Wetlands Network	Implementation of Ramsar Convention in WA.
WADCALM Kimberley Region Ecologist	Facilitation of program design & implementation.
Wetland ecologist	Wetlands (non-marine) & wetland processes.

The initial meeting of the SMMC would be introductory in nature, and would review the list of values and threats. Membership of the committee may change following this meeting if some areas of expertise are found to be unnecessary or if additional values or threats requiring different areas of expertise are identified (changes may also occur for the same reasons following the public meeting proposed below). This first meeting of the SMMC would best be held at or near the site so issues could be viewed first hand. Subsequent meetings could be held by teleconferencing or in Broome or Perth.

Part of the first meeting would be to discuss the format and content of the subsequent public meeting and to delegate members to present brief overviews concerning the site, values and threats, Ramsar obligations, management and the process of developing an EMP.

Likely participants in a public meeting

In addition to the members of the SMMC, the following parties (representatives thereof) were identified during the case study as prospective invitees to the proposed public meeting.

- Aboriginal Groups with an interest or claim to the site
- EABG observer (National Wetlands & National Reserve System Programs)
- Broome Botanical Society
- Cape Keraudren caravan park host (Shire of Port Hedland)
- Broome Shire Clerk
- Commercial fishing operators and recreational fishing clubs using the beach
- Department of Agriculture, Rangelands Management Group
- Department of Environmental Protection, Karratha office
- Department of Land Administration
- Department of Resources Development (re. cotton project)
- Department of Transport
- Friends of Broome Bird Observatory
- Kimberley Conservation Council (NGO conservation group)
- Kimberley Development Commission (WA Government)
- Kimberley Land Council (Aboriginal Council)
- Kimberley Tourist Association
- Local RAOU representatives
- Owners of Anna Plains, Wallal Downs and Mandora Stations
- Operators of tour groups that utilise Eighty Mile Beach
- Owner & managers of Wallal Caravan Park
- Shell Collectors Society
- WADCALM District Wildlife Officer (West Kimberley, Pilbara)
- WADCALM Pilbara Region Ecologist
- Warden of RAOU Broome Bird Observatory

The public meeting would be advertised widely so that all interested parties would have an opportunity to attend. It would best be held on or near the site (e.g. at Sandfire Roadhouse or one of the Station homesteads) or, if this is impracticable, in Broome. The meeting would be chaired by the WADCALM Regional Manager and the purpose would be for SMMC members to present brief overviews concerning the site, values and threats, Ramsar obligations, management and the process of developing an EMP, and for community participation in the process, both during the meeting and subsequently. For example some participants may be aware of additional threats or values or may have important additional information on threats or values already recognised. Some may also wish to form a "Friends of the Ramsar Site" group and become involved in monitoring and other work.

Because of the low population size of the area (West Kimberley), there do not appear to be many resident naturalist groups that might become involved in an EMP for the Eighty Mile Beach site. The "Friends of the Broome Bird Observatory" are already heavily involved in wader counts, banding and related activities in the region. Due to cost, this work is principally restricted to Roebuck Bay, however it is likely that members would be keen to be involved in monitoring at Eighty Mile Beach (in addition to that already undertaken (see following section)). Members of the Broome Botanical Society might also wish to be involved e.g. in rehabilitation of mound spring vegetation.

Identifying current management and monitoring activities at the site

Following the meeting, the SMMC would review the values and threats, incorporating any new information gathered in the public meeting, and prioritise these in preparation for developing an environmental monitoring program.

The next step in the EMP process would be the documentation of current monitoring activities, past and present scientific work on the site, and past and present management activities. This will prevent repetition of costly research and will identify current activities that may be incorporated in the EMP. Also, all works identified would be gathered into a centralised database/reference library for the site. Major threats to the site have been identified in this case study, and a preliminary attempt has been made to prioritise values and threats for management purposes. Current research and monitoring activities at the site are listed below. Current management is not listed because no part of the Ramsar site currently is in the State conservation reserve system and there has been no active management of the site by WADCALM at this stage.

- Currently the most active area of research and monitoring is on wader and other waterbird values, Every two years the Australasian Wader Study Group (AWSG) visits Eighty Mile Beach to conduct "ground counts" (as opposed to counts by plane) and live trapping. The group works mainly in the area 20 kms north and south of Anna Plains Station, both on the beach and the immediate hinterland. Total numbers of each species are recorded and birds are caught (by cannon net) for banding, leg flagging, colour dyeing and to record returns (retraps). In addition, the Broome Bird Observatory/RAOU visits Eighty Mile Beach two or three times each year to conduct wader counts. This is timed to coincide with the National Shore Bird Counts (February and June) and the site will be part of the Australian Wader Network, putting the area into a national context (Watkins 1993). These surveys compliment similar work by the Broome Bird Observatory on Roebuck Bay, entailing monthly cannon netting and banding with assistance from Friends of Broome Bird Observatory. Results of this work are published in *Stilt*, the journal of the AWSG.
- Few data are available on the diets of waders in Australia generally, and the north-west of Western Australia is no exception. WADCALM has limited data on diet of birds taken from Roebuck Bay in mid 1991 (Stuart Halse, WADCALM, unpub. dat.) and Tulp & Goeij (1994) conducted a preliminary study of feeding of waders in Roebuck Bay in March and May 1991, concentrating on Great Knot.
- Behaviour, timing and possible migration routes of waders departing the north-west of Australia, including Eighty Mile Beach and Roebuck Bay, were reported by Tulp *et al.* (1995).
- Dr Rosalind Jessop, of the Phillip Island Penguin Reserve, in association with Mr Peter Collins, school teacher and past assistant warden at Broome Bird Observatory, are conducting a research project at Roebuck Bay and Eighty Mile Beach to look at diet and feeding behaviour of Little Curlew and Whimbrel, use of parts of Roebuck Bay by birds and people and their interactions, and, wader and passerine ("bush bird") use of mangroves and saltmarsh areas at Roebuck Bay. Although

distance restricts the amount of work they will conduct at Eighty Mile Beach, the findings from Roebuck Bay will be of direct relevance. Of particular value will be the dietary study of selected wader species. They intend to determine:

a.) the main foods of the waders and how this diet varies between seasons and habitats;
b.) the density and distribution of invertebrates on the mudflats and grasslands;
c.) feeding rates and feeding patterns in relation to habitat, tide, time of day, weather and stage of migratory cycle, and
d.) the relative importance of coastal compared to grassland plain feeding.

The second component of their research concerns the effects of human usage (i.e. anthropogenic disturbance) of Roebuck Bay on waders. Frequency of human disturbance (4WD usage, fishing, other recreational usage) will be recorded and compared with the frequency of natural disturbances e.g. by raptors. Findings from these projects will be published in the journals *Stilt* and *Emu*.

- The WADCALM, with assistance from the managers of the Wallal Caravan Park, previously monitored sea turtle utilisation of the beach. Data on approximate numbers and species of turtles nesting on the beach at different times of the year are available (Bob Prince, WADCALM, pers. comm.). However, this monitoring program has been suspended in recent years.
- Fisheries and Customs Department officers make occasional visits to the beach to police relevant issues (e.g. illegal fishing, raiding of turtle nests, customs violations).
- Basic flora and fauna surveys were conducted through the Mandora Salt Marsh area in August 1983. Some of the findings of this survey are summarised in WADCALM (1991) and include data on wetland and non-wetland plant and animal communities. As a result of these surveys, the area was recommended for declaration as a Class A Nature Reserve. Additional data are held by WADCALM (Norm McKenzie, unpub. dat.).
- Additional data relating to Mandora Salt Marsh are available from Wyrwoll *et al.* (1986) who collected sediment cores from Eil Eil Spring (Mandora Swamp) and Dragon Tree Soak (in the Great Sandy Desert) for ^{14}C dating. Preliminary ^{14}C dates and stratigraphic findings indicated that present conditions had developed by 7000 y B.P. and, since then, peat deposition had continued uninterrupted, pointing to general climatic stability, 'a tentative conclusion supported by the pollen record' (Wyrwoll *et al.* 1986).

Future monitoring, research and management

Based on the prioritised values and threats, the available historical data and current monitoring, management and research projects on the site, the SMMC will prepare a draft Environmental Monitoring Program for the Ramsar site.

The management, monitoring and research issues listed below were identified in this case study as those needing to be addressed in a draft EMP. The monitoring programs would involve local groups and individuals (e.g. pastoralists, natural history groups) as appropriate. The economist would assess the feasibility of achieving the desired outcomes, depending upon priorities and funding, both from WADCALM and EABG.

- The first priority should be the reservation of Eighty Mile Beach as part of a Marine Park and of the Mandora Salt Marsh system as part of the proposed Mandora Nature Reserve. Without achieving this objective, WADCALM has limited powers to manage the site.
- Until reservation is achieved, an immediate priority is to work with the manager of Anna Plains Station to arrange protection of the mound springs from cattle degradation. Currently the manager is considering fencing part of Saunders Spring, however, there are additional springs suffering from cattle degradation which should also be protected. The construction of suitably located stock-proof fences and the provision of water supplies away from the immediate vicinity of the springs (e.g. to a sump connected by a short channel) appear desirable.
- A low key public awareness campaign should be mounted to inform people about Ramsar and the reasons why the site was nominated as a Wetland of International Importance. This could be achieved by means of a sign and wader identification chart erected at the Wallal caravan park. If the Anna Plains camp site increases in popularity, the same approach could be applied at that location. Media coverage in Broome is also recommended.
- Regular (preferably annual) aerial photography of the mound springs should be trialled as a way of remotely assessing temporal changes in vegetation condition. During the site visit it was logistically

difficult to access all the springs and physically difficult to view all parts of each spring accessed. Aerial photography may provide an easy means of quickly assessing the vegetation status of each spring (and any damage by cattle).

- There needs to be ongoing monitoring of the numbers and diversity of waders utilising the site, particularly the beach. The existing National Wader Network will enable data from this site to be viewed in a national context and any abnormal changes in wader usage with respect to other prime locations (Roebuck Bay and Gulf of Carpentaria) to be identified. The existing monitoring program conducted by Broome Bird Observatory and the AWSG should be sufficient for this purpose. However, some assistance with funding may be needed.
- Findings of the Jessop & Collins' wader diet and human disturbance projects (see previous section) will need to be relayed to the SMMC for consideration of implications for Eighty Mile Beach.
- In the meantime (while waiting for the Jessop & Collins findings), it would be desirable to establish a monitor of human activity on Eighty Mile Beach. This could be achieved with the possible assistance of the managers at the Wallal Caravan Park and Anna Plains Station, the two main points of access to the beach. Visitors would be asked to fill-in a questionnaire that would give an indication of the frequency and level of disturbance to birds (questions such as: did you take a 4WD vehicle onto the beach, how many times, for how long, at high or low tide, how far did you travel along the beach, what other activities did you engage in whilst on the beach?). WADCALM field officers could collect and collate these questionnaires as part of routine site visits or they could be mailed to the Broome office.
- Study of the diversity of benthic invertebrates in the tidal mudflats is required, primarily to relate availability of invertebrates to wader diet, but also to establish baseline data on abundance and biomass of invertebrates. If, as is undoubtedly the case, one of the prime attractions of this area of coast to waders is the abundance and diversity of the food supply, then it is very important to document the current relationships. Loss of this food supply could have devastating repercussions on wader usage of the area.
- A study of inter-tidal benthic invertebrates may also be used to provide data a.) to monitor the effects of an impact (e.g. oil spill) on the inter-tidal fauna, and, b.) to establish a desirable endpoint for any post-impact remediation. The survey would also enable the site to be placed in a national context in respect to mollusc and other invertebrate diversity and species composition.
- A survey of the aquatic fauna (fish and invertebrates) of Salt Creek should be conducted given its historical isolation and high probability of scientific uniqueness.
- A survey of the aquatic invertebrate fauna of surface and subterranean waters of the major springs should be conducted to determine the uniqueness and level of endemism in the fauna.
- For both legal and management reasons, the existing informal camp site at Anna Plains Station needs to be relocated before it is expanded into the proposed fee-paying caravan park. The site should be moved off vacant Crown land (i.e. to at least 40m inland of high water mark) to a suitable location behind the sand dunes. This should be achieved in consultation with representatives from Anna Plains Station, Department of Land Administration, Shire of Broome and WADCALM.
- In the event of a cotton or other irrigated agriculture proposal in the vicinity of the Mandora Salt Marsh being pursued, a hydrological study of the aquifer should be implemented. The study should determine the hydrologic relationships between the mound springs, Salt Creek and the ground water aquifer in the palaeo-channel. This should be part of an EIA for the cotton project, on a "proponent pays" basis. Such a proposal should not be approved until relevant environmental authorities are satisfied that groundwater extractions (or discharges) will have no adverse effect on the water supply to, or ecology of the mound springs.
- It would be desirable to obtain summaries of catch records of the two commercial operators fishing Eighty Mile Beach from the Fisheries Department. If catch per unit effort estimates were available, this would provide an indication of the state of the fishery and these data could be utilised to help determine trophic interactions re: abundance of bait fish, benthic invertebrates and wader diet.

The draft EMP would then be released for public comment. Following review of comments received, the EMP would be revised by the SMMC and then submitted for approval by WADCALM, as both the site management agency and the State government Ramsar implementation agency. Following approval by WADCALM, the EMP for the Ramsar site would be implemented.

Ord River floodplain

Site description

This Wetland of International Importance is located in the Kimberley Region of Western Australia on the eastern side of Cambridge Gulf, and is approximately 50km north-west of the town of Kununurra and 25 km south-east of Wyndham. The Site comprises an extensive system associated with the Ord River and the Gulf, and occupies an area of approximately 116 000 ha. It includes seasonally inundated floodplain wetlands (Parry Lagoons and Jobalong Flat) and permanent waterholes and springs (e.g. Alligator Hole and Palm Spring) south-west of the Ord, and mangroves and mudflats on the eastern side of Cambridge Gulf (principally the False Mouths of the Ord area) and along tidal reaches of the Ord itself. The site is bordered to the east and south-east by Carlton Hill and Ivanhoe pastoral leases respectively, and by El Questro pastoral lease to the south-west, all of which run cattle. There is a small freehold area along Twenty-mile Lagoon that is within the boundaries of the Site, but is not part of the Wetland of International Importance (Figure 8.).

The seasonal freshwater wetlands to the south-west of the river are surrounded by a flat, grass-covered plain (dominated by the cane-grass *Oryza australiense*) and may be fringed by low shrubs or trees. Permanent waterholes are fringed with a variety of trees including *Melaleuca argentea* and *Barringtonia acutangula*; a variety of lilies (*Nymphaea gigantea*, *Nymphoides indica* and *N. crenata*) and other aquatic plants also occur. The mudflats along the river and on the eastern side of Cambridge Gulf support patches of Saltwater Couch (*Sporobolus virginicus*) grassland and samphire (*Halosarcia indica leiostachya* and *Tecticornia verrucosa*). The mudflats are dissected by numerous mangrove-fringed creeks and channels (Jones 1993b). The Site begins 75 km downstream of Lake Kununurra and 127 km downstream of Lake Argyle. These lakes were formed by damming of the Ord River to supply irrigation water for agriculture, and, more recently, to generate hydroelectric power.

Management of the site

When nominated, the majority of the Site was contained within five existing nature reserves (↑30866, ↑1058, ↑1059, ↑31636 and ↑31967). However, the northern extremity of the Ramsar Site, the False Mouths of the Ord, was vacant Crown land, and therefore unprotected except under general provisions (applying to all vertebrate fauna and some flora) of the Western Australian Wildlife Conservation Act.

At the time of nomination it was proposed that reserve ↑31967 be extended northwards to include the False Mouths of the Ord. Since nomination of the Ramsar site, the first four reserves have been amalgamated and extended to form the "Parry Lagoons Nature Reserve" (now reserve no. ↑42155), with an area of approx. 36111 ha, and reserve ↑31967 has been extended northwards to include the False Mouths of the Ord and now forms the "Ord River and False Mouths of the Ord Nature Reserve" (↑31967), with an area of approx. 79842 ha. As a result, most of the Site is now contained within the two "C" Class nature reserves which are vested in the Western Australian National Parks and Nature Conservation Authority and are managed by the Department of Conservation and Land Management (WADCALM). This reservation provides for a higher level protection of the site under the Wildlife Conservation and Conservation and Land Management Acts.

Now that most of the Ramsar Site is within the two nature reserves, management of the Site is the responsibility of WADCALM. The Site falls within the Department's Kimberley Region and day to day management is the responsibility of the Regional Manager based in Kununurra.

Adequate definition of the boundaries of both nature reserves (*viz.* the Site) is an important issue relevant to management. Although the reserves have been legally described, there are no obvious boundaries on the ground apart from some natural and anthropogenic features (e.g. the river bank and the Great Northern Highway). The "Ord River and False Mouths of the Ord Nature Reserve" extends from low water mark to 40 m above the high water mark, i.e. to the boundary of the adjoining pastoral lease. Given the low lying and flat terrain and the large tidal range (~ 8 m), the reserve includes extensive areas of tidal pools, low islands subject to inundation and mangrove-covered tidal mud flats. Use of high water mark in determining the landward limit of the reserve results in an unsurveyed, irregular and virtually

impossible-to-define boundary. Most of this boundary abuts Carlton Hill Station and the absence of either a fence line or clearly defined limits makes control of straying stock a difficult management issue.

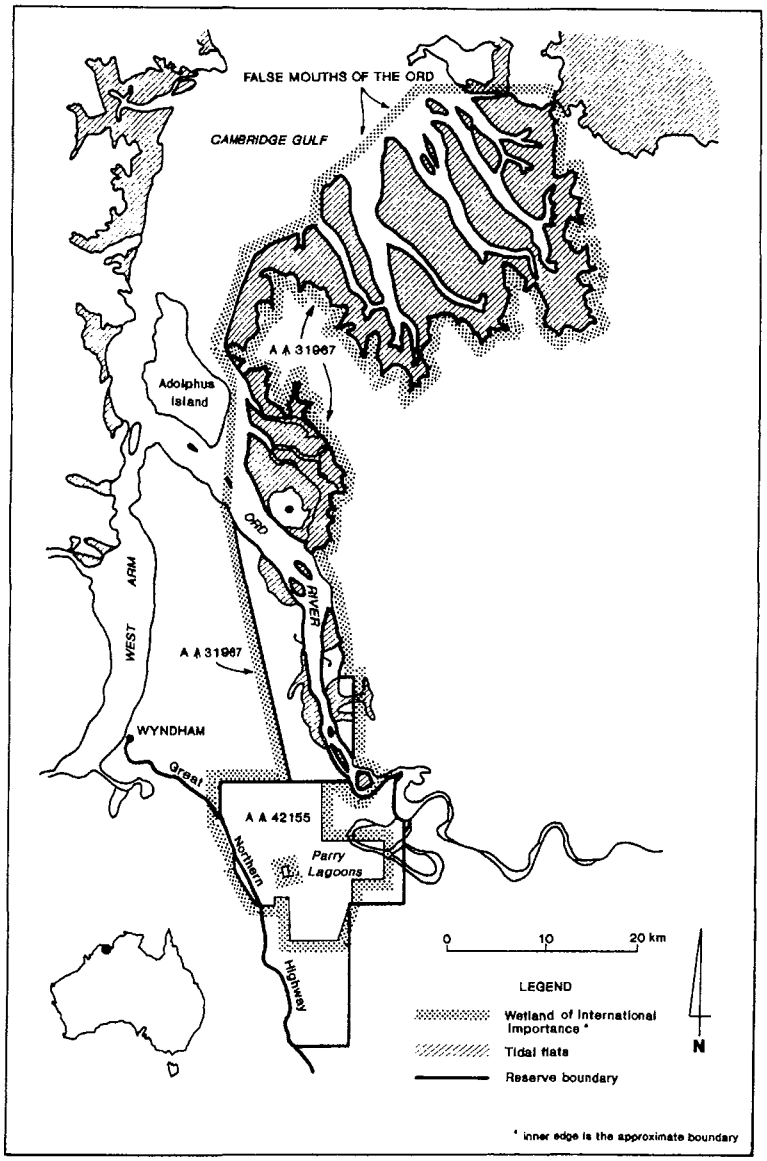

Figure 8. Ord River floodplain, indicating boundaries of the Ramsar site

The boundary of the Parry Lagoons Nature Reserve is defined principally by the Ord River, Ivanhoe Station, El Questro Station, the Great Northern Highway between Wyndham and Kununurra, Wyndham townsite and portions of vacant Crown land. However, the lack of adequate fencing results in uncontrolled movement of stock onto the reserve.

In places, the boundary of the Ramsar site extends beyond those of the two nature reserves to include some additional marine areas (those below low water mark; see Fig. 8). It is proposed that these areas be included in a proposed marine nature reserve adjoining the two "terrestrial" nature reserves (WADCALM 1991).

Another issue for management of the Site is conflict over Native Title claims. In 1994 the Parry Lagoons Nature Reserve was claimed by Aboriginal Groups under the auspices of the Native Title Act (Graham & Gueho 1995). Subsequently, in late 1994, eviction notices were served on a group unlawfully squatting

on the reserve. This is likely to be an ongoing management issue, particularly given the present situation (January 1996) where the Western Australian State government is opposed to proposals from the Federal Government regarding Native Title. As Graham & Gueho (1995) state, "It is not CALM's role to assess the validity of native title even when it impacts on estate managed by this agency yet negotiation at some level must still take place to ensure the values of the area are understood and at least maintained".

Identifying wetland values

In terms of wetland values, the Site may be considered in two parts, the permanent and seasonal freshwater wetlands of the Parry Lagoons Nature Reserve, and the estuarine and marine habitats of the Ord River and False Mouths of the Ord Nature Reserve.

Parry Floodplain is a good example of a tropical floodplain with permanent billabongs, seasonal marshes and wooded swamps. It is one of few such floodplains of substantial area in Western Australia and the herbland/grassland communities are the most extensive of their type in the State. The seasonal floodplains support large numbers of waterbirds and, in years when local rainfall is high, the lagoons and other seasonal wetlands constitute one of the major breeding areas for waterbirds in the Kimberley (Jones 1993b).

A total of 77 species of waterbird have been recorded from the Site, including 4 darters and cormorants, 14 herons and allies, 14 ducks and allies, seven rails, 24 shorebirds and four terns. Twenty-two species are listed under treaties (e.g. JAMBA and CAMBA). Rare species recorded from the Site include the Freckled Duck *Stictonetta naevosa*. Recent surveys have recorded eight waterbird species breeding in the area, with more probable (ANCA 1996). In wetter years, Magpie Geese *Anseranas semipalmata* breed in the south of the floodplain, forming the largest breeding concentration in the State, and there is one breeding colony of egrets and herons in closed-forest in the south-east of the floodplain. Other breeding species include Darter *Anhinga melanogaster*, Comb-crested Jacana *Irediparra gallinacea* and Purple Swamphen *Porphyrio porphyrio*. The Site is a stop-over location for 15 species of migratory shorebird. The most abundant are Little Curlew *Numenius minutus*, Sharp-tailed Sandpiper *Calidris acuminata*, Oriental Pratincole *Glareola maldivarum* and Wood Sandpiper *Tringa glareola*. In terms of numbers of waterbirds on the seasonal floodplain, totals of 13 000 were recorded in May 1979, 20 000 in March 1980, 15 000 in January 1981 and 27 000 in May 1986 (WADCALM 1990). Many of these birds were ducks (18 400 ducks were recorded in May 1986), predominantly Plumed Whistling-Duck *Dendrocygna eytoni*, Grey Teal *Anas gracilis* and Hardhead *Aythya australis*. Large numbers of Glossy Ibis *Plegadis falcinellus*, Red-kneed Dotterel *Erythrogonys cinctus*, Little Curlew *Numenius minutus*, Black-winged Stilt *Himantopus himantopus*, Australian Pratincole *Stiltia isabella* and Masked Lapwing *Vanellus miles* also have been recorded. The Site supports more than 1 % of the national population of Red-kneed Dotterel, Wood Sandpiper, Common Greenshank *Tringa nebularia*, Marsh Sandpiper *T. stagnatilis*, Little Curlew, Australian Pratincole and Oriental Pratincole. The site is also regionally significant for Green Pygmy Goose *Nettapus pulchellus*, Comb-crested Jacana and Yellow Chat *Ephthianura crocea*, and is the only confirmed locality in Western Australia for Zitting Cisticola *Cisticola juncidis*, which breeds in the area and is widespread in the wetland grassland (ANCA 1996).

Freshwater *Crocodylus johnstoni* and Saltwater Crocodile *C. porosus* occur, the latter mainly in the permanent billabongs. There are also anecdotal records of Saltwater Crocodiles breeding adjacent to the billabongs. Two species of fish, Hyrtl's Tandan *Neosilurus hyrtlii* and the Western Rainbowfish *Melanotaenia splendida australis* have been recorded from the Site (ANCA 1996).

There have been no comprehensive surveys of the fauna (except waterbirds) or flora of Parry Lagoons Nature Reserve.

The False Mouths of the Ord is the most extensive mudflat and tidal waterway complex in Western Australia (ANCA 1996). The mangal on the tidal mudflats of the Ord Estuary is the best in Western Australia in terms of species diversity, structural complexity and massiveness of the stands. Fourteen species of mangrove have been recorded and there is distinct zonation in composition. Mangrove species in the seaward zone form a woodland about 8m high, and contain *Sonneratia alba*, *Avicennia marina* and *Aegiceras corniculatum*. Behind this outer zone is a woodland 10m high, containing *Bruguiera parviflora*, *Avicennia marina* and *Aegiceras corniculatum*. Then follows a 12-15m high belt of *Rhizophora stylosa*,

with a 4m high thicket of *Avicennia marina*, *Ceriops tagal* and *Aegialitis annulata* on the landward side. Other common species include *Camptostemon schultzii*, *Excoecaria agallocha* and *Xylocarpus australasicus*.

Although not containing large numbers of waterbirds, notable species such as the Chestnut Rail *Eulabeornis castaneoventris* and Striated Heron *Butorides striatus* have been recorded from the mangroves, and, during brief aerial surveys, many hundreds of herons and allies have been recorded from tidal pools on the coastal flats. The mangrove area is more notable for non-waterbird fauna. Mammals recorded include the only known population in the East Kimberley region of the undescribed Mozaic-tailed Rat belonging to the genus *Melomys*. There is a rich bat fauna including Black Flying Fox *Pteropus alecto*, Yellow-bellied Sheathtail Bat *Taphozous flaviventris*, Common Sheathtail Bat *T. georgianus*, Northern Mastiff Bat *Chaerephon jobensis*, Common Bent-wing Bat *Miniopterus schreibersii*, Hoary Bat *Chalinolobus rogersi*, Little Broad-nosed Bat *Scotorepens greyi*, Western Little Pipistrelle *Pipistrellus westralis*, and Arnhem Land Long-eared Bat *Nyctophilus arnhemensis* (WADCALM 1991). The Site supports 12 of the 13 forest birds that are mainly restricted to mangroves in Western Australia, including the Black Butcherbird *Cracticus quoyi*, Mangrove or Collared Kingfisher *Halcyon chloris* and Shining Flycatcher *Myiagra alecto*.

The original Ord River Nature Reserve was declared primarily to protect the Saltwater Crocodile *Crocodylus porosus*, a species declared "in need of special protection" under the Western Australian Wildlife Conservation Act. This declaration followed recommendations by Bustard (1969; cited WADCALM 1991) who felt the area was ideal for a crocodile reserve because it contained excellent habitat and, at that time, held a number of crocodiles which would repopulate the area if strictly protected. Subsequent surveys have shown that the Ord River has an increasing population and is the major breeding river in Cambridge Gulf (Messel *et al.* 1987; cited WADCALM 1991).In 1989, 14 of 39 nests found in Western Australia were in the upper Cambridge Gulf system, and, in 1992, 149 non-hatchling saltwater crocodiles were counted in the Ord Estuary part of the reserve (ANCA 1996). Initially, the Ord River Nature Reserve did not include significant areas of breeding habitat. However, subsequent extensions to the reserve, as encompassed by the Ramsar site, include additional breeding areas, though the majority of breeding still appears to occur upstream of the reserve.

By virtue of their great extent and shoreline length, the mangroves probably form a major nursery area for estuarine and marine fishes and crustaceans (ANCA 1996).

NB. Within the available time and budget, the author was not able to visit the False Mouths of the Ord region of the Site. Therefore, the listed wetland values are those reported in the literature and determined during discussions with conservation agency staff.

Identifying threats to wetland values

Physical, hydrological and water quality changes related to the development of the Ord River irrigation and hydroelectric schemes potentially have had, are having, or will have a significant effect on the Site. The river and its flows have been progressively modified as these schemes have been developed.

Dams and hydroelectric power generation

In 1963 a diversion dam was constructed on the Ord River at Kununurra to supply the Stage 1 irrigation scheme. This irrigation scheme currently occupies approx. 13 000 ha on the Ivanhoe and Packsaddle Plains on the lower Ord River, and to the north and north-east of Kununurra (Plate 9). Subsequently, to provide greater volumes of water on a reliable basis, a second dam (Argyle) was built approximately 52 km upstream of the diversion dam. This was completed in 1972. The reservoirs created by the construction of the diversion and Argyle dams have been named Lake Kununurra and Lake Argyle respectively and together constitute another, single, Kimberley Ramsar Site.

A further significant development has been the construction of a 30 megawatt hydroelectric power station at the foot of Argyle Dam. This was completed in May 1996 and required the height of the Dam spillway to be raised by 5.77 m to provide additional water for power generation. The next major development will be the Stage 2 expansion of the irrigation scheme. Ultimately, the Ord River Irrigation Area is planned to constitute approximately 75 000 ha of irrigated land.

Plate 9. Ord irrigation area adjacent to the Lower Ord River (photo – Andrew Storey, WR&M, October 1995)

Plate 10. Marlgu Billabong, a permanent freshwater billabong on Parry Floodplain (photo - Andrew Storey, WR&M, October 1995).

Plate 11 Cattle erosion on a bank of the Ord River (photo – Andrew Storey, October 1995).

Plate 12. Jerusalem Thorn (*Parkinsonia aculeata*) in a river course (photo – Andrew Storey, WR&M, October 1995).

At present, water levels in Lakes Argyle and Kununurra are manipulated to maintain supply to the irrigation scheme. With the hydroelectric scheme now on-line there are additional releases from Lake Argyle into Lake Kununurra for power generation. When the Stage 2 irrigation scheme comes on-line, more water will be required. Presently, it has not been decided how the final system will be operated in terms of water allocations for irrigation, hydroelectric power generation, and ecological requirements. However, further alteration of the hydrological regime of the lower Ord River appears certain.

General principles

The ecological effects of impoundment and regulation of rivers has received wide attention, especially in Europe and North America (Ward & Stanford 1979; Lillehammer & Saltveit 1984, Craig & Kemper 1987), and more recently in Australia (Walker 1980; Walker 1985, Doeg *et al.* 1987; Storey & Edward 1989; Storey *et al.* 1991). Although there have been few studies specifically on the effects of impoundment and regulation of tropical rivers in Australia some general statements can be made.

Initial impoundment of a river will disrupt the natural flow regime to which the biota (aquatic and riparian) have adapted. Flow stabilisation results, with wet season / dry season variation in flow volumes and water levels becoming less pronounced and flood events occurring less frequently or not at all. This is particularly relevant to the lower Ord River as the Ord catchment is in a region of pronounced wet season / dry season rainfall variation and, in some years, receives exceptionally heavy falls.

Floods (spates) are recognised as having a very strong influence on the structure (species composition, relative abundance etc.) of aquatic communities, through flushing of fine organic material, nutrients, and woody debris and reorganisation of substrata (fine to coarse sediments). Flow stabilisation downstream from impoundments leads to a build-up of organic material and sediment, causing in-filling of backwaters, smothering of riffle substrate and associated fauna, and increased growth of aquatic macrophytes and algae. The elimination of major floods also affects river floodplains, as they are less frequently inundated.

Continuous, controlled releases further regulate river flows, reducing the frequency and magnitude of floods (those due to overtopping of the impoundment), and increasing downstream flow volumes and levels during what would otherwise be low flow periods (i.e. during the dry season).

The effects of hydroelectric (HE) power stations depend to a certain extent on the mode of operation and the limnology of the reservoir from which water is released. Generally, HE power stations introduce frequent, short-lived but rapid increases in discharge as water is released for power generation. These releases tend to destabilise the substrata and fauna. Substrate may be swept away, leaving bedrock where there is no transport of gravel etc. from upstream to replenish lost material. Recovery in the fauna may occur at a point downstream at which substrate is redeposited. If the reservoir thermally stratifies and hypolimnetic (i.e. taken from below the thermocline) as opposed to epilimnetic (i.e. taken from above the thermocline) water is released, then the water will be cold, relative to the receiving environment, low in oxygen and possibly high in nutrients and metals, such as phosphorous, iron and manganese, which are released from benthic sediments under anoxic conditions. The colder water may affect growth and developmental rates of the in-stream fauna. In some situations, the action of the turbines during power generation, results in discharged water being supersaturated in oxygen. This is known to result in fish kills through the development of oxygen embolisms.

Changes in flow regime downstream of an impoundment may disrupt life cycles. Eggs of aquatic fauna may be washed away by releases or, conversely, desiccated and destroyed by decreases in water level. This is particularly relevant to the fish fauna, with eggs in spawning beds and larvae in backwaters being swept away, or eggs layed on vegetation or other substrata being exposed and desiccated. Reduced flows also result in a decrease in the wetted area of the river and a concomitant loss in habitat for in-stream biota.

The Ramsar Site

With respect to the lower Ord River Site, because relatively little is known of the ecology of the Site, it is difficult to be definitive, but, based on the above processes and principles, it is possible to identify some potential threats to its wetland values. The majority of anticipated changes due to impoundment and regulation will be in the main channel of the Ord River upstream of the Wetland of International

Importance (e.g. the hydroelectric power station at Argyle Dam discharges into Lake Kununurra, which is more than 50 km long and 70 km upstream of the Ramsar site). Therefore, they are not relevant to this discussion, except where they may affect processes within the Site (i.e. fish-eating birds nesting at the Site, but flying to the river to feed).

ANCA (1996) note that prior to damming of the Ord River, its waters would flood the Parry Floodplain during the wet seasons of most years. Since damming, the floodplain is inundated less frequently and in most years there is only sufficient water to fill discrete claypans and swamps. This restricts the area and types of habitat available for waterbirds and, as a consequence, reduces their numbers and the extent of breeding. This is particularly relevant to the Magpie Goose, which breeds in large numbers (for the Kimberley) at this Site during wet years. Raising of the spillway for the HE power station and increased use of water by the Stage 2 irrigation scheme may further reduce the frequency, extent and duration of inundation of the Parry Floodplain. Reduced flooding will also expose the area to more frequent burning and this may impact adversely on wetland vegetation and fauna. While the Floodplain receives diffuse outflow from Parry Creek and other short, seasonal creeks, this is not sufficient to make up for reduced flooding by the Ord.

ANCA (1996) also identified seawater intrusion as a potential issue. Further reduction in freshwater discharge during the wet season may result in salt water moving greater distances up river than before. The Parry Floodplain is currently a freshwater system, except for a limited area close to the main river. If seawater begins to inundate the floodplain, and possibly the surrounding water table, there will be major changes to the character of the wetland (*viz.* changes in water quality, vegetation and fauna).

The extensive exposed and mangrove-covered mudbanks in the lower Ord River and the False Mouths of the Ord are a product of an equilibrium between deposition of sediment derived from the catchment and erosion of this sediment by tidal and wave action. It is likely that impoundment has altered this relationship. Argyle Dam will have reduced the volume of sediment entering the system, because most is now retained within the reservoir. Also, the carrying capacity (sediment) of the lower river is now less, due to impoundment of most of the Ord's flow. Sediment that was once deposited into the estuary (including the Gulf) may now be deposited in the lower river, causing an increase in the number of river mudbanks. Also, the balance between deposition and erosion in the estuary may have been disrupted, leading to erosion and loss of mangrove areas. There are likely to be significant inputs from rivers discharging into the West Arm of Cambridge Gulf that may ameliorate this effect to some extent. Also, current land use practices in the catchment (i.e. cattle) may result in higher sediment loads compared to pre-European settlement, and this may increase the extent of mudbanks. Relationships and likely outcomes are uncertain, but clearly warrant some attention.

Agricultural chemicals

Development of intensive agriculture (e.g. sugar cane, cotton, banana, mango, pineapple) in the Ord Irrigation Area has involved the widespread use of pesticides. In the 1960s and 1970s there were reports of occasional, large-scale fish kills due to pollution of the Ord River by pesticides (ANCA 1996). The current effects of these pesticides on the ecology of the ecosystem are unknown. Although widespread agricultural use of persistent organochlorine pesticides in Western Australia has since been banned, residues may still be present in the environment. It is possible that pesticide-contaminated waters and sediments were deposited onto the Parry floodplain. If this occurred, residues may have accumulated through the food chain and may be affecting the breeding success of birds or other fauna. Similarly, if pesticide residues were deposited in the mangals, larval or juvenile stages of fish and crustacea using this nursery area may be affected. There are no data available on the distribution or concentration of pesticide residues within the Site.

The proposed expansion of the Ord Irrigation Area by commencing Stage 2 will lead to a tripling of the area under irrigation. Much of the area to be opened (Weaber Plain, Knox Creek Plain and Keep River Plain) is to the north-east of Kununurra, towards and into the Northern Territory and away from the Site. However, it is also proposed that parts of Carlton Hill and Ivanhoe Stations be opened for horticulture, including Carlton Plain, on the north-eastern side of the lower Ord River, and Mantinea Flats on the south-west side of the river. Development of Mantinea Flats is of immediate concern with respect to the ecology of Parry Floodplain. The Flats area is approximately 6 000 ha and abuts the floodplain. Currently it is used

for pastoral grazing of cattle, but under the proposed development it will be subdivided to block sizes of 10-20 ha for intensive horticulture.

The groundwaters of Mantinea Flats and Parry Floodplain are likely to be closely linked and changes in the groundwater hydrology of Mantinea Flats may impact upon Parry Lagoons. Initially, it is proposed that horticulturalists will pump water from the Ord River to irrigate land on Mantinea Flats. It is likely that irrigation will lead to seepage to the watertable and this may cause an increase in its level. Groundwater under Mantinea Flats is highly saline (~ 36 ppt). An increase in the level of the water table could bring saline water to the surface of the Flats. If this also occurs at Parry Lagoons it will result in dramatic changes to the ecology of the Site. The permanent freshwater billabongs of Parry Floodplain act as refugia for biota such as birds, fish, aquatic invertebrates, crocodiles and plants (Plate 10). Salinisation of these waterbodies would impact severely upon the fauna. Similarly, salinisation of the floodplain would adversely affect use by waterbirds through changes in water quality, vegetation and faunal communities.

Potential also exists for surface and subsurface water quality to be adversely affected in other ways. Pesticides, herbicides and fertilisers are likely to be applied as part of horticultural practices. Any potential for contamination and subsequent flow of surface or ground water from Mantinea Flats to the Parry floodplain area needs to be assessed.

Development of Mantinea Flats will result in housing developments adjacent to the Ramsar Wetland. Access roads will be needed, both from Kununurra and from Wyndham. Upgrading of the Old Wyndham to Kununurra road (which traverses Parry Floodplain) is proposed. Housing development may bring with it illegal or poorly planned rubbish dumping, contamination with sewage effluent, increased frequency of wildfires, and disturbance, predation and fouling by domestic and semi-domestic cats and dogs. Increased human use of the Site can also be anticipated and will require management.

Changes in water quality in all parts of the Site as a result of the existing irrigation scheme and future extensions should be assessed. Pesticides, herbicides, heavy metals and fertilisers may all be contaminating freshwater or estuarine components of the Site. Current activities of concern include:

- the use of Acrolein (prop-2-enal) by the Water Corporation as an algacide and aquatic herbicide to control submersed aquatic weeds and algae in the irrigation canals. Acrolein has an hydrolysis DT_{50} (half-life in water) of 3.5 days (pH5), 1.5d (pH7) and 4hr (pH10). Toxicity testing has resulted in an acute oral LD_{50} for rats of 29 mg/kg and for male and female mice, 13.9 mg/kg and 17.7 mg/kg respectively. No reproductive toxicity was observed in a two-generation feeding study on rats at 7.2 mg/kg day^{-1}, and there was no teratogenic effect in rabbits at levels causing maternal toxicity (approx. 2 mg/kg day^{-1}). However, non-mammalian testing has produced an acute LD_{50} in mallard ducks of 9.1 mg/kg and an LC_{50} for fish toxicity ranging from 0.04 mg/l for shiners, 0.07 mg/l for bluegill, 0.15 mg/l for rainbow trout, and 0.39 mg/l for mosquito fish. The potential for toxicity to fish and birds exists. Information on the application rates, frequency, spatial extent of application and degree of exposure of wetlands outside of the irrigation system are required.
- During the site visit an extensive plume of coloured water was seen discharging from the main (D4) drain into the lower Ord River upstream of the Site. Apparently the effluent contained sediment and flocculants from a new sugar cane refinery that was being commissioned. Effects of these and other discharges on water quality of the Site need to be monitored.
- Trial aerial spraying of Noogoora Burr with the herbicide 2-4D amine has been conducted. If adopted for routine use, this presents a potential for chemical contamination of wetlands where the burr is prolific.

Crocodiles

Illegal killing of the Saltwater Crocodile, which is protected under the Western Australian Wildlife Conservation Act, occurs within the East Kimberley district. Between May 1989 and November 1992, carcasses of 20 *C. porosus* were found, with specimens ranging in size from 8-9 ft (2.4-2.7 m) up to 13-14 ft (4.0-4.3 m) (WADCALM, unpub. dat.). Five individuals had drowned after being caught in fishing nets (most likely gill nets set to catch barramundi *Lates calcarifer*), and fifteen animals had been shot. In most instances the heads had been removed, presumably by trophy hunters. Ten of the dead animals were found in the Ord River and tributaries. There are fewer records of illegal killing of the freshwater crocodile, *C.*

johnstoni, although it does occur. In October 1991, the carcasses of five *C. johnstoni* were found in Packsaddle Swamp; all had been shot and had their jaws removed.

Given the remoteness of most of the East Kimberley and the difficulties associated with detecting illegal activities, it must be assumed that not all carcasses are found and that total numbers culled are greater. Given the longevity of the animals (~ 50 years) and the formerly threatened status of both species in Western Australia, managers need to continue to document illegal culling.

Livestock

Graham & Gueho (1995) identified exotic animals and plants as an ongoing management problem in the Site. Because of inadequate fencing, cattle are continually wandering onto the Site from adjoining stations. They congregate around billabongs and along the river during the dry season, causing bank erosion (Plate 11) and siltation of the waterbodies. Large quantities of faecal material are deposited in the immediate vicinity of the waterbodies, leading to the net import of nutrients to the wetlands. Toxic algal blooms, fish kills and outbreaks of botulism may occur as nutrients are washed into the billabongs after the first rains of each wet season. Reduced flooding and flushing of the floodplain, due to lowered (currently) groundwater levels and regulation of the river may also lead to a net concentration of nutrients in the billabongs.

Weeds

Exotic plants on the Site include Noogoora Burr *Xanthium occidentale*, Jerusalem Thorn *Parkinsonia aculeata*, Leucaena *Leucaena leucocephala* and Bellyache Bush *Jatropha gossypifolia*.

Noogoora Burr is a monoecious, annual herb or sub-shrub, growing to 2m high. It belongs to a genus of circa 30 species, most of which were originally found in North and South America, but have since been introduced to other temperate and tropical areas of the world (Wheeler *et al.* 1992). The cotyledons of the plant are toxic and the clinging burrs are a serious contaminant of wool. Although not a pest to the cattle industry, the burr is readily spread by stock, and once established, Noogoora Burr forms dense cover, out-competing low shrubby native vegetation. It is basically riparian, but there is evidence from the Daly and Adelaide Rivers regions that it will grow on seasonally inundated floodplains (Miller & Wilson 1995). Areas of the Site and surrounding vacant Crown land and pastoral leases have been quarantined by the Agriculture Department of Western Australia to prevent public access and thereby limit the spread of the burr. However, there are plans to lift the quarantine on the Mantinea Flats area from Buttons Gap to the Parry Lagoons Nature Reserve south of the Ord River, and a strip of Ord River frontage (opposite Parry Lagoons) on its north shore. Roads that have previously been closed will be opened, allowing greater public access and increasing the risk of spread of the burr. It is feared that once established, dense growth will reduce the area suitable for waterbird nesting. Also, the weed will provide a greater fuel load, increasing the fire risk.

The Jerusalem Thorn belongs to a genus of up to 15 species from North and South America and Africa. It forms dense stands of spiny shrubs or trees to 6 m, particularly along watercourses. It is becoming established in parts of the Site and on surrounding creek lines, where it out-competes native vegetation (Plate 12). Though dense stands do have the benefit of stabilising river banks and denying access to cattle, it is not wanted on the Site.

Leucaena is an unarmed (i.e. without thorns or spines) dense shrub growing to 3.5 m. It is native to tropical America and belongs to a genus of circa 50 species (Wheeler *et al.* 1992). The species is widely cultivated around the world as a protein-rich fodder crop for dairy cows, beef cattle, water buffalo and goats. It forms a block of forage, rather than a conventional sward-like pasture and can refoliate within approximately two weeks of the bushes being stripped bare. In the Kimberley, Leucaena grows wild around Wyndham, Derby and Broome (Wheeler *et al.* 1992). Currently it is not present on the Site, but may become established as a consequence of proposed broad-scale planting for stock grazing on Carlton Hill Station. It is fast growing and is likely to form dense stands and outshade native vegetation. Its impact can be seen on the shores of Lake Kununurra.

Bellyache Bush *Jatropha gossypifolia* is extremely invasive and difficult to eradicate once it has set seed. It appears to have the potential to take over the drier parts of the wetlands and gradually spread across the whole landscape (G. Graham *pers. comm.*).

At this stage there are no other aquatic weeds established in the Site. This is noteworthy as tropical wetlands nearby in the Northern Territory are under severe threat. In Kakadu, wetlands are being impacted by mimosa *Mimosa pigra*, a highly invasive neotropical shrub, salvinia *Salvinia molesta*, an aquatic fern, and para grass *Brachiaria mutica*, an African pasture species promoted for ponded pasture across the Territory (Storrs & Lonsdale 1995). Water Hyacinth *Eichhornia crassipes* has been almost eradicated from the Northern Territory.

Other weeds currently found in Australia that pose a threat to tropical wetlands in the Kimberley include alligator weed *Alternanthera philoxeroides* (found in New South Wales), rubber vine *Cryptostegia grandiflora* (across north Queensland to the eastern Northern Territory border), and a creeping sensitive plant *Mimosa invisa*, closely associated with *Mimosa pigra* (North Queensland) (Miller & Wilson 1995).

Human Use

Increasing use of the Site by people presents challenges for management and potential threats to wetland values.

A problem not restricted to the Site is the increasing number of tourists in 4WDs driving off established tracks. This leads to erosion, particularly along watercourses and in seasonal wetlands, and the spread of weeds such as Noogoora Burr.

A member of the Miriuwung Gajerrong family has applied to establish a settlement at Goose Hill. This location is within the Parry Lagoons Nature Reserve, and therefore, within the Ramsar site. It is proposed that up to 15 people will stay at the settlement at any time and that young people will be taught traditional ways such as techniques for hunting and food gathering. Although there may be cultural benefits from the establishment of such a settlement, various disturbances (associated with off-road vehicle use, use of firearms, introduction of cats and dogs, spread of Noogoora Burr, etc.) may also result. Such an application may be consistent in principle with the Ramsar "Wise Use" concept. However, it is also in conflict with the current vesting of the land as a nature reserve for the 'conservation of flora and fauna'. If this is resolved and the application approved, monitoring of impacts will be required.

"Calvano's Block", alongside Twenty-mile Lagoon, is not part of the Site (or the nature reserve), but is contained within its boundaries. The current owner has expressed a desire to develop the homestead as an eco-tourism venue, utilising wetland values as an attraction. Up to 40 people would stay at the homestead. Monitoring of impacts will be required for this development if it also gains approval.

Seasonal wetlands of the Parry Lagoons portion of the Site are regularly visited by tourists and tour groups from Wyndham. Access from Kununurra is limited as the most direct route (via the old Wyndham to Darwin highway) passes through the Noogoora Burr quarantine area and is currently closed to the public. Lifting of quarantine restrictions (as proposed) will result in increased traffic and more visitors to the floodplain. Impacts are likely to be mainly restricted to the dry season as WADCALM closes the tracks in Parry Lagoons Nature Reserve during the wet, which is also the "off" season for tourists.

Aeroplane and helicopter tours to view the wetlands and congregations of waterbirds is a possible threat, through repeated disturbance of wildlife by low-flying aircraft, particularly during the dry season when habitat is limited.

Increased use by people often leads to an increased incidence of fire, both planned and accidental. Some plant and animal species or communities may be adversely affected. For example, the Zitting Cisticola is dependent on the extensive grasslands associated with the wetland. Modification of these grasslands by repeated burning may have a negative impact on this component of the avifauna.

Human use of the "False Mouths of the Ord" part of the Site is limited due to the inaccessibility of the area. Recreational and commercial fishing of barramundi is a potential threat to wetland values. Over-harvesting, should it occur, might not only impact upon this species, it could also have a flow-on effect on other components of the food chain. The use of nets can also result in the accidental death of crocodiles, through entanglement and drowning. In addition, fishing camps are a potential source of litter and other wastes which may have some impact.

Mining exploration, particularly for diamonds, is an issue in the area. Several applications for exploration in the Nature Reserves have been received. For example, Beta Creek Diamond Explorations applied for a licence to explore in Parry Lagoons Nature Reserve and Crest Resources Aust N.L. applied for an exploration licence for the Ord River and False Mouths of the Ord Nature Reserve. Both applications were refused on the grounds of unacceptable environmental disturbance, however other applications can be expected. There may also be interest in dredging estuarine areas within and adjoining the Site for diamonds. Possible impacts on the site will need to be assessed if a licence application is lodged.

There are two gravel pits within Parry Lagoons Nature Reserve, one at Fork Creek on the south-west edge of the reserve, the other near Goose Hill. Both pits have been excised from the reserve and are used by the Shire to obtain gravel for road repairs and are not seen to pose any threat to wetland values.

NB. Within the available time, the author was not able to visit the False Mouths of the Ord region of the Site. Therefore, the listed threats to wetland values are those reported in the literature and determined during discussions with conservation agency staff.

Selection of a provisional Scientific Monitoring and Management Committee

Following identification of known wetland values and threats, it is proposed that the management agency (in this case WADCALM) would draft a provisional list of members for a Scientific Monitoring and Management Committee (SMMC), with the expertise needed to address these issues. This process would be driven by the Regional Manager or his delegate. On the basis of the values and threats identified in the previous section, the following membership is proposed (Table 22.). Members would be selected primarily on basis of expertise rather than affiliation.

Table 22. Proposed membership of a SMMC for the Ord River Floodplain Ramsar Site.

Person	Area of expertise/role on committee
WADCALM Regional Manager	Chairman of the SMM Committee.
Aboriginal community representative	Native title and sacred site issues.
Agriculture W.A, Kununurra office	Noogoora Burr quarantine & other riparian weeds
Botanist	Botanical issues (marine & terrestrial).
Environmental economist/resource manager	Assessment of monitoring program achievability.
Environmental toxicologist	Assessment of chemical threats.
Frog scientist.	Frog conservation issues.
Hydrogeologist	Ground water hydrology & processes.
Icthyologist	Native fish issues.
Ornithologist	Wetland & mangrove bird expertise.
WADCALM Kimberley Region Ecologist	Facilitation of program design & implementation.
WADCALM Operations Officer, Kununurra	On-the-ground management issues.
WA member of ANZECC Wetlands Network.	Implementation of Ramsar Convention in WA.
Water Corporation, Kununurra office	Water allocation, aquatic weed & irrigation issues.
Water & Rivers Commission	Water quality, water allocation & irrigation issues.
Wetland ecologist	Wetlands (non-marine) & wetland processes.
Wetland weed scientist	Wetland weed management issues.

The initial meeting of the SMMC would be introductory in nature, and would review the list of values and threats. Membership of the committee may change following this meeting if some areas of expertise are found to be unnecessary or if additional values or threats requiring different areas of expertise are identified (changes may also occur for the same reasons following the public meeting proposed below). The first meeting of the SMMC would best be held at or near the site (e.g. at Wyndham or Kununurra) so issues could be viewed first hand. Subsequent meetings could be held by teleconferencing or possibly in Perth.

Part of the first meeting would be to discuss the format and content of the public meeting to be held subsequently, and to delegate members to prepare brief overviews concerning the site, values and threats, Ramsar obligations, management and the process of developing an EMP.

Likely participants in a public meeting

In addition to the members of the SMMC, the following parties (representatives thereof) were identified during the case study as prospective invitees to the proposed public meeting.

- Aboriginal Groups with an interest or claim to the site
- Aboriginal Land Council, Wyndham Office
- Agriculture Western Australia, weed quarantine officer, Kununurra
- Broad acre (Leucaena, sugar cane & potential cotton) growers
- Chamber of Commerce
- Commercial barramundi fishing operators utilising the estuary
- CSR Sugar Mill manager & environmental officer
- Department of Environmental Protection, Karratha office
- Department of Land Administration
- Department of Resources Development (irrigation issues)
- Department of Transport, Marine & Harbours section
- East Kimberley Sport and Game Fishing Club
- Environment Australia observer (National Wetlands & National Reserve System Programs)
- Fisheries Department of Western Australia
- Kimberley Conservation Council
- Kimberley Development Commission (WA Government)
- Kimberley Tourist Association
- Kununurra Horticulturalist Society
- Kununurra Recreational Fishing Liaison Committee
- Lions Club
- Owner of 'Calvano's Block'
- Owners & managers of Carlton Hill, Ivanhoe & El Questro Stations
- Pacific Hydro Consortium Pty Ltd (hydroelectric power generation)
- Royal Australasian Ornithologists Union (RAOU)
- Tour operators that utilise the site
- WADCALM Kimberley Region Ecologist
- WADCALM Kimberley District Wildlife Officer
- Western Power environmental officer
- Wyndham & East Kimberley Shire Clerk
- Wyndham & Fremantle Crocodile Farms
- Wyndham Historical Society
- Wyndham & Kununurra Tourist Bureaus
- Wyndham Tourist Association

The public meeting would be advertised widely so that all interested parties would have an opportunity to attend. It would best be held in Wyndham or, if this is impracticable, in Kununurra. The meeting would be chaired by the WADCALM Regional Manager and the purpose would be for SMMC members to present brief overviews concerning the site, values and threats, Ramsar obligations, management and the process of developing an EMP, and for community participation in the process, both during the meeting and subsequently. For example, some participants may be aware of additional threats or values or may have important additional information on threats or values already recognised. Some may also wish to form a "Friends of the Ramsar Site" group and become involved in monitoring and other work.

Because of the low population size of the area (East Kimberley), there do not appear to be many resident naturalist groups that might become involved in an EMP for the Ord River floodplain site. However, any groups that may be keen to be involved in monitoring or possibly other activities at the site should be encouraged to do so.

Identifying current management and monitoring activities at the site

Following the meeting, the SMMC would review the values and threats, incorporating any new information gathered in the public meeting, and would prioritise these in preparation for developing an environmental monitoring program.

The next step in the EMP process would be the documentation of current monitoring activities, past and present scientific work on the site, and past and present management activities. This will prevent repetition of costly research and will identify current activities that may be incorporated in the EMP. Also, all works identified would be gathered into a centralised database/reference library for the site.

Major threats to the site have been identified in this case study, but no attempt has been made to prioritise values and threats for management purposes. Current research and monitoring activities at the site are listed below. Because most of the Ramsar site is in the State conservation reserve system, there has been active management of the site by the State conservation agency. Not all management has been direct specifically at wetland issues, but at general land management issues in the nature reserves (i.e. fire control, spread of weeds, feral animal control etc etc) but most of the management provides direct or indirect protection to the wetland values.

- There is an active program conducted by AgWA to control the spread of Noogoora Burr. Areas of Parry Lagoons Nature Reserve and neighbouring pastoral leases have been placed in quarantine to prevent public access and limit further spread of the burr. Part of this quarantine is about to be lifted, allowing public access to previously inaccessible areas. For instance, the old Wyndham to Darwin Hwy will be re-opened, resulting in increased numbers of visitors to the wetlands and easy access to the Ord River via the Parry Lagoons Nature Reserve for members of a local fishing club. This may increase the likelihood of further spread of the burr.
- The current method of control of Noogoora Burr is by ripping, grubbing and hand spraying plants with herbicide. The work is arduous, involves potential exposure to toxic chemicals and workers in protective clothing are liable to heat stress. Trial spraying of seedlings by helicopter was undertaken by AgWA in Parry Lagoons Nature Reserve in April 1995. As part of this trial, water quality was to have been tested to assess the persistence and spread of the herbicide (2-4D amine). This could not be accomplished, however, due to lack of funds. Pre- and post-spray surveys of the vegetation demonstrated that spraying from above the tree canopies (i.e. > 20m) was not effective, presumably because the herbicide was dispersed or intercepted by tree foliage. However, where there was no tree cover to keep the helicopter at a higher altitude, low-level spraying (at ~ 3 m), was effective.
- To assist in managing tourist visitation to Parry Lagoons, a gazebo and information board has been constructed at Marlgu Billabong, near Telegraph Hill. The track to the billabong has also been upgraded and ground around the carpark area has been ripped to dissuade 4WD vehicles from leaving the graded track. Rehabilitation of previously degraded areas is occurring. In addition, WADCALM proposes to construct a bird hide and viewing platform beside the billabong, together with a nature trail. Funding has been sought under the National Estates Grants program.
- Annual stock musters and helicopter shoots are conducted on the Nature Reserves, with assistance from Carlton Hill and Ivanhoe stations. Any cattle missed in the muster are either shot ('clean skins') or located and mustered (tagged and branded cattle). Donkeys are shot. No action is taken with respect to horses.
- At the recommendation of AgWA, a 5 km fence line has been constructed between Parry Creek Road and Goose Hill to prevent further spread of Noogoora Burr by cattle from the quarantine areas on to Parry Lagoons. This also reduces other impacts associated with cattle entering the wetland. The fence is of limited effectiveness, however, as there is no connection between Parry Creek Road and the River. Large numbers of cattle have been seen in the reserve.
- WADCALM conducts prescribed burning in the Parry floodplain area in the early dry season in an attempt to establish a strategic mosaic of fire histories (years since last burnt). This is principally in response to the increased incidence of fires associated with increased human usage and the potential threat to wetland flora and fauna (e.g. populations of frogs and the Zitting Cisticola) of large uncontrolled fires.
- Annual surveys are conducted of crocodile populations (*C. porosus* & *C. johnstoni*) in the Parry Lagoons and Ord River and False Mouths of the Ord Nature Reserves, as part of more extensive surveys of Cambridge Gulf and associated rivers. Numbers of animals, their approximate size and numbers of nests are recorded.
- In the past, WADCALM has organised a 'Landscope' expedition (where volunteers pay to assist departmental staff in research activities) that included some counting of waterbirds in Parry Lagoons.
- The Kununurra Recreational Fishing Liaison Committee, which represents amateur fishermen's interests, has secured a grant to undertake an economic assessment of issues relating to professional

and amateur use of fish resources of the Ord River. This study will encompass sections of river adjacent to the Site.

- The Water Corporation has a number of surface water and groundwater monitoring sites across the irrigation area and floodplain and along the river. Parameters such as water level, salinity, and concentrations of basic nutrients are determined. Not all sites are currently operational and both length of records and parameters recorded vary. However, these data are available to help assess changes in surface and ground water parameters.
- In relation to the Ord River hydroelectric scheme and the proposed expansion of the irrigation area, the Water and Rivers Commission is developing a water allocation plan for the lower Ord River (contact Water and Rivers Commission, Perth).
- A draft submission has been prepared for funding to conduct a biological and hydrological survey of Parry Lagoons Nature Reserve. Reasonable quality data on waterbirds exist but surveys have been infrequent, and there is little information on other aspects of the fauna or flora. The draft proposal includes a recommendation to conduct an assessment of the current effects on the floodplain of impoundment and regulation of the Ord River and of the existing irrigation scheme, and the possible effects of the proposed expansion of the irrigation scheme onto Mantinea Flats.
- The Water & Rivers Commission is preparing a "resource review" document concerning the proposed Mantinea Flats irrigation scheme. The report will present the results of modelling, based on data from an initial series of groundwater bores on the flats, to give an indication of likely effects of the irrigation scheme on Mantinea Flats. Additional drilling has been recommended to enable the model to be improved. Extrapolation of these data will help indicate possible effects of the scheme on Parry floodplain.

Future monitoring, research and management

Based on the prioritised values and threats, the available historical data and current monitoring, management and research projects on the site, the SMMC will prepare a draft Environmental Monitoring Program for the Ramsar site.

The management, monitoring and research issues listed below were identified in this case study as those needing to be addressed in a draft EMP. The monitoring programs would involve local groups and individuals (e.g. pastoralists, natural history groups) as appropriate. The resource manager/ environmental economist would assess the feasibility of achieving the desired outcomes, depending upon priorities and expected funding (from WADCALM and EABG).

- There is a pressing need to conduct an intensive hydrological study of Parry floodplain to determine the possible effects of the proposed Mantinea Flats irrigation scheme on the hydrology of Parry floodplain. The water budget for the floodplain area needs to be formulated to:
    1. assess the effects of damming of the Ord in 1963 on the flooding regime of the Site,
    2. to determine current sources and relative importance of freshwater inputs to Parry floodplain (i.e. Parry Creek versus the Ord River),
    3. identify the importance of groundwater in maintaining permanent water on the Site, and,
    4. determine the effects, if any, of irrigation at Mantinea Flats on groundwater levels on Parry floodplain, especially the possibility of raised water levels and salinisation.
- There is a need to conduct, on a regular basis during wet and dry seasons, quantitative surveys of waterbird usage of the Site to determine abundance and breeding activity of each species.
- A low scale public awareness campaign should be mounted to inform people about Ramsar and the reasons why the site was nominated as a Wetland of International Importance. This could be achieved by means of a sign and waterbird identification chart erected at a public viewing area (e.g. Marlgu Billabong observation point). Local media coverage in Wyndham and Kununurra is also recommended.
- A biological survey of all elements of the fauna and flora is required to better define wetland values. This will also assist in identifying management issues (e.g. presence of weeds). Dr Mike Tyler, of Adelaide University has surveyed the frog fauna across parts of the Kimberley. An additional survey of frogs in different habitats of the Site would be valuable. Much of the expertise required to assess other components of the fauna and flora is readily available in WADCALM.

- There is a need to identify the main sustaining processes within the Site, changes in which will result in fundamental changes in the ecology of the wetland. For instance, which components of the vegetation, hydrology, and lower trophic levels are most important in maintaining waterbird numbers and breeding success?
- A management plan should be prepared for the Parry Lagoons and Ord River/False Mouths of the Ord Nature Reserves. This will assist in assessing threatening processes and in judging the relative importance of each of the threats and the degree of amelioration possible given available resources and current technical ability. The management plan could assess the possibility of designating the reserves as a National Park. Such a designation may assist managers in dealing with issues relating to human use which currently are in conflict with the reserves' gazetted (legal) purpose of 'conservation of flora and fauna'. Provision of a dedicated ranger to monitor and manage human use of the Park would be required.
- A basic survey of water and sediment quality in the Site is required to assess the presence and extent of pesticides/herbicides etc from the irrigation system. This will assist managers in determining possible impacts of the present irrigation scheme. The survey needs to be timed in relation to the seasonal application of chemicals and growing of crops in order to detect the movements (addition) of contaminants, as well as those previously deposited.
- There is a need to develop a monitoring and management strategy for weed control, part of which would be regular and extensive surveys to assess changes in the distribution of known species and to detect new arrivals. For instance, there is currently no monitoring or control of *Parkinsonia* on the Site. The monitoring and management strategy would *inter alia* assess the benefits and costs of control and provide recommendations on which the management agency may act. Any new infestations found could be quickly dealt with.
- Control programs need to be established to reduce feral cat numbers in the Site.
- The Kununurra Recreational Fishing Liaison Committee has secured a grant to undertake an economic assessment of issues relating to professional and amateur use of the fish resource in the Ord River. It has been recommended that a complementary study be developed to look at the pressures exerted on conservation values of the Site by fishery activities.
- Lobby for the development of State/Federal policy for a 'user pays' system. This is applicable to the irrigation scheme, where horticulturalists/broad acre growers should be charged an environmental levy to pay for monitoring and any remediation work required as a result of their activities.
- Roads through the Site, specifically the Old Wyndham to Darwin Hwy and the Parry Creek Road, are not gazetted as public roads. Therefore, they are part of the Nature Reserve and thus the responsibility of WADCALM. Currently the Shire conducts maintenance grading of the roads, but with limited consideration of possible environmental repercussions (i.e. in June 1995 a maintenance grading on Parry Creek Road had widened and channelled the road and pushed up windrows of 60 - 70 cm height. This is likely to result in gullying and erosion during the wet season). An option is to gazette the roads, but this would require a 100 m road reserve which may add other management problems. An alternative is to excise the roads as access corridors, not as road reserves. This issue needs resolving, particularly given the expected increase in usage following lifting of the Noogoora Burr quarantine.
- Due to its remoteness and inaccessibility, the False Mouths of the Ord area of the Site receives little management or monitoring attention and its biological values are incompletely known. Resources need to be made available to better document the values of this area and to increase the presence of the conservation agency.

Following identification and prioritisation of monitoring, management and research requirements, the draft EMP would be released for public comment. Following review of comments received, the EMP would be revised by the SMMC and then submitted for approval by WADCALM, as both the Site Management Agency and the State Government Ramsar Implementation agency. Following approval by WADCALM, the EMP for the Ramsar site would be implemented.

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APPENDIX 1.

RESOLUTION 6.1: WORKING DEFINITIONS, GUIDELINES FOR DESCRIBING AND MAINTAINING THE ECOLOGICAL CHARACTER OF LISTED SITES AND OPERATION OF THE MONTREUX RECORD

1. CONSIDERING that Article 3.2 of the Convention states that each Contracting Party "shall arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the List (of Wetlands of International Importance) has changed, is changing, or is likely to change as the result of technological developments, pollution or other human interference";

2. RECALLING that Recommendation 4.8 instructed the Bureau to maintain a record of listed sites where change in ecological character had occurred, was occurring, or was likely to occur, and that Resolution 5.4 established guidelines for operating the record, to be known as the Montreux Record;

3. FURTHER RECALLING that Recommendation 5.2 emphasised the need for further studies of the concepts of ecological character" and "change in ecological character", and instructed the Bureau, with the support of the Scientific and Technical Review Panel (STRP) and partner organisations, to report to the present meeting on the results of such studies;

4. NOTING the results of the work carried out by the STRP and during Technical Session B of the present meeting;

5. RECOGNISING the need for definitions and guidelines to assist Contracting Parties with implementation of Article 3.2 and, in particular, with maintaining the ecological character of listed sits;

6. FURTHER RECOGNISING the need for revised guidelines to ensure effective operation of the Montreux Record;

7. NOTING THAT Resolution VI.13 of the present meeting seeks to address the deficiencies in essential baseline data provided by Contracting Parties in the form of Information Sheets on Ramsar Wetlands; and

8. AWARE of the existence of many successful environmental monitoring programmes world-wide (including those which rely on the involvement and enthusiasm of local communities) and of the value of Early Warning Systems to allow Contracting Parties to take sufficiently prompt actions to prevent changes in the ecological character of listed sites;

THE CONFERENCE OF THE CONTRACTING PARTIES

9. ACCEPTS working definitions, to be assessed further during the 1997-1999 triennium, of "ecological character" and "change in ecological character", together with the guidelines for describing and maintaining ecological character of listed sites, as contained in the Annex to the present resolution, recognising that these working definitions are relevant to the management of wetlands in general;

10. REQUESTS the Contracting Parties and the Bureau, with the advice of the STRP, to implement the revised procedure for operation of the Montreux Record, as contained in the Annex to the present resolution;

11. CALLS ON Contracting Parties to support the development, by the relevant authorities within their territories, of Early Warning Systems for detecting, and initiating action in response to, change in ecological character, and

12. INSTRUCTS the STRP, in cooperation with the Bureau and partner organisations, and the wider scientific community, to liaise with the Standing Committee, in order to identify the effects of application of the present resolution, especially at specific sites, and to report accordingly to the 7th Meeting of the Conference of the Parties.

Annex

WORKING DEFINITIONS, GUIDELINES FOR DESCRIBING AND MAINTAINING THE ECOLOGICAL CHARACTER OF LISTED SITES, AND GUIDELINES FOR OPERATION OF THE MONTREUX RECORD

1. Working Definitions

1.1 ***Ecological character:***

> *The "ecological character" is the structure and inter-relationships between the biological, chemical, and physical components of the wetland. These derive from the interactions of individual processes, functions, attributes and values of the ecosystem(s).*

1.2 ***Change in ecological character:***

> *"Change[1] in ecological character" of a wetland is the impairment of imbalance in any of those processes and functions which maintain the wetland and its products, attributes and values.*

The following notes on wetland processes, functions, values, products and attributes, are derived from the *Ramsar Convention Manual* (Davis 1994), and *Wetland Conservation: A Review of Current Issues and Required Action* (Dugan 1990); *Building a new approach to the investigation and assessment of ecosystem functioning*, in Mitsch, *Global Wetlands: Old World and New* (Maltby 1994); and *Defining new procedures of functional assessment for European river marginal wetlands ecosystems* (Maltby in press).

Processes are changes or reactions which occur naturally within wetland ecosystems. They may be physical, chemical or biological.

Functions are activities or actions which occur naturally in wetlands as a product of the interactions between the ecosystem structure and processes. Functions include flood water control; nutrient, sediment and contaminant retention: food web support; shoreline stabilisation and erosion controls; storm protection; and stabilisation of local climatic conditions, particularly rainfall and temperature.

Values are the perceived benefits to society, either direct or indirect, that result from wetland functions. These values include human welfare, environmental quality and wildlife support.

Products generated be wetlands include: wildlife resources; fisheries; forest resources; forage resources; agricultural resources; and water supply. These products are generated by the interactions between the biological, chemical and physical components of a wetland.

Attributes of a wetland include: biological diversity; and unique cultural and heritage features. These attributes may lead to certain uses or the derivation of particular products, but they may also have intrinsic, unquantifiable importance.

[1] Change in the ecological character of a site is interpreted as meaning adverse change, in line with the context of Article 3.2 of the Convention and Recommendation 4.8 (1990), which established the Montreux Record. The definition refers explicitly to adverse change caused by human activities. It excludes the process of natural evolutionary change occurring in wetlands. It is also recognised that wetland restoration and/or rehabilitation programmes may lead to favourable human-induced changes in ecological character.

2. Guidelines for describing and maintaining the ecological character of listed sites

2.1 It is essential that the ecological character of a site be described by the Contracting Party concerned **at the time of designation for the Ramsar List**, by completion of an information Sheet on Ramsar Wetlands (as adopted be Recommendation 4.7). The STRP has proposed some limited modifications to the guidelines for completing the Information Sheet, in order to increase the value of the data provided for assessing ecological character. These proposals are attached below.

2.2 Sources of information which might be consulted by Contracting Parties in describing the ecological character of listed sites include international, national and regional scientific inventories of wetlands; already existing site-specific management plans; and other site-specific scientific surveys or reports.

2.3 Contracting Parties are requested to verify the data which they have provided on Information Sheets on Ramsar Wetlands every six years (ie. every second meeting of the Conference) and to provide the Bureau with updated sheets if necessary. During the intervening period, urgent information on changes at listed sites should be conveyed to the Bureau using the existing mechanisms of regular, day to day contacts and the triennial National Reports.

2.4 Change in the ecological character of a listed site should be assessed against the baseline status presented in the Information Sheet on Ramsar Wetlands, at the time of designation for the List (or at the time the Information Sheet was first provided to the Bureau), together with any information which has been received subsequently.

2.5 Assessment should be linked to the Ramsar criterion or criteria fulfilled by the site at the time of designation for the Ramsar List. Use of the criteria indicates certain benefits and values of the wetland which might be lost as a result of change in the ecological character. However, this forms only part of the assessment needed, since significant degradation of wetland functions and values might occur without any of the designated Ramsar criteria being contravened.

2.6 An effective monitoring and survey programme is a prerequisite for assessing whether or not a wetland has undergone a change in its ecological character. Such a programme is an integral component of a wetland management planning (see Annex to Resolution 5.7) and should enable full consideration of the values and benefits of the wetland when the extent and significance of the change is being assessed. A framework which might be of assistance to Contracting Parties in designing effective monitoring programmes is attached below.

2.7 Monitoring should establish the range of natural variation in ecological parameters at each site, within a given time frame. Change in ecological character occurs when these parameters fall outside their normal range. Thus, in addition to monitoring, an assessment of the extent and significance of the change is required, taking account the need for each wetland to have a favourable conservation status.

2.8 In some instances a Contracting Party may decide to restore a wetland to re-establish the ecological character that existed prior to the date of designation. In the case of such restoration programmes, a new Information Sheet should be provided, to establish a new baseline for assessing any future change. Information should also be given concerning the target state that any restoration is aiming at.

2.9 Improvements to the Guidelines for the Information Sheet on Ramsar Wetlands

2.9.1 Improvements to the Guidelines for completing the Information Sheet on Ramsar Wetlands are proposed, in order to increase the value of the information collected for describing and assessing ecological character of listed sites. New headings in the guidelines will emphasise the importance of:

(i) establishing a baseline be describing the functions, products and attributes of the site that give it benefits and values of international importance (necessary because the existing Ramsar criteria do not cover the full range of wetland benefits and values which should be considered when assessing the possible impact of changes at a site):

(ii) providing information on human-induced factors that have affected or could significantly affect the benefits and values of international importance;

(iii) providing information on monitoring and survey methods in place (or planned) at the site;

(iv) providing information on the natural variability and amplitude of seasonal and/or long-term "natural" changes (eg. vegetation succession, episodic/catastrophic ecological events such as hurricanes) that have affected or could affect the ecological character of the site;

2.9.2 It is recognised that for many sites, such information will not be known at present, nor be readily available. The sheets will also only provide a snap-shot in time. However, the level of information in the Information Sheet on Ramsar Wetlands is the minimum necessary for determining management steps to maintain the ecological character of a listed site. In gathering new data or assembling existing data, Contracting Parties should give emphasis to sites where there appears to be a high-medium risk of human-induced change with a high-medium ecological impact, likely to result in permanent, long or medium term degradation of values and benefits. International technical and/or financial cooperation may be needed to assist in gathering information about listed sites, particularly in developing countries.

2.9.3 All new listed sites should be described according to the revisions set out above. For sites with already submitted Information Sheets the revisions should be taken into account at the next six-yearly review (see Resolution V1.13). National Reports provide an opportunity for providing urgent information in the meantime.

2.10 A framework for designing an effective wetland monitoring programme

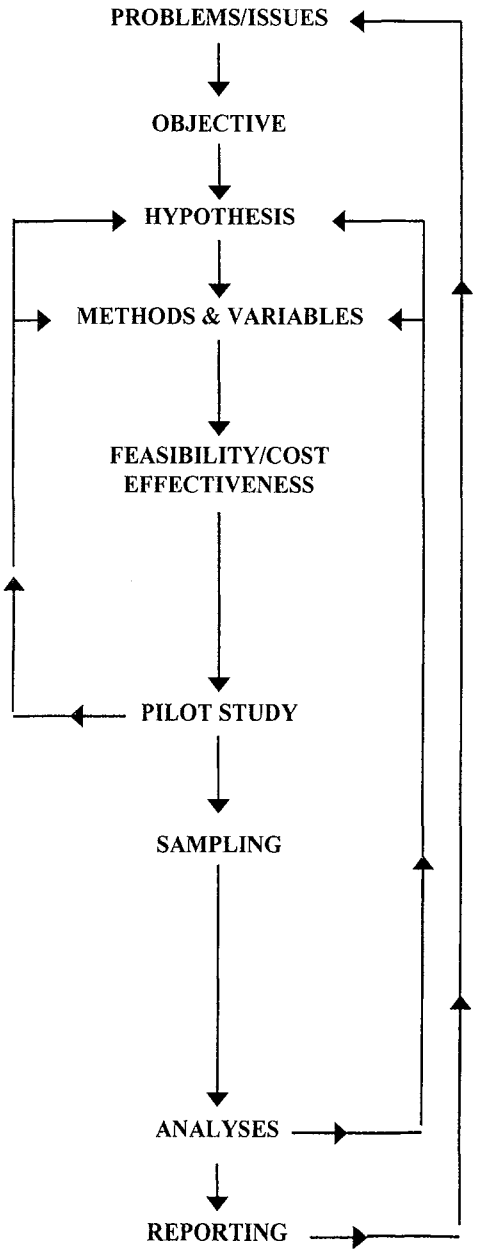
2.10.1 In order to detect actual or potential changes in ecological character, regular monitoring is required. Monitoring is defined in the Additional Guidance for the implementation of the Wise Use Concept (Annex to Resolution 5.) as *"the process of measuring change in ecological character in any wetland over a period of time"*. Monitoring differs from general surveillance in that there is a specific reason and method for collection particular data or information.

2.10.2 The Additional Guidance also points out that monitoring does not automatically require sophisticated technology or high investment and can be carried out at different levels of intensity. It is emphasised that there are many different monitoring techniques available, and that each Contracting Party should select the technique(s) most appropriate to its priorities and available resources.

2.10.3 A monitoring programme should, ideally, be an integral part of a site-specific wetland management plan, as set out in Resolution 5.7. However, where a management plan does not yet exist, it is still possible to implement a monitoring programme (though without the framework of a management plan, it will be difficult to implement the results of monitoring effectively).

Framework for designing a wetland monitoring programme

The framework set out in this table is not a prescriptive recipe for any particular monitoring programme. It simply provides a series of steps, in a logical sequence, that can be used by wetland managers and planners, working in partnership with local users and managers, to design a monitoring programme based on their particular circumstances and needs. The arrows illustrate the feedback which enables assessment of the effectiveness of the monitoring programme in achieving its objective(s). This framework is based on a text entitled A Framework for Designing a Monitoring Programme. (Finlayson 1995b) prepared for the MedWet Methodological Guide for Monitoring Programmes in Mediterranean Wetlands.



- State clearly and unambiguously
- State the known extent and most likely cause
- Identify the baseline or reference situation

- Provides the basis for collecting the information
- Must be attainable and achievable within a reasonable time period

- Assumption against which the objectives are tested
- Underpins the objective and can be tested

- Specific for the problem and provides the information to test the hypothesis
- Able to detect the presence, and assess the significance, of any change
- Identifies or clarifies the cause of the change

- Determine whether or not monitoring can be done regularly and continually
- Assess factors that influence the sampling programme: availability of trained personnel; access to sampling sites; availability and reliability of specialist equipment; means of analysing and interpreting the data; usefulness of the data and information; means of reporting in a timely manner
- Determine if the costs of data acquisition and analysis are within the existing budget

- Time to test and fine-tune the method and specialist equipment
- Assess the training needs for staff involved
- Confirm the means of analysing and interpreting the data

- Staff should be trained in all sampling methods
- All samples should be documents: date and location; names of staff; sampling methods; equipment used; means of storage or transport, all changes to the methods
- Samples should be processed within a timely period and all data documented: date and location; names of staff; processing methods; equipment used; and all changes to the protocols
- Sampling and data analysis should be done by rigorous and tested methods

- The analyses should be documented: date and location (or boundaries of sampling area), names of analytical staff; methods used; equipment used; data storage methods

- Interpret and report all results in a timely and cost effective manner.
- The report should be concise and indicate whether or not the hypothesis has been supported
- The report should contain recommendations for management action, including further monitoring

3. Guidelines for operation of the Montreux Record

3.1 The Montreux Record is the principal tool of the Convention for highlighting those sites where an adverse change in ecological character has occurred, is occurring, or is likely to occur, and

which are therefore in need of priority conservation attention. It shall be maintained as part of the Ramsar Database and shall be subject to continuous review.

3.2 The following procedure should be observed when considering the possible inclusion of a listed site in the Montreux Record:

3.2.1 A Contracting Party may request inclusion of a site in the Montreux Record, because of potential or actual adverse change in its ecological character, in order to draw attention to the need for action or support. Alternatively, the Bureau, on receipt of information on actual or possible adverse change from partner organisations, other international or national NGO's or other interested bodies, may dray the attention of the Contracting Party concerned to this information and enquire whether a Ramsar site should be included in the Montreux Record. A site can only be included in the Record with the approval of the Contracting Party concerned.

3.2.2 The Bureau will pass the information received from partner organisations, other international or national NGO's or other interested bodies, to the Contacting Party, together with a concise voluntary questionnaire (see "Montreux Record - Questionnaire" below) normally to be returned to the Bureau within three months. However, this deadline should be flexible to take into account the circumstances of developing countries and Contracting Parties whose economies are in transition.

3.2.3 The completed questionnaire will, with the agreement of the Contracting Party, be forwarded by the Bureau to the Scientific and Technical Review Panel (STRP) for advice in line with the Working Definitions and Guidelines for Describing and Maintaining the Ecological Character of Listed Sites. The Bureau will, with the agreement of the Contracting Party, relay the completed questionnaire to the original source of the information. If the Contracting Party is not able to agree to this, the Bureau will relay the Contracting Party's decision.

3.2.4 Any technical comment or advice provided by the STRP will be forwarded by the Bureau to the Contracting Party and to the source of the information first received by the Bureau (if different form the Contracting Party).

3.2.5 The Bureau will discuss the STRP's comments and advice with the Contracting Party concerned, with the aim of determining what steps might be taken, including a decision as to whether the site should be included in the Montreux Record. The STRP and other interested bodies will, where appropriate, be informed of the decision made by the Contracting Party, in consultation with the Bureau.

3.2.6 Within the framework of their triennial National Reports, Contracting Parties shall provide a report to the Convention Bureau on the conservation status of any sites included in the Montreux Record. If necessary, further information will be provided to the Bureau on request.

3.3 The following procedure should be observed when considering the removal of a listed site from the Montreux Record:

3.3.1 The Bureau is requested to remove a listed site from the Montreux Record by the Contracting Party in whose territory the site is included. The Bureau may also receive information from other sources suggesting that there is no longer a risk of change in the ecological character of the listed site.

3.3.2 The bureau will submit the concise questionnaire (see "Montreux Record - Questionnaire" below) to the Contracting Party and forward the completed questionnaire to the Scientific and Technical Review Panel STRP) for advice in line with the Working Definitions and Guidelines for Describing and Maintaining the Ecological Character of Listed Sites.

3.3.3 Any requests from the STRP for further information, together with the STRP's technical comments or advice, will be forwarded by the Bureau to the Contracting Party. The Bureau may also request information from other sources.

3.3.4 At the invitation of the Contracting Party, the Bureau may organise a site visit, ideally by the relevant Bureau staff member, the regional member of the STRP, and other appropriate experts.

3.3.5 A wetland will be removed form the Montreux Record based on the request of the Contracting Party and after consideration of advice and/or comment from the STRP. The final decision will be made by the Contracting Party.

3.3.6 The Bureau will, unless the Contracting Party concerned objects, provide information on the decision made by the Contracting Party to other interested bodies.

Montreux Record - Questionnaire

Section One

Information for assessing possible inclusion of a listed site in the Montreux Record

Essential items

- Name of site
- Ramsar Criteria for listing the site as internationally important
- Nature of the change in ecological character/potential for adverse change
- Reason(s) for adverse change, or potential adverse change, in ecological character

Additional items which may be included

- Date Information Sheet on Ramsar Wetlands submitted
- Date and source of Information Sheet updates (eg. National Reports, national wetland inventory, specific survey)
- Benefits and values derived from the site
- Extent to which values and benefits derived from the site have decreased or changed
- Monitoring programme in place at the site, if any (technique(s), objectives, and nature of data and information gathered)
- Assessment procedures in place, if any (how is the information obtained form the monitoring programme used)
- Ameliorative and restoration measures in place or planned (if any) so far
- List of attachments provided by the Contracting Party (if applicable)
- List of attachments provided by the Ramsar Bureau (if applicable)

Section Two

Information for assessing possible removal of a listed site from the Montreux Record

- Success of ameliorative, restoration or maintenance measures (describe if different from those covered in Section One of this questionnaire)
- Proposed monitoring and assessment procedures (describe if different from those in Section One of this questionnaire)
- Extent to which the ecological character, benefits and values of the site have been restores or maintained (provide details)
- Rationale for removing the site from the Montreux Record (refer to Guidelines for operation of the Montreux Record, together with Section One of this questionnaire)
- List of further attachments (if applicable)