Department of
Environment and Conservation

Our environment, our future

Resource Condition Report for a Significant Western Australian Wetland

Le Lievre Swamp (Iljamalkarda)

2009

Figure 1 – A view of the dry floor of Le Lievre Swamp through surrounding eucalypts.

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Contents

1. Introduction

This Resource Condition Report (RCR) was prepared by the Inland Aquatic Integrity Resource Condition Monitoring (IAI RCM) project. It describes the ecological character and condition of Le Lievre Swamp, a seasonally inundated wetland on the Fitzroy River's Camballin Floodplain. The Camballin Floodplain is listed in the *Directory of Important Wetlands of Australia* (DIWA) and has been nominated for listing as a wetland of international significance under the Ramsar Convention (Jaensch and Watkins 1999). Its significance is due to the paucity of floodplains in the Kimberley region, usage of the site by migratory waterbirds and because it contains many sites of significance to the local Aboriginal people. Le Lievre Swamp (*Iljamalkarda* in the local dialect) is crucial to the hydrology of the floodplain and interacts with the regional groundwater system.

1.1. Site Code

Directory of Important Wetlands in Australia: WA017

Register of the National Estate 'Registered' Place ID: 18366

Inland Aquatic Integrity Resource Condition Monitoring Project: RCM014

Transect codes: RCM014-R1

RCM014-A1

1.2. Purpose of Resource Condition Report

The objective of the RCR is to summarise all available ecological information relevant to Le Lievre Swamp and describe the drivers of, and threats to, the system. This 'snapshot' of ecological character will provide context for future monitoring of the site and allow the effectiveness of management planning and actions to be gauged.

1.3. Relevant International Agreements and Legislation

The following is a summary of international agreements and legislation that are relevant to the management of Le Lievre Swamp.

International Agreements

Migratory bird bilateral agreements and conventions

Australia is party to a number of bilateral agreements, initiatives and conventions for the conservation of migratory birds. Twenty species that are listed under these treaties have been recorded on the Camballin Floodplain. The bilateral agreements are:

JAMBA - The Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment, 1974;

CAMBA - The Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment, 1986;

ROKAMBA - The Agreement between the Government of Australia and the Republic of Korea for the Protection of Migratory Birds and their Environment, 2006;

The Bonn Convention on Migratory Species (CMS) - The Bonn Convention adopts a framework in which countries with jurisdiction over any part of the range of a particular species co-operate to prevent migratory species becoming endangered. For Australian purposes, many of the species are migratory birds.

Convention on Wetlands (Ramsar) - Australia a signatory to the Ramsar Convention, an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. As Le Lievre

Swamp is proposed for listing under the Ramsar Convention, this convention may become relevant in the future.

National legislation

The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The EPBC Act is the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places. These are defined in the Act as matters of national environmental significance.

There are seven matters of national environmental significance to which the EPBC Act applies. Two of these are relevant to Le Lievre Swamp:

- national heritage places; and
- migratory species listed under international treaties JAMBA, CAMBA and CMS.

The Camballin Floodplain is also a proposed Ramsar site and, if this listing is achieved, the site will be further protected under the EPBC Act as a wetland of international significance.

Western Australian legislation

Wildlife Conservation Act 1950

This Act provides for the protection of wildlife. All fauna (animals native to Australia) in Western Australia are protected under section 14 and all flora (plants native to Western Australia) are protected under section 23 of the *Wildlife Conservation Act 1950*. The Act establishes licensing frameworks for the taking and possession of protected fauna, and establishes offences and penalties for interactions with fauna.

Aboriginal Heritage Act 1972

There are several important Aboriginal heritage sites within Camballin Floodplain, which are protected under the Aboriginal Heritage Act. The Nyikina & Mangala claimant group, based at Jarlmadangah-Burru Community have been granted Native Title over the Camballin Floodplain.

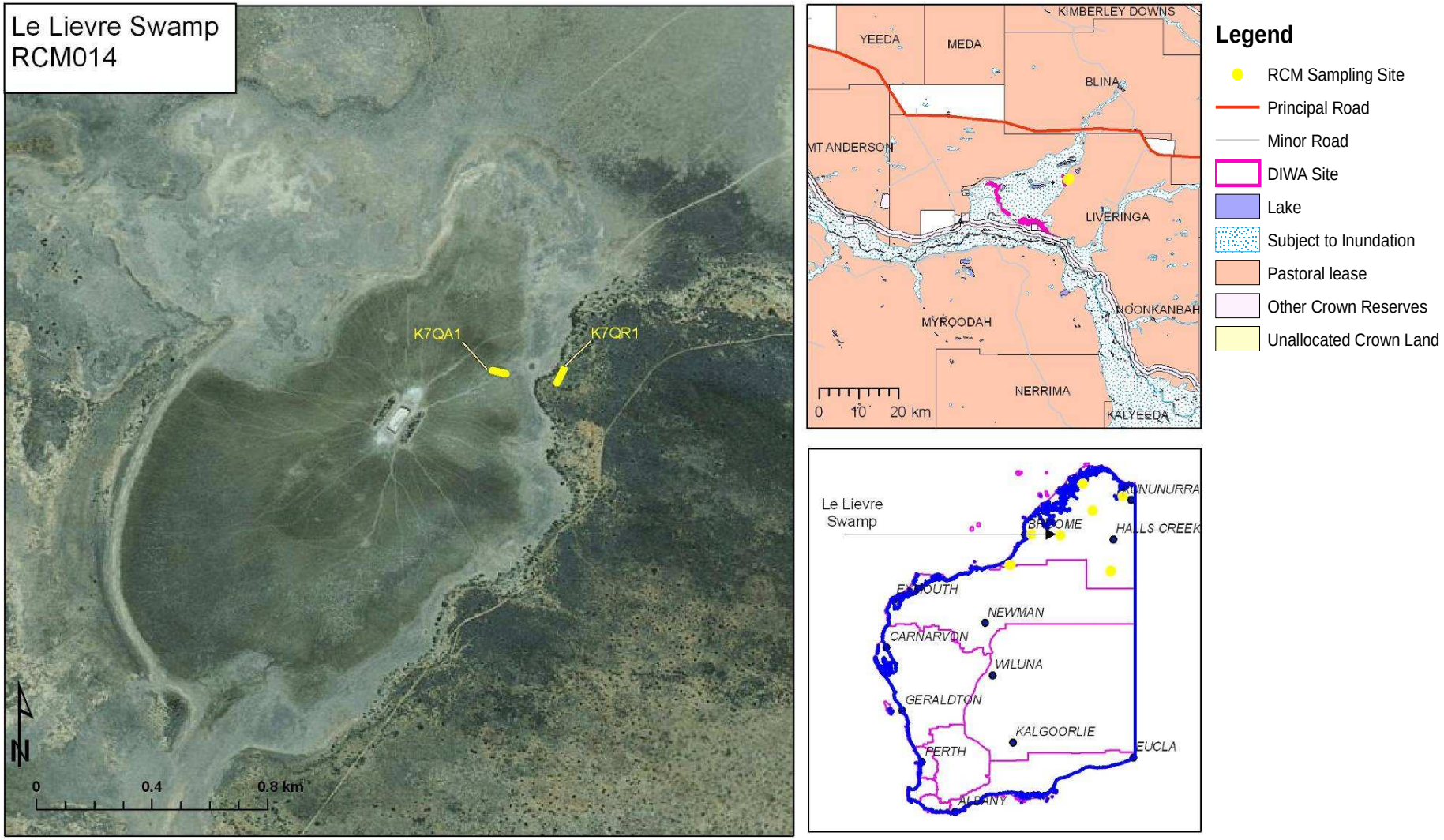


Figure 2 – Satellite imagery showing the location of riparian (K7Q RCM014-R1) and aquatic (K7Q RCM014-A1) transects at Le Lievre Swamp (note that the swamp was dry at the time of survey). The upper insert shows the location of the sampling site relative to surrounding properties. The area that is subject to inundation between Blina and the Fitzroy River is the Camballin Floodplain. The lower insert shows the location of the swamp in relation to other IAI RCM survey sites in the Kimberly and its location in WA.

2. Overview of Le Lievre Swamp

2.1. Location and Cadastral Information

The Camballin Floodplain is an area of approximately 400 km^2 of seasonally inundated land that is contiguous with the Fitzroy River floodplain. It lies about 100 km southeast of Derby, at an elevation of 50 m above sea level. The small township of Camballin lies on the western edge of the floodplain, which is entirely contained within the Liveringa pastoral lease.

The traditional owners of the Camballin Floodplain are the Nyikina & Mangala claimant group, many of whom are based at the Jarlmadangah-Burru Community. They maintain a strong connection to their traditional land and utilise the area for hunting, fishing and gathering food; as well as for ceremonial purposes (National Native Title Tribunal 2002).

The DIWA nominated area of Camballin Floodplain (Le Lievre Swamp System) includes Uralla Creek, Le Lievre Swamp, Lake Josceline, a number of unnamed permanent and seasonal basins, and the surrounding floodplain.

2.2. IBRA Region

Le Lievre Swamp is within the Fitzroy Trough subregion of the Dampierland Interim Biogeographic Regionalisation of Australia (IBRA) region. The Fitzroy Trough contains the middle and lower catchments of the Fitzroy River. It includes alluvial plains associated with that river and areas of sandplain and eroded dune surfaces derived from the Canning Basin. Four component land types have been identified within the subregion(Graham 2001); these are:

1. Quaternary sandplain overlying Jurassic and Mesozoic sandstones with Pindan vegetation;
2. Quaternary marine deposits on coastal plains, with mangal, samphire grasslands, *Melaleuca alsophila* low forests and spinifex-*Crotalaria* communities;
3. Quaternary alluvial plains associated with the Permian and Mesozoic sediments of Fitzroy Trough supporting tree savannahs of ribbon grass (*Chrysopogon* spp.), bluegrass (*Dichanthium* spp.) and Mitchell grass (*Astrebla* spp.), scattered coolibah (*Eucalyptus microtheca*) - *Bauhinia cunninghamii*. Forests of river red gum (*Eucalyptus camaldulensis*) and Cadjeput (*Melaleuca* spp.) fringing drainage lines; and
4. Devonian reef limestone in the north and east supporting sparse tree steppe over lobed spinifex (*Triodia intermedia*) and limestone spinifex (*T. wiseana*) hummock grasses.

2.3 Climate

The nearest Bureau of Meteorology weather station to Le Lievre Swamp is Curtin Aero, 75 km to the northwest (Bureau of Meteorology 2009). Mean annual rainfall at Curtin is thought to be greater than that at Le Lievre Swamp, but rainfall patterns and temperatures are broadly comparable. The Western Australian Department of Agriculture maintained a weather station at Camballin between 1958 and 1970. Incomplete data is available from that station, although climatic conditions may have changed slightly since then.

Curtin Aero receives a mean of 829.1 mm annual rainfall, with the vast majority falling between December and March (Figure 3). Temperatures are warm to hot all year round, with mean maxima of 39.8 ºC in November and 30.6 ºC in June, and minima of 15.2 ºC in July and 25.1 ºC in December and January. Daily evaporation is not available for Curtin Aero but is recorded at Camballin as varying between 5.5 mm per day in June and 11 mm per day in December (approximately 3,000 mm per annum).

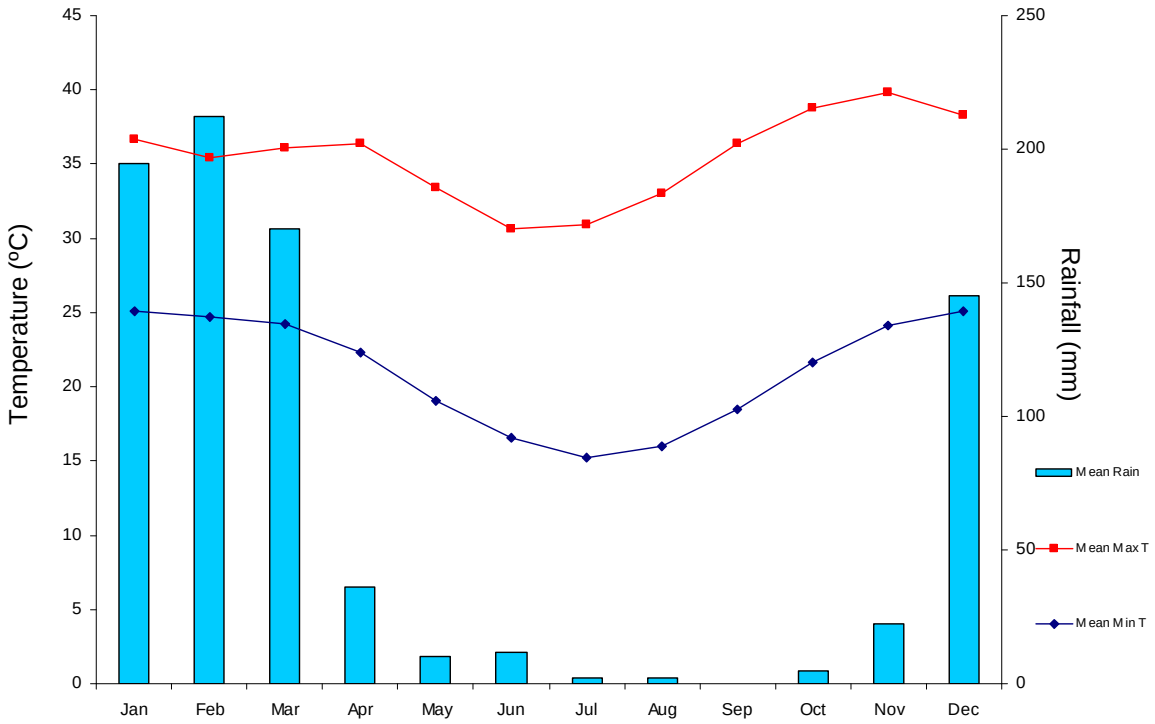


Figure 3 – Climatic averages for Curtin Aero; conditions at Le Lievre are similar, although mean annual rainfall is about 10% lower.

Le Lievre Swamp was surveyed by the RCM project on the 24th of May 2008. In the 6 months preceding the survey, Curtin Aero received 817 mm of rain, with the last rainfall recorded on the 13th of April.

2.4 Wetland Type

The *Directory of Important Wetlands in Australia* (Environment Australia 2001) describes the Le Lievre Swamp System as comprising six different natural inland wetland types:

- Permanent rivers and streams (type B1)
- Seasonal and irregular rivers and streams (type B2)
- Riverine floodplains (type B4)
- Seasonal/intermittent freshwater lakes (>8 ha), floodplain lakes (type B6)
- Seasonal/intermittent freshwater ponds and marshes on inorganic soils (type B10)
- Freshwater swamp forest; seasonally flooded forest, wooded swamps; on inorganic soils (type B14).

Le Lievre Swamp is a seasonally inundated freshwater lake approximately 30 ha in area. It may also be described as a macroscale irregular sumpland.

2.5 Directory of Important Wetlands in Australia Criteria

The Camballin Floodplain (Le Lievre Swamp System) is designated as a wetland of national importance under criteria 1, 2, 3, 4 and 6 of the *Directory of Important Wetlands in Australia*. These criteria are as follows:

1. *It is a good example of a wetland type occurring within a biogeographic region in Australia.* Camballin is a rare example of a floodplain in the Kimberley, and the Le Lievre system includes several different wetland types, including both seasonal lakes/marshes and permanent billabongs (Jaensch 1992).

2. *It is a wetland that plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.* The system, as a whole, is important to the hydrology of the Fitzroy River. More specifically, Le Lievre swamp is thought to play an important role in the recharge of the local groundwater aquifer (Lindsay and Commander 2005).

3. *It is a wetland that is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail.* Camballin Floodplain regularly supports 20,000 waterfowl, with 38,553 individual waterbirds counted at Le Lievre Swamp in 1986. The floodplain is a major post-breeding refuge for waterbirds in the Kimberley, notably Plumed Whistling-duck (*Dendrocygna eytoni*), a major migration stop-over area for Wood Sandpiper (*Tringa glareola*) and other shorebirds and also a major breeding area for Australian Pelican (*Pelecanus conspicillatus*).

4. *The wetland supports 1% or more of the national populations of any native plant or animal taxa.* Sixty-seven waterbird species have been recorded, twenty of them listed under international treaties. The Camballin Floodplain supports more than 1% of the flyway population of Wood Sandpiper (*Tringa glareola*; with up to 185 counted), Australian Pratincole (*Stiltia Isabella*; 600) and Marsh Sandpiper (*Tringa stagnatilis*; 276).The system is also regionally significant for Yellow Chat (*Ephthianura* crocea) (DEHWA, 2004).

6. *The wetland is of outstanding historical or cultural significance.* Camballin Floodplain and the Fitzroy River are highly significant to local Aboriginal people. The Aboriginal Sites Register reveals there are eleven sites registered under the provisions of the *Aboriginal Heritage Act* 1972 (WA), which variously are ceremonial, mythological and burial sites. People of the Looma community continue to utilise the area to harvest natural resources and to maintain their connection to the land.

2.6 Values of Le Lievre Swamp

Values are the internal principles that guide the behaviour of an individual or group. Value systems determine the importance people place on the natural environment and how they view their place within it. Divergent values may result in people pursuing different objectives in relation to nature conservation, having different reasons for desiring a commonly agreed outcome, or favouring different mechanisms to achieve that outcome. Because of this, it is important to be explicit about the values that are driving conservation activities at a wetland.

The Conceptual Framework for Managing Natural Biodiversity in the Western Australian Wheatbelt (Wallace 2003) identified eight reasons that humans value natural biodiversity:

a. Consumptive use

Consumptive use is gaining benefit from products derived from the natural environment, without those products going through a market place, for example, the collection and personal use of firewood or 'bushtucker'. Camballin Floodplain has traditionally been an important source of resources for the Nyikina & Mangala Aboriginal people. This was illustrated by a Supreme Court decision, which refers to the need for local people to hunt, fish, and gather food and other natural materials in the area (National Native Title Tribunal 2002). A chief concern of the local people, discussed in that judgement, is the continuation of traditional knowledge and practices in the area.

b. Productive use

Productive use values are derived from market transactions involving products derived from the natural environment. The same firewood that is collected for personal use may be exchanged for money or another commodity. Camballin Floodplain lies within the Liveringa pastoral lease and the area is used to raise cattle and irrigated vegetable crops.

c. Opportunities for future use

Not all uses of the natural environment may be apparent at present. The potential for future benefit from the natural environment is maximised by maintaining the greatest possible biodiversity. Every lost taxa or ecosystem represents lost opportunities. Le Lievre Swamp may support endemic or rare taxa. Such unique features would increase the potential for future opportunities to present.

d. Ecosystem services

There are many naturally occurring phenomena that bring enormous benefit to mankind. For instance, plants generate oxygen, insects pollinate food crops and wetlands mitigate floods by regulating water flows. The term 'ecosystem services', is used as a broad umbrella to cover the myriad of benefits delivered, directly or indirectly, to humankind by healthy ecosystems. Camballin Floodplain is a system of national significance. It would deliver considerable ecosystem services, including the provision of habitat for large numbers of waterbirds. It is also plays an important role in the hydrology of the Fitzroy River catchment and associated aquifers.

e. Amenity

Amenity describes features of the natural environment that make life more pleasant for people. For instance, pleasant views and shade or wind shelter from a stand of trees. Camballin Floodplain undeniably has significant amenity value for local people and tourists alike.

f. Scientific and educational uses

Parts of the natural environment that remain relatively unmodified by human activity represent great educational opportunities. Such sites allow us to learn about the changes that have occurred to the natural world. They are also 'control' sites that allow us to benchmark other, altered habitats.

g. Recreation

Many recreational activities rely on the natural environment (bird watching, canoeing, wildflower tourism, etc.) or are greatly enhanced by it (hiking, cycling, horse riding, photography, etc.). Recreation may deliver economic benefit derived from tourism and also delivers spiritual and physical health benefits to the recreator. Local people enjoy several recreational pursuits at the Le Lievre Swamp System.

h. Spiritual/philosophical values

People's spiritual and philosophical reasons for valuing natural environment are numerous and diverse. One commonly cited is the 'sense of place' that people derive from elements of their environment. This is evident in many Aboriginal and rural Australians, who strongly identify themselves with their natural environment. Many people also believe that nature has inherent value or a right to exist that is independent of any benefit delivered to humans. A sense of spiritual well-being may be derived from the knowledge of healthy environments, even if the individual has no contact with them. Camballin Floodplain is of cultural significance to the local Aboriginal people, who link it to creation stories. Ceremonial and law sites in the area continue to be used by people from the Nyikina & Mangala groups.

The intent of nature conservation is usually to maintain the ecosystem service values, opportunity values and scientific and educational values at a given site. Doing so is likely to have positive effects on the amenity values, recreational values and spiritual/philosophical values to which the site's natural environment contributes. Consumptive and productive uses of the natural environment are not usually considered, as these are often incompatible with nature conservation. That said, Camballin Floodplain has been described as an important source of resources for local Aboriginal people and may be esteemed by them for its consumptive values.

The floodplain is also used by an active pastoral lease. These conflicting value sets should be considered when attempting to implement conservation management at the site.

3 Critical Components and Processes of the Ecology of Le Lievre Swamp

The objective of the Le Lievre Swamp Resource Condition Report (RCR) is to identify, describe and quantify the critical components and drivers of the wetland's natural environment. These components and processes determine the site's ecological character and are the variables that should be addressed in any ongoing monitoring.

Climate and geomorphology are the most important drivers of wetland ecosystems. Between them, these factors determine the position of a wetland in the landscape and the type and hydrological regime of that wetland. In turn, a wetland's position, type and hydrology exert a strong influence on its biota and biochemical properties and processes.

A summary of Le Lievre Swamp's critical ecosystem components is presented in Table 1, followed by a detailed description of the results of the Inland Aquatic Integrity Resource Condition Monitoring (IAI RCM) 2008 survey as well as findings from any previous studies conducted on the wetland. Le Lievre Swamp was dry at the time of the IAI RCM survey, which prevented several aspects of the system being investigated.

Table 1 – Summary of critical ecosystem components at Le Lievre Swamp.

Component	Summary description
Geomorphology	Macroscale irregular sumpland situated in the Canning Basin on sediments composed primarily of sandstone and shales of marine, deltaic and fluvial origin.
Hydrology	Inflow via surface water; runoff is highly seasonal (wet season); overlies the Liveringa aquifer; associated with the Fitzroy River, which floods regularly.
Water Quality	Fresh (from historical data); likely high in nutrients due to cattle presence.
Vegetation	Tall closed-herbland, dominated by *Sesbania cannabina*, in marginal parts of Le Lievre Swamp; surrounding areas support low open-woodland.
Invertebrates	No data collected; crustaceans known to occur.
Fish	None observed but Camballin Floodplain is known to support fish.
Waterbirds	None observed; 67 species previously recorded on floodplain.
Terrestrial Vertebrates	None observed; three frog species and several mammals and reptiles known to occur in floodplain.

3.3 Geology and Soils

The Fitzroy Trough subdivision of the northern Canning Basin contains Permian, Triassic and Jurassic sediments, intruded by narrow volcanic plugs of Mesozoic lamproite (Middleton, 1990 in Lindsay and Commander 2005). The sediments are predominantly sandstones and shales of marine, deltaic and fluvial origin. The Liveringa group is the most extensive unit underlying the Fitzroy River. This group is up to 900 m thick and composed of sandstone and siltstone with minor beds of claystone and shale. The Liveringa group is the uppermost unit across much of the Camballin Floodplain. In restricted areas, it is overlain by up to 200 m of the Blina Shale (Lindsay and Commander 2005).

The Camballin Floodplain is underlain by the alluvial deposits of the Fitzroy River and its tributaries. The major soil of the floodplain is deep, strongly cracking greyish-brown to brown clay

with variable small occurrences of lime and gypsum (Churchward and Bettenay 1962). The intensive pattern of deep cracking makes this soil highly permeable when dry, but very slowly permeable when wet. This may lead to waterlogging. The soil profile is mildly alkaline to alkaline (pH 7.5 - 8.5) at the surface and shows a slight increase in pH with depth (Yuhun 1989).

Surrounding the floodplain (for instance, to the immediate east of Le Lievre Swamp), soils are principally aeolian sand and gravel, underlain by lateritised sandstone and mudstone of the Liveringa group (Lindsay and Commander 2005).

3.4 Hydrology

The wetlands of the Le Lievre Swamp System are surface water fed. Runoff in the area is highly seasonal occurring during the wet season between December and March. Le Lievre Swamp usually only holds water for a few weeks into the dry season.

The Liveringa group is one of the region's major aquifers. During flood conditions, hydrostatic pressure causes the aquifer to be recharged from the Fitzroy River and the wetlands of the floodplain. The flow of groundwater is reversed during the dry season, with the area's permanent wetlands recharged from the aquifer (Figure 4). Le Lievre Swamp is known to discharge to the Liveringa aquifer when full, but does not receive recharge during dry conditions (Lindsay and Commander 2005).

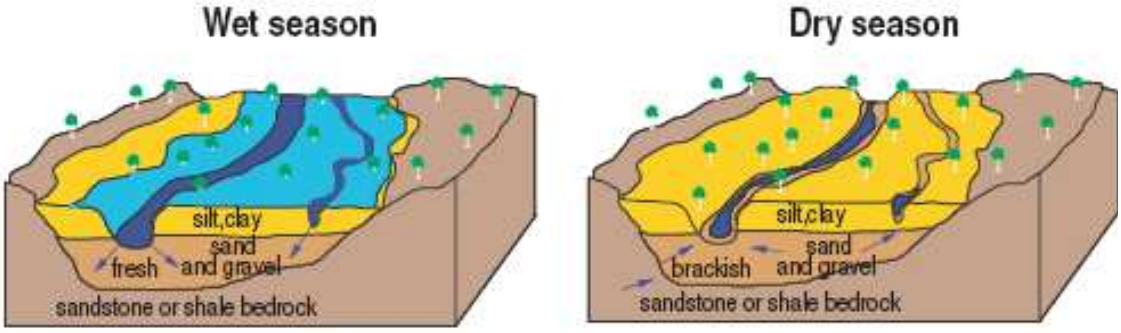


Figure 4 – Conceptual model of the hydrology of the Fitzroy River floodplain (from Lindsay and Commander 2005).

Semi-regular flooding of the Fitzroy River, causing inundation of the surrounding plain, is a natural feature of this system. This process has been disrupted by the construction of levees to contain flood flows and prevent damage to infrastructure. This disruption to the hydrology of the system is likely to be having a deleterious effect on the ecology of the Camballin Floodplain.

3.5 Water Quality

Water quality data was not collected from Le Lievre Swamp, as the wetland was dry at the time of the survey. However, Le Lievre Swamp has previously been described as fresh (Handley 1996). Groundwater in the Liveringa aquifer is marginal to brackish (500 – 3,000 mgL^{-1}). During the dry season, the Fitzroy River and permanent wetlands of the area increase in salinity due to recharge from this aquifer. Le Lievre Swamp does not receive groundwater recharge and thus does not experience this salinisation.

3.6 Vegetation

The margins of Le Lievre Swamp consist of tall and short wetland grasses, herbs and short rush forming a tall closed-herbland, dominated by *Sesbania cannabina*. The surrounding areas support low open-woodland. The black soil plain of the Camballin Floodplain is dominated by open grass comprising Mitchell grass (*Astrelba* spp.), ribbon grass (*Chrysopogon fallax*) and blue grass (*Dichanthium* spp.) (Jaensch 1992; Handley 1996).

Two vegetation transects were established on the north-eastern shore of Le Lievre Swamp and on the dry lake bed. The riparian transect (Table 2, Figure 5) was sparsely vegetated and showed significant disturbance from cattle. Only two species were recorded on the 'aquatic' transect (Table 3, Figure 6): *Cassia* sp. and the introduced couch grass (*Conodon dactylon*).

Although only one species of weed (couch grass) was identified during the IAI RCM survey, it is possible more weeds would be recorded with additional sampling effort. Inappropriate native species may also pose a risk to the ecosystem. For example, the native emu bush (*Eremophila longifolia*) has invaded parts of the floodplain and its presence may affect the suitability of the area as a habitat for some waders and waterbirds (Handley 1996).

Many species of indigenous grasses, such as Mitchell grass, have recolonised the floodplain since agricultural activities ceased in 1983. However, the grazing of cattle is still occurring, with trampling, weeds and erosion posing a significant risk to the vegetation.

Table 2 – Vegetation composition of the riparian transect (RCM014-R1) at Le Lievre Swamp.

Species	Quadrat (m)/% layer cover							
	0-5	**5-10**	**10-15**	**15-20**	**20-25**	**25-30**	**30-35**	**35-40**
Eucalyptus limitaris	40	10	10	60	25	25	75	60
Acacia colei	5	0	0	0	0	0	5	0
Abutilon otocarpum	1	1	0	5	5	1	0	0
Cassia sp.	0	0	1	5	0	0	0	0
Solanum lucani	0	0	0	0	0	1	0	0
Acacia victoriae	0	0	0	1	1	0	0	0
Grass (alive and dead)	20	10	10	20	20	30	20	10
Litter	20	20	30	40	40	40	40	40
Bare ground	50	70	60	40	40	30	40	50

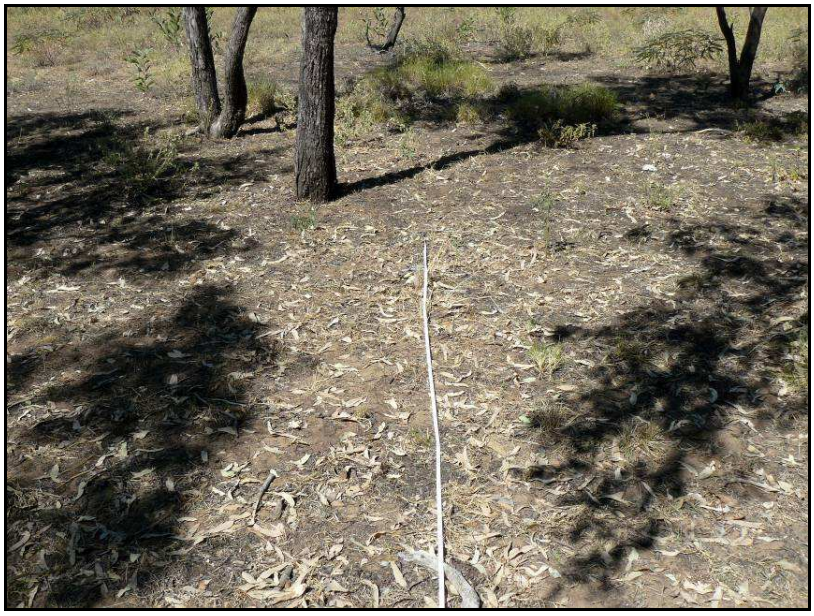


Figure 5 – Riparian vegetation transect (RCM014-R1) at Le Lievre Swamp.

Table 3 – Vegetation composition of the aquatic transect (RCM014-A1) at Le Lievre Swamp.

Species	Quadrat (m)/% layer cover									
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50
Cassia sp.	80	80	80	80	80	80	80	80	80	80
* *Conodon dactylon*	50	50	40	40	50	50	30	30	10	10

* Introduced species

Figure 6 – Aquatic vegetation transect (RCM014-A1) at Le Lievre Swamp.

3.7 Aquatic Invertebrates

Le Lievre Swamp was dry at the time of the IAI RCM survey in 2008. Therefore, no aquatic invertebrate data were collected. The wetland has not previously been sampled for aquatic invertebrates. However, crustaceans such as cherrabun (*Macrobrachium rosenbergii*) are known to occur at the site (Jaensch 1992).

3.8 Fish

No fish were observed during the 2008 IAI RCM survey as the wetland was dry at the time. However, the Camballin Floodplain is known to support a variety of fishes, including fork- tailed catfish (*Arius australis*) (Jaensch 1992).

3.9 Waterbirds

Waterbirds were not present at Le Lievre Swamp during the IAI RCM survey in 2008, as the wetland was dry at the time. However, waterbirds were observed at inundated wetlands elsewhere within the floodplain (Figure 7).

The Camballin Floodplain is an important site for waterbirds and has been recognised as such in DIWA (Jaensch 1992). It has also been nominated as a wetland of international significance under criteria 3a and 3b of the Ramsar Convention (Jaensch and Watkins 1999). Specifically, the floodplain regularly supports 20,000 waterfowl, with up to 38,553 individual waterbirds counted at Le Lievre Swamp in 1986. Although poorly surveyed, it is highly likely the wetlands regularly support such high numbers as suitable habitat is certainly available. The Camballin Floodplain also supports more than 1% of the flyway population of Wood Sandpiper (*Tringa glareola*; up to 185 counted), Australian Pratincole (*Stiltia Isabella*; 600) and marsh sandpiper (*T. stagnatilis*; 276).

A total of sixty-seven waterbird species have been recorded on the Camballin floodplain, including twenty species listed under international migratory bird treaties (see section 1.3). The floodplain is a major migratory stop-over point for many species and is considered internationally significant for the Australian Pratincole, and nationally significant for the Wood Sandpiper and the Marsh Sandpiper. The most abundant species at Camballin Floodplain are plumed Whistling-duck (*Dendrocygna eytoni*; 20,000), Magpie Goose (*Anseranas semipalmate*; 5,000), Wandering Whistling-duck (*Dendrocygna arcuata*; 5,000), Grey Teal (*Anas gracilis*; 4,000), Glossy Ibis (*Plegadis falcinellus*; 3,000), Sharp-tailed Sandpiper (*Calidris acuminata*) and Australian Pelican (*Pelecanus conspicillatus*; 1,000).

Six species of waterbird have been found breeding on the Camballin Floodplain. Of these, Australian Pelican (more than 10,000 chicks in 1974), Little Black Cormorant (*Phalacrocorax sulcirostris*), Little Pied Cormorant (*P. melanoleucos*) and Plumed Whistling-duck breed in or near Le Lievre Swamp. The Camballin Floodplain is also a major post-breeding refuge for waterbirds in the Kimberley, notably Plumed Whistling-duck.

The floodplain is important for the maintenance of the threatened Freckled Duck (*Stinctonetta naevosa*), and is also one of the main habitats within the West Kimberley for the uncommon Yellow Chat (*Ephthianura crocea*). The floodplain is also important at the state and regional level for the Wandering Whistling-duck, Great Egret (*Ardea alba*), Glossy Ibis and Magpie Goose.

Figure 7 – (left) Great Egrets (*Ardea alba*) and (right) an Australian White Ibis (*Threskiornis molucca*) on the Camballin Floodplain.

3.10 Terrestrial Vertebrate

The Camballin Floodplain supports three species of frog, all of which are restricted to the Kimberley region. One of these, Mjobergs Toadlet (*Uperoleia mjobergi*), has a very restricted distribution in the lower Fitzroy floodplain area. The other two, the Hidden-ear Frog (*Cyclorana cryptotis*) and Wailing Frog (*C. vagitis*), are only known from the lower Fitzroy and Ord River valleys (Handley 1996).

Mammals recorded on the Camballin Floodplain include the Agile Wallaby (*Macropus agilis*), Euro Kangaroo (*M. robustus*), Red Kangaroo (*M. rufus*) and fruit bats (pteropodids). Herpetofauna include tree frogs (*Litoria* spp.), the skink (*Ctenotus saxatilis)*, the Blind Snake (*Ramphotyphlops diversus diversus)*, freshwater turtle (*Emydura australis)*, and the Freshwater Crocodile (*Crocodylus johnstonii)* (Handley 1996).

4 Interactions between Ecological Components at Le Lievre Swamp

An appreciation of the interactions between the elements of a wetland ecosystem is essential to understanding the condition of the system. Although components of a wetland are often monitored and managed as discrete entities, they exist as nodes in a complex ecological web.

Documenting the full extent of the interactions that occur at a wetland would be impractical. However, it is essential to identify key interactions that define the system's ecological character. This section of the RCR considers the ecological character of Le Lievre Swamp. The key components and processes of the swamp's ecology, and the interactions between them, are summarised in Table 4.

The equivalence of primary determinants of ecological character and Ramsar nomination criteria at a given site has been demonstrated by Hale and Butcher (2007). This concept may also be extended to the criteria for nomination as a nationally significant wetland in the Directory of Important Wetlands in Australia.

Therefore, the primary determinants of the ecological character of Le Lievre Swamp are the characteristics that contribute to the DIWA nomination of the Camballin Floodplain system. That is:

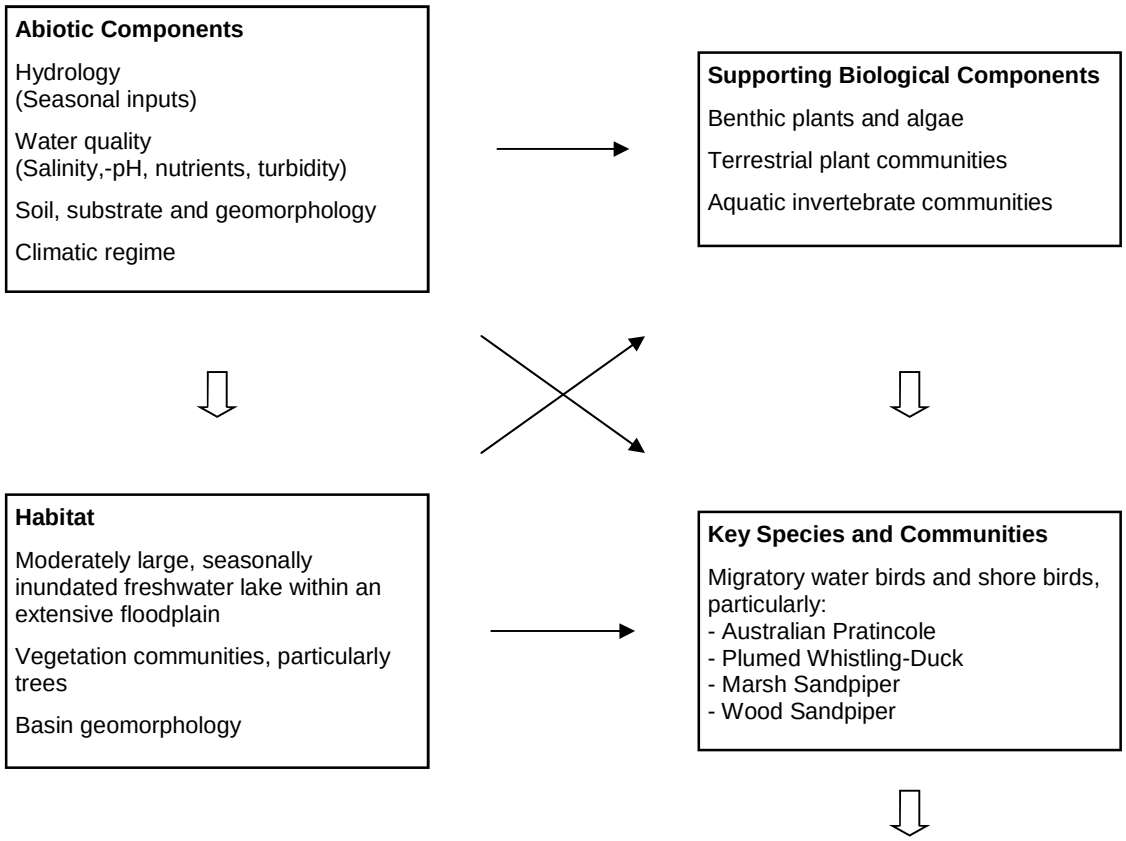
- The morphology and hydrology that make the swamp a good example of a seasonally inundated lake/marsh in the Kimberley biogeographic region.
- The role the swamp plays in the ecological and hydrological functioning of the Camballin Floodplain and the Fitzroy River system.
- The habitat that provides a post-breeding refuge for waterbirds, notably Plumed Whistling-duck, migration stop-over area for Wood Sandpiper and other shorebirds and also a breeding area for Australian Pelican.
- The habitat for Wood Sandpiper, Australian Pratincole and Marsh Sandpiper.

More specifically then, the primary determinants of the ecological character of Le Lievre Swamp are:

- Climate and hydrology, particularly regular inflow from reliable tropical rain in the north Fitzroy catchment, seasonal inundation and non-recharge of the swamp from regional groundwater.
- Nesting sites and food sources (algae, benthic plants, aquatic invertebrates and fish) for Wood Sandpiper, Australian Pratincole, Plumed Whistling-duck and Marsh Sandpiper.

Figure 8 attempts to specify the primary determinants of the ecological character of Le Lievre Swamp and the biological components that support them. Table 4 lists the components that are directly responsible for the provision of each service or benefit of the wetland and the biotic and abiotic factors that support or impact these components. Also listed are the key threats that may affect the components or processes. This information assists in the identification of the primary determinants of ecological character.

Primary Determinants of Ecological Character



Reasons for the nomination of Le Lievre Swamp as a wetland of National significance

It is a good example of a seasonally inundated lake/marsh within a large floodplain in the Kimberley biogeographic region.

It plays an important ecological and hydrological role in the natural functioning of a major wetland system/complex (Camballin Floodplain).

It is an important post-breeding refuge for waterbirds, notably Plumed Whistling-Duck, a major migration stop-over area for Wood Sandpiper and other shorebirds and a major breeding area for Australian Pelican.

It supports 1% or more of the national population of Wood Sandpiper, Australian Pratincole and Marsh Sandpiper

Figure 9 – Schematic depiction of the interactions between critical components of the Le Lievre Swamp ecosystem.

Table 4 – The relationship between the services and benefits delivered by Le Lievre Swamp and the key components and processes that support them.

Benefit or Service	Component	Factors Influencing Component		Threats and Threatening Activities
		Biotic	Abiotic	
Consumptive Value Traditional food, medicines and materials	Plants and animals	Plant pollinators Animal food sources	Hydrological regime Water quality Fire regime Climatic factors Habitat requirements	Grazing by cattle and introduced pest animals Changed fire regimes Altered hydrology due to climate change or irrigation Weeds Sedimentation due to catchment disturbance Feral predators Overexploitation of resources Mining
Productive Value Pastoralism	Cattle	Fodder	Hydrological regime Water quality Fire regime Climatic factors	Overexploitation of resources Competition from feral animals Mining
Opportunity Value Potential future use of unique flora and fauna	Endemic flora, fungi, algae Endemic fauna	Plant pollinators Food sources	Habitat extent and distribution Hydrological regime Fire regime Water quality	Grazing by cattle and introduced pest animals Alteration to hydrology due to climate change, catchment perturbation or irrigation Inappropriate fire regimes Weeds Predation of fauna
Ecosystem Service Value It is a good example of a wetland type occurring within a biogeographic region in Australia	Seasonally inundated lake/marsh within a large floodplain in the Kimberley biogeographic region	Vegetation	Hydrological regime, particularly regular overland inflow Climatic factors, particularly reliable seasonal rain in catchment System geomorphology	Alteration to hydrology due to climate change, catchment perturbation or irrigation Erosion leading to wetland infill Mining Weeds

Benefit or Service	Component	Factors Influencing Component		Threats and Threatening Activities
		Biotic	Abiotic	
Ecosystem Service Value It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail; The wetland supports 1% or more of the national populations of any native plant or animal taxa	Waterbirds, notably: Plumed Whistling-Duck Wood Sandpiper Australian Sandpiper Australian Pratincole Marsh Sandpiper Other shorebirds	Invertebrate populations (food source) Phytoplankton (food source) Benthic plant biomass Vegetation communities, particularly trees	Soils Nutrient concentrations Water salinity and pH Hydrological regime Climatic regime Fire regime	Grazing and pugging by cattle and introduced pests Alteration to hydrology due to climate change, irrigation or catchment perturbation Inappropriate fire regimes Excessive nutrient inputs from stock Weeds Predation of fauna Loss of migratory bird populations due to offsite factors Mining
Recreational Value Bird watching Bush walking Camping	Landscape amenity Waterbird populations Vegetation communities Significant flora Significant fauna	Invertebrate populations (food source) Phytoplankton (food source) Benthic plant biomass Vegetation communities Plant pollinators	Soils Hydrological regime Nutrient concentrations Water salinity and pH Climatic regime Fire regime	Grazing and pugging by cattle and introduced pests Alteration to hydrology due to climate change, irrigation or catchment perturbation Inappropriate fire regimes Excessive nutrient inputs from stock Weeds Predation of fauna Loss of migratory bird populations due to offsite factors Mining
Spiritual Value The wetland is of cultural significance to local Aboriginal people	Geomorphology of lake and surrounds, particularly sites linked to creation stories and law grounds Native flora and fauna communities	Flora and fauna populations Pollinators and food sources for above	Soils Hydrology Water quality	Grazing by cattle and introduced pests Alteration to hydrology due to climate change or catchment perturbation Inappropriate fire regimes Excessive nutrient inputs from stock Weeds Predation of fauna Loss of migratory bird populations due to offsite factors Tourism Mining

4.3 Primary Determinants of Ecological Character

4.3.1 Climate and Hydrology

Le Lievre Swamp receives very reliable inflows from tropical rains in the catchment. It is the reliability of the wetland filling that makes Le Lievre Swamp and the surrounding floodplain a valuable resource for waterbirds. Seasonal separation from the regional groundwater table prevents salinisation of the swamp.

4.3.2 Habitat

The Camballin Floodplain provides a large area of suitable habitat for waterbirds, including shorebirds and waders. Abundant water and year-round warm weather makes for a highly productive system. The area is particularly significant as habitat for three species of birds:

Plumed Whistling-Duck (*Dendrocygna eytoni*) is one of two whistling, or tree, ducks found in Australia. The Plumed Whistling-duck is mainly found in the northern and eastern tropics of Australia. It also extends southwards to New South Wales in the east but does not come far south of the Kimberley in Western Australia.

During the day, the Plumed Whistling-duck congregates in large numbers with other waterfowl on the margins of lagoons, swamps and mangrove creeks, for preening and sleeping. At night they fly out, often quite long distances, to feed on grasslands. In the breeding season the Plumed Whistling-duck leaves the water and nests on the grassy plains. The Camballin Floodplain provides ideal habitat with an abundance of grass plains surrounding the wetlands.

Plumed Whistling-ducks graze on tropical grasses. They pluck grass (like a goose) and also take food from the water by dabbling from the surface.

Breeding for the Plumed Whistling-duck begins in the tropical wet season. The nest is a scrape in the ground, sparsely lined with grass, usually under shelter of a bush or other vegetation (Australian Museum 2006).

Wood Sandpiper (*Tringa glareola*) is a fully migratory species, travelling overland on a broad front across Europe and the Middle East to winter feeding grounds in the southern hemisphere. The adults start to move away from the breeding grounds in late June, with juveniles following in late August, arriving in Western Australia from late July. Departure from the wintering grounds begins in late March to early April, with breeding areas starting to be reoccupied from late April. Some non-breeding birds may also remain in the south throughout the summer.

Outside of the breeding season Wood Sandpipers are commonly found in open areas such as the margins of inland freshwater lakes and reservoirs, muddy marshlands, grassy stream banks, sewage farms, wet paddy fields, small temporary pools, permanent swamps, flooded grassland and irrigation channels. The Camballin Floodplain provides ideal habitat.

Whilst on the breeding grounds, this species is chiefly carnivorous, taking small insects (up to 2 cm long), especially the aquatic forms such as dytiscid or hydrophilid beetles, Hemiptera, and Dipteran larvae such as midges. During the non-breeding season the Wood Sandpipers have a more varied diet consisting of aquatic and terrestrial insects and their larvae, worms, spiders, crustaceans, gastropod molluscs, small fish (up to 2 cm long) and frogs, as well as plant matter such as seeds (BirdLife International 2008).

Australian Pelican (*Pelecanus conspicillatus*) is found throughout Australia, Papua New Guinea and western Indonesia, with occasional reports in New Zealand and various western Pacific islands. In Australia, it is widespread on freshwater, estuarine and marine wetlands and waterways including lakes, swamps, rivers, coastal islands and shores.

Pelicans mainly eat fish, but they are opportunistic feeders and eat a variety of aquatic animals including crustaceans, tadpoles and turtles. Reports of fish and prawns present in Le Lievre Swamp suggest the wetland provides good feeding grounds for pelicans. During periods of

starvation, pelicans have been reported capturing and eating seagulls and ducklings. Pelicans will also rob other birds of their prey. The Australian Pelican may feed alone, but more often feeds as a cooperative group. Sometimes these groups are quite large. Flocks of pelicans will herd fish shallow water or surround them in ever decreasing circles.

Pelicans are colonial breeders with up to 40,000 individuals grouping on islands or secluded shores. Breeding may occur at any time of year depending on environmental conditions, particularly rainfall (Australian Museum 2001).

5 Threats to the Ecology of Le Lievre Swamp

The ambition for management at Le Lievre Swamp is to maintain those elements of the ecology that resulted in its recognition as a wetland of national significance. Management for that goal should also include the range of values identified in Table 4.

The critical components of the ecology are the hydrologic and habitat factors that make the swamp an important area for waterbirds, shore birds and waders. Wood Sandpipers, Plumed Whistling-ducks and Australian Pelicans have been specifically highlighted as important visitors to the system.

Threats to Le Lievre Swamp must be considered in relation to their likelihood of causing the failure of the above management goal for the system. An assessment is made of the probability that goal failure will result due to the impacts of each threatening process identified at the site, or potentially acting there. The results of this assessment are presented in Table 5.

Failure to achieve the management goal for Le Lievre Swamp is most likely to result from the impacts of pastoral activities. Cattle have a number of detrimental impacts on this wetland. Grazing removes native ground cover, providing a niche for weed establishment and allowing soil erosion to occur. Erosion is also facilitated by soil disturbance from hoofed animals. Disturbed and overgrazed areas are more likely to be eroded, leading to increased rates of sedimentation in the lake and increased turbidity. Deposition of sediments is a serious issue, as it alters the geomorphology of wetlands, changing their character.

Heavy grazing pressure will also kill larger plants, particularly when combined with excessive nutrient inputs from animal waste. Germinants and regenerating plants are highly susceptible to grazing, as they tend to be more palatable to stock. This is of particular concern when riparian and fringing vegetation is recovering following flooding or fire events. The loss of a generation of young plants to grazing can prevent the system from rebounding after such a disturbance.

The vegetation of the littoral zone of Le Lievre Swamp was heavily grazed at the time of the site visit. Soil structure in the area was also degraded and the plentiful cow dung raises concerns about nutrient enrichment of the system. Cattle pads across the lake floor were clearly visible, both from the ground (Figure 10) and in aerial photographs (Figure 2). Interestingly, *Sesbania cannabina* covering the lake floor was not heavily grazed, despite this being suitable fodder for cattle. This may be attributable to the ready availability of more palatable grasses and other food sources.

It is desirable that cattle be excluded from the lake floor and its littoral zone. Although good grazing land, the fragility of this area and its importance to the lake ecology necessitates its protection from cattle.

Another threat to Le Lievre Swamp and the broader Camballin Floodplain is agriculture. Currently, Uralla Creek is dammed to provide water for irrigated sorghum crops on the floodplain. This is certain to be having negative impacts on the hydrology and ecology of the system. Plans also exist for the expansion of agriculture on the Camballin Floodplain. These plans require the Fitzroy River to be dammed to allow large-scale cotton cropping on the floodplain. This would be devastating to not only Camballin Floodplain, but the Fitzroy River as well. Any further agricultural activity in this catchment should be discouraged, particularly if it relies on irrigation.

Mining is a second potential threat to the Camballin Floodplain. Much of the area has been surveyed for coal, oil, gas and uranium potential, and mining tenements are either pending or current. It currently seems unlikely that the coal, oil or gas reserves in the area will become economic in the foreseeable future. Uranium mining has only recently been legalised by the WA state government and the likelihood of the uranium resource being developed is difficult to predict. Uranium mining in an area such as the Camballin Floodplain will be impossible to undertake without serious environmental degradation. Should it go ahead, the natural values of the flood plain will almost certainly be lost.

Altered fire regimes are a threat to biodiversity across the Kimberley region. The Environmental Protection Authority recently released an issues paper that details the current and future impacts of changes to the natural frequency and intensity of wildfire in that region (Russell-Smith 2005). That paper found that the season of burning has changed during the period of European occupation of the region. Most Aboriginal burning in the Kimberley occurred through the dry season, whereas today most fires occur at the end of the dry season. Late dry season fires in the Kimberley have major impacts across all land use and industry sectors. In particular, fire-sensitive vegetation in the Kimberley is being severely impacted upon by intense late dry season fires. It is likely that fires in recent times have had a major impact on small to medium sized animals such as bandicoots. Together with the effects of grazing on grass species and seed availability, fire may also have a major impact on many birds. Late dry season fires can also have significant impacts on soil loss, loss of nitrogen in smoke, increased greenhouse gas emissions, and impacts on air quality and human health.

In the context of Le Lievre Swamp, fire has the potential to facilitate the establishment of weed species, expose soils to erosion, cause the loss of fire-sensitive flora taxa and negatively impact on fauna. It is very difficult to manage fire in the Kimberley. Native perennial grasses accumulate biomass very rapidly, meaning that prescribed burning is largely ineffective in establishing buffers to limit the spread of fires. Any fire control measures need to be maintained annually to ensure their continued effectiveness. It is very important that areas regenerating following fires are protected from excessive grazing, in order to allow plants to re-establish.

Wetlands are highly productive environments, but are also easily disturbed. Fires, pest animals, stock and human activities may all disturb native vegetation and create the niche required for exotic plants to become established. Weed propagules are introduced via the vectors of inflowing water, grazing stock, exotic animals, visiting waterbirds or wind. Once established, the productivity of the ecosystem often allows weed populations to flourish and exclude native plants. An additional problem is the difficulty in implementing weed control in wetland environments. The fragility of the system and fluxes of water usually make chemical weed control inappropriate. Mechanical control is often complicated by difficulty in accessing infestations.

Only one introduced plant has previously been recorded at Le Lievre Swamp: *Vachellia farnesiana.* Couch grass (*Conodon dactylon*) was also found during the IAI RCM survey. However, flora survey at the site has been minimal and the lack of weeds recorded is likely due to this. It is recommended that a flora survey of the Camballin Floodplain be undertaken to fully document its native taxa and also to record the presence and location of exotic plants. This will allow a better estimation of the threat posed by weeds in the area.

Figure 10 – The floor of Le Lievre Swamp with cattle pads to a dam visible in the background. Cattle are currently the greatest threat to the wetland.

Table 5 – Threat assessment for Le Lievre Swamp.

An estimate is provided of the perceived likelihood of goal failure resulting from the impacts of each identified threat category.

Goal: to maintain those components of the ecology, geomorphology and hydrology that provide habitat for waterbird, shore bird and wader populations.

Threat category	Management issue	Probability (%) that threat will cause goal failure with:		Assumptions underlying initial probability assessment and explanatory notes
		Existing management	Extra management	
Altered biogeochemical processes	Hydrological processes, particularly salinity	0	0	There is no evidence of increasing salt loads in the system nor of any hydrological perturbation.
	Erosion and sedimentation	1	1	Overgrazing of land in the catchment could potentially result in excessive erosion and infilling of Le Lievre Swamp, which is a very shallow pan. This is unlikely to become a major management issue in the foreseeable future.
	Carbon cycle and climate change	0	0	Changes to rainfall are expected to be fairly minor in the Kimberley, perhaps as little as 1% over the next 50 years (CSIRO Undated). Such a small change is unlikely to have any impact on Le Lievre Swamp.
Impacts of introduced plants and animals	Environmental weeds	5	1	Only two introduced plant species have been recorded at or in the vicinity of Le Lievre Swamp. Given its location within an active pastoral lease, it seems likely that this simply reflects a lack of historical collecting effort.
	Herbivory, wallowing and trampling by introduced species	25	0	Le Lievre Swamp and its surrounds are heavily grazed by cattle. The aerial photograph (Figure 2) shows cattle pads radiating from a dam on the lake bed. The impacts of cattle are clearly visible on the riparian vegetation. The lake floor is heavily covered with *Sesbania cannabina*, which was not heavily grazed despite being suitable as cattle fodder (CSIRO Undated). Fencing to exclude stock will ameliorate this threat.
Impacts of problem native species	Overgrazing by native species	0	0	No impacts evident.
Impacts of disease	Plant pathogens	0	0	No impacts evident.

Threat category	Management issue	Probability (%) that threat will cause goal failure with:		Assumptions underlying initial probability assessment and explanatory notes
		Existing management	Extra management	
Detrimental regimes of physical disturbance events	Fire regimes	5	1	Increasing frequency and intensity of late season wildfires are having deleterious impacts on ecosystems across the Kimberley. Such fires facilitate the establishment of exotic grasses and other weeds, and create the potential for erosion of soils with the next rainfall event. Management of fire in the Kimberley is difficult because of the size and remoteness of the region and the fast return rate of native annuals. Fire management should be an achievable goal for specific sites, however.
	Drought	5	5	Rainfall projections for the Kimberley show climate change may result in longer periods of drought, interspersed with severe storms and heavy rainfall (CSIRO Undated). The impacts on the ecology and geomorphology of Le Lievre Swamp are difficult to predict. Some alteration to the system's hydrology is possible.
	Flood	0		Vegetation at Le Lievre Swamp is adapted to periodic inundation. Although flood events cause extensive plant death, these individuals are replaced by new recruits when floodwaters recede. Some deleterious impacts may be observed on the ecology of the system if climate change results in more frequent or more severe flooding events. It is important that regenerating plants are protected from grazing.
Impacts of pollution	Herbicide, pesticide or fertiliser use and direct impacts	1	0	Liveringa Station has an extensive irrigation system and various agricultural crops are produced. No impacts of chemical usage at Le Lievre Swamp were detected during the site visit, but the potential for pollution remains.
Impacts of competing land uses	Recreation management	1	0	Some recreational use is made of Camballin Floodplain. Traditional owners have documented complaints of over fishing, hunting for sport and littering in the area (National Native Title Tribunal 2002).
	Nutrient enrichment of water body	5	0	Nutrient levels in Le Lievre are unknown. It is likely that nutrient enrichment may occur, given the number of stock accessing the wetland.
	Urban and industrial development	0	0	None likely.

Threat category	Management issue	Probability (%) that threat will cause goal failure with:		Assumptions underlying initial probability assessment and explanatory notes
		Existing management	Extra management	
	Productive uses	Currently: 25 If agricultural expansion occurs: 50	5	Cattle are causing considerable degradation of vegetation and soil structure. Cattle need to be excluded from the lake margins and care should be taken that grazing in the catchment does not cause excessive soil erosion or nutrient inputs. Plans for further agriculture on the floodplain are concerning. The hydrology of the plain is already significantly perturbed by the construction of a dam, canals and other irrigation infrastructure. Any expansion of the irrigated area is likely to be highly deleterious, particularly if it involves drawing water from the Liveringa aquifer or constructing a dam on the Fitzroy River.
	Illegal activities	0	0	Illegal fishing and hunting of crocodiles may be occurring in the area (National Native Title Tribunal 2002).
	Mines and quarries	If mining occurs: 75 If not: n/a	n/a	The Camballin Floodplain has been explored for mineral potential, particularly in relation to oil, gas and uranium (T. Sinclair, pers. comm.) Recent changes in state legislation regarding uranium mining may see increased interest in the area.
Insufficient ecological resources to maintain viable populations	Habitat, genetic exchange	1	1	Although extensive areas of native vegetation remain on the Camballin Floodplain, much of it is perturbed by agriculture and pastoralism. The relatively 'soft' nature of the matrix will assist in supporting and connecting wild populations, so most should be able to maintain viability. This may not be the case for all taxa, however. Further study is required to better document the health of the system.

6 Knowledge Gaps and Recommendations for Future Monitoring

There is relatively little knowledge of wetlands of the Kimberley region. Remoteness and access limitations have traditionally discouraged surveys. While this IAI RCM survey has provided a 'snapshot' of the ecological character of Le Lievre Swamp, aquatic invertebrates, water quality and waterbirds could not be surveyed as the wetland was dry. Additional surveys are required when the wetland is full to fill these data gaps. Repeat surveys are also required to provide a good understanding of the entire ecosystem and to determine trends over time.

Any future monitoring of Le Lievre should concentrate on the components of the site that contribute to its outstanding ecological character, as outlined in Section 3. Therefore, future monitoring should concentrate on the following:

- Water quality, as this is valuable in providing a resource to the native fauna and the local indigenous people as well as maintaining habitat for aquatic invertebrates.
- Aquatic invertebrates, as there are currently no data available despite being a significant food resource for waterbirds and a valuable indicator of wetland condition.
- Vegetation surveys, to monitor the effects of cattle intrusion such as weeds, trampling, loss of vegetation and soil erosion (Figure 11). This should include weed mapping and species identification, to monitor weed invasions.
- Repeated waterbird surveys, to ensure compliance with DIWA (and potentially Ramsar) criteria, particularly that the wetland *regularly* supports 20,000 waterbirds.
- Habitat condition, to ensure waterbird populations may continue to be supported at the site.

On a landscape scale, and particularly in relation to the Camballin Floodplain, it is important to maintain the ecological functioning of the Fitzroy River and its associated tributaries.

Three species of frog endemic to the Kimberley region are known to occur on the Camballin Floodplain. As such, frogs are likely to occur at Le Lievre Swamp. These may be an important study topic considering cane toads are expected to invade the Kimberley in the near future.

Figure 11 – Evidence of soil disturbance caused by cattle at La Lievre Swamp - the loss of vegetation to grazing makes the soil susceptible to erosion.

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