Department of
Environment and Conservation

Our environment, our future

Resource Condition Report for Significant Western Australian Wetland

Dunns Swamp

2008

Figure 1 – A view across the water body at Dunns Swamp.

This report was prepared by:

Anna Nowicki, Technical Officer, Department of Environment and Conservation, PO Box 51, Wanneroo 6946

Adrian Pinder, Senior Research Scientist, Department of Environment and Conservation, PO Box 51, Wanneroo 6946

Stephen Kern, Botanist, Department of Environment and Conservation, Locked Bag 104 Bentley Delivery Centre 6983

Glen Daniel, Environmental Officer, Department of Environment and Conservation, Locked Bag 104 Bentley Delivery Centre 6983

Invertebrate sorting and identification was undertaken by:

Nadine Guthrie, Research Scientist, Department of Environment and Conservation, PO Box 51, Wanneroo 6946

Ross Gordon, Technical Officer, Department of Environment and Conservation, PO Box 51, Wanneroo 6946

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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 Dunns Swamp, a permanent saline to brackish lake within the Jerdacuttup River catchment in the South Coast region.

Dunns Swamp was selected as a study site in the current project as it has been identified as a regionally significant wetland (Comer *et al.* 2002). Long-term monitoring (from 1999 to 2009) has occurred at Dunns Swamp as part of the South Coast Wetland Monitoring Program conducted by the Department of Water (DoW).

1.1. Site Code

Inland Aquatic Integrity Resource Condition Monitoring Project (DEC): RCM041.

Salinity Action Plan Wetland Biological Survey (DEC): SPS128.

1.2. Purpose of Resource Condition Report

The objective of this RCR is to set a benchmark against which future measures of condition can be assessed. This will allow the effectiveness of management planning and actions to be gauged. The report provides a summary of all available ecological information relevant to the site and describes the key drivers of, and threats to, the system. It provides a current 'snapshot' of ecological character that provides context for future monitoring of the site.

1.3. Relevant Legislation and Policy

This section provides a brief summary of the legislation and policy that are relevant to the management of Dunns Swamp.

International

Migratory bird bilateral agreements and conventions

Australia is party to a number of bilateral agreements, initiatives and conventions for the conservation of migratory birds that are relevant to Dunns Swamp. 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.

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. One of these is relevant to Dunns Swamp: migratory species listed under international treaties JAMBA, CAMBA and CMS. Nationally listed threatened flora, fauna and ecological characters are also protected under the EPBC Act and it is possible that some of these may occur at Dunns Swamp.

The EPBC Act regulates actions that will have, or are likely to have, a significant impact on any matter of national environmental significance. Such actions are subject to environmental assessment and approval under the EPBC Act. An 'action' includes a project, a development, an undertaking, or an activity or series of activities (http://www.environment.gov.au/epbc/index.html).

Western Australian state policy

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.

Local Government Act 1995

This Act lays down the responsibilities, powers and procedures for election of Local Government Bodies. If a reserve is vested in or placed under the control and management of a local government, the local government may do anything for the purpose of controlling and managing that land that it could do under section 5 of the *Parks and Reserves Act 1895* if it were a Board appointed under that Act to manage and control the land.

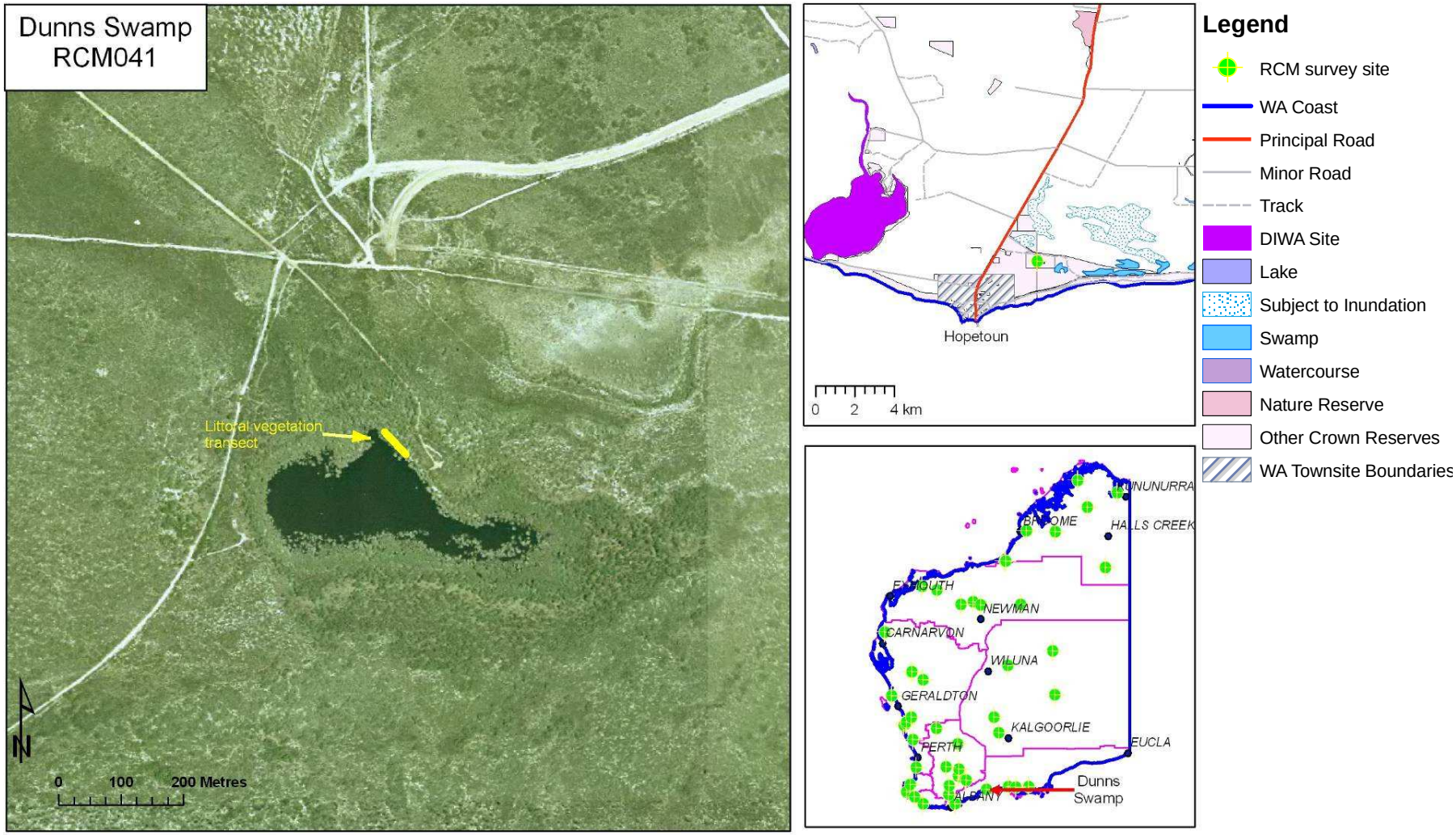

Figure 2 – Aerial photograph showing the location of the vegetation transect at Dunns Swamp. Aquatic invertebrates and water quality were sampled adjacent to the transect. The upper insert shows the location of the sampling site. The lower insert shows the location of the lake in the state of Western Australia and in relation to remaining RCM survey sites.

2. Overview of Dunns Swamp

2.1. Location and Cadastral Information

Dunns Swamp is the main lake belonging to the Dunns Swamp suite, which also includes an area of 'perennial swamp' to the east (Chapman 2007a). Dunns Swamp lies approximately 3.5 km as the crow flies or 5.5 km by road east-northeast of Hopetoun. The wetland may be accessed west off Hopetoun-Ravensthorpe Road, at the end of Dunns Swamp Road (Figure 2). The lake is contained within an un-named Reserve (31920) vested in the Shire of Ravensthorpe since 1973. The current land use is water supply.

2.2. IBRA Region

Dunns Swamp lies within the Recherche subregion of the Esperance Interim Bioregionalisation of Australia (IBRA) region. The subregion has variable relief, comprising the Quaternary coastal sandplains and dunes overlying Proterozoic gneiss and granite as well as Eocene and more recent coastal limestone. It is characterised by proteaceous scrub and mallee heaths on sandplain overlying Eocene sediments and is rich in endemics. The vegetation of the Recherche subregion comprises heath, coastal dune scrub, mallee, mallee-heath and granite heath with diverse vegetation types (Comer et al. 2002).

2.3. Climate

The nearest Bureau of Meteorology weather station to Dunns Swamp is at Ravensthorpe, 39 km away. Records have been kept at Ravensthorpe since 1901. Weather conditions at Dunns Swamp would not differ appreciably from those at Ravensthorpe.

Ravensthorpe experiences a temperate Mediterranean climate, which is characterised by a cool winter with reliable rainfall and a warm dry summer with occasional thunderstorms. It receives a mean annual rainfall of 426.6 mm, mostly falling between May and September (Figure 3).

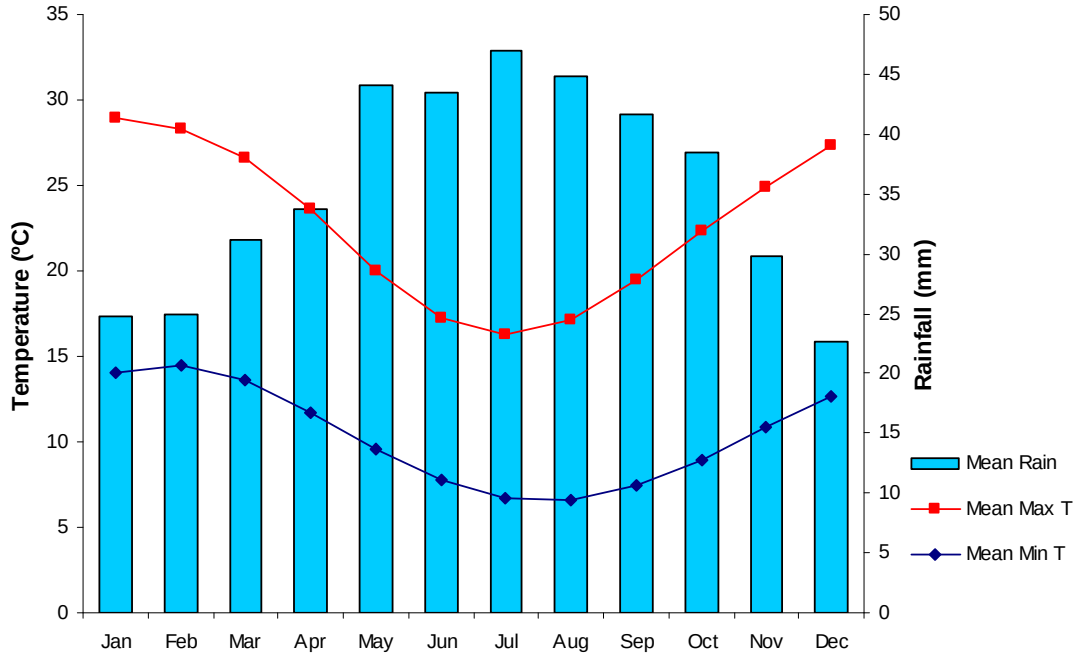

Figure 3 – Climatic averages for Ravensthorpe, approximately 39 km west-northwest of Dunns Swamp.

Dunns Swamp was sampled on the 13th of November 2008. In the year preceding the IAI RCM survey (1st Dec 2007 – 13th Nov 2008), Ravensthorpe received 394.6 mm of rain. Rainfall was variable throughout the year, with December 2007 and April, July, September and October 2008 having the highest rainfall (total of 287.9 mm).

2.4. Wetland Type

The Directory of Important Wetlands in Australia (Environment Australia 2001) describes Dunns Swamp as a seasonal/intermittent saline lake (type B8) (Chapman 2007a; Frodsham 2007). According to the Semeniuk and Semeniuk classification system, Dunns Swamp is a hyposaline-mesosaline poikilohaline microscale (180 x 460) irregular lake (Semeniuk and Semeniuk 1995; Water 2008). It is permanent basin wetland with fringing vegetation dominated by *Melaleuca*.

Despite its name, Dunns Swamp is more accurately described as a Lake considering most of the wetland is open surface water (Frodsham 2008a). This is also one of the characteristics of Dunns Swamp that makes it unique compared to other local wetlands (Frodsham 2008a).

2.5. Values of Dunns 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 these products going through a market place, for example, the collection and personal use of firewood or 'bushtucker'. While Dunns Swamp is likely to have been used historically by local Aboriginal people, the lake supports no consumptive use values in the present day.

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. While Dunns Swamp is likely to have been used historically by local Aboriginal people, it is unknown if the lake supports any productive use values in the present day.

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 taxon or ecosystem represents lost opportunities. Dunns 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. As a permanent lake, Dunns Swamp is regionally significant for the drought

refuge it provides to domestic waterbirds. It also provides valuable habitat that is not locally available elsewhere for a wide range of terrestrial birds (Frodsham 2008b).

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. It is difficult to quantify the amenity value of a site such as Dunns Swamp, but it is certainly valued by the local community for the amenity it provides. Dunns Swamp has been described as a "calm and beautiful freshwater lake surrounded by paperbark trees" (Shire of Ravensthorpe 2006).

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. Dunns Swamp provides significant research opportunities. DoW has been conducting ongoing long-term monitoring of aquatic invertebrates and water quality as part of the South Coast Wetland Monitoring Program (Department of Water 2006; 2008). Dunns Swamp was one of twenty-five wetlands between Hopetoun and Oldfield Estuary assessed for waterbird use, condition and potential threats by Green Skills Inc. in 2007 (Frodsham 2007). Aquatic invertebrate, waterbird and water quality data have also previously been collected by DEC as part of the biodiversity survey (SPS) of agricultural lands under the Salinity Action Plan (Keighery *et al.* 2004; Pinder *et al.* 2005).

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. Dunns Swamp is used by the local community as a recreation site. It is an ideal spot for picnicking, bushwalking and bird-watching (Ashworth *et al.* 2004). The lake is also of value to tourists interested in the history of the Hopetoun area. A track runs from Dunns Swamp to the ruins of Dunns Cottage built in 1877. The Dunn brothers, the first European settlers in Hopetoun, chose this spot to water their sheep, shear them and transport the wool from Mary Ann Haven by boat rather than by land from Cocanarup to Albany (Shire of Ravensthorpe 2006).

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. Although no Aboriginal sites are known within Dunns Swamp itself, it is located in the vicinity of, and historically connected to, several sites of heritage value (Frodsham 2007). Cocanarup, where John Dunn first prepared for pastoral occupation, and Phillips River are historically associated with massacres of Aboriginal people who lived in the area. John Dunn was killed by local Aborigines in an alleged payback killing in 1880. His grave is located on Cocanarup Road, west of Ravensthorpe. Today, it is said that Aboriginal people stay away from Ravensthorpe, or stay briefly if it cannot be avoided (Frodsham 2007).

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.

3. Interactions between Ecological Components at Dunns 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.

Table 1 summarises the interactions between key components and processes at Dunns Swamp. The table 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.

Table 1 – The relationship between the services and benefits delivered by Dunns Swamp and the key components and processes that support them.

Benefit or Service	Component	Factors Influencing Component		Threats and Threatening Activities
		Biotic	Abiotic	
Opportunity Value Potential future use of unique flora and fauna	Endemic flora Endemic fauna	Pollinators Food sources	Habitat extent and distribution Hydrological regime Fire regime Water quality	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Salinisation Excessive nutrient inputs from agricultural runoff Inappropriate fire regimes Weeds Predation by introduced fauna Grazing by introduced pest animals
Ecosystem Service Value It is a good example of a wetland type occurring within a biogeographic region in Australia	Dunns Swamp basin – a permanent fresh waterbody Habitat for a wide range of avifauna that is not found elsewhere on the coastal plain	Vegetation communities	Soil Hydrological regime	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Salinisation Erosion Surrounding land use changes Weeds
Ecosystem Service Value It is a wetland which provides a refuge when adverse conditions such as drought prevail	Domestic waterbirds that utilise the site as a drought refuge	Invertebrate populations (food source) Phytoplankton (food source) Benthic plant biomass	Soils Nutrient concentrations Water salinity and pH Groundwater level	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Inappropriate fire regimes Salinisation Excessive nutrient inputs from agricultural runoff Weeds Predation by introduced fauna

Benefit or Service	Component	Factors Influencing Component		Threats and Threatening Activities
		Biotic	Abiotic	
Recreational Value Bird watching Picnicking Bush walking Sight-seeing	Landscape amenity Waterbird populations Vegetation communities	Invertebrate and phytoplankton populations (food source) Vegetation communities (habitat) Hydrology	Soils Nutrient concentrations Water salinity and pH Groundwater level	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Inappropriate fire regimes Salinisation Excessive nutrient inputs from agriculture Weeds Predation by introduced fauna
Spiritual Value The wetland is of outstanding historical or cultural significance	Geomorphology of lake and surrounds Native flora and fauna communities Association with early pastoral industry	Flora and fauna populations Pollinators and food sources for above	Soils Hydrology Water quality	Alteration to hydrology due to climate change, groundwater extraction or catchment perturbation Salinisation Inappropriate fire regimes Excessive nutrient inputs from agriculture Weeds Predation of fauna Erosion

4. Critical Ecological Components and Processes of Dunns Swamp

The primary objective of the Dunns Swamp 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 Dunns Swamp's critical ecosystem components is presented in Table 2, followed by a detailed description of the results of the IAI RCM 2008 survey as well as of any previous studies conducted on the wetland.

Table 2 – Summary of critical ecosystem components at Dunns Swamp.

Component	Summary description
Geomorphology	Microscale irregular lake situated on Quaternary lacustrine deposits of clay and silt
Hydrology	Drainage from the northwest across a low lying dry swampy area and affected by surrounding land use
Water Quality	Hyposaline-mesosaline (24.46 mS/m), high nitrogen and phosphorous levels, coloured
Littoral Vegetation	Dominated by *Melaleuca cuticularis* low woodland of impacted condition; seven weed species recorded
Invertebrates	Nine families of macroinvertebrates sampled but 19 families (38 species) recorded previously
Fish	None sighted
Birds	Five species of waterbirds sighted, the most abundant of which were ducks and grebes

4.1. Geology and Soils

Dunns Swamp lies on Quaternary lacustrine deposits of clay and silt between consolidated coastal deposits of calcarenite to the south and coastal dune sand to the north (Witt 1997; Chapman 2007b).

4.2. Hydrology

Drainage into Dunns Swamp is from the northwest across a low lying dry swampy area from a low limestone hill to the west of the Ravensthorpe-Hopetoun Road (Frodsham 2007). The dominant land use surrounding Dunns Swamp is agriculture, particularly wheat/cattle and cereal cropping. Drainage into Dunns Swamp and its associated wetlands appears to be influenced by extensive alteration by human activities, and this is likely to have impacted on salinity and flooding levels (Frodsham 2008b). Additionally, the secondarily saline swamp to the north of Dunns Swamp is contributing to the increasing salinity of the lake (Frodsham 2007).

Dunns Swamp is situated 5-15 m above groundwater (less in the immediate vicinity of the wetland). The underlying groundwater has a salinity of 7,000–14,000 mg/L (Frodsham 2008b).

The water depth of the swamp is approximately 2 m in the centre, although higher water levels have been recorded in the past (Frodsham 2008b).

4.3. Water Quality

Salinity in Dunns Swamp in 2008 was more than twice that recorded in 1998 (Table 3). However, in the absence of an intervening salinity data series or depth data for both dates, the higher salinity in 2008 is difficult to interpret. The wetland was at least 60 cm deep in 1998 and at least 110 cm in 2008, but maximum water depth was not recorded on either occasion. Data collected by Green Skills (Frodsham 2007) reported a range of salinities at Dunns Swamp, from 4.83 TDS (g/L) in July 2000 (when Dunns Swamp had a depth of 2.0 m) to 165.53 TDS (g/L) in December 2003 (at a depth of 0.4 m).

Total soluble phosphorus concentration was fifteen times higher in 2008 than in 1998 and much higher than would be natural, suggesting that nutrient enrichment is an issue. However, total soluble nitrogen concentration remained the same and chlorophyll was lower in 2008, the latter possibly also related to the higher salinity. Data previously collected by Green Skills (Frodsham 2007) also indicated very high levels of nitrogen and phosphorous beyond normal tolerances of most natural systems. It was suggested such high levels may be attributed to run-off of these nutrients from upstream agricultural areas.

Table 3 – Water quality parameters at Dunns Swamp, as measured by the IAI RCM surveyas well as the Salinity Action Plan survey.

	SPS128 Sep 98	**RCM041 Nov 08**
pH	7.36	8.68
Alkalinity (mg/L)	53	280
TDS (g/L)	6.2	16
Turbidity (NTU)	1.5	0.6
Colour (TCU)	440	120
Total nitrogen (ug/L)		6,200
Total phosphorus (ug/L)		1,100
Total soluble nitrogen (ug/L)	1,900	1,900
Total soluble phosphorus (ug/L)	30	450
Chlorophyll (ug/L)	43	8
Na (mg/L)	1,700	4,540
Mg (mg/L)	220	514
Ca (mg/L)	130	219
K (mg/L)	59	147
Cl (mg/L)	3,000	7,730
SO_4 (mg/L)	620	1,060
HCO_3 (mg/L)	64	342
CO_3 (mg/L)	1	0.5

4.4. Benthic Plants

No benthic vegetation was recorded at Dunns Swamp during the 2008 IAI RCM survey.

4.5. Littoral Vegetation

The vegetation of Dunns Swamp consists of an inner zone (approximately 25 m wide) of mature *Melaleuca cuticularis* woodland to a height of 8 m. The understorey consists mainly of *Gastrolobium bilobum, Acacia subcaerulea, A. cyclops, A. crassiuscula* to 2-3 m with *Carpobrotus virescens* and *Threlkeldia diffusa* groundcover. The outer littoral zone has *Eucalyptus occidentalis* to 15 m which overlaps *Melaleuca cuticularis*, understorey species are *Labichea lanceolata, Spyridium globulosum, Rhagodia preissii, Dianella revoluta* and *Billardiera fusiformis* (Frodsham 2007). *Isolepis nodosa* has also been recorded (Department of Water 2008).

There are a number of dead *M. cuticularis* on the fringes of the lake, which is in part due to previous harvesting of wood for fence posts, and also may relate to periods of increased inundation (Department of Water 2008). Several weeds are also present at the wetland, including bridal creeper (*Asparagus asparagoides*), boxthorn (*Lycium ferocissimum*), scotch thistle (*Onopordum acanthium*), blackberry nightshade (*Solanum nigrum*) and fleabane (*Conyza* spp.) (Frodsham 2007).

A single vegetation transect was established on the northern side of Dunns Swamp within the riparian zone dominated by *Melaleuca* (Table 4).

Table 4 – Site attributes of the Dunns Swamp vegetation transect.

Datum		WGS84
Zone		51
Easting		236972
Northing		6242712
Length		50 m
Bearing		315
Wetland state		Full
Soil state (%)	Dry	80
	Waterlogged	20
	Inundated	0
Substrate (%)	Bare	20
	Rock	0
	Cryptogam	0
	Litter	20
	Trash	10
	Logs	0
Time since last fire		>20 years
Community condition		Impacted
Upper Stratum	Cover (%)	35.49021
	Height (m)	<8
Mid Stratum	Cover (%)	-
	Height (m)	-
Ground Cover	Cover (%)	46.96667
	Height (m)	<0.3

The transect was established within 10 m of the water's edge. Soil was waterlogged at the time of the survey. Vegetation was dominated by *Melaleuca cuticularis* low woodland (35.5% cover, <8 m tall) over an understorey comprised of various low open sedge, forb, shrub and grass species (47% cover, <0.3 m tall). Table 4 provides a complete list of plant taxa recorded on the transect.

Further from the edge of Dunns Swamp vegetation was dominated by a band of *Eucalyptus occidentalis* woodland.

Seven species of weeds were recorded on the transect. Approximately 70% of *Melaleuca cuticularis* trees were dead (Figure 5). Whilst seedlings of this species were abundant, none were taller than 10 cm. Due to the level of weed invasion and tree death, the overall community condition was considered 'impacted' (Table 10 in Appendix 1).

Figure 4 – Dunns Swamp vegetation transect.

Figure 5 – Looking south across Dunns Swamp, extensive *Melaleuca cuticularis* death is evident in the background.

Table 5 – Plant taxa recorded along the vegetation transect at Dunns Swamp (in order of stratum then dominance).

Genus	Species	Height (m)	Stratum[1]	Form
Melaleuca	*cuticularis*	8	U1	Tree
Cassytha	*melantha*	8	U1	Vine
Isolepis	*cernua*	0.1	G1	Sedge
Centrolepis	*polygyna*	0.1	G1	Forb
Tecticornia	sp.	0.3	G1	Chenopod
**Helichrysum*	*luteoalbum*	0.4	G1	Forb
Lachnagrostis	*filiformis*	0.1	G1	Grass
**Chenopodium*	*glaucum*	0.2	G1	Forb
Lobelia	*anceps*	0.2	G1	Forb
**Juncus*	*bufonius*	0.1	G1	Forb
**Spergularia*	*marina*	0.1	G1	Forb
Senecio	*multicaulis*	0.3	G1	Forb
**Polypogon*	*monspeliensis*	0.2	G1	Grass
Disphyma	*crassifolium*	0.1	G1	Forb
**Sonchus*	*oleraceus*	0.5	G1	Forb
**Vellereophyton*	*dealbatum*	0.3	G1	Forb

1 In an NVIS description, 'U' denotes the upper storey, 'M' the mid storey and 'G' the under storey (ground cover). Numerals to denote substrata from tallest (ESCAVI 2003).

* Introduced species.

According to the National Vegetation Information System (NVIS), the vegetation community may be described as (ESCAVI 2003):

U1+ ^*Melaleuca cuticularis*\tree\6\i; G1 ^*Isolepis cernua*, ^*Centrolepis polygyna*, *Tecticornia* sp., **Helichrysum luteoalbum*, *Lachnagrostis filiformis*\forb, samphire shrub, grass\1\i.

4.6. Aquatic Invertebrates

Nineteen macroinvertebrate families were recorded from Dunns Swamp during the Biological Survey of the South-west Agricultural Zone (SPS) (Pinder et al. 2004) whereas only nine were recorded in this project (Table 6). However, this reduced richness is a result of the increase in salinity in November 2008 (16 g/L) compared to (6.2 g/L) September 1998, although salinity had been 25 g/L in July 1998 (unpublished data). The species composition in 1998 (Table 7) largely reflects the brackish water salinity, with most species being freshwater animals tolerant of low salinity, although some halophiles (e.g. the *Diacypris*, *Daphnia* and *Brachionus*) were also collected.

In 2008, there was unlikely to have been more than one species in most of the families present, with the exception of the chironomid dipterans and possibly the beetle families, so macroinvertebrate species richness would not have been higher than about twenty-five.

Most species present are widespread and moderately common to common. The mosquito *Aedes nigrithorax* occurs in shallow wetlands with low salinity and abundant leaf litter but has not commonly been collected in the agricultural zone. Some of the orthoclads are uncommon but not geographically restricted.

Table 6 – Aquatic invertebrate diversity at Dunns Swamp as measured by the IAI RCM Project and by the Salinity Action Plan survey.

Diversity measure	**SPS128 Sep 98**	**RCM041 Nov 08**
Total invertebrate species richness	46	-
Macroinvertebrate species richness	38	-
Total invertebrate family richness	25	-
Macroinvertebrate family richness	19	9

Table 7 – Aquatic invertebrate composition at Dunns Swamp as measured by the IAI RCM Project and by the Salinity Action Plan survey.

Class	Order	Family	Lowest ID	SPS128 Sep 98	RCM041 Nov 08
Nematoda			Nematoda	1	
Rotifera	Ploimida	Brachionidae	*Brachionus plicatilis* s.l.	1	
Oligochaeta	Tubificida	Enchytraeidae	Enchytraeidae	1	
Arachnida	Acariformes		Oribatida	1	
	Parasitiformes		Mesostigmata	1	
	Acariformes		Trombidioidea	1	
Crustacea	Cladocera	Daphniidae	*Daphnia queenslandensis*	1	
		Moinidae	*Moina australiensis*	1	
	Ostracoda	Cyprididae	*Australocypris insularis*	1	
			Diacypris compacta	1	
	Copepoda	Centropagidae	*Boeckella triarticulata*	1	
		Cyclopidae	*Australocyclops australis*	1	
			Apocyclops dengizicus	1	
	Amphipoda	Ceinidae	*Austrochiltonia subtenuis*	1	3
Insecta	Coleoptera	Dytiscidae	*Allodessus bistrigatus*	1	
			Antiporus gilberti	1	
			Antiporus femoralis	1	
			Necterosoma penicillatus	1	
			Megaporus howitti	1	
			Hyderodes crassus	1	
			Dytiscidae		3

Class	Order	Family	Lowest ID	SPS128 Sep 98	RCM041 Nov 08
		Hydrophilidae	*Berosus discolor*	1	
			Berosus macumbensis	1	
			Hydrophilidae		3
		Staphylinidae	Staphylinidae	1	
	Diptera	Tipulidae	Tipulidae type A (SAP)	1	
		Culicidae	*Aedes camptorhynchus*	1	
			Aedes (Och.) *nigrithorax*	1	
		Ceratopogonidae	Bezzia sp. (not 1 or 2)	1	
			Culicoides sp.	1	
			Forcypomyia sp. 2 (SAP)	1	
			Dasyhelea sp.	1	
			Ceratopogonidae		3
		Psychodidae	Psychodinae sp. 2 (SAP)	1	
		Tabanidae	Tabanidae	1	
Insecta	Diptera	Dolichopodidae	Dolichopodidae sp. A (SAP)	1	
			Dolichopodidae sp. B (SAP)	1	
		Ephydridae	Ephydridae		3
			Ephydridae sp. 3 (SAP)	1	
			Ephydridae sp. 6 (SAP)	1	
		Muscidae	Muscidae sp. A (SAP)	1	
		Chironomidae	Chironomidae		1,2,3
			Procladius paludicola	1	
			Orthocladiinae sp. G (SAP)	1	
			Orthocladiinae sp. J (SAP)	1	
			Orthocladiinae sp. K (SAP)	1	
			Tanytarsus barbitarsis	1	
			Chironomus tepperi	1	
	Hemiptera	Notonectidae	*Anisops thienemanni*	1	
			Anisops gratus	1	
			Anisops baylii	1	
			Anisops sp.		1,2
	Odonata	Coenagrionidae	Coenagrionidae		3
	Trichoptera	Leptoceridae	Leptoceridae		3

* Numbers indicate the three habitats sampled:

1. Deep bare sediment
2. Deep bare sediment
3. Shallow edge with *Melaleuca*

4.7. Fish

No fish were sighted during the IAI RCM survey in November 2008. However, the Swan River goby (*Pseudogobius olorum*) has previously been recorded at Dunns Swamp in February 2000 (D. Morgan & A. Chapman, unpublished data, in Morgan *et al.* 2006; Frodsham 2007).

4.8. Waterbirds

Several waterbirds were observed at Dunns Swamp during sampling by the IAI RCM project (Table 8). The waterbirds of Dunns Swamp had previously been recorded during the biodiversity survey (SPS) undertaken by DEC in 1998. During their assessment of the Hopetoun Suite of Wetlands in November 2007, a total of fifty-six bird species were recorded, eighteen of which were waterbirds utilising Dunns Swamp (Frodsham 2008b). Additionally, a Red-necked Stint (*Calidris ruficollis*) had been sighted opportunistically by T. Frodsham (Green Skills) in December 2006 (Frodsham 2007).

Despite early signs of degradation of the littoral vegetation, Dunns Swamp and its associated wetlands provide valuable habitat that is not locally available elsewhere for a wide range of birds other than waterbirds. This is due to the *Eucalyptus occidentalis* and *Melaleuca cuticularis* woodlands, which have a structural and floristic complexity that is unique on the coastal plain (Frodsham 2008b).

Table 8 – Waterbirds observed at Dunns Swamp (brackets indicate number of birds sighted, where known).

Organisation/Project Duration of project		**Green Skills Nov 2007**	**DEC/SPS Sep 1998**	**DEC/RCM Nov 2008**
Common name	**Latin name**			
Australasian Grebe	*Tachybaptus novaehollandiae*			✓(20)
Australasian Shoveler	*Anas rhynchotis*	✓		
Australian Shelduck	*Tadorna tadornoides*	✓		
Australian White Ibis	*Threskiornis molucca*	✓		✓ (1)
Black-fronted Dotterel	*Charadrius malanops*	✓		
Black Swan	*Cygnus atratus*	✓		
Chestnut Teal	*Anas castanea*	✓		
*Common Greenshank	*Tringa nebularia*	✓		
Darter	*Anhinga melanogaster*			✓ (1)
Eurasian Coot	*Fulica atra*	✓		
*Great Egret	*Ardea alba*	✓		✓ (3)
Grey Teal	*Anas gracilis*	✓	✓ (3)	
Hardhead	*Aytha australis*			✓ (25-30)
Hoary-headed Grebe	*Poliocephalus poliocephalus*	✓		
Little Black Cormorant	*Phalacrocorax sulcirostris*	✓		
Little Pied Cormorant	*Phalacrocorax melanoleucos*	✓		
Musk Duck	*Biziura lobata*	✓	✓ (2)	
Pacific Black Duck	*Anas superciliosa*	✓		
Pied Cormorant	*Phalacrocorax varius*	✓		
Red-necked Avocet	*Recurvirostra novaehollandiae*	✓		
White-faced Heron	*Egretta novaehollandiae*	✓	✓ (2)	

* Listed under Migratory Bird Agreements JAMBA, CAMBA or ROKAMBA

4.9. Terrestrial Vertebrates

No frogs were sighted or heard, and no evidence of other terrestrial vertebrates was found during the IAI RCM sampling.

5. Threats to the Ecology of Dunns Swamp

The ambition for management at Dunns Swamp is to maintain those elements of the ecology that make it an ecologically significant wetland. The critical components of the ecology are the geomorphologic, hydrologic and water quality factors that make the lake a suitable stopover for migratory birds and refuge site for domestic waterbirds. These factors are the primary determinants of the lake's ecological character. They are influenced by and exert an influence on the vegetation communities that surround the water body, the aquatic invertebrate and benthic vegetation communities that inhabit it, and the threatening processes that face all of these. Also of importance are the elements of the system that contribute to its cultural and scientific value. These are the same as the above listed influences on the primary determinants of ecological character, with the addition of landscape amenity.

Threats to Dunns Swamp must be considered in relation to their likelihood of causing failure of the above management goal for the lake. 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 9. In summary, failure to achieve the management goal for Dunns Swamp is most likely to result due to the impacts of an altered hydrology, elevated salinity and compromised water quality caused by land clearing and surrounding agriculture and subsequent eutrophication. Weeds and potential semi-rural development are also significant threats, whilst the impacts of climate change should also be considered.

Dunns Swamp is a wetland of subregional significance within the Recherche IBRA subregion due to its importance to waterbirds (Comer et al. 2002). It is a breeding, feeding, roosting, moulting or nursery area, or refugia for animal taxa in accordance with criterion 3 in the Directory of Important Wetlands in Australia (Environment Australia 2001). Dunns Swamp has been described as being of good condition, with recovery expected in the short term with minimum intervention (Comer et al. 2002).

Land clearing

The dominant land use surrounding Dunns Swamp is agriculture, predominantly wheat/cattle and cereal cropping. Increased run-off from this cleared land has caused waterlogging and extended the residence times of flooding at Dunns Swamp. This, coupled with salinisation, has resulted in Dunns Swamp exhibiting stress in the form of large-scale mortality of fringing paperbark (*Melaleuca cuticularis*). Intensive rainfall events may also be contributing to the problem (Frodsham 2007, 2008a). In addition, a swampy area north of Dunns Swamp has turned saline and is contributing to increasing salinity of the lake. Paperbark deaths are abundant and apparent here (Frodsham 2007).

Chapman (2007a) states that interpretation of regrowth, morbidity and deaths of *M. cuticularis* is likely to be instrumental in managing the wetland. Recent and ongoing clearing activity to expand the agricultural land area and intensified stocking will further increase downstream pressures (sediment transport, erosion and vegetative changes) (Frodsham 2008a).

Eutrophication

Pollution has been identified as a threatening process at Dunns Swamp (Comer et al. 2002). The dominant land use surrounding the lake is agriculture, a main contributor of pollutants. As the hydrology of Dunns Swamp is reliant on surface drainage from surrounding areas, excess nutrient input poses a threat to the wetland's ecology. The two major nutrients leaching from agricultural lands are phosphorus and nitrogen. Imbalances of these nutrients may lead to algal blooms or favour introduced aquatic species (Frodsham 2007). Dunns Swamp is a coloured wetland at 440 TCU in 1998 and 120 TCU in 2008 as recorded by DEC. A high colour content

can help to reduce algal blooms in wetlands by limiting light penetration through the water column. However, considering the high nitrogen and phosphorous levels at Dunns Swamp it is unlikely that the high colour of the water would be sufficient to prevent algal blooms.

Weeds

Weeds are not considered a high priority threat to the Dunns Swamp area (Frodsham 2008a), although several weeds are present at the wetland. Weeds previously recorded at Dunns Swamp include bridal creeper, boxthorn, scotch thistle, blackberry nightshade and fleabane (Frodsham 2007). While these were not identified during the IAI RCM survey, seven additional species were recorded. This suggests a high degree of weed infestation and has resulted in the condition of the vegetation being classed 'impacted' (Table 10 in Appendix 1). Weeds may inhibit the generation of native seedlings and affect nutrient cycling (Hopkinson 2003). The risk of fire may be heightened, particularly in the case of annual and perennial grasses (Frodsham 2007). In managing for weeds, great care needs to be taken to avoid or minimise activities that lead to the baring of soil or disturbance of the soil profile.

Residential development

A semi-rural residential subdivision has been proposed adjacent to, and north of, Dunns Swamp. This subdivision is currently proposed and pending approval. If residential development were to proceed in this sub-division, there may be potential impacts on the hydrology, water quality and fauna of Dunns Swamp. High waterbird use of the wetland will be under potential pressure from predation by domestic cats or dogs. Drainage to the Dunns Swamp system may also be affected by increased sediment and nutrients loads. The spread of weeds may also be facilitated by increased human visitation of the swamp as well as through garden escapes.

Climate Change

Climate change modelling conducted by the CSIRO predicts that rainfall received by the south-west of WA will decline by as much as 20% by 2030 and 60% by 2070, relative to 1990 figures (EPA 2007). Rainfall is expected to decline by approximately 5-10% in the Dunns Swamp area. Average annual temperatures are also expected to rise across Western Australia (EPA 2007). The hydrology of Dunns Swamp is reliant on precipitation and drainage from surrounding areas. A reduction in rainfall and increase in evaporation caused by climate change could result in changes to the overall hydrology and ecology of the lake. However, the impact of such changes is considered negligible, particularly considering the current impacts of prolonged inundation.

Table 9 – Threat assessment for Dunns Swamp.

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

Goal: to maintain the geomorphology and hydrology of Dunns Swamp, thus ensuring it remains a suitable drought refuge and migratory stopover for waterbirds and retains its scientific values.

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	50	20	Altered hydrological regime and salinisation are the major threats facing Dunns Swamp. They are the likely causes for large-scale death of fringing paperbark. This can lead to the disappearance of waterbird habitat.
	Carbon cycle and climate change	5	5	Rainfall is expected to decline by approximately 5-10% in the Dunns Swamp area by 2070. Average annual temperatures are also expected to rise across WA. However, the impacts of climate change are expected to be negligible for Dunns Swamp.
Impacts of introduced plants and animals	Environmental weeds	20	5	Several weeds have been recorded at the wetland including the environmental weed, bridal creeper.
	Herbivory, wallowing and trampling by introduced species	0	0	No impacts evident.
Impacts of problem native species	Overgrazing by native species	0	0	No impacts evident.
Impacts of disease	Plant pathogens	0	0	No impacts evident.
Detrimental regimes of physical disturbance events	Fire regimes	10	5	The vegetation of Dunns Swamp is susceptible to fire. However, fire management should be an achievable goal for this site.
	Drought	0	0	The main threats to Dunns Swamp involve increased waterlogging and prolonged residence times of flooding. Drought is unlikely to impact on Dunns Swamp.

Threat category	Management issue	Probability (%) that threat will cause goal failure with:		Assumptions underlying initial probability assessment and explanatory notes
		Existing management	Extra management	
	Flood	10	5	The main threats to Dunns Swamp involve increased waterlogging and prolonged residence times of flooding. This has contributed to paperbark death.
Impacts of pollution	Herbicide, pesticide or fertiliser use and direct impacts	20	5	The dominant land use for Dunns Swamp is agriculture. The lake's hydrology is dependent on surface drainage. As such, Dunns Swamp is susceptible to pollution.
Impacts of competing land uses	Recreation management	1	0	Recreational usage of Dunns Swamp is low impact and unlikely to have any deleterious impacts.
	Nutrient enrichment of water body	20	5	Nutrient enrichment may result from pollution from surrounding agricultural areas.
	Urban and industrial development	20	5	Surrounding land is extensively cleared. Further land clearing will exacerbate the issues facing Dunns Swamp. A residential (semi-rural) development is planned adjacent to Dunns Swamp.
	Consumptive uses	0	0	There re no known consumptive uses of Dunns Swamp in the present day.
	Illegal activities	0	0	No impacts evident.
	Mines and quarries	0	0	No mineral potential.
Insufficient ecological resources to maintain viable populations	Habitat, genetic exchange	1	1	Dunns Swamp is part of a complex of wetlands and is connected to areas of near-natural environment. Populations are likely to self-supporting in this setting. Off-site impacts on migratory birds could potentially reduce their population size to unsustainable levels, but this could not be addressed at a site level.

6. Knowledge Gaps and Recommendations for Future Monitoring

The hydrology of Dunns Swamp needs further study. Groundwater studies may be of value to better understanding the hydrology of the area, especially in connection with ascertaining any groundwater relationship between the wetlands in the 'Triple Swamps', which includes Dunns Swamp. Regular water depth and salinity measurements of the swamp would also help to determine aspects of the hydrology such as the permanence of water and evaporation rates, and allow comparison over a shorter temporal scale. This would help interpret natural variability. The effects of nearby land development on the drainage to Dunns Swamp should also be investigated.

More information is required on the full extent and effect of weeds at Dunns Swamp. Some significant weeds, including a listed environmental weed (bridal creeper), have previously been recorded at Dunns Swamp. However, an entirely different suite of weeds was recorded by the IAI RCM survey. This is possibly due to a difference in survey location. A systematic search of weeds around the perimeter of the wetland is recommended. Any weed infestations should be mapped, monitored and appropriately managed.

Future monitoring of fauna could attempt to monitor presence and abundance of fish, such as the Swan River Goby, and other vertebrate taxa.

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Appendix 1

Table 10 – Overall Vegetation Community Condition Rating as adapted from Thackway and Lesslie (2005). Shading indicates the condition of Dunns Swamp.

Overall Community Condition Rating					
	0	1	2	3	4
	RESIDUAL BARE	**NATURAL**	**IMPACTED**	**DEGRADED**	**REMOVED/REPLACED**
Community Condition Class	Areas where native vegetation does not naturally persist	Native vegetation community structure, composition and regenerative capacity intact - no significant perturbation from land management practices	Native vegetation community structure, composition and regenerative capacity intact but perturbed by land management practices	Native vegetation community structure, composition and regenerative capacity significantly altered by land management practices	Species present are alien to the locality and either spontaneous in occurrence or cultivated. Alternatively, vegetation may have been removed entirely
Regenerative Capacity	Natural regenerative capacity unmodified - ephemerals and lower plants	Regenerative capacity intact. All species expected to show regeneration are doing so	Natural regenerative capacity somewhat reduced, but endures under current/past land management practices	Natural regenerative capacity limited and at risk due to land management practices. Rehabilitation and restoration possible through removal of threats	Regenerative potential of native vegetation has been suppressed by ongoing disturbances. There is little potential for restoration
Vegetation Structure	Nil or minimal	Structural integrity of native vegetation is very high. All expected strata, growth forms and age classes are present	Structure is altered but persists, i.e. some elements of a stratum are missing	Structure of native vegetation is significantly altered, i.e. one or more strata are missing entirely	All structural elements of native vegetation are missing or highly degraded
Vegetation Composition	Nil or minimal	Compositional integrity of native vegetation is very high. All species expected at the site are present	Composition of native vegetation is altered. All major species are present, although proportions may have changed. Some minor species may be missing	Significant species are missing from the site and may have been replaced by opportunistic species. Loss of species affects structure of vegetation	Native vegetation removed entirely +/- replaced with introduced species

Appendix 2

Plant specimens submitted to the Western Australian Herbarium:
Chenopodium glaucum (RCM041-R1-06)

Table 11 – Herbarium Records for Dunns Swamp.

Search Coordinates: NW corner 33.9195°S, 120.1497° E; SE corner 33.9286°S, 120.16°E

Family	Species	Alien	Cons. Status
Aizoaceae	*Disphyma crassifolium* subsp. *clavellatum*		
Amanitaceae	*Amanita* sp.		
Asteraceae	*Rhodanthe citrina*		
Caesalpiniaceae	*Labichea lanceolata*		
Dasypogonaceae	*Lomandra rupestris*		
Epacridaceae	*Andersonia parvifolia*		
Goodeniaceae	*Velleia trinervis*		
Haemodoraceae	*Conostylis seorsiflora* subsp. *seorsiflora*		
Lobeliaceae	*Lobelia anceps*		
Loranthaceae	*Nuytsia floribunda*		
Menyanthaceae	*Villarsia parnassiifolia*		
Mimosaceae	*Acacia subcaerulea*		
Myrtaceae	*Astartea* sp. Jerdacuttup (A. Strid 21898)		P1
Myrtaceae	*Beaufortia micrantha*		
Myrtaceae	*Calothamnus quadrifidus*		
Myrtaceae	*Darwinia diosmoides*		
Myrtaceae	*Darwinia vestita*		
Myrtaceae	*Kunzea preissiana*		
Myrtaceae	*Melaleuca carrii*		
Myrtaceae	*Melaleuca* sp.		
Myrtaceae	*Verticordia inclusa*		
Olacaceae	*Olax phyllanthi*		
Papilionaceae	*Callistachys* sp. south-coast variant (M. Carter 180)		
Papilionaceae	*Kennedia nigricans*		
Portulacaceae	*Calandrinia* sp. Kenwick (G.J. Keighery 10905)		
Proteaceae	*Banksia speciosa*		
Proteaceae	*Lambertia inermis* var. *drummondii*		
Proteaceae	*Stirlingia anethifolia*		