

CATCHMENT REPORT CARD

Lake MacLeod and the Northern Ponds

Caring for our Country funded Project
Carnarvon IBRA Region 2009 - 2011

November 2011



CARING
FOR
OUR
COUNTRY



Department of
Agriculture and Food


Rangelands NRM
Western Australia

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Report prepared by Ecologically Sustainable Rangelands Management Program, 2011

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Acronyms

CfoC	Caring for our Country
CFI	Carbon Farming Initiative
CMP	Catchment Management Plan
DAFWA	Department of Agriculture & Food WA
DEC	Department of Environment & Conservation (formerly CALM)
DIWA	Directory of Important Wetlands of Australia
DPI&F	Department of Primary Industries & Fisheries
ECU	Edith Cowan University
EMS	Environmental Management System
EMU	Ecosystem Management Understanding
EPA	Environmental Protection Agency
EP Act	Environmental Protection Act 1994
ESRM	Ecologically Sustainable Rangeland Management program
EV(s)	Environmental Value(s)
IBRA	Interim Bio-geographic Regionalisation of Australia
LCDC	Land Conservation District Committee
LMNP	Lake MacLeod & Northern Ponds
MAG	Management Action Group (Lake MacLeod)
NHT	Natural Heritage Trust
NHT 2	Natural Heritage Trust [Round 2]
NLP	National Landcare Program (until 2005)
NROCA	Ningaloo Reef Outback Coast Association
NSDO	Ningaloo Sustainable Development Office
PMP	Property Management Plans
NHT	Natural Heritage Trust
RLF	Regional Landcare Facilitator
RNRMWA	Rangelands Natural Resource Management (NRM) WA
RTDSL	Rio Tinto Dampier Salt Ltd
SC	Shire of Carnarvon
SUG	Shire of Upper Gascoyne
UCL	Unallocated Crown Land

Executive Summary

In 2005 the Rangelands Natural Resource Management (NRM) co-ordinating group compiled a Regional Strategy document outlining the management of the natural resources of WA Rangelands. The Gascoyne-Murchison was highlighted as a potential future investment opportunity and a range of actions at the catchment scale directly related to the management of up-stream impacts on Lake MacLeod were identified. This document highlights these recommended actions and notes what has been achieved thus far on committing to the recommendations highlighted in the regional NRM Plan.

Rangelands NRM delivered a 2 year project through the Ecologically Sustainable Rangelands Management (ESRM) Program. The ESRM team, hosted by Department of Agriculture & Food WA (DAFWA), worked together with the land managers and stakeholders of the catchment to identify best practice techniques. The project team also assisted land managers to develop Property Management Plans (PMPs) which facilitated on-ground works with ecological benefits to the overall catchment, specifically the Lake MacLeod and the Northern Ponds area.

This report acknowledges current and previous works conducted throughout the catchment and also identifies the key threatening processes and issues facing the catchment. Strategies to manage and reduce the effects of these processes and concerns are also identified.

A synopsis of the overall health of the catchment nourishing the Lake and the Ponds, including its assets, threats and issues as expressed by stakeholders and previous research has been outlined throughout this document. It investigates the physical, historical and social elements that have resulted in its present status. To date, available information relating to the catchment and how it functions has been fragmented. The intention of this document was to combine all information available relating to the catchment into one accessible document.

This Catchment Report Card has been designed to outline the current status of the catchment with a specific emphasis on current land use and land management practices (specifically pastoral). The Report Card identifies recommendations for future management and developments required in order to improve water quality, vegetation health and sustainable agricultural practices in the region.

The immediate outcomes of the ESRM operated Lake MacLeod Project included:

- **14 Pastoral Businesses** (covering an area of 24,624km²) completed Property Management Plans (highlighting ecological baselines, productivity, financial and social outcomes)
- **66km of riparian fencing** designed for total grazing control to reduce erosive impacts in sensitive land systems
- **2 Total Grazing Management Yards** designed to cater for feral goats, and wild livestock
- **2 Watering Points Relocated** from sensitive riparian land systems
- **7 ha of Intensive Landscape Rehabilitation Works** including control and eradication of *Cylindropuntia* cactus species, mesquite species and organic buffering of surface water flow
- Development of the **Lake MacLeod & Northern Ponds Catchment Report Card 2011**

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1.0 Introduction

The Lake MacLeod & Northern Ponds Catchment Report was developed for Rangelands NRM as a completion of Milestones required by the *Caring for our Country* Program. The program operated from November 2009 until November 2011. The Ecologically Sustainable Rangeland Management (ESRM) Program worked together with representatives of Land Conservation District Committees (LCDC's), Local Management Action Groups, local pastoral and mining businesses, Local Government officers and the community to produce this document.

The Caring for our Country Business Plan of 2009 identified Lake MacLeod as being:

...“a regionally significant Lake of international importance”...

The Business Plan also highlighted various focus points for investment:

“...a priority land area within the Carnarvon Basin is the Lake MacLeod/Ningaloo Coastline (Lyndon / Minilya catchments)”..

... “Improving land management practices and HCVAE¹ within the Carnarvon Basin”.

The aim of this document is to:

- highlight and identify the current status of works conducted throughout the catchment leading to improved land management practices;
- provide future recommendations for management of the Lake MacLeod catchment;
- meet reporting obligations as determined by the *Caring for our Country* funding scheme

Using well established participatory and community development practices the project was designed to promote further development of changed farm practices within key coastal environments and critical aquatic habitats in the Carnarvon (IBRA²) Bioregion. The main focus was aimed at implementing sustainable invasive species control (weeds and animals), reduced sedimentation into the main waterways and an increased awareness and commitment to natural resource management practices.

The project worked within the identified target region to:

- Facilitate the development and implementation of pastoral property management plans linking ecology, livestock and business;
- Improve soil stability and reduce wind erosion;
- Improve the condition of high priority native vegetation and riparian communities;
- Coordinate integrated invasive species (WoNS³) control;
- Deliver targeted incentives to reduce wind and water erosion in priority zones; and
- Offer structured and professional support to rangeland managers to enable them to more adequately deal with complex land management and sustainable agricultural production issues of their region

¹ HCVAE High Conservation Value Aquatic Environment

² IBRA - Interim Biogeographic Regionalisation of Australia

³ Weeds of National Significance

2.0 Background

The Lake MacLeod catchment covers an area of approximately 52,682km². The coastal lake wetland itself covers an area of 2,072km² and is separated from the Indian Ocean by coastal dunes and outcrops of limestone rock. At the furthest points, Lake MacLeod is 110km long and 40km wide.

The lake is a large evaporate pan and recognised wetland in the Carnarvon area and has regionally significant environmental, social and cultural values. The lake has a Conservation Category status and is considered highly significant for migratory bird species.

The lake sits within the Carnarvon IBRA (Interim Bio-geographic Regionalisation of Australia) region. The majority of the Lake MacLeod catchment lies within the Shire of Carnarvon and the Shire of Upper Gascoyne, with a small section being located within Shire of Exmouth (see Appendix 1).

The land tenure of Lake MacLeod is registered as Unallocated Crown Land, with Mining Leasehold for commercial salt production in the southern half of the lake. The surrounding catchment area is Pastoral Leasehold utilised predominantly for grazing and tourism.

The entire region described within this catchment report is situated within the Gnulli Native Title Claim area (WC97.28, WAD6161/98).

Land use activities occurring throughout the whole catchment area can impact on the health of the lake system. An integrated catchment management approach allows all of the stakeholders positioned within the catchment area to be involved in the creation and implementation of the best practice management of their landscape. The geology, geomorphology, hydrology, biological and physical characteristics of the catchment affect the processes that occur throughout the catchment area and directly influence the physical and chemical characteristics of the receiving waterways.

In June 2009, Rio Tinto Dampier Salt Ltd (leaseholders of the lake bed of Lake MacLeod) hosted a stakeholder workshop and Lake and Northern Ponds tour in order to identify the assets and threats within the catchment area. Following this workshop a Management Action Group (MAG) was established with representatives of all stakeholders involved. This group continues to meet annually to update the evolving MAG document for the best management of Lake MacLeod and the Northern Ponds. This group (co-ordinated by Rio Tinto staff) aims to be a dynamic group which can respond to the shifting priorities, challenges and opportunities presented by all stakeholders of the region. The regular revision and modification over time will reflect the dynamic partnerships evident between our regional, yet nationally significant, environment and industries.

In November 2009, Rangelands NRM commenced a two year Project, delivered by the ESRM Program and funded through the Caring for our Country initiative to *“Improve Land Management Practices within the Carnarvon IBRA region – specifically impacting Lake MacLeod and the Northern Ponds.”*

Throughout this document the term ESRM refers to the Program funded by RNRM – Ecologically Sustainable Rangelands Management - but also refers in a broader sense, to the sustainable management of the economic, environmental, social and cultural base of the rangelands.

2.1 The ESRM Process

The Ecologically Sustainable Rangeland Management Program has been functioning since 2007. Initially funded by Natural Heritage Trust (NHT) and more recently Caring for our Country (CfoC) the program has operated throughout the Gascoyne, Murchison and Pilbara regions of WA's rangelands. The ESRM team has worked with over 80 pastoral businesses, covering an area of 152,000km². (Please refer to Appendix 2 for a map of ESRM properties)

ESRM is an integrated project tool that streamlines delivery of information, research & development, training, investment and targets funding to pastoral properties and rangelands communities. ESRM works closely with pastoralist driven groups aimed at developing ecologically sustainable, profitable and respected pastoral communities.

Experience has shown that a well implemented ESRM plan can lead to significantly better land management which not only improves productivity but also produces positive NRM outcomes. The ESRM process enables land managers to receive support to develop whole of property plans which include mechanisms for reporting on rangeland condition, implementing rehabilitation works, managing threats, and coordinating landscape and catchment approaches to maintain and improve vegetation cover. The focus is on industry and community driven approaches to sustainable land management, based on maintaining the integrity of ecosystems in all property planning and actions.

Building trust with land managers is the key focus in any natural resource management related activities and ESRM has built and maintained very strong relationships with a bulk of the land managers of the region. Many land managers have preconceived ideas about NRM projects in the region due to experiences in the past, believing that funded projects will work in an area for a couple of years then desert them. Another common opinion is that there are unrealistic restrictive conditions placed on NRM funding. It takes time to break through these ideas and to build engagement in the project. The ESRM team works consistently with industry leaders to encourage best practice activities and ensure they continue throughout the region.

The ESRM Philosophy is based on the EMU (Ecosystem Management Understanding) model of property planning. The EMU Program was funded by NHT from 2002-2005 and worked with numerous properties throughout the Goldfields, Murchison and Gascoyne region. EMU is a holistic land management approach designed on reading and understanding how the landscape captures, retains and utilises rainfall. Once the landscape linkages have been identified and 'eyes have been opened' re-alignment of certain practices begins through landscape rehabilitation projects, adjustment of grazing practices and resource utilisation.



Representatives from Rio Tinto Dampier Salt, Lyndon LCDC, Gascoyne Catchments Group, Rangelands NRM, ESRM and neighbouring pastoral properties visiting the Northern Ponds in April 2009.

2.2 The Lake MacLeod & Northern Ponds Catchment Area

The Lake MacLeod & Northern Ponds catchment is located within the Carnarvon Basin. The southern most boundary of the lake is located approximately 30km to the north of the township of Carnarvon (see Figure 1). The lake has an area of approximately 2,072 km² and depends on seasonal rainfall and river flows as well as geo-tidal activity to replenish surface water. The Northern Ponds nestled on the western side of the lake form a permanent salt water lagoon supported by tidal flows connected by solution tubes to the Indian Ocean.



Figure 1: Map of the Lake MacLeod Catchment within the Carnarvon Basin (DAFWA 2010)

2.2.1 Climate

The climate of the Lake MacLeod catchment is classified as semi-arid. Rainfall is highly variable with most rainfall associated with cyclonic events in the summer and troughs in the winter.

Most of the rainfall within the catchment occurs during the months of February, May, June, and July. Maximum summer temperatures are high (mid 30s to low 40s) and maximum winter temperatures are mild (high 20s).

Table 1: Temperature and evaporation data for the township of Carnarvon

Month	Mean max temp (°C)	Av. days > 35 °C	Highest day on record	Mean min temp (°C)	Lowest day on record	Pan evaporation (mm/day)
Jan	31.3	5	47.7	22.4	15.9	7.0
Feb	32.7	7	46.9	23.3	17.1	7.0
Mar	31.5	6	45.3	21.9	13.4	5.6
Apr	28.7	2	41.1	19.0	9.5	4.2
May	25.7	0	36.2	14.8	6.1	3.6
Jun	23.2	0	31.8	12.4	3.6	2.9
Jul	22.0	0	30.7	11.0	2.4	3.0
Aug	22.6	0	31.6	11.6	3.5	3.3
Sep	24.2	0	38.4	13.9	5.9	4.0
Oct	25.6	1	42.4	16.3	8.8	4.7
Nov	27.2	2	43.4	18.5	10.7	5.3
Dec	28.9	3	45.4	20.4	14	6.1
Year	27.0	—	—	17.1	—	4.7

The rainfall data presented is from *Rainman Streamflow*™ which utilises Bureau of Meteorology data for an average of various stations throughout the catchment collected from 1898 - 2011. The annual median rainfall for the whole Lake MacLeod catchment region is approximately 230 mm (Appendix 2: Chart 1 & 2).

The rainfall for the whole catchment area is generally most **reliable during the months of June and July**. Summer rainfall is associated with localised thunderstorms and cyclonic events. Rainfall is therefore variable across the region (due to the localised nature of thunderstorms). Cyclonic events usually result in excessive falls (in excess of 100mm) across large areas. Rainfall events of more than 30 mm in June (the most reliable month) occurs 50% of the time.

High summer evaporation rates (Table 1) reduce the effectiveness of small rainfall events in the summer months. There is high variability in rainfall from year to year. **September, October, November and December** are the least reliable/likely rainfall months.

Lake MacLeod records an average evaporation (of fresh water) of 3,250mm/year with an average direct rainfall of only 220mm per year.

Rainfall data, median rainfall patterns and historical average data can be found in Appendix 3.

2.3 Geology

2.3.1 Catchment Geology

The Lake MacLeod catchment is nestled within the broader Carnarvon Basin. The Carnarvon Basin is an epicratonic⁴ faulted and folded basin covering over 650,000 km². The Onshore Carnarvon Basin covers 115,000 km² and the Offshore covers approximately 535,000 km² with water depths up to 3,500 metres. The Southern Carnarvon Basin is founded on almost 7 km deep Palaeozoic sedimentary rocks (250-540 million years). These foundations have weathered and buckled through time to display the surface terrain we see today. Some of the world's oldest known exposed landscapes can be found within the Carnarvon Basin (aged 3 billion + years).

Lake MacLeod is positioned on the eastern half of the Southern Carnarvon Basin with the broader catchment reaching the eastern-most reaches of the Basin boundary. There are numerous fault lines within the far eastern half of the basin, none of which pass directly through the geology underlying Lake MacLeod. (See Figures 2 & 3).

The geological history of the Carnarvon Basin has been dominated by the sporadic regressions and transgression of the sea and a complex tectonic setting from the Silurian (443mya) to the Tertiary (2.6mya). In the early stages of deposition of sediments, the area we now know as the Carnarvon Basin was connected to the supercontinent of Gondwana and was drifting southward in a relatively stable warm ocean environment. Over time the Basin has witnessed mountain building phases, and has seen them worn down to produce more sediment through the presence of glaciers and hyper arid phases.

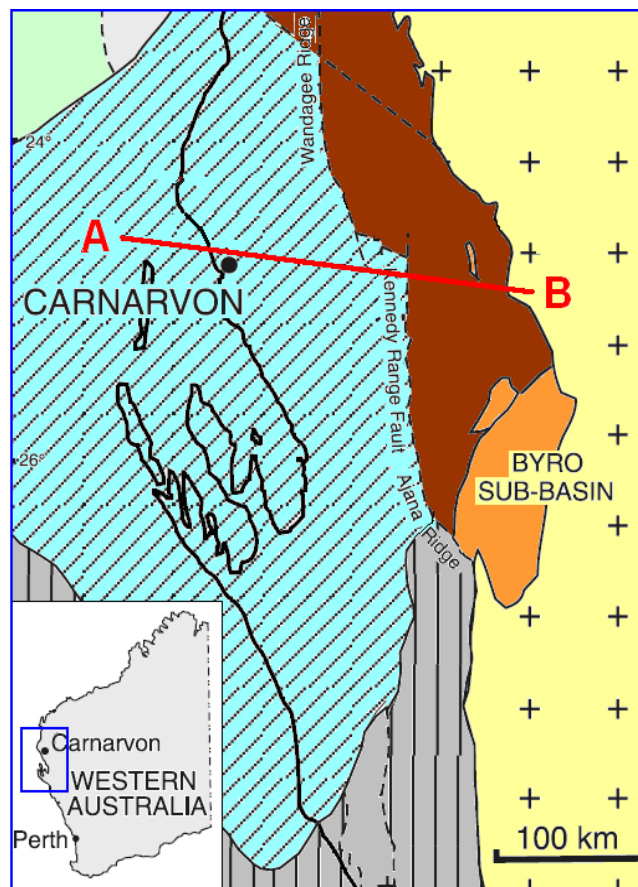


Figure 2: Underlying Geology of the Carnarvon Basin formation and the Lake MacLeod Catchment

⁴ A basin lying on the edge of a continental crust

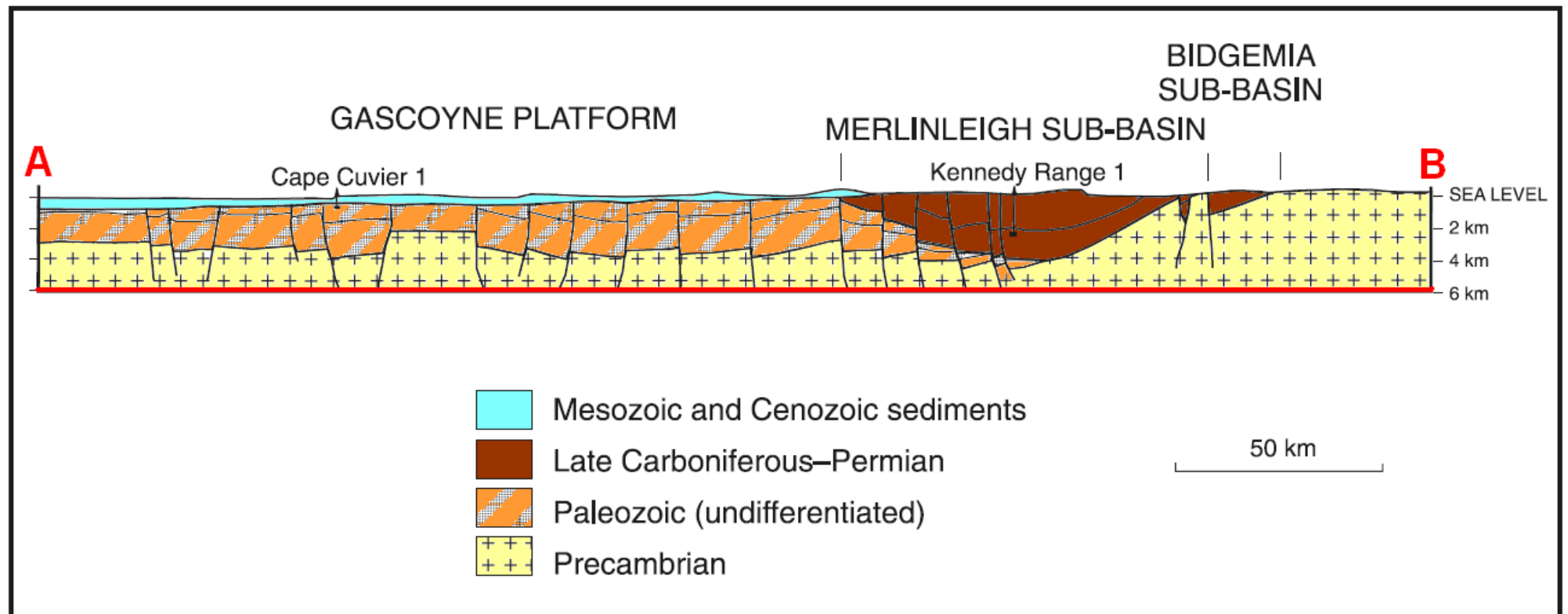


Figure 3: Geological Timescale cross section of Lake MacLeod Catchment area as referred to in Figure 3 as A-B line. (Image courtesy the Australian Journal of Earth Sciences 2002).

2.3.2 Lake Geology

Lake MacLeod's lake bed is a former sea embayment which was separated from the Indian Ocean (at the southern end) by the movement of sand dunes initiated by earlier glacial ice ages and disruptive lifting and rifting activities of fault lines to the east of the lake. The western shelf of the lake catchment is characterised by the steep "upland limestone" cliffs recognised at Quobba, Red Bluff and Gnaraloo, remnants from materials deposited when ocean levels were higher and oceans were cooler and shallower. The north-eastern section of the lake also holds remains of limestone ridges in the Giralia Range whilst directly north and south-east of the lake are the alluvial flats replenished by Gascoyne, Minilya, Lyndon and Cardabia creeks, rivers and their tributaries.

The lake is regarded as an evaporate lake also known as a Salina (hyper saline pool with no outlet). Catchments with no surface water outlet are referred to as 'internally draining' (see Figure 4). All water entering an internally draining catchment such as Lake MacLeod must leave by both evaporation and transpiration or by drainage to the groundwater system. Evaporation of Lake MacLeod has been recorded to exceed 3,000mm per year and results in excessive salt accumulation. It is with this resource that the mining of salt and gypsum began in the 1960s by Texada and is today owned and operated by Rio Tinto Dampier Salt..

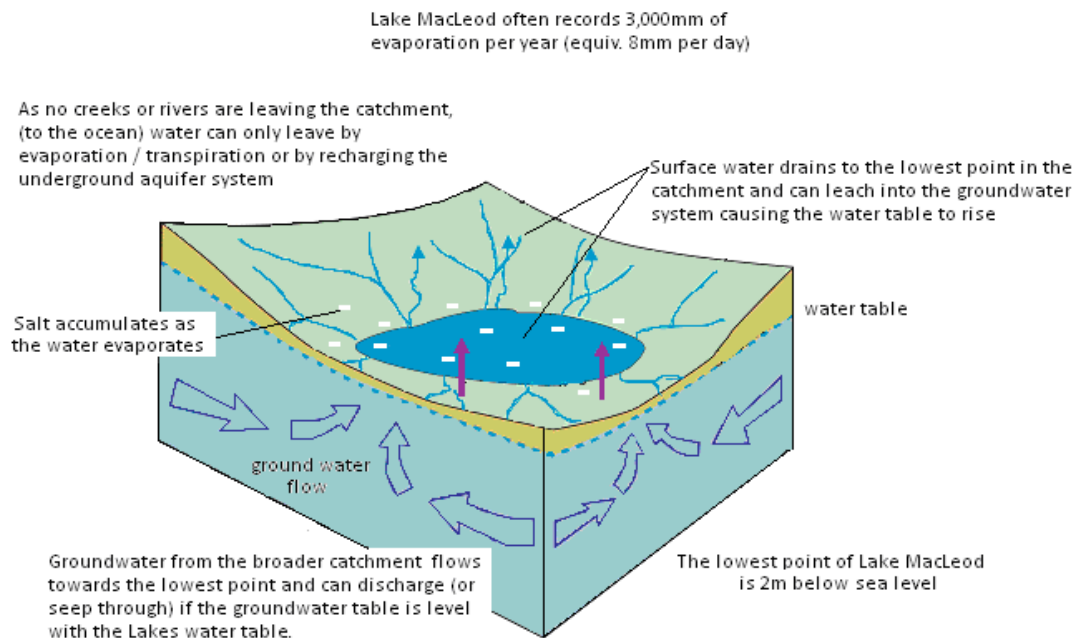


Figure 4: Diagram of a typical internal drainage system.

Base image design courtesy of www.naturalresources.nsw.gov.au

Paleontologically speaking, modern scientific methods of carbon dating and rich fossil evidence indicate vast differences in landscape patterns and climate to produce the catchment we see today. Very rich marine fossil deposit sites (mostly including sea lilies, sea stars) have been found surrounding the lake and associated catchment indicates the once living organisms flourished in cool but warming waters of a storm-swept coastal shelf, emerging from a major ice age some 280 million years ago. Deposited within the sandstone rich Giralia Range 120m above sea level (skirting Lake MacLeod to the north-east) is one of the world's richest deposits of ammonites and also holds the remains of 95 million year old Shark vertebrae and teeth from a newly discovered species.

2.4 Geomorphology

The surface of the Carnarvon Basin slopes very gently towards the coast and is broadly characterized by low relief, large gently undulating sand plains and open drainage, with the internally draining Lake MacLeod being the only exception within the whole basin area.

There are various topographical elements within the Lake MacLeod catchment area. The elevated areas including the Giralia Range (a limestone ridge pinching the catchment area which has been weathered by the Lyndon River system) and the Ridge of the Kennedy Range block.

The Basin can be divided into several geomorphic districts which outline the combinations of relief and shape which reflects the evolution of the landscape of the Basin. Since descriptions of the landscape processes began in the Carnarvon Basin region in the 1930s (by Jutson) there have been many alterations and additions to the categories of land types, but most continue to agree that the region can be divided into Erosional surfaces and Depositional surface. Within the Erosion surface the dominant landscapes include: Plains, Plains and Hills, Hills. The Depositional surface type can be divided into Aeolian⁵, Fluvial⁶, Lacustrine⁷ and Marine⁸ (Payne). Lake MacLeod belongs to the surface type category of Lacustrine and Marine.

Lake MacLeod geomorphology as described by Payne et al. 1980:

“Lacustrine and marine forms [including Lake MacLeod and Saline Plains District (3,935km²)] are district of flat saline plains located on the periphery of Lake MacLeod, and is subject to regular inundation.

The shape of Lake MacLeod was largely determined by the gently dipping Tertiary anticlines which flank it to the east and west. Subsequent marine deposition, erosion and Lake aeolian deposition have formed the basis for three land-systems, McLeod, Chargoo and Warroora.

The McLeod landsystem of highly saline plains, tidal mudflats with low sandy banks is based predominantly on lake bed deposits of gypsiferous sand with areas of shallow marine deposits (calcarenite) and Aeolian calcareous sand. Broad alluvial plains and lacustrine deposits of bedded gypsum with clay, silt and sand characterise the Chargoo landsystem, located predominantly to the north of Lake MacLeod. Slightly higher in the profile, the Warroora landsystem of flat saline plains with sluggish drainage tracts is located throughout the district. It is based on marine deposition with small areas of sand displaying an Aeolian origin.”

Given the ancient nature of the whole Carnarvon Basin region, the underlying geology has been exposed to millennia of extreme climatic elements. Resulting from such prolonged exposure, the physical limitations of the soils in this highly weathered landscape include: shallow, weak structured soils with low water holding capacity and highly erodible, and in many areas chemical limitations (lack of nutrients and excessive salt levels).

⁵ Aeolian – activity of wind to erode, re-shape, transport and deposit geological material

⁶ Fluvial – activity of water to erode, re-shape, transport and deposit geological material

⁷ Lacustrine – pertaining to anything related to Lake activity

⁸ Marine – pertaining to anything relating to ocean activity

2.5 Hydrology

The catchment (including the Lyndon and Minilya River systems) originates 200km east of the Lake and the overall catchment equates to an area of approximately 52,700km² (not including the Gascoyne River catchment which is known to reach the Lake MacLeod wetland system only in times of excessive flooding events).

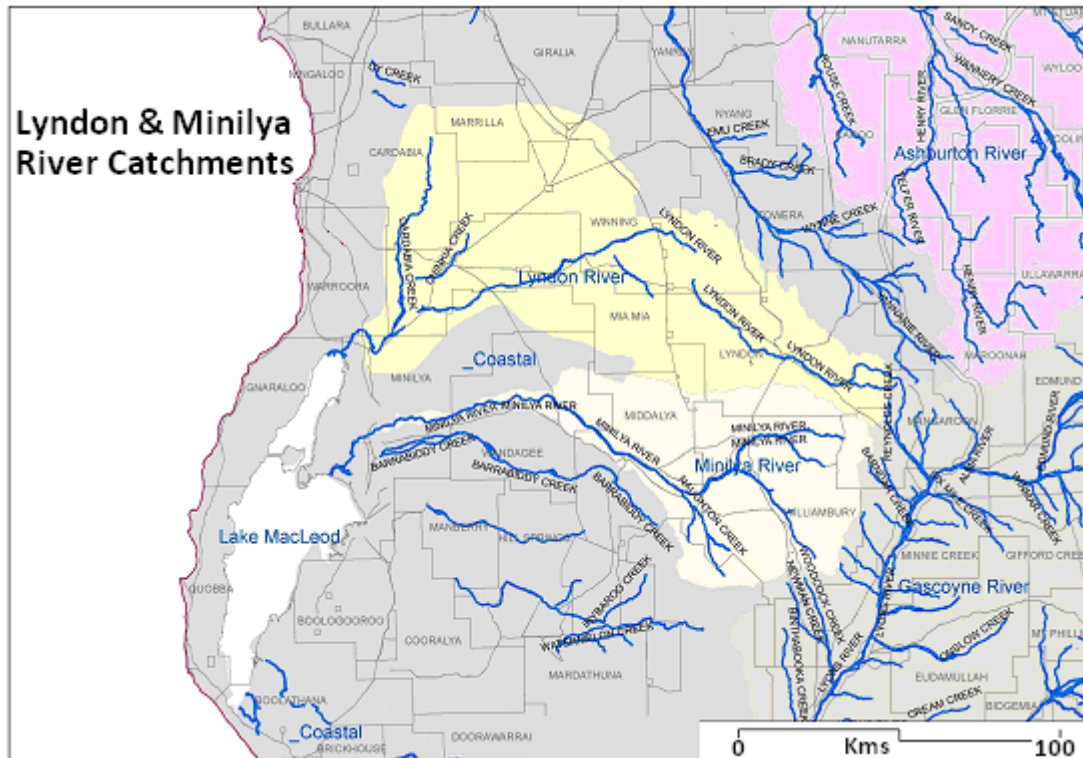


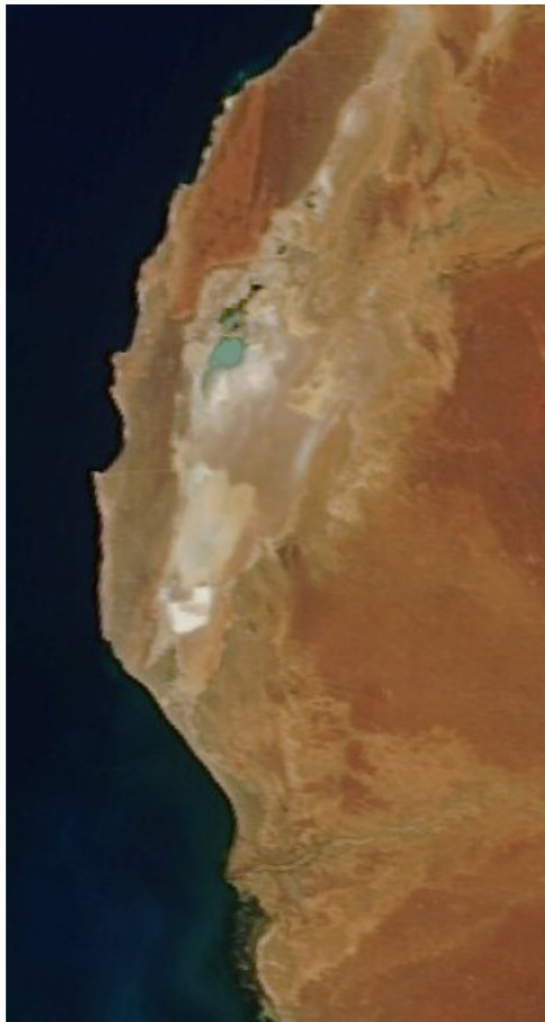
Figure 5: Map of immediate Lyndon and Minilya River catchments.

Lake MacLeod is the main receiving water body for the catchment, meaning any water that falls throughout the Lyndon or Minilya River and Cardabia Creek catchment area has the potential to ultimately be discharged into Lake MacLeod (either through surface or subterranean groundwater flow as seen in Figure 4). Major flooding from the Gascoyne River (to the south of Lake MacLeod) occurs infrequently, with significant flow via Boolathana Creek, such flows have occurred in 1960, 1961, 1980, 1995, 2000 and 2010. The 2010 flood was the largest recorded over this period, with water contributed by all major and minor waterways and local rainfall. (See Figure 6 to view the changing face of the catchment before and after the 2010 flood).

The Northern Ponds wetland on the western side of the Lake (approximately 60km² in area) are joined by small channels and fed by solution tunnels in the underground geology from the Indian Ocean 18km to the west. Ocean water passes underground through the Limestone barrier driven by tidal activity to rise in the sinkholes (or vents) in the western bed of the lake. The lake surface is at an elevation of 3–4 m below sea level, and the Northern Ponds area consist of Cygnet (1m deep) and Ibis (1 ½ m deep) Ponds and numerous outflow channels of variable depths. The salinity at the vents is close to that of seawater with the salinity gradient rising towards the southern pond.

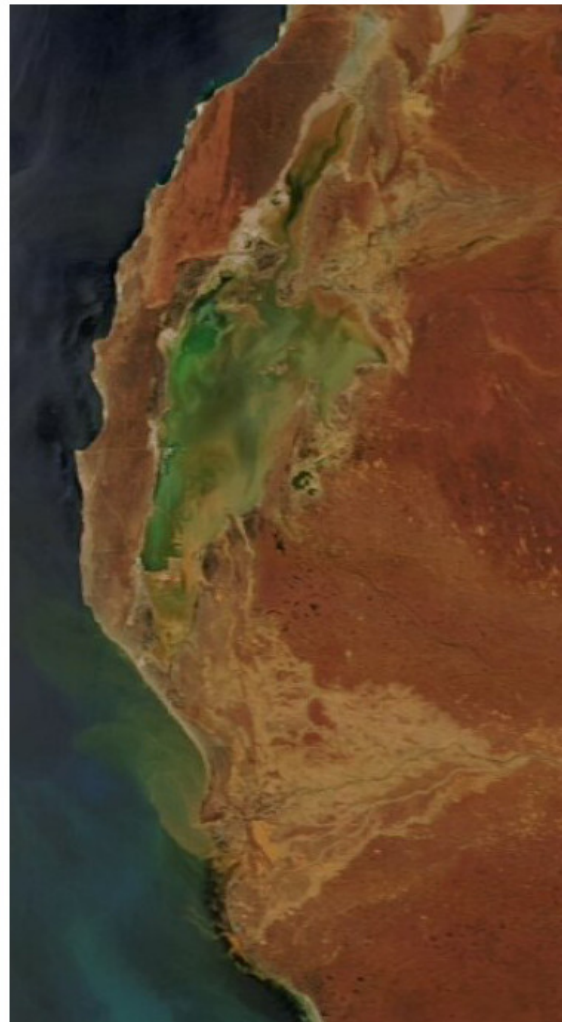
Lake MacLeod is a regionally significant wetland on the Ningaloo Coast, as it is the largest wetland in Carnarvon Basin and it supports a wide diversity of wildlife species, serves as an important bird breeding ground and is a summer refuge for trans-equatorial migratory birds (CALM 2004).

Figure 6: The changing face of Lake MacLeod and the broader catchments before and after the most recent significant floods of December 2010.



29th November 2010

Following 2 years of below average rainfall. Note the pale blue image is the location of the Northern Ponds



13th January 2011

Following excessive rain falls in December 2010 (more than 12 inches across the region) Note the Gascoyne River delta and plume continuing to enter the ocean



14th May 2011

Western side of Lake still retaining water 5 months after rainfall and river flows. Water distribution is highly influenced by seasonal prevailing winds

2.6 Land use

Prior to European settlement, the lake area was home to the Baiyungu Aboriginal people and was likely utilised as a seasonal food and water source. The broader Carnarvon region's traditional owners are the Inggarda, Baiyunga, Thalanji, Malgana and Thudgarri people all of which may have had connections with the Lake through time. The Baiyungu Aboriginal Corporation is responsible for the regions described cultural and heritage sites. Since European settlement, the land within the area has been utilised for a variety of land uses.

2.6.1 Pastoralism

Since the 1880s the lake catchment area has been utilised for pastoral activities. Grazing of livestock (sheep, cattle and non-domestic goats) has been the dominant land use and land management tool of this rangelands region. Given the dominant land use practices within the catchment utilise naturally occurring resources minimal mechanical clearing of vegetation has occurred within the region (as with other agricultural regions of the state).

Pastoral activities in the Carnarvon basin have been described in ***An inventory and condition survey of Carnarvon Basin:***

"By the late 1880's squatting leases were granted for a 21 year period in blocks not less than 20,000 acres, costing 10 shillings per 1,000 acres for each of the first seven years.....

...The number of pastoral properties and the amount of wool exported continued to rise, and by the turn of the century the sheep population for Western Australia was almost 2.5 million head, approximately 20% of which came from the Carnarvon Basin area. From this time sheep numbers in the Carnarvon Basin area rose from about 530,000 to reach a peak in 1924 of 1,065,000. Then followed a dramatic fall to an all time low reached after the 1930's Drought and the Great Depression.

Because of overstocking, lack of vermin control, unpredictable seasons and few improvements on many of the properties, large tracts of land had become degraded and no longer supported the pastures present at the time of settlement. Recovery from the 1930's drought and Depression was very slow until the 1950's when a boost in wool prices once again brought the pastoral industry back onto its feet.

In the 1970's when wool prices once again fell dramatically it forced pastoral businesses to re-evaluate their traditional wool production practices. Taking advantage of the then high returns of beef cattle production, many pastoral businesses offset their activities by introducing beef cattle into their production systems. Since the 1970's there have been numerous rises and falls in returns for beef cattle production and wool prices, all highly influenced by international market trends and seasonal hardships. Many pastoral businesses are looking to diversify opportunities available to them on their leasehold land; tourism has provided much opportunity to a few businesses, but not all."

Due to the low and variable nature of rainfall the catchment area was not suitable for intensive agriculture until the introduction of deep aquifer irrigation technologies. Today the Carnarvon Basin acts as a horticultural food bowl with most (horticultural) produce coming from the plantation strip along the Gascoyne River at Carnarvon. The presence of deep bore water supply has further supported and broadened pastoral activities throughout the catchment.

2.6.2 Mining

In the 1960s mining of salt began in the southern section of Lake MacLeod by the Texada mining company, later sold to Dampier Salt Ltd in 1978. The Rio Tinto Dampier Salt Ltd held mineral lease covers the entire lake area (220,000ha), and actively mines 764ha in the current operating area. The material mined consists of a layer of gypsite (natural gypsum) approximately 2m deep overlying a body of halite (mineral salt) measuring up to 6m deep. Plans to expand the current operations to 1,000ha by 2014 are underway.

The Lake MacLeod mining system is based on the concentrated brine resources protected from inundation by the Indian Ocean by dune systems. The saturated brine in the lake is 10 times saltier than seawater and eliminates the need for a series of concentration ponds generally required to evaporate water to achieve the sodium chloride saturation point. The current production capacity is 2.9 million tonnes per year, all transported to awaiting load ships at Cape Cuvier.

2.6.3 Tourism

Tourism is becoming increasingly popular along the Coral Coast, with numbers of tourists rapidly growing every year. Lake MacLeod has long been an intriguing destination and has proven a unique tourism opportunity for many locals and travellers alike. However, given the strict management by which the land managers control access to the lake, it is unlikely that masses of people will be accessing and impacting on the resources of the lake. Access to the lake will continue to be a very important issue for leaseholders of the area and on-going shared management arrangements are in place between the leaseholders of the lake bed and neighbouring pastoral leases. Discussions between the numerous lease holders on how to best manage the security of the landscape, whilst still providing the opportunity for travellers to enjoy the unique scenery (Lake MacLeod) are ongoing.



Image 1: Ibis Pond at the Northern Ponds in 2009

3.0 Ecological Importance of the area

Lake and wetland systems are essential ecological features in any landscape. They are often the primary habitat for numerous species of plants and animals and are the filtering sink of entire catchments. The overall health of a wetland indicates the health of the landscape throughout the whole catchment. If a wetland (in this case Lake MacLeod) is thriving ecologically, there is a fair indication that the catchment as a whole is functioning well.

3.1 Wetland systems

Lake MacLeod is regionally and nationally significant due to its unique saline-freshwater habitat, for this reason Lake MacLeod is listed in the *Directory of Important Wetlands in Australia* (DIWA) (See Appendix 4 for specific categories). In 2006 the Northern Ponds were submitted for a Ramsar listing, meeting 5 of the 8 criteria required for a permanent listing. While no Ramsar site has been declared to date at Lake MacLeod, consultation is on-going with key stakeholders. (See Appendix 5: for Map of the proposed Ramsar listing).

Whilst the lake is predominantly dry, the episodic flooding by the Lyndon, Minilya and immediate tributaries following heavy rains provides great diversity to plant and animal species dependent on the highly changing habitat. The region of the lake retaining water all year round (irrespective of rainfall) is the Northern Ponds and overflow from the ponds also provides a source of water to the broader Lake bed.

3.2 Plants

The dominant vegetation type surrounding the Northern Ponds is the White Mangrove (*Avicennia marina*) community; the population found at Lake MacLeod is regarded as the world's largest inland mangrove population (Ellison and Simmonds 2003). Mangroves are versatile plants providing protection to land by buffering wind and wave action and also protection of the water ways by trapping sediments and debris known to disturb marine habitats. The colony of mangroves surviving around the Northern Ponds and Lake MacLeod are considered to have been isolated from their coastal cousins for approximately 6,000 years since the last time the lake was connected to the ocean.

Surrounding the lake shores are the ever present salt loving Samphire (*Tecticornia spp*), varying in colour from ruby to grey, green to gold dependent on season and salt accumulation levels. On the hinterland of the samphire are the low open shrublands synonymous with the broader Carnarvon Basin.

3.3 Animals

Surviving within this unique environment are numerous species of water bird. The lake system and the Northern Ponds are regarded as somewhat of a stopover and drought haven for migratory shorebirds. Of the 70 bird species recorded at the lake since 2008, 28 are listed under the Japan-Australia and China-Australia Migratory Bird Agreements (JAMBA and CAMBA).

Within the Northern Ponds two predominant native fish species have been recorded (Flag tailed grunter and Estuarine hardy head), such species are known to survive here as the salinity is at its lowest in the ponds and is regarded as close to sea water, within metres of the edge of the ponds the salinity levels drastically spike beyond survival levels for most fish species. It is within the hyper-saline brine that the species known to survive and thrive are the likes of the brine shrimp and numerous other invertebrate communities which are relics from Gondwanan times, a suitable resource for the many visiting birds to the area.

4.0 Ecological Threats

It is widely regarded that lake ecosystems are the most vulnerable and difficult to restore of all natural ecological systems. The unique soil and water chemistry and flora and fauna habitats reliant on the stable chemistry are highly vulnerable to change. The most notable impacts to the Lake MacLeod system include an alteration in hydrological capacity, increase in sedimentation and a change in species composition (flora and fauna). As with any lake system, vast changes to the health of a system can result in loss of flora and fauna, loss of economic, ecological and cultural value.

4.1 Introduced Weeds

The most common weeds known to exist within the whole catchment area include Mesquite (*Prosopis spp.*), Parkinsonia species (both listed as Weeds of National Significance) and the regionally significant Jumping Cholla Cactus (*Cylindropuntia spp.*).

Mesquite and Parkinsonia are highly adaptable plants and are known to inhabit and travel along waterways. In thicket form, they can become impenetrable and impact on native plants and animals by out competing for resources. The plants can also pose great fire risk in thicket forms and can have dramatic impacts on ecological balances. Both of these species have been controlled through mechanical, chemical and biological controls, however the most successful treatment in the Lake MacLeod catchment to date has been through chemical control.

The most successful control has been determined by foliar and basal spraying, often difficult given thorny nature of plants. Over the past 5 years the land managers and government departments of the catchment area have spent in excess of \$200,000 in controlling Mesquite and Parkinsonia.

Jumping Cholla Cactus (as seen in images below) is a noxious weed with minute spines able to grip to objects moving past the plant, in the case of native animals, livestock and ferals, the plant has the ability to very easily re-locate to new sites for colonisation. The cactus is known to exist in or nearby the river systems entering Lake MacLeod and can grow into colonies exceeding 1 hectare in area causing great competition for native plants and animals, thereby unsettling the ecological balance.

To date the controlling of cactus has been absorbed by land managers, Department of Environment & Conservation (DEC), Department of Agriculture & Food (DAFWA) and Rangelands NRM through numerous funded programs targeting weeds. Funds invested in the control of the cactus are believed to have exceeded \$80,000 since 2006.



Jumping Cholla spines on fleshy limbs



One plant can reach 2m height, 6m width

4.2 Feral and Introduced Animals

The largest threats to the ecological values of the Northern Ponds include predation of birds and animals by introduced pest animals such as cats and foxes. Rabbits have been known to impact areas through seasonal fluxes of population resulting in intensive grazing activity.

Goats grazing throughout the pastoral region have been known to access the pond systems and have been recorded drinking the fresh water lens above the salt layer. Un-managed goats can impact on the overall stability of the Lake fringe habitats through grazing and increasing soil agitation.

The Mozambique Mouthbrooder (*Tilapia spp.*) fish species has been recorded to be found in the Northern Ponds (RTDSL Report 2008) however this fish species has not been seen in recent explorations. Tilapia, known as aquatic invaders due to their rapid breeding cycles and dominant behaviour, are known to occur in the Gascoyne River catchment and the risk of them entering the lake system is present, however minimal. If the Tilapia species does become established in the Northern Ponds their presence may impact greatly on the species of native fish and invertebrates known to survive in the ponds.



Foxes are known to prey on native fauna



Goats thrive in rangelands environments

4.3 Land use Threats

4.3.1 Mining

The lake is positioned within the land tenure of Rio Tinto Dampier Salt Pty Ltd, at the southern end of the Lake the extraction of brine through mining operations may have impacts on the overall health of the hydrological and ecological balance of the immediate region. The salt production involves pumping groundwater onto the lake surface, allowing it to evaporate and then collecting the crystallised salt. This carries a risk of disturbing the hydrology of the system.

RTDSL is currently considering increasing production by mining the profile beneath the lake bed. Doing so will require dewatering the profile, with potentially more serious consequences than current water extraction. RTDSL adhere to strict environmental regulations and codes in order to monitor any potential threats their operations may contribute to the immediate region. The location of the Northern Ponds in relation to the main site of mining activities means that RTDSL staff visit the site on an as needs basis. There are currently basic monitoring techniques utilised to record un-managed human access and ecological change (*pers. comm.* Brett Renton), but will be improved with the introduction of the Edith Cowan university Research Program commencing in 2011/12.

4.3.2 Tourism

Tourism is increasingly providing pressures onto the sensitive environments of the Lake MacLeod and Northern Ponds system, as it is also extending greater pressures on the land managers immediately adjacent to the sites, by seeing increases in illegal entry to the site. With increased visitation comes the risk of weed introduction to sensitive sites, an exploitation of natural resources, increase in wastes and the risk of erosion resulting from illegal track construction.

The Lake is often portrayed as a large 'mythical' site, seen by most only on maps or via *GoogleEarth™* and understandably, curiosity is high with Lake MacLeod. Whilst the Lake itself is bound within the lease of RTDSL, access to the lake is often via pastoral leases. Un-managed vehicle access is a key issue affecting the management of the area. With this difficult problem comes the increased risk of illegal track construction, weed re-location, rubbish disposal and trespassing.

4.3.3 Grazing

Grazing has been regarded as having the highest impact on the lake and the Ponds through sedimentation entering the lake system following heavy rainfalls (as reported in the RTDSL Report 2008). Much of the on-ground work through this project has been designed to decrease the risk of large loads of sediment entering the lake system. Whilst it is widely accepted that sediment can not be stopped from entering waterways, erosive forces are a natural part of landscape evolution, awareness of decreasing the risk of large scale erosion has been increased. As a result of this 2 year project all land managers are aware of the significance of ground cover in retaining moisture in the immediate landscape, from this comes improved nutrient cycling thereby improved vegetation composition and enhanced productivity. Very little evidence exists of grazing pressure impacting on the actual Northern Ponds area, so immediate grazing risks are considered minimal.

The death of Mangroves surrounding the Northern Ponds following the 2000 floods were reported to be as a result of increased sedimentation entering the system from up-stream pastoral leases (RTDSL Report 2008). Flood events are a major part of the natural ecology of the Lake MacLeod system and the regeneration of mangroves is occurring at the site, thus it is considered unlikely that past flooding has been solely responsible for mangrove deaths (pers. comm. D. Bauer). The limitation to this information is the lack of specific data describing the species composition before the flood in comparison to after the flood.

4.3.4 Agricultural, Transport and Infrastructural Contaminants

Typically, the most dominant contaminants entering the lake system contain residual elements and nutrients from agricultural, mining and transport activities. As a whole, contaminants entering the lake system are very minimal mostly due to the vast and lowly populated nature of the catchment. Roads have the potential to contribute contaminants to the lake system, primarily debris, heavy metals and hydrocarbons. The types of contaminants contributed to the lake from the road networks are very minimal considering the limited access of vehicles to the immediate lake area.

Contaminants contributed through the agricultural sector are limited to times of flood, when variable levels of sediments and minimal animal based nutrients enter the river systems (no fertilisers are used on pastoral lands). Unless floods are significant in scale (as was the case with 2000 and 2010) such flood waters are quickly filtered away from the Northern Ponds area by means of wind or fresh filtering seawater coming from the seepage ponds.

5.0 Research (Scientific) Programs conducted throughout the catchment

The Carnarvon Basin is one of the major sedimentary basins of Western Australia (Wyrwoll et al. 2000). To date the information available on Lake MacLeod and more specifically the Northern Ponds has been rather vague, with minimal information presented on the system as a whole.

In 2010 Pierre Horwitz of **Edith Cowan University** (ECU) compiled a Meta-database of all known research efforts for the Northern Ponds (and Lake MacLeod) in the *Biophysical Characteristics. Data Audit and Research Framework*. The report highlighted significant gaps in research allowing for the design of research programs to align with required knowledge.

Dr **Brian Logan** (Geologist) conducted numerous studies and compiled various publications outlining the regions geology and hydrology from the early 1980's. As a result of this work, the Geology and Geomorphology knowledge of the Lake and the Ponds is perhaps the most extensive of all research to date. Much of the geological and geomorphological information presently known was compiled by **Hocking** et al 1987.

Birds Australia (WA) have conducted numerous Bird surveys near the Northern Ponds (most intensively 1999-2006), as part of ecological monitoring program, facilitated by Rio Tinto Dampier Salt Ltd.

Under the same ecological monitoring program **Streamtec Ecological Consultants** conducted a water quality, aquatic invertebrates and fish study of the Northern Ponds from 1997-2003. Specific mangrove studies were completed in early 2000s as follow up from late 1990s research conducted near the Northern Ponds relating specifically to mangrove bird communities.

The **Western Australia Museum** conducted a major biological study of the Carnarvon Basin in 2000 describing the biodiversity patterns of the whole basin and also highlighted the gaps in the reserve systems of the region. Following this study the Department of Environment & Conservation purchased selected parcels of land to increase the state reserve register, for preservation and conservation of unique rangeland land systems.

The **Department of Environment & Conservation** have conducted numerous field visits. Of particular interest are the 2009 *Resource Condition Report for Lake MacLeod* and the 2004 *Report relating to the application for World Heritage listing*.

The **Department of Agriculture & Food WA** conducted field surveys following the flood of December 2010, and reviewed the ecological stability of the entire Gascoyne region. The report (titled "Gascoyne Review") findings were based on re-assessing all WARMS monitoring sites in the region to gauge the overall condition of the landscape following the extreme flooding events. From communications with officers involved, the findings are stated to "*be consistent with the messages portrayed by earlier reports of the region, in Lightfoot (1961) and Wilcox & McKinnon (1974)*". (The "Gascoyne Review" was still in the process of development at time of printing this document).

In 2011 **Edith Cowan University** and RTDSL launched a new research collaboration agreement which is "designed to pave the way for a unique series of research opportunities in Australia's north-west. Initial projects administered under this research collaboration agreement will see ECU receive \$900,000 over four and a half years to better understand the ecology and biodiversity of salt lakes and migratory bird habitats near Dampier Salt Ltd operations in north-west Western Australia. The program will focus on the "Biodiversity of Lake MacLeod and the Feeding Ecology and Habitat Use of Migratory and Other Shorebirds."

6.0 Natural Resource Management on-ground works

Substantial efforts throughout the whole catchment have been made to manage the natural resources dependent for rangelands industries. Land Conservation District Committee groups (LCDC's) have been functioning since the 1980's and independently such groups have been actively committed to landscape scale activities. Government funding and assistance has provided catchment and region scale opportunities for planning and implementing on-ground works to deliver sustainable use of rangelands resources. Such programs have included the Gascoyne-Murchison Strategy (1998-2004) and the Gascoyne Catchments Group (since 2008). All funding programs within the region have been matched dollar for dollar by the land managers (in many cases land managers have contributed much more).

Monitoring Tool

Through previous financial support from RNRM, a Self Assessment Monitoring and Reporting Tool has been developed by the Gascoyne Catchments Group (GCG – a collection of three LCDC's). The aim of the tool is to collect specific and consistent information at a property and a regional scale to document the changes in rangeland condition throughout the Gascoyne region. It provides landholders with a tool to record the observations they are making with the country's condition, which in turn, provides a greater ability to make more effective management decisions. The continued development of the Monitoring Tool will allow for a sustained effort to up-date the status of the regional catchments through the format of Catchment Report Cards.

When developing the monitoring tool, the GCG investigated a variety of alternative monitoring methods including David Tongway's Landscape Function Analysis (LFA), Queensland's Department of Primary Industries *Stocktake* program, Grazing Land Management (GLM courses) and the Western Australian Rangeland Monitoring System (WARMS). Derived from the principles of these systems and utilising the Pasture Monitoring Sites approach to assessing & monitoring perennial species trends, the GCG developed the Monitoring Tool using a value based approach to rangeland monitoring. This approach removes any subjective conclusions to rangelands trends and provides a generic methodology that can be utilised by all landholders. The tool is available in an easy to use Microsoft Excel format and is currently utilised by a majority of land managers involved with the GCG.

6.1 Summary of NRM projects conducted from 2007-2011 throughout the broader Lake MacLeod catchment region

530km of Fencing constructed

Fencing along the major drainage systems (Cardabia, Lyndon, Minilya, Chinkia, and Gascoyne tributaries, Fringe of Lake MacLeod) has been constructed to gain greater control of total grazing pressures. Most fences were designed for the control of cattle (which inadvertently controls sheep) and some fencing was designed to control goats (higher capacity fencing such as ring lock was required).

27 sets of Total Grazing Management Yards (TGM's) constructed

Livestock trapping compounds assist in reducing total grazing pressures as the yards are designed to hold multi species, appropriate for sheep, goats and cattle. TGM yards are widely used throughout the whole catchment as they have proven to be the most cost effective and stress free way of capturing and managing grazing animals. The ability to capture livestock means that when seasons require a removal or reduction of animals from the system an easy solution is to open up the trap yards (designed to allow animals in to water, but not out of the water yard) to capture and remove livestock daily.



Sheep & Cattle proof fence



Total Grazing Management Yards (goats and sheep)

40 Relocated watering points (including 65km of water network pipelines)

By moving historically established watering points and associated infrastructure from sensitive areas, greater control and management of the rangelands resources can be achieved. Historically watering points were located at known easy locatable ground water supplies and these sites were generally the most vulnerable to intensive grazing pressures. With modern technologies and appliances we are able to see a shift towards altering sites of waters to harder more resilient ground to assist in the preservation of more sensitive, seasonally productive sites.



Multi Use watering points located in strong land systems (left). Pipe lines aligned to existing infrastructure such as tracks, reducing further impacts/disturbance to land systems (right).

Landscape Rehabilitation projects

160 Ponding/Landscape bund banks (approximately 450ha) constructed in areas of historically degraded country designed to support the landscape to rehabilitate and rehydrate. Projects have included earth works to assist surface water flow to spread further abroad traditional drainage systems (such as floodplains) rather than channelling directly into incised gullies (altered by changes in drainage patterns influenced by some infrastructures eg. Roads, pipelines, channels, dams etc.)

Numerous landscape rehabilitation techniques have been conducted throughout the catchment mostly aligned to brush packing and mechanical assistance to slow surface water flow. Activities conducted have been focussed on areas of intensive water flow following rains, the design is not to stop water flow but to promote speed bumps in the landscape to slow surface water flow, which historically would have travelled much slower. The speed of the surface water flow has been altered as a result of altered landscape function due to historical degradation or poor infrastructural construction.



Ponding banks (left) and brush packing (right) act as landscape speed bumps for surface water flow

Control of invasive cactus species (*Cylindropuntia spp.*) throughout the catchment has resulted in approximately 4ha of infestations being controlled (see images below). Management and control of populations will continue in order to prevent the spread of cactus reaching the waterways of the catchment again. Control measures were conducted on 5 properties throughout the catchment with an average of a 95% mortality rate. Control of Mesquite (*Prosopis spp*) has also been conducted throughout the catchment.



August 2010 (left) August 2011 (right). Sprayed with one application of **Garlon:Diesel** (1:10). Plants did not re-generate. Follow up treatments were required only on very few plants due to human error.

7.0 Community Discussion

During the life of the project, resulting from discussions with numerous stakeholders throughout the Lake MacLeod catchment, many opinions have been expressed outlining the barriers and opportunities to achieve the sustainable management of environment, businesses and community. In a broad sense, the opinions expressed can be classified into the three categories synonymous with the principles of ecologically sustainable rangeland management – Ecological, Economic and Social.

7.1 Ecological

Challenges

The difficulty in achieving healthy ecosystems often rests in the fact that the areas with the highest biodiversity (and those most likely to respond to rehabilitation) are also regarded as the highest value (most desirable) country for grazing. Striking the perfect balance between maintaining healthy country and operating a sustainable business is often difficult to achieve. The challenge is made more difficult by the (often historically) degraded conditions of the land-systems and how they are able to respond to the unpredictable nature of the variable climate.

The financing of rehabilitating degraded country, removing certain areas from production, or introducing infrastructure to better support areas for protection is often limited to and dependent on agreements with government funding schemes (LCDC's, DEC, RNRM, DAFWA) or company investment (such as mining companies). Quite often, within a business, the cost-benefit-analysis of conducting rehabilitation works is un-viable.

The expectations and assumptions put in place by various agencies and organisations are often fuelled by perceived opinion rather than confirmed fact. Unrealistic expectations and lack of understanding often leads to land managers' frustration over certain agendas and policies.

Opportunities

A mutual respect, recognition and support for innovative practices and traditional understandings (indigenous and non-indigenous) are vital links in developing strong appreciation throughout the community on how rangeland businesses and communities function.

Multiple land use opportunities arise from healthy ecosystems. With healthy ecosystems come opportunities for tourism and eco-tourism. Whilst it is acknowledged that tourism does not always work everywhere, it is still a viable option worth considering.

An ecological approach to rangelands management means understanding and working with the uncertainties of climate, using proven management tools, manipulating total grazing pressure, managing invasive species and protecting significant areas of productive land which provide ecological services – such as critical habitats like water holes, rocky outcrops and eco-junctions. Sensitive management of rangelands is required in order to protect and restore (where possible) commercial and non-commercial values, provide opportunities for multiple use, and the overall protection of biodiversity.

7.2 Economic

Challenges

In order to meet ecological goals, and maintain community and social structures, rangeland businesses must be self reliant and have a solid economic base. They also need to be resilient and profitable to enable management for the long term. Recently, pastoral enterprises have been under considerable pressure from climatic and commodity price and market uncertainty (eg. the live export ban of 2011) as well as declines in the resource base.

Matters such as land tenure arrangements, access to financing, infrastructure improvements, development of markets and access to information and skills and services, need to be addressed if a wider array of economic opportunities is to be realised throughout the rangelands.

For most rangeland managers, security and certainty of tenure is vitally important in making sound business decisions, however different their requirements:

- Pastoralists primarily link certainty of tenure with the probability of personal investment in infrastructure and the ability to secure continued finance.
- Environmentalists want to see certainty and security of tenure for the conservation of biological diversity (both on-and off-reserves).
- Indigenous people want their rights acknowledged and require access to their traditional lands for making a living and carrying out traditional practices.
- Mining industries want access to areas which have mineral potential and the certainty of tenure for potential operational developments.

For many pastoral land managers, the desire for the Pastoral Lands Board (PLB) to re-assess the carrying capacity of their lease/region is highly important, however the PLB has declared a re-assessment is unlikely to occur in the Gascoyne region. The PLB has recommended that land managers will be responsible for managing their own carrying capacities, dependent on individual self monitoring results (the cc will not be considered; only the condition of the landscape and its responsiveness to management will be considered). This troubles many land managers as financial institutions still require the cc potential when considering financial assistance. The PLB needs to highlight this altered land practice to financial institutions to provide clarity and reduce frustration. The alternative would be to provide livestock production records from the past demonstrating the productive capacity of the land across different seasons.

Opportunities

Planning in the rangelands needs to be for the long term to ensure ecological and economic sustainability. Certainty of tenure underpins the ability and motivation of all land managers to take a long term view of their roles and responsibilities in the planning process. It also provides a framework for the assessment of performance. Tenure is a key issue for land managers, and is likely to continue to be a concern for many pastoralists.

Emerging industries such as tourism and bush foods, including commercial use of native animals, can provide some scope for diversification (tenure dependent).

Rangeland businesses have many opportunities to manage changes (climate, market, community) through opportunities for diversification, multiple use and alternative resource use (as promised by Minister Terry Redman in 2008). Clarification of tenure and access to resources to enable users and managers to make appropriate investment and management decisions for ecologically sustainable rangeland management including business viability should be made.

7.3 Social

Challenges

In many regional areas, support networks have slowly begun to retreat, leaving communities feeling isolated from technical, financial and community support. The withdrawal or downgrading of services (government and non-government) often impacts on rangeland communities through decreases in population, morale and income bases for communities.

Networks which are able to provide technical support are often funded for short periods of time, leaving large gaps when funding rounds are finished. The '*re-invention of the wheel*' is a common frustration for many land managers, as often it takes several years to build up the relationship with the support staff and get them '*trained up just right*' before the funds dry up and the person is relocated to other regions, jobs, projects (either within government organisations or independent organisations). The short longevity of support networks is a great barrier to achieving positive on-going outcomes relating to sustainable land management.

Opportunities

Support agencies and support staff (working in relevant fields) should collaborate (as much as possible) with all land managers and communities to utilise and record knowledge and practical experience to find optimal solutions and opportunities relating to future sustainable land management of the catchment region.

Monitoring of landscape condition is considered to be crucial in providing feedback to land managers as well as governing regulatory bodies, and as such, ecologically sustainable rangeland management is unlikely to be achieved without such monitoring. For programs of monitoring to be successful in determining trends in land condition, they must be implemented through the use of agreed criteria and indicators (between both land managers and officiating bodies). Such criteria and indicators required for the ongoing development of Regional Strategies (NRM) and Property Management Plans need also to be tailored to meet the needs of each landholder, business and community group.

The acceptance and encouragement of the 'producer driven' Self Monitoring Tool developed by the Gascoyne Catchments Group should be supported in any way possible to ensure uptake of ecologically sustainable management practices throughout the region.



The Northern Ponds (aqua colour) situated on the western edge of the sedimentary lake bed of Lake MacLeod.

8.0 Recommendations:

8.1 ESRM Plans be supported, updated and implemented

The ESRM Property Management Plans developed throughout the past 4 years (with 90% of the pastoral leases in the Lake MacLeod catchment) have highlighted ecological, economic and social factors relating to pastoral businesses. All of these plans have been maintained and are updated as required by the land managers with the assistance of the ESRM team.

The value of the Property Management Plans highlights the need for a service provider to support land managers in developing strategic plans aligned to achieving goals beneficial to the environment, animal welfare and business. Commonly, service providers of the regional centres (particularly in the rangelands) are at best, short-term funded. As a result the on-ground extension staff with the local knowledge and established community relationships are no longer able to provide the support services required. As was outlined earlier in this document, the hesitance of land managers to adopt projects through NRM funded programs is once again confirmed with the completion of the ESRM project in November 2011.

All of the activities which have been identified and have been implemented within the scope of this program should be able to be continued if there is adequate support (technical and financial) to do so. Projects conducted throughout the life of the ESRM Program and projects strongly recommended to continue include: Landscape rehabilitation, control of invasive weeds, total grazing control, fencing of sensitive land systems (more information is available on listed recommendations in the following pages).



Left landscape rehabilitation



Right: Control of invasive weeds



Left: Total Grazing Control and Trap Yards



Right: Fencing of sensitive /riparian areas

8.2 Landscape rehabilitation of vulnerable and/or high biodiversity value land-systems

Rehabilitation of landscapes and land-systems is the *treatment of degraded or disturbed areas to a pre-determined standard*. Rehabilitation is required wherever there has been a measurable change in the landscape or if degradation is occurring. It may be required where there is active erosion, or where the capacity of the landscape is no longer functioning sustainably. Ideally, prevention is better than cure.

Preferably, vegetation is the best defence to protect the soil against erosion. With vegetation comes increased water infiltration, decreased surface water flow and improved nutrient cycling throughout the system. However, the factors that caused the erosive problem must be treated first. The control of total grazing pressures is the priority control method to ensure improved landscape function. A combination of grazing control, erosion control works and revegetation will provide the highest chance of success in preventing further erosion, and therefore increase stability and overall landscape function.

Rehabilitation should be carried out to the extent where no further soil loss occurs, meaning, the area needs to be stabilised. Areas of priority for rehabilitation are those with active (and often the most aggressive) erosion occurring. Indicators throughout the landscape will provide the clues to which landscapes should be assisted with repairs. Freshly deposited materials/sediments are an indication of active erosion (upstream) and should be treated as a priority. Whilst gullies may appear aggressive, they could be stable (the best indication is to gauge the vegetative materials particularly grass, shrub and tree root systems within the soil profile, if they appear to be recently exposed, active erosion is occurring).

The cost of rehabilitation can be reduced if stabilisation works are carried out as soon as possible (physically and financially). If areas are left bare for any length of time, erosion will increase, as bare surfaces often generate increased surface water flow thereby increasing erosion of the most vulnerable areas. Costs of rehabilitation can be reduced if new works are being conducted near the degraded sites (eg. road/track construction, fence line clearing) and rehab works can be worked into the same contract to reduce overall costs.

Degraded areas which are at a 'point of no return' should be assessed for likely response to rehabilitation and the costs of achieving positive changes. Sometimes such areas are best left to their own recovery, as long as they are not responsible for further degradation down stream. Such areas could be fenced off from total grazing pressures and/or enhanced with mechanical regeneration and re-seeding if deemed to be a viable option.

Once the landscape has been prepared (if ripping of the soil profile is required in the case of constructing bunds or ponding banks) revegetation should be carried out by using locally sourced seeds. By maintaining the genetic similarity with plants locally sourced, the likeliness of successful re-growth will be greatly increased.

Numerous operators throughout the rangelands are licensed to source seeds and sell for rehabilitation purposes. **Dave Bauer** of Carnarvon is a locally licensed seed collector with extensive knowledge of the Carnarvon Basin's land-systems and vegetative requirements. Alternatively **KimSeed International** (www.kimseed.com.au) holds an extensive supply of native seeds, although such seeds are sourced from right across the WA rangelands, so the issue of non-endemism could influence decisions on purchasing seeds for local rehabilitation projects.

To ensure the successful rehabilitation of degraded landscapes, several key management techniques must be followed:

Drainage Control: The cause of the erosion/degradation must first be removed (or managed) prior to rehabilitation/revegetation. 'Critical control points' within a landscape, allow for strategic interventions to be put in place which allow for maximum outcomes from minimal input. This may involve surface reshaping, construction of diversion banks upslope, or the construction of drains to divert excess water.

Water surface flow can also be managed by organic means such as **brush packing**. Brush Packing is achieved by stacking native scrub into gullies or crevices within the drainage system. This is designed to buffer and slow surface water speed, whilst trapping sediments and seeds. This can also be achieved through **enviro-coils** (sausage shaped rolls of chicken mesh or an organic equivalent) filled with vegetation and pinned to the ground running at right angles to the surface water flow direction, this technique is particularly successful near scalded areas.

Ground Preparation: In degraded areas the ground is often compacted and, in many cases, the topsoil may have been completely removed. Therefore the area should be ripped to create a suitable seed bed. Ripping of the soil should generally be carried out across the slope, not directly up and down slope. If financially viable to do so, if importing topsoil to the rehabilitation site, the ground should be ripped to ensure the top soil remains. Topsoil should be spread to a depth of approximately 10cm, ensuring that soil containing any seed is on the surface.

Seeding: Re-seeding is often necessary where the existing soil profile is unlikely to hold any remnant seed stores. If topsoil is being reintroduced to the area, seeds are likely to be found within the transferred soil, however, for best results, extra localised seeds will provide for greater results of increased ground cover. When sourcing soil pits, be mindful of weed seeds when re-distributing soil. Seed can be purchased from registered seed suppliers; however native seed can be collected from the surrounding area within the lease.

Native Plants: Native shrubs and trees can be established by planting seed or tube stock. It is recommended to select plants that are commonly found within the landscape and immediate land system, rather than those species known to grow the fastest.

Mulching: If viable, mulch helps to retain soil moisture and keeps the soil at an even temperature, assisting vegetation to establish. It also helps to prevent further erosion. Mulch materials should be weed free to prevent the introduction or spread of undesirable plants or weeds.

Fencing: While vegetation is establishing areas may require fencing to prevent grazing by native or feral animals. Areas undergoing revegetation will need protection from fire with appropriate firebreaks.

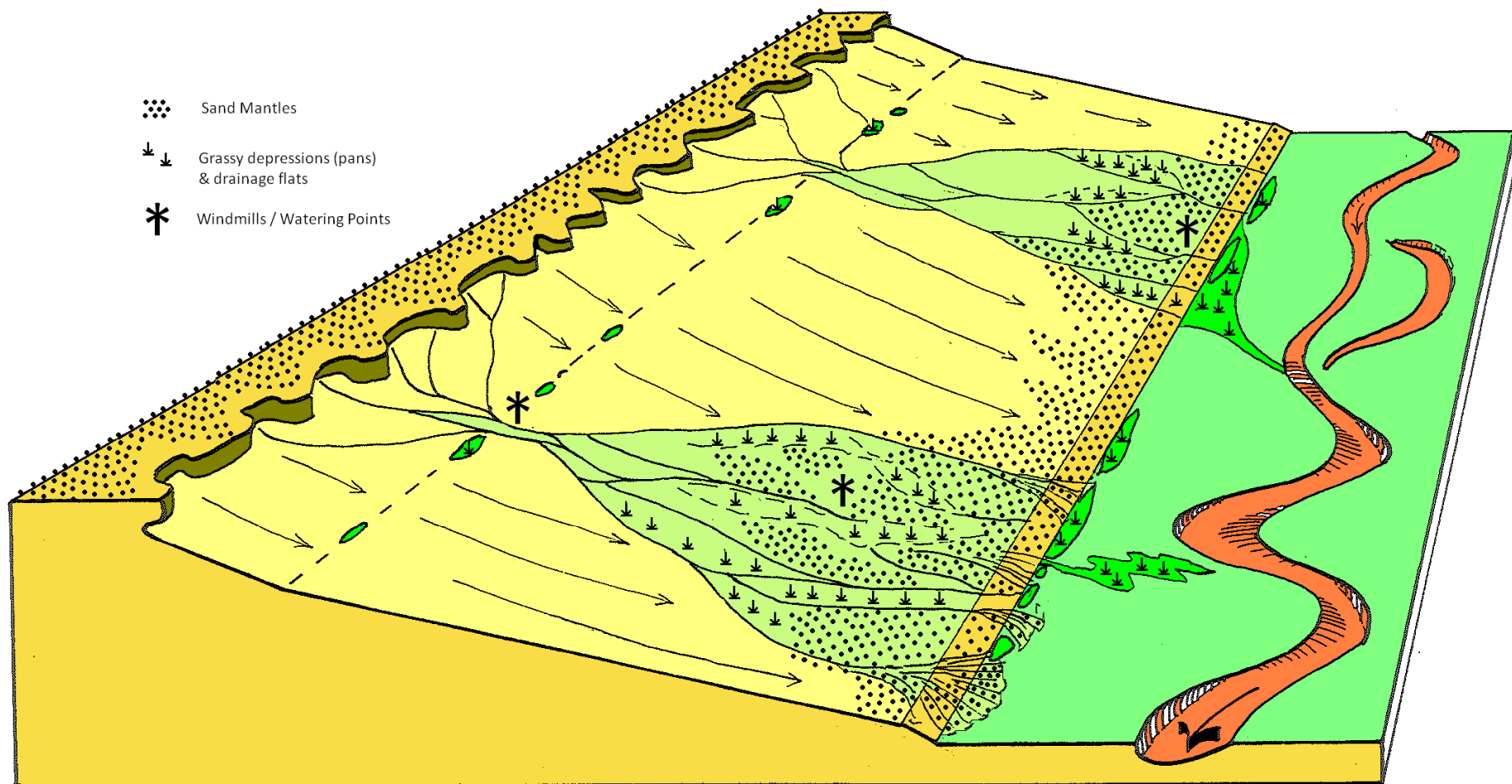
Management: If an area is being returned to native vegetation, then maintenance will involve regular monitoring to ensure that:

- plants are establishing
- grazing pressures are reduced
- drainage control works are functioning
- firebreaks are maintained
- weeds are not establishing



The above images show an example of a productive landscape within the Lake MacLeod catchment (the Marloo Landsystem) and one of the potential threats associated with such land-systems. The image on the left shows a highly productive floodplain at risk of 'drying out' if the erosion of the river system dissecting the floodplain, on the right, continues to erode at its current speed.

The base level of this floodplain carves lower every flood event, leaving the floodplain perched and vulnerable to much faster drying out, where historically this flood plain would have held water for weeks after floods, the landsystem now is able to hold floodwaters only for days. So essentially, the plug has been pulled from this system. The most appropriate technique to reduce the impacts of this degradation is to reduce the speed by which water travels down this waterway, this can be achieved by ensuring greater ground cover throughout the catchment (through grazing pressure control), and constructing buffer zones upstream which will assist in slowing down surface water flow and promote the spreading of water back out onto the floodplain, rather than immediately channelling down the waterway. In this case, up-stream buffer zones would include the construction of a "sieve" of organic material like scrub, pegged into the ground. The sieve would run across the creek bed and stretch for approx 50m either side of the bank and would be designed to allow water to filter through and spread out to the flood plain, whilst trapping debris, sediments and seeds.



The above diagram (illustrated by Dr Ken Tinley) outlines the importance of reading the landscape as a whole connected unit when identifying problem areas. As the diagram suggests, sharp erosive banks on the edge of the river are influenced and connected by the processes happening up-slope. This is often difficult to manage, particularly when lease boundaries are involved, as ecological problems (and opportunities) generally don't respect human made boundaries. Regionally, all land managers and stakeholders must work co-operatively to ensure the most appropriate management of the landscape is occurring (to the benefit of the triple bottom line).

8.3 Control of Invasive weed species

Control measures of identified weed species throughout the catchment to date have included chemical, mechanical and organic works. The highest priority weed species of the Lake MacLeod region include Mesquite and Parkinsonia (both are listed as Weeds of National Significance - WoNS) and the regionally significant Jumping Cholla Cactus (*Cylindropuntia spp*).

Weed control and eradication programs have previously been funded through grants from NHT, CfoC and State NRM programs. There are numerous local land managers equipped with the skills, qualifications and the knowledge in controlling invasive species, assistance with purchasing equipment, materials and control agents will continue to be required through such grants.

Following the widespread floods of the Gascoyne region in December 2010, the weed seed distribution has increased dramatically and now poses potential threats to drainage tracts and waterways previously free from these weed species. It is recommended that, in collaboration with DAFWA, the Carnarvon Regional Biosecurity Group and the Carnarvon and Lyndon LCDC groups, a program be implemented to update the maps of known weed species throughout the region. A control program should be implemented as soon as is possible to prevent future outbreaks which may be difficult to control. History has shown the risk of leaving known weed species uncontrolled at the mouth of the Fortescue River at Mardie Station. The Gascoyne regions river and creek systems are transitioning into chiefly grassland pastures and with this comes an alteration of soil moisture and nutrient levels, two factors highly desirable for the generation of Mesquite and Parkinsonia. Prevention is better than cure.

8.4 Total Grazing pressure Control

Total grazing pressure describes the combined grazing pressure exerted by all stock – domestic and wild, native and feral – on the vegetation, soil and water resources of rangeland landscapes. Total grazing pressures exceeding the sustainable capacity of the landscape threatens the function of ecosystems and the survival of flora and fauna species. Grazing management should include a consideration of the impact of both domestic stock and wild stock to ensure conservation of biodiversity and sustainability of grazing industries. The challenge for land managers to achieve effective control of total grazing pressure is easy to underestimate (Brennan 2010). For land managers to maintain stock numbers within feed supply in a highly variable climate, it requires skills in feed budgeting and livestock trading. Pastoralists who are able to manage domestic stock numbers to stay within carrying capacity during a dry season will normally have more feed than their neighbours. Such a scenario will result in kangaroos and goats from neighbouring properties moving across the boundary to take advantage of the more substantial feed (Norbury and Hacker 1993).

It can be argued that under current policy settings, such challenges are unsurmountable by the lone pastoralist and as such, mitigate strongly against the achievement of sustainable pastoralism in the arid and semi-arid rangelands. The challenge for all institutions and the commercial pastoral industry is to address this 'wicked problem' with the tools that have been shown to be necessary to effectively address a wicked problem. The word wicked is used in the sense that a problem is highly resistant to resolution and that cannot be addressed with traditional problem solving methods. Wicked problems 'require thinking that is capable of grasping the big picture, including the interrelationships among the full range of causal factors underlying them. They often require a broader, more collaborative and innovative approaches' (Australian Public Service Commission 2007).

As identified throughout the life of the project the significant factors attributed to the success/or failure of achieving total grazing control are directly linked to the ability to remove animals at critical times. As all animals are morphologically different, there is no one simple animal control solution, particularly given the variable economic value of each species.

Total grazing control strategies and opportunities highlighted throughout the project requiring on-going consideration and funding include:

- Improved techniques for controlling total grazing pressures through modern technologies (e.g. Telemetry systems, digital selective entry yards)
- Improved consistency of marketable opportunities for licensed shooters to operate (able to control numbers and decrease pressures on resources). Including all grazing species – kangaroos, goats, donkeys, camels, horses.
- Incentives to maintain trap yards and re-locate watering points, given the general trend to manage animals by water manipulation rather than increasingly expensive fencing infrastructure.
- Improved development of grazing systems designed on rotation principles, feed budgeting and seasonal spelling of pastures.



Rotation fence (3 Barb, 3 Plain) designed to support grazing systems on a seasonal basis. During times of rest, the paddock is managed through the use of restricting access to watering points, external spear gates and kangaroo control programs.

8.5 Fencing off sensitive land systems

The banks of waterways and adjacent floodplains are prime grazing lands. Excessive and uncontrolled access of grazing animals to sensitive river/creek systems can lead to bank erosion and water pollution down stream. Issues such as the cost of installing and maintaining fences, the potential for weed and pest infestations and providing alternative watering points need to be carefully considered when fencing off riparian areas from grazing.

Managing grazing access to riparian zones does not mean complete exclusion from grazing, rather, numbers can be managed to maintain the valuable functions of the most productive areas of the catchment.

Quite often the most effective way of gaining complete control of grazing pressures on sensitive land systems is by fencing up to the “flood line”, the zone where – in the event of floods- floating debris such as trees and brush will not carry the fence materials away with it. Generally such areas are very clearly identified by a change in the landsystem (available on all property maps).

Factors to consider when constructing riparian fences are the increase in vegetation (including weeds) and the subsequent increase in risk of fuel load for wild fires. In many cases “crash grazing” can assist in controlling rapid growth of weeds and can maintain a level of vegetative cover adequate for healthy ecosystem function, whilst benefiting productivity on a seasonal basis (not a permanent solution). Continuous management and alteration of stocking numbers within riparian zones is vital to ensure the resources are able to function and can support productive, perennial pastures and healthy ecosystems.



Livestock fence (constructed of salt-proof pine posts and recycled plastic droppers) following the fringe of Lake MacLeod. Designed to reduce livestock accessing the sensitive lake bed and land-systems, whilst reducing animal stress if animals are lured to the Lake’s deceptive water source.

8.6 Monitoring of resources

Continue encouragement and development of the Gascoyne Catchments Group Monitoring Tool [www.gascoynecatchments.com.au]. The aim of the tool is to collect specific and consistent information at a property and a regional scale to document the changes in rangeland condition throughout the Gascoyne region. It provides landholders with the ability to record the observations they are making with the country's condition, which in turn, provides a greater ability to make more effective management decisions.

The best return on investments in monitoring is when it is used to inform a land manager whether or not management objectives are being achieved and to provide information as to why or why not they are being achieved. By consistently monitoring the resource base, land managers will be able to determine best practice methods and alter land management practices according to range condition. The most consistent themes resulting from monitoring are based on the understanding of the role of water travelling throughout the landscape (and how the country is able to respond to rainfall) and the presence of ground cover (influenced by controlling total grazing pressures).

8.7 Follow up on the Gascoyne Flood Survey completed by DAFWA

Following the extreme flooding events of December 2010, the Department of Agriculture & Food conducted a **Gascoyne River Catchment – Post Flood Assessment**. The findings have not been published (as at November 2011).

This document will be important to consider for future recommendations of regional management plans or natural resource management strategies. The document should be considered in conjunction with the regionally collected data from the GCG Monitoring Tool (as described in 8.2 above).

8.8 Rio Tinto Dampier Salt Ltd continued protection and research of NP & LM

Lake MacLeod and (the Northern Ponds) have significant ecological values which are influenced by the actions in the broader catchment. The mining operation depends wholly on the Lake for its source of mineral wealth and is obliged to adhere to regional and national ecological obligations.

RTDSL is well positioned to contribute research funds into learning more about the significance (ecological, geomorphological and hydrological) of this unique sedimentary basin. Such information should be shared with the broader public rather than remain in reports on shelves.

The current relationship with the Edith Cowan University will be highly significant; as it is anticipated the information gained from this program will shed much more light on the overall ecological importance of the area and the significance of this wetland to the whole catchment. From a landscape perspective RTDSL have a great opportunity to work in a '*whole of catchment approach*' with their up-stream neighbours to build stronger relationships to manage the whole ecological system that every land manager depends upon for their business survival.

8.9 Carbon Capture opportunities

With the introduction of the Federal Governments Carbon Farming Initiative [CFI] (effective as of July 2012) come opportunities for land managers to augment potential land use activities and income streams. Whilst, at the time of this documents publication, legislative details are still unclear within the Western Australian rangelands, there is still scope for investigating the potential.

The CFI is a carbon offsets scheme designed to provide new economic opportunities for land managers whilst also assisting the environment by reducing carbon pollution. It is hoped that land managers will be able to generate credits which can be sold to other businesses wishing to offset their own carbon pollution. The CFI plans to create incentives to reduce emissions from agriculture and increase carbon storage in soils and vegetation. The current government aims to achieve its long-term emissions reduction target of at least 80 per cent below 2000 levels (Kyoto) by 2050.

Almost \$1 billion will be available to deliver biodiversity and environmental co-benefits, ensuring that CFI and other projects deliver protection and enhancement of Australia's natural resources. This will be complemented by support to enhance regional NRM plans with up to date climate science, and provide guidance to land managers on the type and location of CFI projects so they deliver maximum social and environmental benefits. <http://www.cleanenergyfuture.gov.au/carbon-farming-initiative/>

For any land manager to be eligible to trade carbon credits captured on their lands, they must be aligned to an established and approved methodology. To date six methodologies have been submitted through the Domestic Offsets Integrity Committee (DOIC) including:

- Management of large feral herbivores (camels) in the Australian rangelands
- Savanna burning
- Avoided emissions from diverting waste from landfill for process engineered fuel manufacture
- Capture and combustion of landfill gas
- Destruction of methane generated from manure in piggeries
- Environmental plantings

Currently the only methodologies relating to carbon farming initiatives available for the rangelands regions include the *Management of Camels* and *Savanna burning*.

The difficulty with pastoral leasehold land in the rangelands at the moment is that while the land managers are directly responsible for the management of the landscape (and the subsequent carbon capture and storage) the rights for the carbon sit with the Minister for Lands. As such, pastoralists do not have a commercial pathway and are currently ineligible to receive a dollar value from any offsets created. The government is aware of this and will have to deal with this and other institutional issues to ensure the industry can access the CFI.

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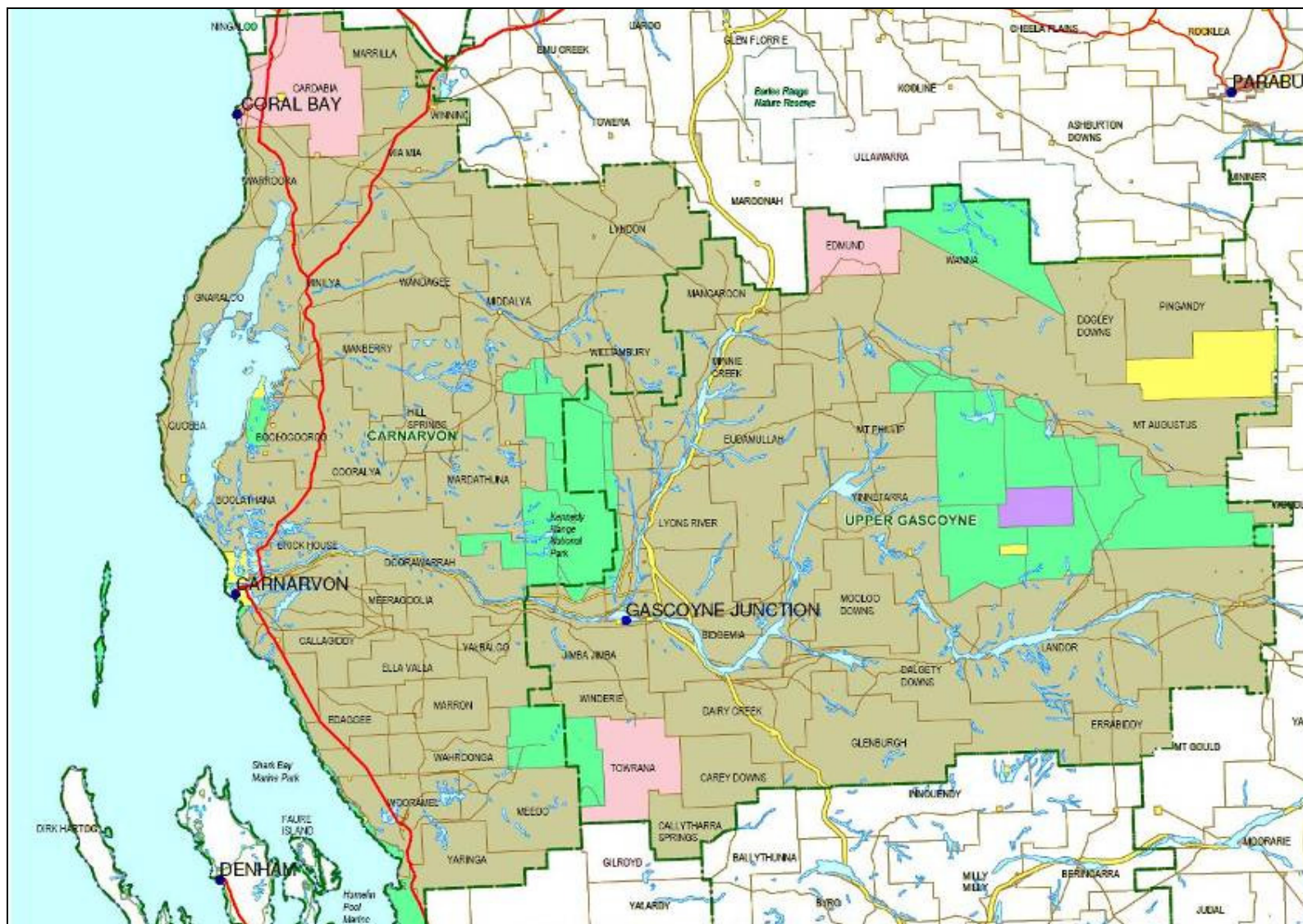
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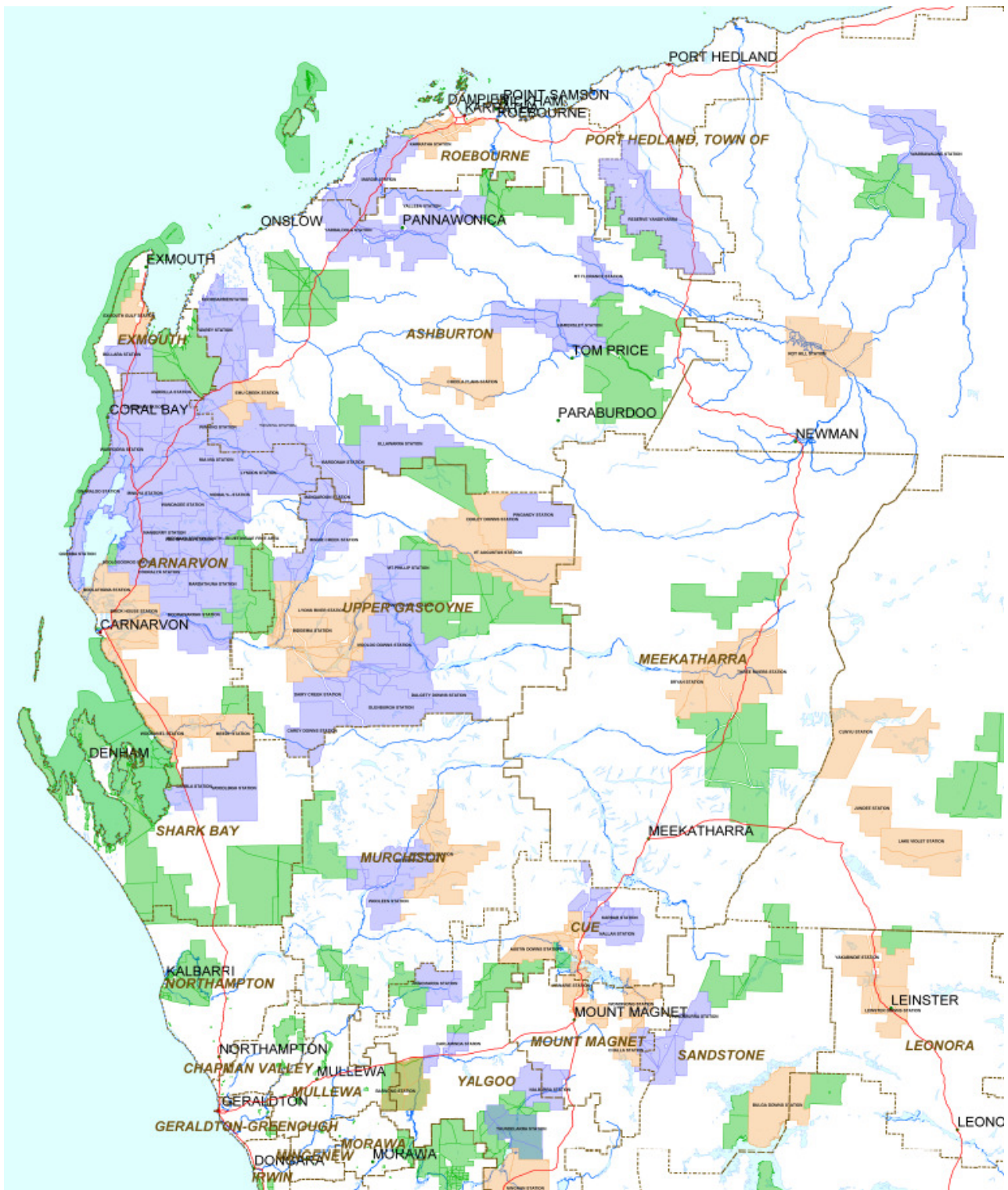
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Appendix 1: Map of the Carnarvon and Upper Gascoyne Shires (Land Tenure: Brown=Pastoral, Green=DEC, Yellow=Vacant, Pink=Indigenous)



Appendix 2: ESRM Property involvement throughout the Rangelands since 2007.



Purple – Property Planning & Updated
Orange – Property Planning & Workshop/Visits
Green – DEC reserves

Appendix 3: Rainfall records

Chart 1: Monthly rainfall recorded at **Doorawarrah** Station from 1898 – 2011. (Located 80km east of Carnarvon)

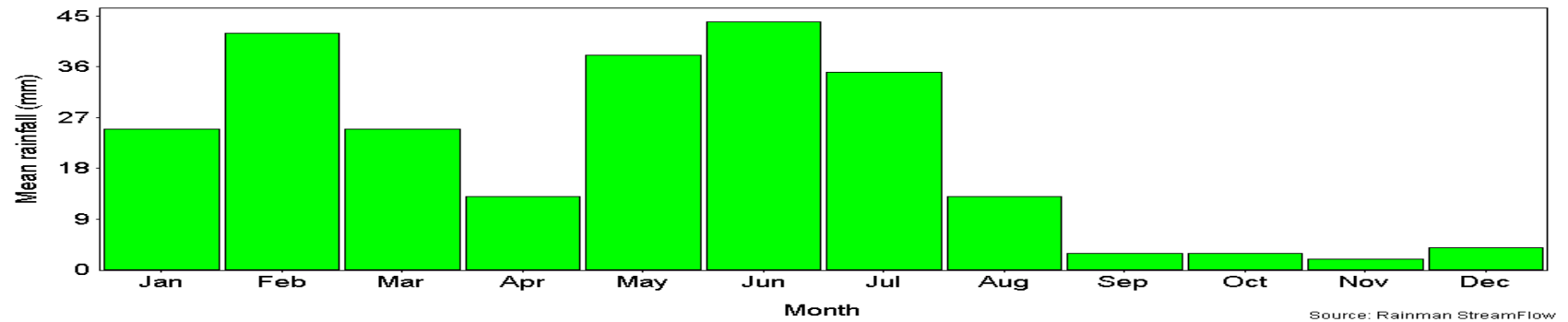


Chart 2: Monthly rainfall recorded at **Minilya** Station 1898 – 2011. (Located 120km north-east of Carnarvon)

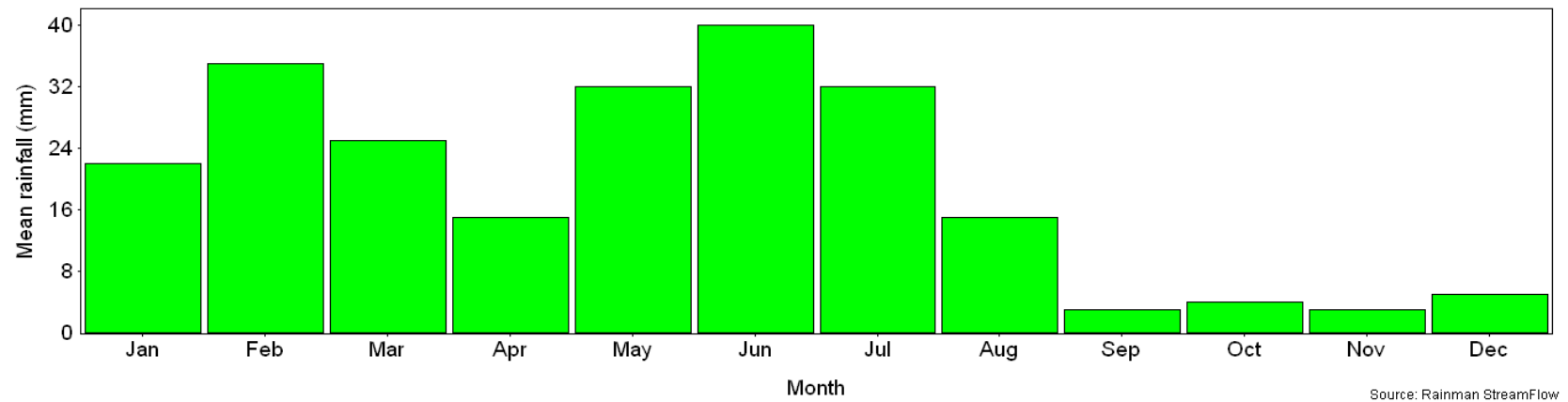


Chart 3: Historical average annual rainfall at **Doorawarrah** station 1898 – 2008

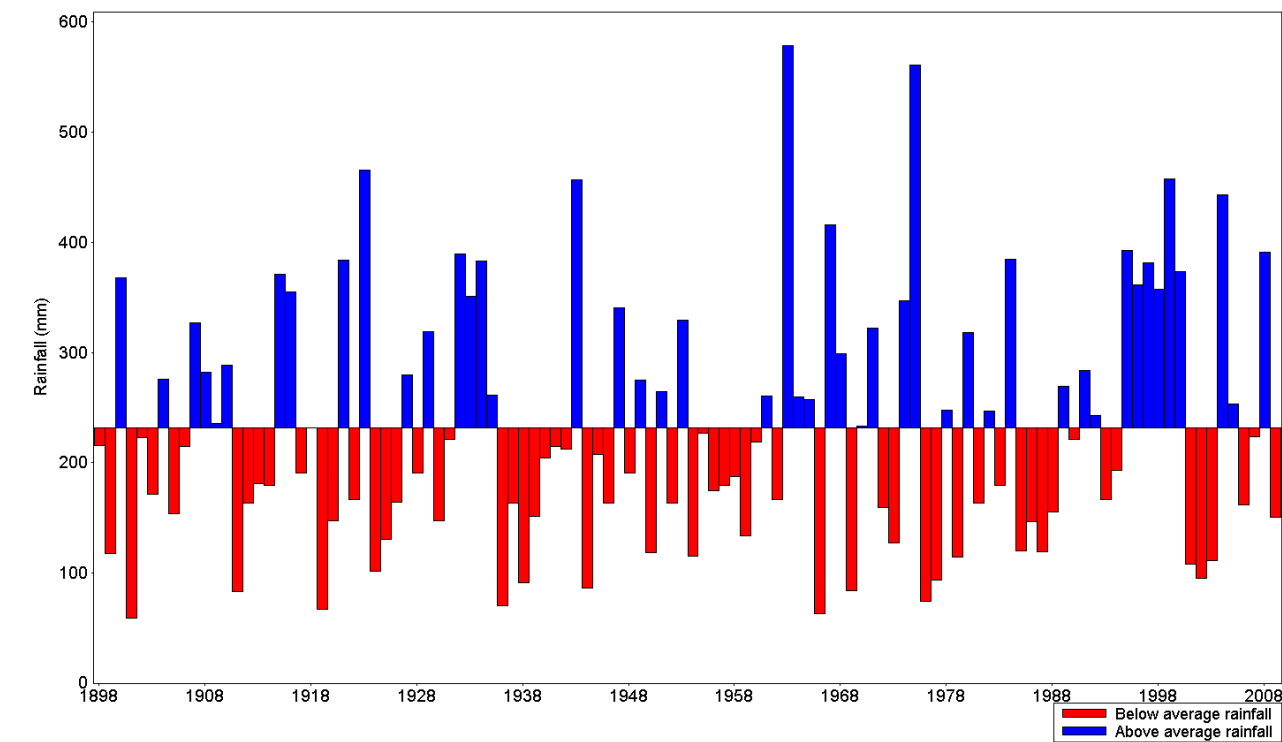
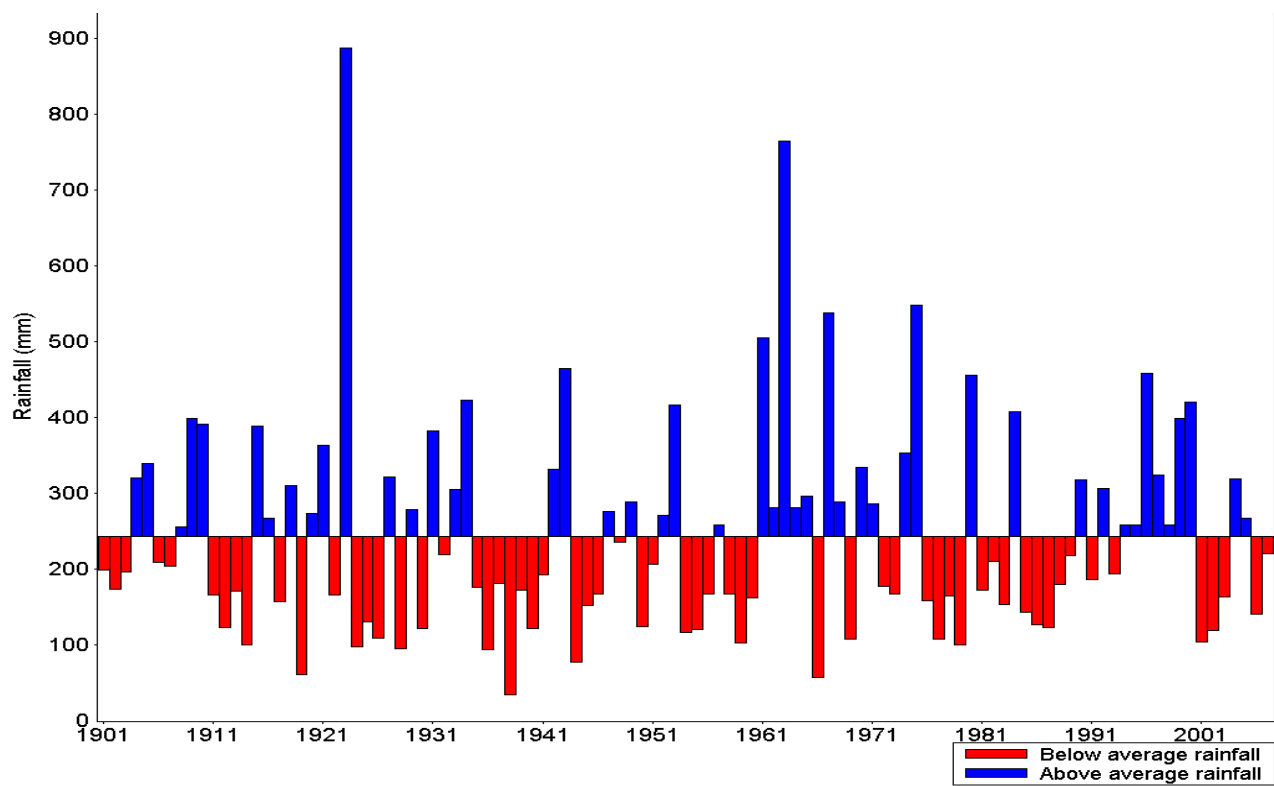


Chart 4: Historical average annual rainfall at **Minilya** station 1898 – 2008



Appendix 4: Directory of Important Wetlands in Australia criteria for Lake MacLeod

The Lake MacLeod System is currently identified as a wetland of national importance under criteria 1, 2, 3, 4 and 6 of the Directory of Important Wetlands in Australia (DIWA). These criteria are as follows:

1.

It is a good example of a wetland type occurring within a biogeographic region in Australia.

The Lake MacLeod System is an outstanding example of a major coastal lake that is episodically inundated by fresh water, which includes permanent saline wetlands and inland mangrove swamps that are maintained by subterranean waterways - a unique assemblage of wetland types in Australia.

2.

It is a wetland that plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.

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. *The Lake MacLeod system is a major migration stop-over and drought refuge area for shorebirds, including Banded Stilt (Cladorhynchus leucocephalus), Curlew Sandpiper (Calidris ferruginea) and Red-necked Stint (Calidris ruficollis). It also supports Australia's largest inland community of mangroves and associated fauna.*

4.

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

Surveys at Lake MacLeod have recorded as many as 111,600 shorebirds and 114,956 waterbirds belonging to fifty-eight different species. The system supports more than 1% of the national population of the following shorebirds:

Banded Stilt (Cladorhynchus leucocephalus);

Curlew Sandpiper (Calidris ferruginea);

Red-necked Stint (Calidris ruficollis);

Red Knot (Calidris canutus);

Pied Cormorant (Phalacrocorax melanoleucos);

Red-necked Avocet (Recurvirostra novaehollandiae);

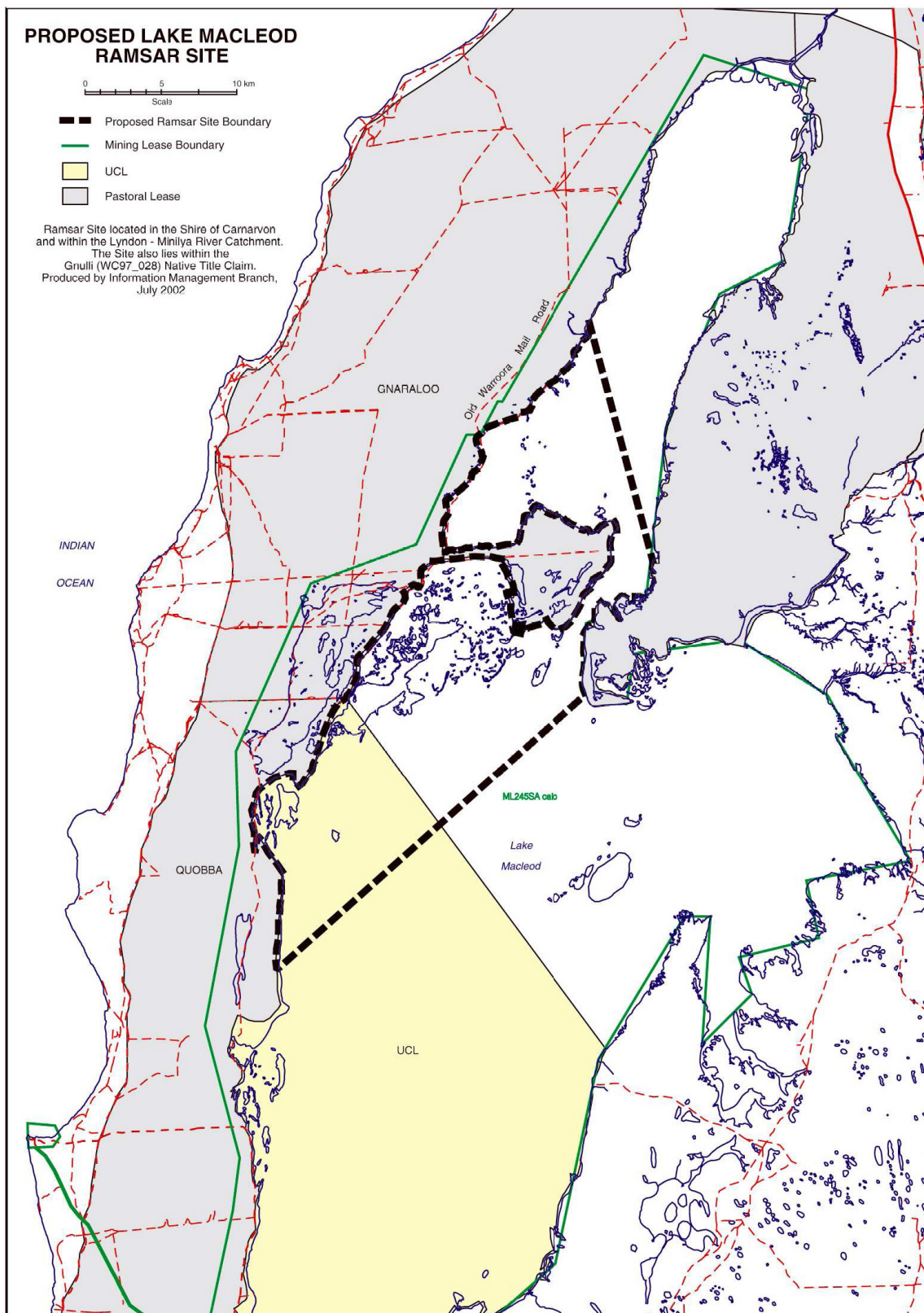
Red-capped Plover (Charadrius ruficapillus); and

Australian Pelican (Pelecanus conspicillatus).

6.

The wetland is of outstanding historical or cultural significance.

Appendix 5: Map of the proposed site of Ramsar Listing as outlined in DEC RCM Report 2009.



Appendix 6: Relevant legislation, policies, strategies, plans and recommendations related to the Lake MacLeod catchment region

The table below provides a comprehensive list of International, Federal, State, Regional and Local policies, strategies, plans and recommendations that support the strategies and discussions within this document.

INTERNATIONAL

Japan-Australia Migratory Birds Agreement (JAMBA) 1974
China-Australia Migratory Birds Agreement (CAMBA) 1986
Republic of Korea Migratory Birds Agreement (ROKAMBA) 2006
World Heritage Listing of Ningaloo Marine Reserve
Convention of Wetlands – proposed Ramsar Listing
Kyoto Protocol (2008)

FEDERAL

Environment Protection and Biodiversity Conservation Act (1999)
Wildlife Conservation Act (1950)
National Action Plan for Salinity and Water Quality (2000)
Towards Sustainability: Achieving Cleaner Production in Australia (1998)
National Greenhouse Strategy
National Local Government Biodiversity Strategy (1999)
National Weeds Strategy: A Strategic Approach to Weed Problems of National Significance
National Water Quality Management
National Framework for the Management and Monitoring of Australia's Native Vegetation (2000)
National Strategy for the Conservation of Australia's Biological Diversity
Australian Heritage Council Act 2003

STATE

Land Administration Act (1997)
Western Australian Greenhouse Strategy (2006)
Western Australian State of the Environment Report. Environmental Protection Authority, Perth 1998
Government Response to the State of the Environment Report. Government of Western Australia 1998
Agriculture and Related Resources Protection Act
State Weed Plan. Department of Agriculture (2001)
Environmental Protection Act (1986)
Environmental Protection Act for the Protection of Native Vegetation in Western Australia
Local Government Act (1995)
Wildlife Conservation Act (1950)
Western Australian State Sustainability Strategy
State Water Quality Management Strategy
Statement of Planning Policy No 2: Environment and Natural Resources Policy
Soil and Land Conservation Act (1945)
Aboriginal Heritage Act (1972)
Native Title Act (1993)
Wetland Conservation Policy for Western Australia (1997)
Conservation and Land Management Act (1984)

REGIONAL

Gascoyne Murchison Strategy for Natural Resource Management. Rangelands NRM CG 2005
Gascoyne Murchison Strategy (GMS) 1998-2004
Biodiversity Project – Western Australian Local Government Association (2004)
Rangelands NRM Pilbara Investment Strategy 2010

LOCAL

Ningaloo World Heritage Management Strategy (administered under EPPBC Act)
Lake MacLeod & Northern Ponds Management Plan (Management Action Group) 2011
Rangelands NRM MidWest Investment Strategy 2011

