THE HEALTH OF THE DARWIN REGION LAGOONS (NORTHERN TERRITORY):

TRIALS OF NATIONALLY PROPOSED WETLAND CONDITION INDICATORS

GISELA LAMCHE

Report 05/2008D

Aquatic Health Unit




National Land & Water Resources Audit
An Initiative of the Natural Heritage Trust

Northern Territory Government
Department of Natural Resources, Environment and the Arts

The Health of the Darwin Region Lagoons: Trials of Nationally Proposed Wetland Condition Indicators

This report should be referenced as:

Lamche, Gisela (2008): The Health of the Darwin Region Lagoons: Trials of Nationally Proposed Wetland Condition Indicators. Report 05/2008D. Aquatic Health Unit, Department of Natural Resources, Environment and the Arts.

ISBN: 1 920772 90 1

Acknowledgements:

This project was carried out as part of the regional trials of 'National Wetland Extent, Distribution and Condition' project and financed by the National Land and Water Resources Audit, contract DNA 8.

Francis Wait carried out the GIS mapping and calculations of this work in a patient and highly skilled way, which is gratefully acknowledged. Simon Townsend provided guidance during the planning stage of the GIS work. Thanks to Graeme Owen for generously sharing his knowledge on spatial data, available layers, interpretation of imagery and project management.

Leonie Williams spent time to provide data on surface water extraction from the lagoons and her and Christos Despotis provided general information on water extraction licensing. Robin Lawrence made comprehensive water extraction licence information available.

Helen Larsen, Blair Grace, Mark Kennard, Brad Pusey, and Duncan Buckle kindly shared their fish record data. Dale Dixon and Stephen Hester helped obtaining Herbarium records on macrophytes. Philip Short, Ian Cowie and Dale Dixon provided advice on aquatic macrophytes and how to collect them.

The field work would have been impossible without the collaboration of Quentin Allsop, Poncy Kurnoth, Robert Charters, Chris Errity, Dave Wilson, Tony Boland, Julia Schult, Julia Fortune, Matt Majid, and Lizzy Skinner.

Ben Stuckey provided the identification service for the macrophytes collected in the field, which is gratefully acknowledged.

Julia Schult, Mike Lawton, Simon Townsend and Julia Fortune constructively commented on earlier versions of this report.

CONTENTS

LIST OF FIGURES AND PLATES

LIST OF TABLES

ABBREVIATIONS

BI	Biota Index
CDI	Catchment Disturbance Index
DEW	Department of the Environment and Water Resources (now Dept. of Environment, Heritage and the Arts)
FZI	Fringing Zone Index
GIS	Geographic Information System
HDI	Hydrological Disturbance Index
I	Infrastructure indicator or sub score
LCC	Land Cover Change indicator or sub score
LU	Land Use indicator or sub score
LUMP	Land Use Mapping Project
NLWRA	National Land & Water Resources Audit
PDI	Physical Disturbance Index
WCI	Wetland Condition Index
WEI	Water Extraction Indicator
WQI	Water Quality Index
WWTF	Wetlands & Waterbirds Taskforce

1. SUMMARY

The National Wetland Indicators Project was carried out through a National Wetland Indicator Review as a collaborative project between the National Land & Water Resources Audit (NLWRA), the Department of the Environment and Water Resources (DEW), and the Wetlands & Waterbirds Taskforce (WWTF).

The National Wetland Indicators Project reviewed wetland condition indicators used for environmental and natural resource management projects in 2006 and 2007 with the goal to stream line them and provide national recommendations on the types of indicators to be used.

The project presented in this report is part of the National Wetland Indicators Project regional trials, trialing the National Framework and Indicators for Wetland Extent, Distribution and Condition on the lagoons in the Darwin region.

The extent and distribution component of the lagoons in the Darwin region is presented as mapping based on Quickbird Imagery.

Wetland condition indicators were selected on the basis of data availability for the nationally recommended indicators. The six proposed condition indicator themes were trialed on the Darwin region lagoons and results are presented.

The regional trials of indicators for the six themes produced the following outcomes:

- The Catchment Disturbance Index revealed that approximately one third of lagoons in the study area were largely unmodified, another third was classed as the worst condition of severely modified and the last third was distributed in between. Generally catchments of natural lagoons were in a better condition than those containing man-made lagoons. The Catchment Disturbance Index was found useful as an indicator for lagoon catchment health in the trial region as it appeared to distinguish the variously impacted lagoons well.
- The Fringing Zone Index is based on remnant native vegetation in a 100 m wider buffer zone around the wetland complex. One third of the lagoon complexes examined were in the best and another third in the worst condition class with the remainder distributed amongst the three moderate condition classes. There was also a large difference between natural lagoon complexes that scored better overall in this index, in comparison to the man-made ones.
- The indices calculated for catchment disturbance and fringing zone condition are assessed as meaningful and suitable and could be used without modification, although some minor modification for the Catchment Disturbance Index is suggested. Land use and vegetation or clearing data are likely to be readily available for all of the Northern Territory. However, as the wetland mapping -including mapping of catchments- is not comprehensively available in the NT, the indices can not simply be calculated NT-wide.
- The Physical Disturbance Index placed only three of the natural lagoon complexes in the best condition class, with the majority of lagoons being assessed as slightly to moderately modified. This is mainly due to the way one of the sub scores of this index, the 'area sub score', is calculated, which at its current setting is assessed as not representing the Darwin region lagoons well and will need changing. However, more information is required from other parts of the NT to adjust and finalise the scoring system for the 'area' as well as 'proximity to closest wetland' sub indices, if they are to be used in the way trialed.
- The Hydrological Disturbance Index was calculated based on water extraction. The index placed all wetlands in the largely unmodified category. This is assessed as representing the current situation. There have been modifications to the drainage of many lagoons, including stormwater entry into lagoons. The latter would have a negative impact on the water quality and will be picked up in that index. It is not known whether the ecology of the lagoons has been

impacted negatively through the modified drainage lines. Data on these modifications are sparse.

The index is assessed as meaningful with the limitation of only using licensed water extraction information with data on domestic use and unlicensed water extraction not available.

- The Water Quality Index was only calculated for natural wetlands, which were mostly unmodified, fewer being slightly modified and two of the 12 for which data were available were categorised as moderately modified.

  The Water Quality Index was trialed using six water quality parameters and provides meaningful results. It is however suggested to reduce the number of water quality parameters required from six to three including turbidity and total nitrogen. It is suggested to sample in the late wet to early dry season. At this stage it is recommended to sample more than once for a Water Quality Index calculation.

- There was not enough data to calculate the Biota Index. The fish taxa number indicator was calculated for Girraween Lagoon only, which was classed as largely unmodified when surveyed in the dry season. Not enough macrophyte data were available to develop the planned macrophyte taxa number indicator. Collections of macrophyte data are underway and another fish survey round is planned in order to obtain more data to further develop the Biota Indicator. If fish taxa numbers per lagoon are found to be low, i.e. below ten, the establishment of a fish taxa indicator is not meaningful. In contrast, the establishment of a macrophyte indicator is promising.

- The Wetland Condition Index (WCI) is integrated from the six index scores for each wetland, with at least three indices required. When considering all lagoon complexes, the scores were reasonably well distributed between the bands A to D with fewer than a quarter of lagoon complexes being classed as largely unmodified (A) or moderately modified (C) and a little more than a quarter placed into the categories slightly modified (B) and substantially modified (D). None of the Darwin lagoons were classed as severely modified (E).

  Natural lagoons were overall of a far better condition than the man-made lagoons. Three lagoon complexes, namely Fischer Lagoon, Limul Limul 3, 4, 5 lagoon complex and Lyons Lagoon achieved the unmodified score in all of the four indices data were available for, and these were also the only lagoon complexes that had a similar band placing for all of them. The highest WCI score was 0.90, obtained by those three natural complexes of Fischer Lagoon, Limul Limul 3, 4, 5 lagoon complex and Lyons Lagoon. The lowest WCI score of 0.21 was obtained by the man-made lagoon ‘5073-231’, which is the golf course lake on the RAAF Base – airport ground.

  The WCI can be calculated on the basis of three out of the six indices. However, it is debatable how well the WCI represents wetland condition, when calculated from the reduced amount of indices. Other authors had concluded previously that it is better to calculate the overall index on fewer than the six indices than to have no data at all, although this was considered not ideal.

- The overall condition of all lagoon complexes in the study area scored 0.71, which is classed as slightly modified. The overall condition of all natural lagoon complexes scored a little higher with 0.76, which is also in the slightly modified category. The overall condition of man-made lagoon complexes scored considerably lower with 0.56, which places them into the moderately modified band. This was assessed as representing the current situation.

- When comparing wetland scores on a broader scale across the country, it appears that a large amount of work remains to be done. Validation and sensitivity analysis of the indicator system trialed for the Darwin region are required to enable comparison of scores between regions, and within the country.

2. INTRODUCTION

The ecological importance of wetlands has now been widely acknowledged, but the amount of knowledge on wetland condition still lags far behind that on rivers and streams (Norris et al. 2007a, Finlayson et al. 2005, Finlayson & Davidson 2001, Finlayson & Spiers 1999).

The National Wetland Indicators Project reviewed wetland condition indicators used for environmental and natural resource management, with the aim to provide national recommendations on the types of indicators to be used (Conrick et al. 2007).

The National Wetland Indicators Project was carried out through a National Wetland Indicator Review as a collaborative project between the National Land & Water Resources Audit (NLWRA), the Department of the Environment and Water Resources (DEW), and the Wetlands & Waterbirds Taskforce (WWTF) (Conrick et al. 2007). The project only addressed lacustrine and palustrine wetlands (lakes and marshes) and produced a final report in June 2007 after consultation with jurisdictions and a national workshop. At the end of the project, it was decided to trial the proposed national indicators for wetland condition in order to have a broader data basis to finalise the indicators recommended nationally for use in condition monitoring and reporting.

The project presented in this report is part of the trials of the Framework and Indicators for Wetland Extent, Distribution and Condition of the lagoons in the Darwin region. The project is composed of two parts, with the first being the mapping of the extent and distribution of the lagoons, and the second their condition assessment.

The Darwin region lagoons were chosen for the NT trials as a reasonable amount of information is available on them, which was used to examine the condition indicators. The Darwin region lagoons are quite unique, they are characterized as being perched fresh water bodies with low electrical conductivity, very high clarity throughout most of the year and are generally considered to be in a healthy state but under threat from human activity associated with the urban centre of Darwin and surrounds including local industrial and agricultural/horticultural activities (Haig & Townsend 2003, Schult & Welch 2006).

This projects selected the Darwin lagoons being characterized through having an open water body of 50 m or larger in diameter, which can but might not be associated with a section of tree swamp. Other wetland types such as brackish and saline wetlands, floodplains and tree swamps without an open water body were excluded. However, the mapping process identified and included wetland types other than lagoons due to the decision rules set (see section 4), many of which included man-made water bodies such as dams and quarries. This project did not produce a complete wetland map of all wetland types in the study area and the wetland condition indicators were trialed on the lagoons and wetland types mapped under the decision rules only.

The national recommendation on wetland condition assessment works with six themes, each of which cover one part of the physical and biological components and processes, that contribute to the ecological integrity of the wetland (Conrick et al. 2007, Norris et al. 2007b). The six themes and the currently proposed indicators are (Conrick et al. 2007):

Catchment disturbance	• Disturbance in the catchment
Physical Form and Processes	• Area of wetland - change in wetland area • Wetland topography – change through erosion, excavation, banks and levees, deposition or rehabilitation • Soil disturbance – change through physical disturbance, compaction or cultivation
Hydrological disturbance	• Physical modification to hydrology in-flow, drainage and extraction (catchment and wetland scale) • Changes to water regime timing, frequency, duration, extent and depth, and variability, including groundwater contribution

Water and Soil Quality	• Turbidity (light climate) regime • Salinity regime • Change in pH • Soil properties – change in salinity, acidity
Fringing zone	• Change in fringing zone (measured by change in vegetation condition and extent)
Biota	• Change in wetland vegetation • Change in invertebrate diversity and community composition • Change in wetland-dependent vertebrates (fish, frogs, reptiles, birds, mammals) presence, breeding and abundance • Change in introduced species (weeds and ferals) presence and abundance • Change in algae (as a measure of primary productivity rather than water quality).

As part of the project, one or two indicators per theme were selected and trialed for the Darwin region lagoons. Data availability was reviewed and indicator values then calculated and discussed with respect to their utility.

Furthermore, this report provides protocols for the calculation of all indices as well as the protocols for integration and aggregation of index data. Maps displaying the results of the indices per individual wetland can be found in Appendix 3.

3. CURRENT KNOWLEDGE ON THE DARWIN REGION LAGOONS

3.1 Review of assessment frameworks and indicators in use at the trial regional level

The work on wetlands in the Northern Territory (NT) has been carried out in the form of regional projects, with no regular or ongoing monitoring currently being undertaken, although some community groups carry out some local monitoring. This local monitoring is normally limited to one lagoon per Landcare group collecting some regular or irregular water quality data, sometimes weed management and the opportunistic collection of data on some animal and plant groups, which is dependant on the energy and expertise of the local community group and varies with time. There is no coordinated approach or protocol for data collections.

The NT is at the stage of collecting baseline data for selected regions. No condition assessment is currently carried out on wetlands and no specific indicators are in use.

The project work that has been completed in the study area is listed and summarised in the following.

3.2 Baseline information available for wetlands in the Outer Darwin Area

3.2.1 Inventory of Freshwater Lagoons in the Darwin Region

Schult (2004) used the aerial photography series 'Darwin Rural Stages 1+2', produced in 2002 as a baseline for the mapping of the lagoons of the Darwin region using Fugawi 3.1 software. Small to medium sized water bodies with macrophyte cover and/or a fringe of aquatic vegetation were classified as lagoons and included in the inventory. Large dams and flooded quarries were not included. A total of 137 lagoons were identified in the study area. The name, location, area and perimeter were presented for each lagoon.

3.2.2 The Water Quality of fifteen Lagoons in the Darwin Region

Fifteen lagoons representing various sizes, depths, land use settings and vegetation covers were selected from the inventory of Schult (2004). Physical and water quality data were collected monthly over a period of 12 months by Schult and Welch (2006). Most of the lagoons were shallow (<3m maximum depth), with two thirds of the lagoons holding water throughout the survey period. The lagoons appear to be perched, and are not hydraulically connected to the groundwater table.

The water quality of the lagoons was generally good with low nutrient concentrations and clear water. As the water levels dropped during the dry season, water quality declined, due to increased concentrations of dissolved solutes and particulate material associated with evaporative concentration and re-suspension of lagoon sediments by fauna (water birds, feral animals) and wind induced wave action.

Rural development appears to have had little impact on the water quality of the lagoons, although the highest nitrate concentrations were generally observed in lagoons with the highest degree of catchment development.

3.2.3 Knuckeys Lagoons

Two of the four lagoons aggregated in the Knuckey Lagoons complex were studied by Lloyd (1999) over a period of 14 months. Water quality was recorded fortnightly and aquatic vegetation surveyed approximately every two months.

Water quality was "good" (low turbidity, nutrients and chlorophyll) until approximately one month before the lagoons dried up completely. This last month was characterised by very high conductivity, low oxygen, high temperature, high turbidity, high nutrients and high chlorophyll a concentrations. This was explained through reduced water volume, increased wind action and activity of birds.

A total of 26 emergent and floating aquatic plant taxa were identified, with most of the vegetation identified to genus level. The North West Lagoon had the greatest richness with 21 taxa recorded, with a maximum of 16 of these recorded in December and the minimum of 6 in September. The second lagoon revealed a total of 14 taxa with a maximum of 8 recorded in May and August and a minimum of 2 registered in September when the lagoon was nearly dry.

This study was very important as it provided the first baseline information of water quality parameters in connection with vegetation information over a seasonal cycle.

3.2.4 Girraween Lagoon

A recent report by the Girraween Landcare Group (2007) provides a summary of knowledge about Girraween Lagoon, mainly gathered through a literature review, but also through data collection by or for the Landcare group. It is stated that there is a general lack of information on the flora of the lagoon, which is a habitat for the very rare carnivorous aquatic plant *Aldrovandra vesiculosa* and the reed-like plant *Lepironia articulata*, which is uncommon in the NT, but thought to be successful in Girraween Lagoon as a result of stable year-round water levels. These stable water levels distinguish Girraween Lagoon from other local lagoons, making it unique and therefore more valuable for conservation.

The report also lists a summary of fauna recorded from the lagoon with respective references, including macroinvertebrates, butterflies, fish, amphibians, reptiles, mammals and birds. Some of the taxa listed however need confirmation.

Another report on Girraween Lagoon (Staben & Forsyth 2002) focuses on management issues of the lagoon. It also contains a list of flora including weeds, and fauna, including birds, fish and frogs as well as sightings of insects, mammals and reptiles.

3.2.5 A GIS based risk assessment of Darwin Harbour Region Lagoons

This project was not completed. The draft report provides another inventory of lagoons and their catchments in the Darwin region of the Darwin Harbour catchment, including two GIS data layers. However, information as to how the layers were derived and decision rules used were not recorded, making this work unreliable to use (Freeman J, draft report). The project calculated an erosion risk model for sedimentation, and used this as well as clearance, land use, roads and fire data layers to calculate the risk to the wetlands. Only a few of the 41 lagoons were classed as high risk or low risk, whereas most of the lagoons were placed in the three moderate categories.