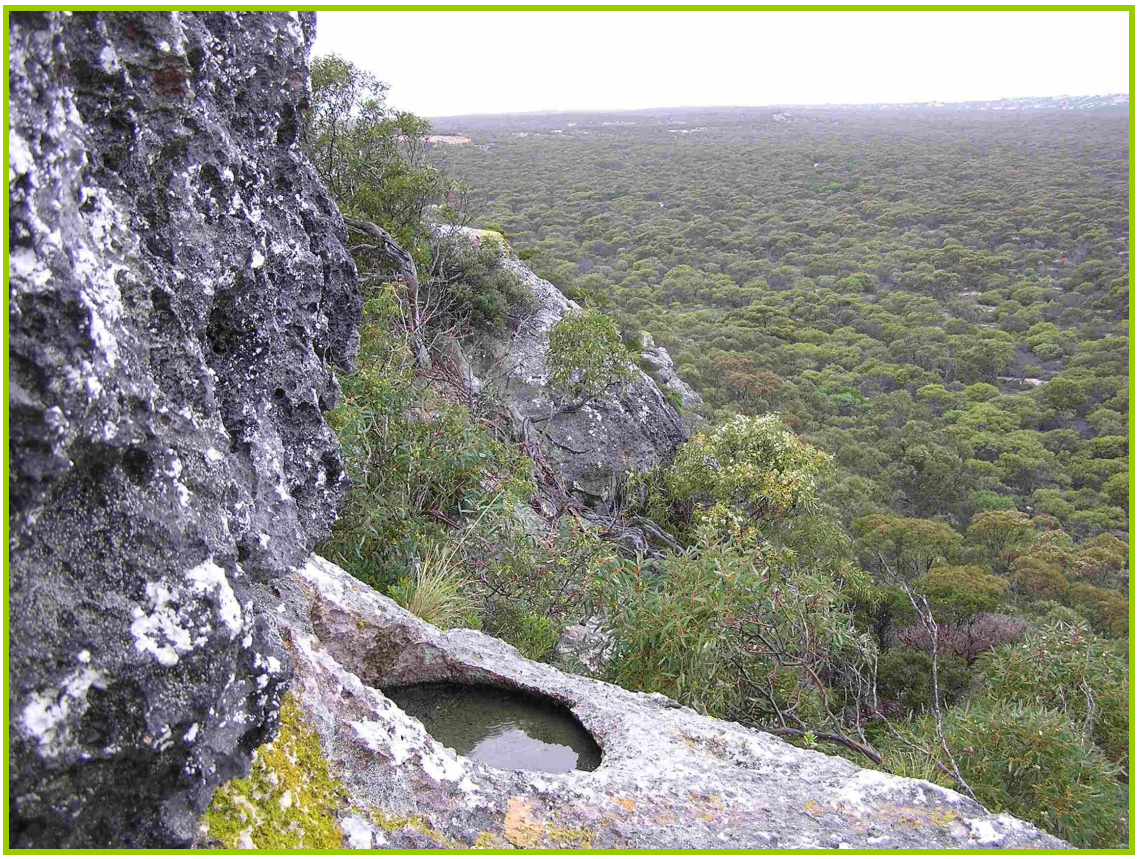
Nomination and improved documentation of nationally important wetlands in under-represented IBRA regions in Western Australia



Report prepared for the Commonwealth Department of Environment, Water Heritage and Arts - Funded by Environment Australia under the Rivercare Program of the second phase of the Natural Heritage Trust – *Conservation of Internationally and Nationally Important Wetlands*

S.V. Elscot, J.A.K. Lane, A.G. Clarke and W.P. Muir
Western Australian Department of Environment and Conservation

April 2009

Cover Photograph: WA124 Hampton Scarp Rockholes – Photograph by Alan Clarke.

CONTENTS

1 FINAL REPORT 2

1.1 INTRODUCTION 2
1.2 OUTCOMES 2
1.2.1 Review of Directory coverage and existing site descriptions 2
1.2.2 Collation of recent reports and publications, site maps, aerial photographs and satellite images 3
1.2.3 Contacting and interviewing site managers and others with substantial relevant knowledge 3
1.2.4 Collection of field data and specimens, data analysis and specialist taxonomic identifications 4
1.2.5 Preparation and new/improved site documentation 5
1.2.6 Update the WA component of A Directory of Important Wetlands in Australia – Deliverables provided to DEWHA 6
1.3 APPROPRIATENESS 7
1.4 EFFECTIVENESS 9
1.5 TRANSFERABILITY 9

2 TEN NEW NATIONALLY IMPORTANT WETLANDS IN UNDER-REPRESENTED IBRA REGIONS 10

2.1 WA121 BENNETTS LAKE 11
2.2 WA122 CREEKS, SPRINGS AND FLOODOUT OF THE GARDNER AND DENISON RANGES 17
2.3 WA123 DUNN ROCK GNAMMA HOLES 22
2.4 WA124 HAMPTON SCARP ROCKHOLES 25
2.5 WA125 HARRIS LAKE 30
2.6 WA126 KONDININ SAMPHIRE MARSH 36
2.7 WA127 LAKE WILLSON 40
2.8 WA128 NURINA CAVE 44
2.9 WA129 PAPERBARK SWAMP 50
2.10 WA130 WALCOTT INLET AND MUNJA LAGOON 54
2.11 REFERENCES USED FOR THE TEN NEW NATIONALLY IMPORTANT WETLAND DESCRIPTIONS 62

3 IMPROVED DOCUMENTATION OF EXISTING DIRECTORY SITES 67

3.1 CHANGES MADE TO EXISTING SITE DESCRIPTIONS 67
3.2 REFERENCES USED TO UPDATE EXISTING DIRECTORY SITE DESCRIPTIONS 74

1 FINAL REPORT

1.1 INTRODUCTION

This report details the outcomes and deliverables achieved on completion of the federally funded project "Nomination and improved documentation of nationally important wetlands in under-represented IBRA regions in WA". This project was funded by Environment Australia (now the Department of Environment, Water, Heritage and the Arts – DEWHA) under the Rivercare Program (National component of the second phase of the Natural Heritage Trust – *Conservation of Internationally and Nationally Important Wetlands*). The format of this final report follows the format required by Section J (Records and Reporting Requirements) of the project Contract between the Western Australian Department of Conservation and Land Management and Environment Australia, commenced in 2003.

Section 1.2 of this report details the outcomes achieved for each of the six milestones identified in Table 1 of the project contract. Section 1.3 provides comments on the appropriateness of the approaches used in the development and implementation of the project. Section 1.4 assesses the degree to which the project met its stated objectives and section 1.5 examines the transferability of the approaches used for this project.

1.2 OUTCOMES

(Contract Reporting Item 1.1: The degree to which the project has achieved the outcomes referred to in Table 1 of the Contract, the Table of Milestones. Discuss each separately)

At completion of the project the following outputs and outcomes towards the nomination and improved documentation of nationally important wetlands in under-represented IBRA regions in WA have been achieved:

1.2.1 Review of Directory coverage and existing site descriptions

- The current representation of nationally important wetlands in WA was tabulated by IBRA region and mapped to allow a review of Directory coverage which enabled both the definition and identification of under-represented IBRA regions to be made (those with less than 4 existing sites), and subsequently a comparative, subjective assessment of the adequacy of existing site descriptions within the under-represented IBRA regions was undertaken. The following fifteen IBRA regions, containing a total of 27 existing Directory sites, were determined to be under-represented:

  Hampton
  Nullabor

Ord-Victoria Plains
Central Ranges
Great Victoria Desert
Tanami
Coolgardie
Gibson Desert
Little Sandy Desert
Yalgoo
Mallee
Central Kimberley
Geraldton Sandplains
Gascoyne
Northern Kimberley

1.2.2 Collation of recent reports and publications, site maps, aerial photographs and satellite images

- A thorough search of all published and grey literature relating to wetlands within under-represented IBRA regions was completed. All potentially useful literature was obtained, catalogued and reviewed. This work resulted in the identification of a total of 119 wetland sites within the 15 under-represented IBRA regions for further investigation.
- A spreadsheet compiling all known information and references relating to potential nationally important wetland sites in under-represented IBRA regions was created. The spreadsheet included fields of information relating to Directory listing, including ecological values, significance against the Directory criteria and information relating to tenure, threats and conservation measures taken. This allowed for systematic planning of a field programme for acquisition of new data to characterise the ecological values of the most promising potential new Directory sites for which there was no or very limited information currently available.
- Aerial photographs and site maps were obtained and used to plan the fieldwork program.

1.2.3 Contacting and interviewing site managers and others with substantial relevant knowledge

- Site managers and others, particularly wetland ecologists and naturalists, with substantial relevant knowledge about wetland systems within each of the under-represented IBRA regions were contacted and interviewed. Because there has been relatively little scientific study of wetlands in the under-represented IBRA regions, most information about potentially important new wetland sites was provided by Department of Conservation and Land Management (CALM, now the Department of Environment and Conservation, DEC) regional nature conservation staff, CALM (now DEC) Science Division staff, private landholders and pastoral

leaseholders, members of the Western Australian Naturalist's Club and local nature-based tour operators.

1.2.4 Collection of field data and specimens, data analysis and specialist taxonomic identifications

- Aerial surveys were undertaken during 2004 to investigate the waterbird values and habitat quality of potentially important wetlands within the Ord-Victoria Plain and Tanami IBRA regions (Sturt Creek, Wolfe Creek Crater, Lake Willson, Slatey Creek, Lewis Creek, Lewis Creek Floodout and Lake Gregory), Great Victoria Desert (Lake Minigwal – in response to reports of very large numbers of Banded Stilt) and the Yalgoo IBRA region (scouting for potential new sites and checking existing sites including Lakes Moore and Mongers, Thundelarra Lignum Swamp, Wagga Wagga Salt Lake, Yalgoo Salt Lake, Greenough River Pools, Billilly Claypan).
- During 2004, field data and specimens were collected from four potential Directory sites within the Mallee IBRA region (Harms Lake; Harris Lake; unnamed lake near Harris Lake; Bunningonia Spring), two large potential sites in the Hampton IBRA region (ten rockholes on the Hampton Scarp between Cocklebiddy and Madura; Twilight Cove Wetlands), two potential sites in the Nullarbor IBRA region (Duck Pond Arubiddy Station; Lake Boonderoo), four sites in the Yalgoo IBRA region (large salt lake south of the Yalgoo townsite, Geeloo Claypan, Greenough River Pools, Billilly Claypan), and six potential and existing sites within the Little Sandy Desert IBRA region (Lake Disappointment, and rockholes within Terrace Hill, Durba Springs, Calvert Ranges, Constance Headland and the Carnarvon Ranges). Western Australian Department of Environment and Conservation, Science Division, staff who were involved in the collection of field data were Alan Clarke, Bill Muir and Grant Pearson.
- All data was collected using a protocol that is consistent with all other current and recent Department of Conservation and Land Management wetland sampling and analysis procedures to allow for the maximum transferability and interpretation of data.
- During the field programme, a large number of aquatic invertebrate collections were made from five, geographically distant IBRA regions (NUL, HAM, MAL, YAL and LSD) and these have undergone identification by CALM (now DEC) technical officers and research scientists, and independent taxonomic specialists. The results of the identifications have assisted to determine the significance of the potential new Directory sites. Because of the standardised protocols employed during the field programme, the data will also be of use to determine the wider biogeographic significance of aquatic invertebrates in Western Australia through the input of the data into DEC's aquatic invertebrate

database for the State, which is maintained by Adrian Pinder, Research Scientist, DEC Science Division, Woodvale.

- In 2005, CALM (now DEC) allocated additional funding of $8,000 to enable the sorting and specialist taxonomic identifications of the aquatic invertebrate samples taken during the project to be completed between 2005 and 2007. The subsequent analysis of this data will greatly benefit aquatic invertebrate biogeography work in Western Australia when the results are added to DEC's aquatic invertebrate database for the state (noted above).
- Systematic planning for the field program identified several potential new Directory sites which could be investigated in future field programmes. A number of potentially important wetlands in the Gibson Desert and Central Ranges IBRA regions that received 'very much above average rainfall (top 10^{th} percentile)' in 2002 and 2003 subsequently dried in 2004 when the field program for this project was undertaken. These wetlands lie within land covered by Native Title ownership, some within an Indigenous Protected Area, and could be investigated in the future if the consent of the traditional owners is provided (this could not be achieved while the lakes were still inundated). More than 20 sites of interest in the Mallee and Coolgardie IBRA regions that were dry or in the late stages of drying when the field program was being undertaken, could be investigated should significant rainfall occur in the bioregions in the future.
- During the Little Sandy Desert fieldwork, a significant failed breeding attempt of Banded Stilt *Cladorhyncus leucocephalus* was discovered at Lake Disappointment (more than 700 dead juvenile Banded Stilt were recorded). A short note about this significant discovery has been published in *The Stilt*, the journal of Birds Australia's Australasian Wader Study Group. The citation for this publication is:

  Clarke, A.C., Muir, B., Elscot, S. and Lane, J. (2004). Banded Stilt breeding attempt at Lake Disappointment. *The Stilt* 46:39.

1.2.5 Preparation and new/improved site documentation

- Of the 27 existing Directory sites within the 15 IBRA regions which were defined to be 'under-represented' (those with less than 4 existing Directory sites), the site descriptions were improved for 25 sites (93%). Of those, 52% of the sites had considerable revision of two or more sections, while 41% of the site descriptions underwent major revision in response to new literature found during the collation of all existing literature, or as a result of new information gained about the sites during the field program.
- A total of ten new nationally important wetlands have been documented for listing in the Directory of Important Wetlands, and their site descriptions are provided in section 2 of this report. The ten new wetlands are:

WA121 Bennetts Lake
WA122 Creeks and Springs of the Gardner and Denison Ranges
WA123 Dunn Rock Gnamma Holes
WA124 Hampton Scarp Rockholes
WA125 Harris Lake
WA126 Kondinin Samphire Marsh
WA127 Lake Willson
WA128 Nurina Cave
WA129 Paperbark Swamp
WA130 Walcott Inlet and Munja Lagoon

1.2.6 Update the WA component of *A Directory of Important Wetlands in Australia* – Deliverables provided to DEWHA

- Ten new nationally important wetlands have been described, and the site description for each is provided in section two of this report, together with a list of references used for the new descriptions. The new sites have been added to the current access database for Western Australia which is contained within the thumb drive provided to DEWHA as part of this report (V3.1 – file name WA Wetland Database 2005). An electronic version (Microsoft Word) of each of the ten new site descriptions is also provided on the thumb drive (file name is the site name, as shown in section 1.2.5 above). The list of the references used in the ten site descriptions is also provided on the thumb drive (file name References for the ten nominated sites).
- Improved descriptions for the 25 existing wetland sites in under-represented IBRA regions have been updated in the current access database for Western Australia which is contained within the thumb drive provided to DEWHA as part of this report (V3.1 – file name WA Wetland Database 2005). A list of changes to the 25 site descriptions is provided in section three of this report, as is a list of references used to update the site descriptions. Electronic versions (Microsoft word) of the document detailing changes made to the existing sites and the references used to make the changes is included on the thumb drive (file names Refs used to update existing site descriptions). Please note that the references used to update the 25 existing sites have not been added into the reference field in the electronic database (WA Wetland Database 2005) as the reference field for these sites simply states “refer to the Western Australian reference list”. DEWHA staff will need to add the references provided in the list on the thumb drive to the appropriate location required by DEWHA (File name Refs used to update existing site descriptions).

1.3 APPROPRIATENESS

(Contract Reporting Item 2.1: The appropriateness of the approaches used in the development and implementation of the project)

The appropriateness of the approaches used to meet the following milestones, as listed in the Schedule, were:

- 1. Review of Directory coverage and existing site descriptions - At the project outset, the current representation of nationally important wetlands in WA was tabulated and mapped by IBRA region to allow a review of Directory coverage which enabled both the definition and identification of under-represented IBRA regions, and a subjective assessment of the adequacy of existing site descriptions within the under-represented IBRA regions was made. This was considered to be an appropriate approach to systematically define target IBRA regions and sites for improved documentation.
- 2. Collation of recent reports and publications, site maps, aerial photographs and satellite images - A thorough search of all published and grey literature relating to existing nationally important and potentially important wetland sites was completed. The search included online searches of the catalogues of Government Department and University libraries, notably, the Department of Conservation and Land Management, the Department of Environment, Murdoch University, the University of Western Australia, and Edith Cowan University. Major electronic journal databases were searched including: Australian Informit (including Streamline, Australian Public Affairs Information Service, Australian Heritage Bibliography, Australian Historic Records Register, Environmental Abstracts, Endanger – threatened species in Australia and ELIXIR – NRE's library exchange for information resources), CSA (including Aquatic Sciences and Fisheries Abstracts and Digests of Environmental Impact Statements), Wiley Interscience (all science journals published by Wiley), Science Direct (all science journals published by Elsevier Science) and CSIRO publishing (all journals published by CSIRO). In addition, the hard copy of several highly specific journals (post 1995 issues only) were searched by hand at the CALM (now DEC) Wildlife Research Centre Library, including: The WA Naturalist, Journal of the Royal Society of WA, WA Bird Notes, Emu, Nuytsia, Corella, the Stilt, and Records of the WA Museum. This literature search was considered to be very thorough and resulted in the collation of a large amount of new information relating to both the existing Directory sites and potential new sites in under-represented IBRA regions. Following this, all potentially useful literature was obtained, catalogued and reviewed. From this, a spreadsheet that compiles information known about potentially important wetland sites in under-represented IBRA regions was created. This spreadsheet identified a possible 119 wetland sites within the 15 under-represented IBRA regions for further investigation. This information was used, together with information gained from interviews with site managers and others with substantial relevant knowledge (milestone 3) to

undertake systematic planning of data acquisition (milestone 4) for nomination of new nationally important wetland sites in WA (milestones 5 and 6).

- 3. Contacting and interviewing site managers and others with substantial relevant knowledge – Information about potentially important new wetland sites was provided by CALM (now DEC) regional nature conservation staff, CALM (now DEC) Science Division staff, private landholders and pastoral leaseholders, members of the Western Australian Naturalist's Club and local nature-based tour operators. This approach was particularly useful for identifying potential new sites for which there was no literature available whatsoever and some of the sites included in the field programme were brought to our attention this way.
- 4. Collection of field data and specimens, data analysis and specialist taxonomic identifications - The database of potentially important wetland sites in WA was reviewed and analysed against current representation of wetland types and criteria within the 3rd edition of the *Directory of Important Wetlands in Australia*. This facilitated the prioritisation of potential sites for inclusion in the Directory based on IBRA region, known values weighed against *Directory* criteria, wetland type, condition, threats, tenure, level of existing knowledge, and other factors. Fieldwork to obtain further data and specimens from high priority wetlands was planned on the basis of this prioritisation. Prior to the commencement of any fieldwork, a systematic sampling protocol, consistent with data collection methods used by CALM (now DEC) in other wetland management programs, was designed to ensure that sufficient information to enable *Directory* nomination was gathered at each site visited. This approach was considered to be appropriate to ensure the maximum usefulness, interpretability and transferability of the collected the data.
- 5. Preparation and new/improved site documentation – new and improved site documentation was prepared using the standard format for describing wetlands in the Directory. As this format was used in part as a basis for the design of the field programme sampling protocol, sufficient information was gathered to enable preparation of adequate new site descriptions with ease. Existing site documentation was systematically improved through the use of an efficient cataloguing system implemented during the collation of literature phase.
- 6. Update the WA component of *A Directory of Important Wetlands in Australia* – Use of the existing V3.1 Access database was an appropriate and efficient approach to update existing site descriptions, while preparation of the new site descriptions using a blank proforma of the standard format for describing Directory wetlands (provided in the third edition), created in Microsoft Word, was considered appropriate for new sites as it enabled the documents to be emailed and reviewed by site managers and other specialists with ease (unlike the Access database forms which could only be reviewed by faxing hard copies which was not preferred by the reviewers). Review by site managers and other specialists was considered necessary to ensure that all new and improved documentation is as factually correct as is possible.

1.4 EFFECTIVENESS

(Contract Reporting Item 3.1: The degree to which the Project has effectively met its stated objectives)

The project objective was the nomination and improved documentation of Nationally Important Wetlands in under-represented IBRA regions. The project has effectively resulted in the improved documentation of 93% of the existing 27 wetland sites within the 15 under-represented IBRA regions in Western Australia, and the nomination of nine new Nationally Important wetland sites within under-represented IBRA regions. In addition, the project has resulted in the compilation of a spreadsheet detailing 119 potentially important wetland sites in under-represented IBRA regions in Western Australia, a proportion of which may be suitable for listing in future editions of the Directory when tenure and other issues such as Native Title are resolved, or when further ecological information becomes available. Also, the project has resulted in the collection of a significant amount of aquatic invertebrate material that will enable the current understanding of the biogeographic significance of aquatic invertebrates in Western Australia to be significantly improved.

1.5 TRANSFERABILITY

(Contract Reporting Item 4.1: The degree to which the approach used to establish, implement and administer the operations of the project could be applied to the nomination and improved documentation of Nationally Important Wetlands in other under-represented IBRA regions in WA and in other States/Territories.)

The approach used to nominate and improve the documentation of Nationally Important Wetlands in under-represented IBRA regions in WA was a systematic, stepwise approach that enabled the establishment of a list identifying potential new wetland sites for further investigation in the future (beyond the lifespan of this project), and allowed for the collection of standardised data that was useable not only for this project but could be transferred to other wetland studies within Department and possibly further. The approach used could be transferred to any of the other States or Territories with ease.

2 Ten New Nationally Important Wetlands in Under-represented IBRA Regions

Ten new nationally important wetlands have been identified within the 15 under-represented IBRA regions in Western Australia. Listing documentation has been prepared and added to the WA database which has been provided to DEWHA. The ten new sites, together with the wetland reference numbers assigned to each site are:

WA121 Bennetts Lake
WA122 Creeks and Springs of the Gardner and Denison Ranges
WA123 Dunn Rock Gnamma Holes
WA124 Hampton Scarp Rockholes
WA125 Harris Lake
WA126 Kondinin Samphire Marsh
WA127 Lake Willson
WA128 Nurina Cave
WA129 Paperbark Swamp
WA130 Walcott Inlet and Munja Lagoon

New Directory report forms for each of these ten wetlands are provided on the pages that follow.

2.1 WA121 Bennetts Lake

Name of Wetland:
Bennetts Lake

Reference number:
WA121

Location:
33°17’ S, 119°36’ E, approximately 25 km south-west of Lake King.

Bioregion:
Mallee

Shire:
Shire of Lake Grace

Area:
Approximately 100 ha, the wetland basin is c. 58 ha.

Elevation:
Approximately 300 m AHD.

Other wetlands in the same aggregation:
None.

Wetland types:
B8

Criteria for inclusion:
1, 5

Site description:
The site comprises Bennetts Lake, a small, seasonal, naturally saline lake, and it’s fringing vegetation within Dunn Rock Nature Reserve.

Physical features:
Landform: Mesoscale ovoid sumpland. Bennetts Lake is characterised by a flat basin with moderately sloping, short banks, increasing in length on the south-eastern side (Gurner et al., 2000). A white sandy beach exists around the edge of the lake bed with a large area of the wetland devoid of vegetation on the south-eastern side (Gurner et al., 2000).
Geological Setting: Bennetts Lake is situated in the headwaters of a vast palaeodrainage system that includes the Lake Grace, Lake King, Lake Magenta and Lake Bryde wetland chains and eventually discharges into the Avon River (Watkins and McNee, 1987). Bennetts Lake is surrounded by undulating reworked sandplain containing yellow to

white sand and clay with scattered lateritic outcrops. Climate: Mean annual rainfall at Lake King is 340.8 mm per year, median 340.9 mm, mostly falling between May – September.

Hydrological features:
Water supply and inundation: Bennetts Lake is seasonally inundated although it may dry or remain inundated for several years at a time. Bennetts Lake receives water by direct precipitation, surface runoff and discharges from two inflow channels, one located on the south-southwest side of the lake, which originates 15 km south-east of the lake, and a smaller channel on the east side of the lake, which originates in farmland to the east (Gurner et al., 2000). The southern catchment encompasses an area of approximately 12,000 ha and the smaller eastern catchment is approximately 2000 ha (Cale et al., 2004). Bennetts Lake overflows during floods and empties into Lake Ronnerup to the north (Cale et al., 2004). When fully flooded (depth greater than 2 m) a series of channels form on the eastern side of the lake as several parallel dune swales fill (Cale et al., 2004). In 1986, Bennetts Lake filled for the first time in at least 10 years (Watkins and McNee, 1987). Water depth: September mean 1.15 m, median 0.80 m, range 0.08-2.84 m (n=5); November mean 0.96 m, median 0.57 m, range dry-2.43 m (n=5) (Lane et al., 2004). Water salinity: September mean 43.3 ppt, median 15.1 ppt, range 4.1 to 183.5 ppt (n=9); November mean 37.0 ppt, median 19.6 ppt, range 4.8 to 153.8 ppt (n=8) (Lane et al., 2004). Hyposaline to brine, poikilohaline. Groundwater salinity: In 2000, groundwater salinity ranged from 2.8 to 3.6 ppt and was therefore less saline than the surface waters (Cale et al., 2004).

Ecological features:
While generally a seasonally inundated naturally saline lake, Bennetts Lake periodically fills to >2 m deep and may be brackish for a time as the lake slowly dries over following years (Cale, 2004). The lake bank supports a closed low woodland of *Melaleuca strobophylla, M. hamulosa* and *M. halmaturorum* over an understorey dominated by the samphires *Sarcocornia* and *Halosarcia* (Cale et al., 2004). Further upslope, and on dune crests to the east, there is open woodland of *Eucalyptus occidentalis* and *M. hamulosa* (Cale et al., 2004).

Significance:
The site is a good example of a naturally saline, seasonally inundated wetland with fringing vegetation in good condition within the bioregion. The site's fringing samphire community includes the critically endangered Lake King Eremophila *Eremophila subteretifolia* (Scr, Ne), which is specially protected by the Western Australian *Wildlife Conservation Act* (1950) and the Commonwealth *Environment Protection and Biodiversity Conservation Act* (1999) (Phillimore et al., 2002).More than 1% of the Western Australian population of Hooded Plover *Thinornis rubricollis tregellasi* has been recorded on one occasion. Further surveys are needed to determine if this is a regular event.

Notable flora:
Threatened Species: The critically endangered Lake King Eremophila *Eremophila subteretifolia* (Scr, Ne), which is specially protected by the Western Australian *Wildlife Conservation Act* (1950) and the Commonwealth *Environment Protection and Biodiversity Conservation Act* (1999), occurs within the fringing samphire community on the western side of the lake (Phillimore et al., 2002). Currently, it is known from only five populations, of which the Bennetts Lake population, at 37 plants in 2000, is the second largest known (Phillimore et al., 2002). Composition: The vegetation surrounding Bennetts Lake has been described by Gurner et al. (2000). The wetland vegetation on the elevated sandy ridges and mounds of the western side of Bennetts Lake is characterised by open woodlands of mature *Eucalyptus occidentalis* and *Melaleuca hamulosa* over *Schoenus* sp., *Frankenia* sp. and *Gastrolobium pusillum.* Significant recruitment of *M. hamulosa* is evident in some elevated areas. Downslope of this vegetation, *E. occidentalis* is replaced by *M. strobophylla*, forming dense closed stands with *M. hamulosa* and *M. halmaturorum* over an understorey dominated by *Sarcocornia* spp.. Large recruitment events of *M. halmaturorum* have occurred in recent years, with many individuals located in distinct lines suggesting previous high water marks, with distribution almost exclusively in the samphire zone and/or on the lake bed.

Notable fauna:
Threatened fauna: None known. Composition: A total of 25 species of waterbirds have been recorded at Bennetts Lake during biennial monitoring of waterbirds and aquatic invertebrates carried out by CALM since 1998, under the State Salinity Strategy (Cale, 2004). While the overall species richness varied little from year to year, with 15-16 species recorded each year (n=4), the species present changed according to the stage of filling of the lake at the time (Cale, 2004). In 1998, when water levels were very low, many shorebird and other wading species were present, and in 2000, following filling of the lake in January and again in March, the lake supported a different assemblage and abundance was low (400 individuals in 2000) (Cale, 2004). As the water levels began to decline, annual abundances were in excess of 3000 individuals, dominated by Australian Shelduck *Tadorna tadornoides*, Black Swan *Cygnus atratus* and Grey Teal *Anas gracilis* (Cale, 2004). During the monitoring, 11 species were recorded on only one occasion, with several shorebird species (Red-necked Stint *Callidris ruficollis*, Red-kneed Dotterel *Erythrogonys cinctus*, Sharp-tailed Sandpiper *C. acuminata*, Common Greenshank *Tringa nebularia* and Hooded Plover *Thinornis rubricollis tregellasi*) seen only prior to the filling of the lake, when extensive areas of shallows were present (Cale et al., 2004). A total of 90 Hooded Plover were recorded at Bennetts Lake in early January 1998, when the lake was in the late stages of drying (Singor, 1999). This represents more than 1% of the global population of the Western Australian subspecies of Hooded Plover, which is estimated to number 6,000 individuals (Wetlands International, 2002). One week earlier, 39 adult Hooded Plover together with 3 juveniles were using the lake however there is no evidence to confirm that the plovers were breeding there (Singor, 1999). In November 1998, 39 Hooded Plover were again recorded to be using the lake (Cale et al., 1999). While more than 1% of the population of the Western Australian subspecies of Hooded Plover (60 individuals) has been sighted at Bennetts Lake on only one occasion (on January 4 and 5, 1998), it is possible that the lake may support more than 1% of this

species on other occasions when lake levels are sufficiently low. Further survey work is required to confirm this. Numbers: In December 1986, the lake supported a total of 140 waterbirds from 12 species (Watkins and McNee, 1987). Breeding: In 1986, Eurasian Coot *Fulica atra* and Black Swan were found to have used flooded *M. halmaturorum* for nesting, while immature (juvenile plumage, flightless) Australian Shelduck, Pink-eared Duck *Malacorhynchus membranaceus* and Grey Teal were also present (Watkins and McNee, 1987).

Other fauna:
A total of 19 species of aquatic invertebrate were collected at Bennetts Lake in spring 1998 (Cale et al., 2004). Crustaceans (nine species) and insects (eight species) displayed similar levels of diversity. Ostracods were the most diverse crustaceans present, represented by four salt-tolerant species, with three copepods, one cladoceran and one amphipod also recorded. Insects present included 4 dipterans, 3 coleopterans and 1 hemipteran, which were typically salt-tolerant species of wide distribution (e.g. *Berosus* sp. and *Necterosoma penicillatus*) (Cale et al., 2004). Watkins and McNee (1987) recorded 15 species of invertebrates from a single sample taken in December 1986, when the lake depth was approximately 1 m and salinity was 19.5 ppt, with some similarity of species to those found in Spring 1998, when the lake was close to drying and hypersaline (Cale et al., 2004).

Social and cultural values:
A portion of Bennetts Lake to the north of the access road is a designated water ski area under the Western Australian *Navigable Waters Regulations 1958*. Water skiing is not permitted within 45 m of the foreshore and must cease when water levels drop below 1.6 m (DPI, 2005).

Land tenure:
On site: Dunn Rock Nature Reserve.
Surrounding area: Dunn Rock Nature Reserve and freehold agricultural properties (farmland lies approximately 500 m to the west and 2 km to the east).

Current land use:
On site: Nature conservation.
Surrounding area: Nature conservation and agriculture, primarily wheat and sheep production.

Disturbances or threats:
Current: A small area on the western side of the lake has been cleared and gravelled to allow water-skiers access to the lake (Watkins and McNee, 1987).
Potential: Increased recreational use; secondary salinisation (Cale et al., 2004). Given the high soil salinities of the lake floor and surrounds, and the probable increase in lake salinity in the future, the littoral vegetation and the vegetation on the lower elevations is likely to deteriorate (Gurner et al., 2004). Of particular concern is the littoral vegetation on the eastern side of the lake which, due to the lower elevations and flooding, is the most susceptible to increasing soil salinity (Gurner et al., 2004).

Conservation measures taken:
The site is within Dunn Rock Nature Reserve (Reserve No. 36445). Bennetts Lake is one of 25 'biological monitoring' wetlands within the Wheatbelt which are monitored by the Western Australian Department of Conservation and Land Management under the State Salinity Strategy. Two permanent vegetation transects have been established at the site to monitor the health of the vegetation on a triennial basis (Gurner et al., 2000). Waterbirds, aquatic invertebrates and groundwater are monitored biennially (Cale et al., 2004), while depth, salinity and water quality are measured each September and November (Lane et al., 2004).

Management authority and jurisdiction:
The nature reserve is managed by the Wheatbelt Region of the Western Australian Department of Conservation and Land Management for the Conservation Commission of Western Australia. Regional office is located at Narrogin.

Compiler and date:
Compiled by Sue Elscot, Western Australian Department of Conservation and Land Management, Busselton, in August 2005.

References:
Cale, D.J. (2004). Bennetts Lake Waterbirds. Summary pamphlet produced by the Department of Conservation and Land Management, Perth.

Cale, D.J., Halse, S.A. and Walker, C.D. (2004). Wetland monitoring in the Wheatbelt of south-west Western Australia: site descriptions, waterbird, aquatic invertebrate and groundwater data. *Conservation Science Western Australia* **5(1)**:20-135.

Wetlands International (2002). Waterbird Population Estimates (Third Edition). Wetlands International Global Series Number 12. Wageningen, the Netherlands.

DPI. (2005). Western Australian *Navigable Waters Regulations 1958.* Accessed online at: http://www.dpi.wa.gov.au/imarine/rec_boating/pdfs/REG_Navwater_All_Report.rtf (29/8/05).

Gurner, R. Froend, R., Ogden, G., and Franke, B. (2000). Wetland Vegetation Monitoring, 1999/2000 (Salinity Action Plan). Unpublished report prepared for the Department of Conservation and Land Management by the Centre for Ecosystem Management, Edith Cowan University, Perth.

Lane, J.A.K., Pearson, G.B., Clarke, A.C., Winchcombe, Y.C. and Munro, D.R. (dec.). (2004). Depths and Salinities of Wetlands in South-western Australia: 1977-2000. Department of Conservation and Land Management, Perth.

Phillimore, R., Stack, G. and Brown, A. (2002). Lake King Eremophila (*Eremophila subteretifolia* ms): Interim Recovery Plan 2002-2005. Western Australian

Threatened Species and Communities Unit, Department of Conservation and Land Management, Woodvale.

Singor, M. (1999). Hooded Plover Report No. 2: 1996-1999. Supplement to *Western Australian Bird Notes*, No. 90, June 1999.

Watkins, D. and McNee, S. (1987). A survey of wetlands in and adjacent to Dunn Rock and Lake Bryde Nature Reserves. Unpublished report prepared for the Wheatbelt Region of the Department of Conservation and Land Management.

2.2 WA122 Creeks, Springs and Floodout of the Gardner and Denison Ranges

Name of Wetland:
Creeks, Springs and Floodout of the Gardner and Denison Ranges

Reference number:
WA122

Location:
Lewis Creek – 19°15'00" S, 128°40'00" E, Lewis Creek Floodout - 19°18'40" S, 128°24'19" E and 19°16'45" S, 128°24'05" E, Slatey Creek – 19°20'00" S, 128°40'00" E, Mt Brophy Spring – 19°06'39" S, 128°49'08" E, Talbot Spring – 19°14'20" S, 128°17'20" E; approximately 140 – 180 km southeast of Halls Creek.

Bioregion:
Tanami

Shire:
Shire of Halls Creek

Area:
Lewis Creek c. 50 km, Lewis Creek Floodout c. 3000 ha, Slatey Creek c. 40 km, Brophy Creek c. 20km, springs and soaks within the ranges c. 50 ha.

Elevation:
Gardner Range 690 m AHD, Denison Range 429 m AHD.

Other wetlands in the same aggregation:
Lake Willson may have an ecological connection with the site (Pearson, 2005), possibly as the terminal drainage basin for Slatey Creek in exceptional flood years (Coate et al., 1998).

Wetland types:
B2, B4, B17

Criteria for inclusion:
1, 2, 3, 5, 6

Site description:
The site encompasses the Lewis, Slatey and Brophy Creek systems from their headwaters in the Gardner Ranges, the Lewis Creek Floodout system which is an extensive area of wooded floodplain to the south of Lewis Creek, and also includes the permanent springs and soaks of the Gardner Range, notably Mt Brophy Spring and Granny Soak, and the

Denison Range, notably Talbot Spring and Maurice Spring. Nearby wetlands: Lake Willson is 30 km southwest; Lake Gregory is 160 km southwest.

Physical features:
Landform: Mesoscale sinuous creeks (Lewis, Slatey and Brophy Creeks), macroscale and microscale irregular floodplains (Lewis Creek Floodout and Granny Soak), and microscale irregular springs and rockpools (Mt Brohpy Spring, Talbot Spring, Maurice Spring). Geological setting: Situated in the Canning Basin. The Gardner and Denison Ranges are composed mostly of Proterozoic sandstones surrounded by flat to gently undulating sandplains. The sandplains are dissected by the drainage channels of the Lewis Creek which drains to the west from the north side of the Gardner Range, Slatey Creek which drains to the west from the south side of the Gardner Range, and Brophy Creek which drains to the north from the northeastern corner of the Gardner Range. The creek systems occur on Quaternary sand, silt and clay of alluvial and lacustrine nature. Lewis Creek Floodout is an outwash fan to the south of the Creek that occurs on a gently undulating sandplain bordered to the west by the Denison Range and the east by the Gardner Range. This Floodout comprises two main waterbodies which lie between the northerly Lewis Creek and southerly Slatey Creek systems, at times linking them. Climate: Median and mean annual rainfall at Balgo Hills are 281 mm and 307 mm respectively, mostly falling in December-March; annual evaporation is c. 3900 mm.

Hydrological features:
Water Supply and Inundation: The creeks are ephemeral and fill following substantial rainfall events which are mostly cyclonically generated. Lewis Creek Floodout fills when the Lewis and Slatey Creek systems flood. The floodout contains water for a considerable period after the Lewis and Slatey Creeks cease flowing (Kenneally et al. 1999). Mt Brophy Spring, Talbot Spring and Maurice Spring are permanent. Water Depth: Lewis Creek Floodout - In July 1995 and May 1997, the overall depth of water was no more than about 1 m (Coate et al., 1998). Prior to May 1997, it appeared from water marks on trees that the water level had remained at about 2 metres for some time and from the age and position of old Eurasian Coot *Fulica atra* nests, it appeared that the water level peaked around March 1997 (Coate et al., 1998). No information on water depth in the creeks or springs or Granny Soak. Water Salinity: Probably fresh to subhaline, stasohaline.

Ecological features:
Semi-permanent water holes along Slatey Creek are lined with River Gums *Eucalyptus camaldulensis, Melaleuca nervosa crosslandiana* and *Acacia neurocarpa* and surrounded by rocky hills which are covered in Spinifex *Triodia* sp. with a few sparse Snappy Gum *Eucalyptus brevifolia* (Coate et al., 1998). Along the creek where the valley broadens out are a number of pockets where the vegetation is quite dense with *M. nervosa crosslandia*, a number of *Acacia* spp., *Eucalyptus aspera* and *Gastrolobium grandiflorum.*

Lewis Creek Floodout, comprising two main waterbodies, is created when the Lewis Creek floods out over a large sandplain to the south of the creek, between the Gardner and Denison Ranges. Stands of good-sized mature Coolibah Trees *Eucalyptus victrix*

with extensive hollows are scattered over both lakes and a dense cover of Spiny Mudgrass *Pseudoraphis spinescens* with occasional patches of the native water lily *Nymphoides indica* float on the surface (Coate et al., 1998). In shallow water around the lake's edge a fresh water algae (*Chara* sp.) is abundant (Coate et al., 1998). When flooded, Lewis Creek Floodout supports thousands of waterbirds of at least 36 species with 13 species recorded breeding there (Coate et al., 1998).

Mt Brophy Spring is surrounded by River Gums, and dense stands of *A. neurocarpa* and *M. nervosa crosslandia* trees (Coate et al., 1998). Talbot Spring is located in a small gorge, the entrance of which is fenced off to prevent cattle from wandering in and damaging the spring (Coate et al., 1998). *Eucalyptus aspera* and Rock Fig *Ficus platypoda* grow near the source of the spring. Palms *Livistonia* sp. at one time were the dominant plant species in the gorge but were used locally for construction of stockyards and buildings and no longer occur (Coate et al., 1998). Maurice Spring at the southern end of the Denison Range has many similarities to Talbot Spring and according to local people was also previously heavily vegetated with the *Livistonia* sp. palm (Coate et al., 1998).

Significance:
The Lewis, Slatey and Brophy Creek systems are good examples of ephemeral creek systems with semi-permanent waterholes within the semi-arid Tanami bioregion that have not been impacted by pastoral activities. Lewis Creek Floodout is a good example of a wooded floodplain wetland which is uncommon within the bioregion. When flooded, Lewis Creek Floodout supports thousands of waterbirds of at least 36 species with 13 species recorded breeding, and the floodout contains water for a considerable period after the Slatey and Lewis Creeks cease flowing (Coate et al., 1998; Kenneally et al., 1999). Mt Brophy Spring, Talbot Spring and Maurice Spring are permanent waterholes in an otherwise arid environment and are likely to be important drought refuges for a variety of fauna. Ecosystems immediately surrounding Brophy Spring and Granny Soak support one mammal (the Greater Bilby *Macrotis lagotis*) and one bird (the Night Parrot *Pezoporus occidentalis*) which are specially protected at a state and national level, and one new species of *Pseudomys* which has yet to be described (Kenneally et al., 1999). Unusual, ancient Aboriginal rock engravings occur within the Talbot Spring gorge (Kenneally et al., 1998).

Notable flora:
Threatened species: None known. Composition: No information.

Notable fauna:
Threatened Species: None known. Composition: A total of 37 waterbird species have been recorded using the Lewis Creek floodout system, of which four are listed under international treaties (four under JAMBA and three under CAMBA). The 37 species include 8 ducks and allies (Anatidae), 7 herons and egrets (Ardeidae), 5 ibises and spoonbills (Threskiornithidae), 5 crakes and rails (Rallidae) and 3 waders and shorebirds (Coate et al., 1998; Pearson, 2005). Numbers: A total of 2500 waterbirds were recorded using the two remaining waterbodies in the Lewis Creek Floodout during a dry season

aerial survey in July 2004 (Pearson, 2005). Significant waterbird counts at Lewis Creek Floodout in July 2004 include 1020 Plumed Whistling Duck *Dendrocygna eytoni*, 370 Wandering Whistling Duck *D. arcuata* and 80 Glossy Ibis (Pearson, 2005). Flocks of up to 200 Black Swan *Cygnus atratus* and Pacific Black Duck *Anas superciliosa* have been recorded during flood years (Coate et al., 1998). More than 5000 Black-tailed Native Hen *Gallinula ventralis* were using the floodout in September 1993 (Coate et al., 1998). At least 20 Baillon's Crake *Porzana pusilla* were present in May 1997, when several Australian Spotted Crake *P. fluminea* were also flushed from Spiny Mudgrass in the floodout (Coate et al., 1998). There are few records of the Australian Spotted Crake in the Kimberley region. Breeding: A total of 13 species of waterbirds have been recorded breeding within the Lewis Creek Floodout (Coate et al., 1998). These are the Black Swan, Grey Teal *Anas gracilis*, Darter *Anhinga melanogaster*, Little Black Cormorant *Phalacrocorax sulcirostris*, Little Pied Cormorant *P. melanoleucos*, White-necked Heron *Ardea pacifica*, Glossy Ibis *Plegadis falcinellus*, Royal Spoonbill *Platalea regia*, Yellow-billed Spoonbill *P. flavipes*, Whistling Kite *Haliastur sphenurus*, Brolga *Grus rubicunda*, Purple Swamphen *Porphyrio porphyrio* and Eurasian Coot *Fulica atra* (Coate et al., 1998).

Other fauna:
Threatened species: Active Greater Bilby *Macrotis lagotis* (Sr, Nv) burrows occur at Granny Soak and the Night Parrot *Pezoporus occidentalis* (Sr, Nr) has been heard, and characteristic clipped burrows in vegetation have been found, at Mt Brophy Spring (Kenneally et al., 1999, Coate et al., 1998). Both species are specially protected by the Western Australian Wildlife Conservation Act (1950) and the Commonwealth Environment Protection and Biodiversity Conservation Act (1999). Composition: A new species of *Pseudomys* which has yet to be described was captured in a Greater Bilby burrow at Granny Soak in May 1998 (Kenneally et al., 1999). A Northern Nail-tailed Wallaby *Onychogalea ungifera* was observed in Lewis Creek Floodout in May 1998 (Kenneally et al., 1999). Dingoes *Canis lupus dingo* (a native species), feral Cats *Felis catus*, feral Horses *Equus caballus*, Donkeys *Equus asinus*, Camels *Camelus dromedarius* and Cattle *Bos taurus* (all introduced species) have been recorded within the creeks, springs and floodout of the Gardner and Denison Ranges (Kenneally et al., 1999).

Social and cultural values:
Unusual ancient Aboriginal rock engravings, known as the Meearu Aboriginal rock art site or the "Armoured Knight Site", are present within the Talbot Spring gorge (Coate et al., 1998).

Land tenure:
On site: Unallocated Crown Land.
Surrounding area: Unallocated Crown Land. Sturt Creek Station homestead is located approximately 50 km to the west.

Current land use:
On site: None.
Surrounding area: Limited pastoral grazing.

Disturbances or threats:
Current: Grazing and altered fire regimes. Cattle, donkeys, horses and camels have been observed wandering both within and around the floodout area (Coate et al., 1998; Kenneally et al., 1999).
Potential: No information.

Conservation measures taken:
The site is within the area proposed to form the Gardner Range Nature Reserve (Coate et al., 1998).

Management authority and jurisdiction:
The Western Australian Department of Planning and Infrastructure is responsible for managing Unallocated Crown Lands although the Department of Conservation and Land Management has partial responsibility for the management of fire, feral animals and weeds.

Compiler and date:
Compiled by Sue Elscot, Western Australian Department of Conservation and Land Management, Busselton, in August 2005.

References:
Coate, K.H., Johnstone, R.E. and Lodge, G.A. (1998). Birds of the Gardner and Denison Ranges, and Lake Willson area, south-east Kimberley, Western Australia. *Western Australian Naturalist* **22(1)**:25-55.

Kenneally, K., Edinger, D., Coate, K. and How, R. (1999). *Craters and Creatures of the Tanami Desert 1998*: Landscope Expedition Report No. 27. Department of Conservation and Land Management, Perth.

Pearson, G.B. (2005). Report on aerial survey of wetlands of the Ord Victoria Plain (OVP), Tanami (TAN) and Dampierland (DL) IBRA regions. Unpublished report prepared by the Department of Conservation and Land Management, Wildlife Research Centre, Woodvale.

2.3 WA123 Dunn Rock Gnamma Holes

Name of Wetland:
Dunn Rock Gnamma Holes

Reference number:
WA123

Location:
33°20'11" S, 119°29'37" E, approximately 20 km south south-west of Lake King.

Bioregion:
Mallee

Shire:
Shire of Lake Grace

Area:
Approximately 25 ha.

Elevation:
Approximately 400 m AHD.

Other wetlands in the same aggregation:
None.

Wetland types:
B17

Criteria for inclusion:
1, 3

Site description:
The site comprises multiple gnamma holes on a large, domed, granite outcrop in Dunn Rock Nature Reserve.

Physical features:
Landform: The granite dome encompasses an area of approximately 25 ha while individual gnammas vary from 1 to 10 square metres in size and less than 25 cm deep. The catchment area of the gnammas is restricted to a small portion of the granite dome. Geological Setting: The site is an Archaean granite rock outcrop, described as seriate adamellite with variable texture and a range of grain size that is weakly porhyritic. The rock is surrounded by undulating reworked sandplain containing yellow to white sand and clay with scattered lateritic outcrops. Climate: Mean annual rainfall at Lake King is 340.8 mm per year, median 340.9 mm, mostly falling between May – September.

Hydrological features:
Water supply and inundation: The granite pools are filled by rainfall, usually in winter, and persist for several weeks or months, depending on the time of year they fill. Water salinity: Fresh (0.03 ppt in August 1998), stasohaline (Pinder et al., 2000). Water pH: 7.12 in August 1998 (Pinder et al. 1998). Water colour and Turbidity: Clear water, 23 TCU (true colour units) and 1.0 NTU (nephelometric turbidity units) in August 1998 (Pinder et al., 1998).

Ecological features:
The granite pools contain the plants *Isoetes australis* and *Glossostigma drummondii*. Centrolepidaceae and annual Cyperaceae are abundant in the herb rich moss swards and pool edges. Taxa include *Centrolepis strigosa, C. polygyna, Aphelia nutans, A. brizula, Schoenus odontocarpus* and *Isolepis congrua*. Other taxa include the Pennyworts, *Hydrocotyle callicarpa* and *H. diantha,* the fern ally *Ophioglossum gramineum* and several members of the Asteraceae including *Siloxerus multiflorus, Brachyscome perpusillum, Quinetia urvillei* and *Brachyscome goniocarpa* (CALM, unpublished data).

Significance:
The site contains good examples of granite outcrop gnamma holes in the Mallee Bioregion. The site's gnamma holes are an important refuge for insects with an aquatic life-cycle stage. Thirty four species of aquatic invertebrate are known only from granite outcrop pools in south-west Western Australia and Dunn Rock supports a significant proportion of these (A. Pinder, pers. comm.). The site supports a high diversity of aquatic invertebrates (a total of 69 species have been recorded) including one cladoceran and one ostracod known only from this location (rank 2 of 9 sites in terms of species richness, Pinder et al., 2000).

Notable flora:
Threatened Species: None known. Composition: No information.

Notable fauna:
Threatened fauna: Malleefowl *Leipoa ocellata* (Sr and Nv) have been recorded within the surrounding nature reserve (Graham, 1995). Composition: No waterbirds have been recorded using the site.

Other fauna:
A total of 69 species of aquatic invertebrates from 31 families have been recorded from the gnamma holes including: 1 turbellid, 1 nematode, 8 rotifers, 1 gastropod, 1 conchostraca crustacean, 10 cladocerans (including one known only from this location), 11 ostracods (one restricted to granite pools, one known from this location only and 1 known from this location and Dingo Rock only), 2 copepods, 12 coleopterans, 12 dipterans, 7 hemipterans, 1 odonatan and 1 trichopteran (CALM, unpublished data). Three native mammals (*Pseudomys occidentalis,* Mitchell's Hopping Mouse *Notomys mitchelli* and the Echidna *Tachyglossus aculeatus*) and the introduced House Mouse *Mus musculus* have been recorded within the surrounding nature reserve (Graham, 1995).

Social and cultural values:
No information.

Land tenure:
On site: Dunn Rock Nature Reserve.
Surrounding area: Dunn Rock Nature Reserve.

Current land use:
On site: Nature conservation.
Surrounding area: Nature conservation.

Disturbances or threats:
Current: No known current threatening processes (Beecham and Danks, 2001).
Potential: No information.

Conservation measures taken:
The site is within Dunn Rock Nature Reserve.

Management authority and jurisdiction:
The nature reserve is managed by the Wheatbelt Region of the Western Australian Department of Conservation and Land Management for the Conservation Commission of Western Australia. Regional office is located at Narrogin.

Compiler and date:
Compiled by Sue Elscot, Western Australian Department of Conservation and Land Management, Busselton, in July 2005.

References:
Beecham, B. and Danks, A. (2001). Mallee 2 (MAL2 – Western Mallee subregion). Pp. 435-465 in: May, J. and McKenzie, N.L. (Eds.). (2002*). A Biodiversity Audit of Western Australia's Biogeographical Subregions in 2002.* Department of Conservation and Land Management, Perth.

Pinder, A.M., Halse, S.A., Shiel, R.J. and McRae, J.M. (2000). Granite outcrop pools in south-western Australia: foci of diversification and refugia for aquatic invertebrates. *Journal of the Royal Society of Western Australia*, **83**:149-161.

A. Pinder, Research Scientist, Western Australian Department of Conservation and Land Management, Woodvale.

2.4 WA124 Hampton Scarp Rockholes

Name of Wetland:
Hampton Scarp Rockholes

Reference number:
WA124

Location:
Yarrabie Rockhole - 32°09.611 S, 126°18.060 E; Cologna Rockhole - 32°02.808 S, 126°31.447 E; Yudenda Rockhole - 32°01.791 S, 126°37.511 E; Norina Rockhole – 32°01.706 S, 126°40.683 E. Approximately 30-60 km west of Madura along the Hampton Scarp.

Bioregion:
Hampton

Shire:
Shire of Dundas

Area:
Gullies containing the rockholes are c. 25 ha each.

Elevation:
Approximately 50 to 110 m AHD.

Other wetlands in the same aggregation:
None.

Wetland types:
B17

Criteria for inclusion:
1, 3

Site description:
The site comprises numerous rockholes found within the exposed limestone pavement of the gullies of the Hampton Scarp face, between Burnabbie and Madura. Named rockholes are Yarrabie, Cologna, Yudenda and Norina.

Physical features:
Landform: Yarrabie Rockhole is a small rockhole, approximately 0.4 m in diameter, lying in bare rock towards the top of the Hampton Scarp. A few smaller rock holes occur nearby. Cologna Rockhole comprises five circular holes in a large, slightly inclined rock face. These rock holes are unusual in that they are at the top of the scarp, to the east of a

small gully. The largest of the Cologna rock holes is approximately 2 m in diameter and would be about 1 m deep when full (Watkins and Jaensch, 1997). Yudenda Rockhole is a small (approximately 1 m diameter) single rock hole located in the centre of a gully line approximately one-third of the way up the Hampton Scarp face (Watkins and Jaensch, 1997). Norina Rockhole is the largest of these rock holes, measuring 2.5 m by 2 m with a depth of approximately 0.8 m (Watkins and Jaensch, 1997). Norina rockhole is surrounded by several other smaller rockholes. Geological Setting: The Hampton Scarp separates the Hampton Tableland (the southern part of the Nullarbor Plain) from the low-lying, coastal Roe Plain. The Hampton Scarp is situated on the Bunda Plateau, which is underlain by deep limestone deposits that were formed 45-35 million years ago when the area was flooded by a shallow sea which subsided approximately 15 million years ago when the plateau also experienced uplifting (Watkins and Jaensch, 1997). During the period 3-5 million years ago, a period of increased rainfall and diffuse drainage on the plateau led to increased erosion and dissolution of the overlying Nullarbor Limestone to create the caves and sinkholes (solution dolines) of the southern Nullarbor Plain and Hampton Tableland, and reveal the underlying Akraburrie Limestone in places (Watkins and Jaensch, 1997; Davey et al., 1992). During the Pleistocene, downfaulting occurred along the southern edge of the Hampton Tableland to form the Hampton Scarp (Watkins and Jaensch, 1997). Climate: Mean annual rainfall at Madura is 268.9 mm, median is 254.5 mm, annual evaporation is c. 1600 mm.

Hydrological features:
Water Supply: The rockholes are filled by ephemeral drainage off small gullies in the face of the Hampton Scarp. Water Inundation: Most likely to be episodic to semi-permanent. Water Depth: 0.24 m at Yarrabie, 0.35-0.8 m at Cologna, 0.13 m at Yudenda, 0.26 m at Norina, all in August 2004 (CALM, unpublished data). Water Salinity: Cologna – 0.25 ppt TDS, Yudenda – 0.57 ppt TDS, Norina – 0.60 ppt TDS, all in August 2004 (CALM, unpublished data). All are fresh and stasohaline. Water pH: Yarrabie – 7.71, Cologna – 9.37, Yudenda – 7.54, Norina – 7.67, all in August 2004 (CALM, unpublished data). Water Colour and Turbidity: All rockholes were tannin stained in August 2004. Cologna – 74 TCU and 20 NTU, Yudenda – 73 TCU and 30 NTU, Norina – 150 TCU and 1.4 NTU, all in August 2004 (CALM, unpublished data).

Ecological features:
The site comprises multiple rockholes within the exposed limestone pavement of the gullies along the Hampton Scarp face. The rockholes lie within bare rock, and other than the occurrence of some filamentous algae (and small rocks and fine sediment) the rockholes are largely devoid of emergent or fringing vegetation. Overhanging and fringing vegetation is restricted to depositional areas of soil within cracks and crevices of the gullies and on the scree slopes that fringe the gullies.

Significance:
The rockholes are part of a chain of small waterholes along the Hampton Scarp that contain freshwater for long periods in an otherwise arid environment. As semi-permanent or long-lasting fresh water sources are extremely rare within the bioregion, the Hampton

Scarp Rockholes are an important water source for local fauna (birds and small mammals) and are most likely important drought refuge sites (A. Clarke, pers. comm.).

Notable flora:
Threatened Flora: None known. Composition: Yarrabie rock hole is surrounded by bare limestone with occasional plants, including *Austrostipa trichophylla, Rostraria pumila* (introduced) and *Avellinia michelii* (introduced), growing in soil filled holes. Surrounding the rock pavement, growing in cracks and shallow soils, are Mallee, *Eucalyptus discreta, E. diversifolia ssp hesperia, E. rugosa* with scattered *Melaleuca lanceolata,* shrubs *Prostanthera serpyllifolia ssp microphylla, Dodonaea stenozyga, Rhagodia latifolia, R. baccata,* Cockies Tongue *Templetonia retusa*, a sedge *Gahnia deusta*, with grasses *Austrostipa trichophylla, Rostraria pumila* (introduced) and scattered herbs *Anemocarpa calcicola,* Blackberry Nightshade *Solanum nigrum* (introduced), *Parietaria cardiostegia, Senecio glossanthus,* and *Sonchus oleraceus* (introduced).

The immediate surrounds of the Cologna Rockholes is bare, exposed, pavement limestone with some small holes filled with soil that contain the introduced Herbs Blackberry Nightshade *Solanum nigrum,* and *Anagallis arvensis.* Mallees, *E. gracilis, E. discreta,* and *E. diversifolia ssp hesperia* with scattered shrubs *Pittosporum angustifolium, Acacia erinacei, D. stenozyga, Santalum acuminatum* and the annuals *Crassula colorata, Gnaphalium indutum, Ptilotus obovatus,* and *S. oleraceus* (introduced) grow in shallow soil and cracks fringing the limestone gully.

Yudenda Rockhole is surrounded by bare limestone pavement and boulders for a radius of 4 metres with a few spindly *P. angustifolium* and *Brassica sp.* growing in small cracks. Growing in cracks and shallow soils fringing the limestone pavement are Mallee, *Eucalyptus yalatensis, E. diversifolia ssp hesperia* with scattered *M. lanceolata* with the shrubs *D. stenozyga, R. latifolia, R. sp., T. retusa, Atriplex nummularia, Maireana erioclada,* and *Scaevola spinescens* over the grass *Austrostipa nullarborensis* and scattered herbs *Anagallis arvensis* (introduced), *Brassica sp,* and *Galium migrans.*

Norina Rockhole is surrounded by bare limestone with no vegetation for a radius of at least 1.5 metres, except for a soil filled crack which contained the grass *Paspalidium sp.* and the introduced herbs *S. oleraceus* and *Anagallis arvensis.* Surrounding the rock hole and in the gully-creek line, growing in cracks and shallow soils are Mallee, *E. diversifolia ssp hesperia* with scattered shrubs *A. nummularia, A. vesicaria, D. stenozyga* and *R. latifolia,* over the grasses *R. pumila* (introduced), *Austrostipa dongicola, A. sp* and scattered herbs *Oxalis perennans, Tetragonia implexicoma,* Blackberry Nightshade *S. nigrum* (introduced) and *G. migrans.*

Notable fauna:
Threatened fauna: None known. Composition: No information.

Other fauna:
Aquatic macro- and micro-invertebrates were sampled at five rockholes during August 2004 (CALM, unpublished data). A preliminary identification of the samples has

revealed the presence of at least four taxa at Yarrabie (all crustaceans); at least 10 taxa at Cologna (comprising at least six crustaceans including three ostracods, one cyclopoid copepod, one cladoceran and one cochostracan); at least 10 taxa at an unnamed rockhole to the west of Yudenda (including at least five crustaceans - three ostracods, one isopod and one cladoceran, and three dipteran insects); at least seven taxa at Yudenda rockhole (including at least five crustaceans - three ostracods, one isopod and one cladoceran); and at least 13 taxa at Norina rockhole, including seven crustaceans (CALM, unpublished data). In all but one of the rockholes, crustaceans, particularly ostracods and cladocerans were the most numerically abundant animals (CALM, unpublished data). Western Grey Kangaroo *Macropus fuliginosus* and Emu *Dromaius novaehollandiae* faeces were observed around the rockholes in July 1997 (Watkins and Jaensch, 1997).

Social and cultural values:
Cultural Significance: Pre-settlement, the Roe Plain and southern edge of the Nullarbor was inhabited by the Mirning people (Watkins and Jaensch, 1997; Davey, 1978). The Mirning are thought to have lived mainly around freshwater soaks on the coast, moving up and along the Hampton Scarp during winter when rockholes along the scarp were a major source of freshwater (Watkins and Jaensch, 1997; Davey, 1978). To maintain the rockholes, decrease evaporation and prevent access by animals, Aboriginal people traditionally covered the small rock holes with large flat rocks (Jaensch and Watkins, 1997).

Land tenure:
On site: Nuytsland Nature Reserve (western end of the site) and Unallocated Crown Land (eastern part).
Surrounding area: Nuytsland Nature Reserve, Unallocated Crown Land and Madura Pastoral Lease.

Current land use:
On site: Nature Conservation (within the Nature Reserve).
Surrounding area: Nature conservation (Nature Reserve) and pastoral sheep grazing (Madura Station).

Disturbances or threats:
Current: None known.
Potential: Increased visitation by tourists.

Conservation measures taken:
The Hampton Scarp Rockholes are within an area proposed for addition to the Nuytsland Nature Reserve. The site is within a much larger area that has been identified for listing as a World Heritage Area (Natural Heritage category) because of the significance of its landforms, particularly karst features, which are of outstanding international importance (Davey et al., 1992).

Management authority and jurisdiction:

The Nature Reserve is managed by the Western Australian Department of Conservation and Land Management for the Conservation Commission of Western Australia. South Coast Regional Office located at Albany. The Department of Planning and Infrastructure is responsible for managing Unallocated Crown Lands although the Department of Conservation and Land Management has partial responsibility for the management of fire, feral animals and weeds. The Esperance District Office of the Department of Conservation and Land Management manages fire response in the area.

Compiler and date:
Compiled by Sue Elscot, Department of Conservation and Land Management, Busselton, in August 2005.

References:

Davey, A.G. (1978). Rescource Management of the Nullarbor Region, WA. A report to the Environmental Protection Authority by the Australian Speliological Federation.

Davey, A.G. Gray, M.R., Grimes, K.G., Hamilton-Smith, E., James, J.M. and Spate, A.P. (1992). World Heritage significance of karst and other landforms in the Nullarbor region. Report prepared by the Applied Ecology Research Group, University of Canberra, for the Commonwealth Department of The Arts, Sport, The Environment and Territories, Canberra.

Watkins, D. and Jaensch, R. (1997). Wetlands of the Hampton and Nullarbor Bioregions: Collation of data on wetlands for potential listing in the Directory of Important Wetlands in Australia. A report to the Western Australian Department of Conservation and Land Management by Wetlands International – Oceania, Canberra.

A. Clarke. Senior Technical Officer. Department of Conservation and Land Management, Science Division, Woodvale.

2.5 WA125 Harris Lake

Name of Wetland:
Harris Lake

Reference number:
WA125

Location:
31°19' S, 123°35' E; approximately 30 km south of the Zanthus siding on the Trans-Australian Railway Line

Bioregion:
Coolgardie

Shire:
Shire of Kalgoorlie – Boulder

Area:
Approximately 2500 ha.

Elevation:
Approximately 200 m AHD.

Other wetlands in the same aggregation:
None.

Wetland types:
B8, B10

Criteria for inclusion:
1

Site description:
The site includes Harris Lake, a large, naturally saline lake located on a major palaeodrainage channel, and Samphire Pool, an associated smaller, freshwater, ephemeral perched wetland located at the south-eastern corner of Harris Lake.

Physical features:
Landform: Megascale irregular (Harris Lake) and microscale ovoid (samphire wetland) seasonally inundated shallow sumplands. Harris Lake, approximately 12 km long and up to 5 km wide, is a flat-floored salt lake that contains ephemeral water up to approximately 25 cm deep following rainfall. Peripheral dunes, 1-4 m high, occur mainly on the southern and western margins. The associated Samphire Pool, which is perched upslope of Harris Lake, is approximately 80 m long, 60 m wide and up to 0.5 m deep. Geological

Setting: Harris Lake lies in an ancient river valley, the western portion of which is now marked by Lake Lefroy (Doepel and Lowry, 1970). Remnants of this former major drainage line, now reduced to a scattered chain of salt lakes and extensive areas of flats, occur to the southwest and northeast of Harris Lake. The salt lakes and flats are underlain by Archaean and Proterozoic gneisses and granites which have been eroded by the transgression of the Eocene sea and covered with Tertiary soils (Lowry, 1970). The soils of Harris Lake have a complex history which includes colluvial, alluvial and aeolian actions and frequent reworkings, especially by wind during Recent arid periods (Bowler, 1976). Climate: Mean annual rainfall at Rawlinna 198.9 mm, falling over all months, annual evaporation is c. 2400 mm.

Hydrological features:
Water Supply and Inundation: The lake is part of an ancient palaeoriver that extends south westerly of the lake. The lake is ephemeral, filling episodically following exceptional rainfall events, notably rain-bearing depressions associated with the passage of degrading cyclones through the arid interior. Two main surface inflows enter Harris Lake on the southeastern and western shores of the southern arm of the lake. Water Depth: In August 2004, the southern arm of Harris Lake contained water to a maximum depth of 0.20 m, and there was evidence of recent fast flows into the lake at both the eastern and western inflow points (A. Clarke, pers. comm.). Although the lake was dry at the western inflow point, there were strand lines which indicated that the lake depth had recently been approximately 0.25 m (A. Clarke, pers. comm.). Water Salinity: Harris Lake – hypersaline, 170 ppt in August 2004; Samphire Pool – fresh, 0.4 ppt in August 2004 (CALM, unpublished data). Water pH: Harris Lake - 7.7 in August 2004; Samphire Pool – 10.0 in August 2004 (CALM, unpublished data). Water Colour and Turbidity: Harris Lake - <5 TCU and 2.9 NTU in August 2004; Samphire Pool – 48 TCU and 36 NTU in August 2004 (CALM, unpublished data).

Ecological features:
The site includes Harris Lake, a large, shallow naturally saline ephemeral lake with a non-vegetated lake floor and Samphire Pool, an associated small, perched ephemeral wetland surrounded by samphire, upslope of Harris Lake. The fringing vegetation communities of both Harris Lake and Samphire Pool are in good condition and there is no evidence of secondary salinisation (A. Clarke, pers. comm.). Vegetation Pattern: Harris Lake and Samphire Pool - zoniform. Vegetation Cover: Harris Lake and Samphire Pool - peripheral.

Significance:
The site is a good example of a large, naturally saline ephemeral lake and an associated small, perched, ephemeral freshwater wetland with fringing vegetation in good condition within the bioregion.

Notable flora:
Threatened Species: None known. Composition: At the southeastern shore of Lake Harris, a collection of plants was made from a fringing dune either side of an inflow creek mouth in August 2004 (CALM, unpublished data). On the dune were scattered

Casuarina pauper to 6m high with shrubs *Dodonaea viscosa, Senna sp., Maireana appressa, M. erioclada, M. glomerifolia, Atriplex vesicaria, Frankenia sp.* and grasses *Aristida contorta, Austrostipa elegantissima, Eragrostis dielsii, E. eriopoda* with the herbs *Angianthus tomentosus, Senecio pinnatifolius, Zygophyllum eremaea, Z. glaucum, Sonchus oleraceus* (introduced), and *Gunniopsis septifragal.* At the rear of the dune and fringing the creek line were the samphires *Halosarcia sp., H. pergranulata, H. aff lepidosperma* (thin leaf) with scattered grass *E. dielsii* and the herbs *S. pinnatifolius, Z. eremaea,* and *Z. glaucum.*

Plant collections were also made along the western shore of Lake Harris in August 2004 (CALM, unpublished data). Along the low dune at the Lake edge were *Melaleuca uncinata* in patches with *Eucalyptus gracilis* on the dune with shrubs *Persoonia sp., Westringia rigida, A. vesicaria* and scattered grasses *A. elegantissima, E. dielsii, E. eriopoda* with the herbs *Z. eremaea, Z. glaucum,* and *G. quadrifida.* Along the creek a narrow line of *Melaleuca quadrifaria* occurred over low shrubs *Frankenia pauciflora,* samphires *Halosarcia* sp., *Sclerolaena* spp., grasses *E. dielsii, E. eriopoda* and herbs *Angianthus conocephalus, A. tomentosus* and *G. septifragal.* Inland of the dune and above the creek line were *E. gracilis, E. incrassata,* scattered *C. pauper* with *Senna sp., Dianella revoluta, Lomandra effusa* and *L. leucocephala ssp robusta.* Woodland of *Eucalyptus salubris* over the shrub *Cratystylis conocephalus* occurred on higher ground.

Plants were collected from the fringing Chenopod community at the Samphire Pool in August 2004, when the water body was approximately 50m wide and contained some submerged aquatic plants. The seasonally inundated shoreline was colonised by occasional *Halosarcia pergranulata, Marsilea drummondii, Marsilea sp.* and clumps of the grass *Eragrostis australasica.* Above the apparent high water mark was a narrow band of samphire *H. pergranulata* with annual herbs *S. pinnatifolius, Podolepis* sp., *Calandrinia granulifera* and the sedges *Isolepis cernua, I. marginata* (introduced) and *Juncus bufonius* (introduced). Further back from the water's edge was a broad area of *C. subspinescens* with *Disphyma crassifolium ssp. clavallatum* shrubland over the grasses *E. dielsii, Rostraria pumila* (introduced) and the annual herbs *S. pinnatifolius, Pseudognaphalium luteoalbum* and *Rhodanthe strictum.*

Notable fauna:
Threatened Species: None Known. Composition: Seven Hooded Plover *Thinornis rubricollis* (3 adults and 4 juveniles) were using the south-eastern shore of Harris Lake in August 2004 (CALM, unpublished data). No other waterbirds were recorded at Harris Lake however, within the degree square surrounding Lake Harris, the Atlas of Australian Birds (Birds Australia, 2003) records at least 10 species of nomadic or migratory waterbirds and shorebirds which use salt lakes during periods of inundation. Empty burrows of White-Backed Swallow *Chaeramoeca leucosterna* were found on the sandy margins of Harris Lake in August 1980 (Dell and How, 1984). Five species of waterbirds were recorded using Samphire Pool in low numbers during August 2004: Australian Shelduck *Tadorna tadornoides*, Hardhead *Aythya australis*, Grey Teal *Anas gibberifrons*, Hoary-headed Grebe *Poliocephalus poliocephalus*, and Black-winged Stilt *Himantopus himantopus* (CALM, unpublished data). Breeding: A breeding pair of Hooded Plover

with four juveniles (runners) were recorded using the south-eastern shoreline of Harris Lake in August 2004 and the lake has large areas of low fringing dunes and exposed gently-sloping shoreline which is suitable for Hooded Plover breeding (CALM, unpublished data).

Other fauna:
A preliminary identification of aquatic invertebrates found in Harris Lake in August 2004 has shown that at least 6 taxa occur of which 5 (83% of the taxa) were Crustacea (2 Ostracoda, 1 Daphniidae Cladoceran, 1 Anostracan, the parartemia shrimp *Parartemia serventyi*, and 1 Harpacticoid Copepod) (CALM, unpublished data). One Dipteran Insect was also recorded. Numerically, the parartemia shrimp and ostracods were most abundant and although they were not present in particularly high numbers in August 2004, the presence of these species suggests that Harris Lake may support large numbers of wading species when conditions are conducive (A. Clarke, pers. comm.).

A preliminary identification of aquatic invertebrates found in the Samphire Pool in August 2004 has revealed that at least 24 taxa of aquatic invertebrates occur, including 14 Insecta (58% of the taxa, comprising three Diptera, six Coleoptera, two Hemiptera, two Odonata and one Trichoptera), seven Crustacea (30%, comprising three Ostracoda, three Cladocera, and one Conchostraca), two Rotifera (8%, both Brachionidae) and one Acariformes Arachnida (CALM, unpublished data). Numerically, the most abundant taxa were the Crustacea, particularly the three ostracod species and one Daphnia species (A. Clarke, pers. comm.).

Amphibians, reptiles, birds and mammals using the fringing vegetation of Harris Lake were sampled during the Biological Survey of the Eastern Goldfields, undertaken in the late 1970s and early 1980s (Dell and How, 1984). A total of 1 frog species (*Neobatrachus* sp.), 11 reptile species, 16 bird species and 3 native mammal speces were found within the *Halosarcia* Low Shrubland, while 1 frog (*N.* sp.), 13 reptiles, 19 birds and 1 native mammal were recorded within the fringing *Maireana sedifolia* Low Shrubland. The fauna recorded during the survey reflected the biogeography of the area as an 'interchange zone', comprising a mix of elements of both the southwestern (Eremean) and arid zone (Bassian) fauna, and including many species at or near the limits of their range (Dell and How, 1984). Introduced feral species recorded around Lake Harris include the House Mouse *Mus musculus*, Dog *Canis lupus familiaris*, Fox *Vulpes vulpes*, Cat *Felis catus*, One-humped Camel *Camelus dromedarius* and the Rabbit *Oryctolagus cuniculus* (Dell and How, 1984).

Social and cultural values:
No information.

Land tenure:
On site: Unallocated Crown Land.
Surrounding area: Unallocated Crown Land and Fraser Range Pastoral Lease.

Current land use:
On site: None.
Surrounding area: Pastoral grazing.

Disturbances or threats:
Current: None known.
Potential: Fraser Range pastoral leaseholder has a diversification permit for a caravan park in the southern part of the lease which may see controlled visitor access to the site.

Conservation measures taken:
The lake is within the area proposed to form the Bunningonia Spring Nature Reserve (Henry-Hall, 1990).

Management authority and jurisdiction:
The Western Australian Department of Planning and Infrastructure is responsible for management of all Unallocated Crown Land although the Department of Conservation and Land Management has partial responsibility for the management of weeds, fire and feral animals within Unallocated Crown Land.

Compiler and date:
Sue Elscot, Western Australian Department of Conservation and Land Management, Busselton in July 2005.

References:
Birds Australia (2003). Atlas of Australian Birds. Birds Australia, Melbourne.

Bowler, J.M. (1976). Aridity in Australia: age, origins, and expression in aeolian landforms and sediments. *Earth – Science Review* **12**:279-310.

Dell, J. and How, R.A. (1984). IV Vertebrate Fauna. Pp. 57-81 in: Biological Surveys Committee. The Biological Survey of the Eastern Goldfields of Western Australia, Part 2. Widgiemooltha – Zanthus Study Area. *Records of the Western Australian Museum, Supplement Number 18*.

Doepel, J.J.G. and Lowry, D.C. (1970). Zanthus. Geological Survey of Western Australia 1:250,000 Geological Series Explanatory Notes.

Lowry, D.C. (1970). Geology of the Western Australian part of the Eucla Basin. Geological Survey of Western Australia: Bulletin 122.

Newbey, K.R. (1984). II Physical Environment. Pp. 29-40 in: Biological Surveys Committee. The Biological Survey of the Eastern Goldfields of Western Australia, Part 2. Widgiemooltha – Zanthus Study Area. *Records of the Western Australian Museum, Supplement Number 18*.

A. Clarke, Senior Technical Officer, Western Australian Department of Conservation and Land Management, Woodvale.

2.6 WA126 Kondinin Samphire Marsh

Name of Wetland:
Kondinin Samphire Marsh

Reference number:
WA126

Location:
32°35'25" S, 118°24'42" E; approximately 10 km southeast of Kondinin

Bioregion:
Mallee

Shire:
Shire of Kondinin – Hyden

Area:
Approximately 2200 ha

Elevation:
Approximately 267 m AHD

Other wetlands in the same aggregation:
None.

Wetland types:
B12

Criteria for inclusion:
1, 5

Site description:
The site is a seasonally inundated samphire marsh that includes braided saline drainage lines and associated channels, playas and small pans.

Physical features:
Landform: The wetland system consists of braided saline drainage lines with associated channels, flats, playas and small pans that lie within the Lake King palaeodrainage channel. The system is part of the Lake King drainage line and occurs where this line meets the Lake Magenta/Lake Grace palaeodrainage flats. Geological setting: The system lies in the broad flat salt drainage lines that are dominant in this region. These broad meandering, braided creek channels consist of highly weathered alluvial sands and gravel. Climate: Mean annual rainfall at Kondinin is 343.5 mm, median is 339.5 mm per year, mostly falling between May – Aug, annual evaporation is c. 1800 mm.

Hydrological features:
Water supply and depth: The system is part of the Lake King drainage line. Inundation: Seasonally inundated. Water salinity: An area of flooded samphire marsh had a salinity of 10 ppt, while a small playa was 84 ppt in August 1998 (CALM, unpublished data). Hyposaline to hypersaline. Water pH: The samphire marsh had a pH of 9.25 in August 1998 whereas the small playa had a pH of 3.67. Water Colour: Samphire marsh – clear with low turbidity, 15 TCU (true colour units) and 6.9 NTU (nephelometric turbidity units) in late August 1998 (CALM, unpublished data).

Ecological features:
Low rises within the drainage line support *Eucalyptus spathulata* woodland and *Melaleuca brophyi, M. lateriflora* and *M. thymoides* Shrubland, with species rich herb layers. The fringes of the rises support dwarf shrublands with the endangered *Roycea pycnophylloides* (Se, Ne), *Halosarcia* sp. Central Wheatbelt (M.N. & S.D. Lyons 2760), *H. lylei, Didymanthus roei* and *Frankenia* spp. Inundated flats and channels contain *Halosarcia leptoclada* subsp. *inclusa, H. halocnemoides* and *Sarcocornia blackiana*.

Significance:
The site is a good example of a braided saline drainage system within the Mallee Bioregion that remains in good condition (M. Lyons, pers. comm.), and includes 'the best area of lowland mallees and central gypsophilous communities in very good to good condition' within the Western Mallee subregion (Beecham and Danks, 2001). These systems have been severely impacted throughout the SW agricultural zone. The site supports a fringing dwarf shrubland community that includes one plant species, *Roycea pycnophylloides,* which is considered endangered at a national level. The site supports two aquatic invertebrates, one ostracod and one coleopteran, that are known from this location and one other site only (CALM, unpublished data).

Notable flora:
Threatened species: Two declared rare flora have been recorded at the site: *Ptilotus fasciculatus*, which is specially protected by the Western Australian *Wildlife Conservation Act* (1950) (Se), and *Roycea pycnophylloides* which is specially protected by the Western Australian *Wildlife Conservation Act* (1950) (Se) and the Commonwealth *Environment Protection and Biodiversity Conservation Act* (1999) (Ne). Western Australian Department of Conservation and Land Management priority taxa include *Millotia steetziana* and *Frankenia drummondii.*

Notable fauna:
Threatened species: None known. Composition: No waterbirds have been recorded within the site, which appears to have very little suitability for birds of this group.

Other fauna:
A total of 36 aquatic invertebrate species have been recorded within the site including 1 nematode, 1 rotifer, 1 parasitiform, 2 cladocerans, 11 ostracods, 3 copepods, 5 coleopterans, and 9 dipterans (Pinder et al., 2004). During a survey of 286 wetlands

across the wheatbelt, one ostracod species, *Cabonocypris* 'kondinensis' (Halse and McRae, 2004) was found only within the samphire marsh at this site and Mullet Lake, Esperance, and one coleopteran, *Paroster* sp. 1 (Frank Hann) was found only within this site and a small claypan in Frank Hann National Park (Pinder et al., 2004). The low pH of the small playa within the site is reflected in a particularly low species richness however, the aquatic fauna recorded for the playa includes the anostracan shrimp *Parartemia contracta*, which is one of only a few species know to prefer acid saline conditions, and the apparently rare ostracod *Reticypris* n. sp. LA, which is known only from this site and Lake Austin (Pinder et al., 2004).

Social and cultural values:
No information.

Land tenure:
On site: The site is within the Kondinin Salt Marsh Nature Reserve (Reserve numbers 26905 and 26692).
Surrounding area: Freehold agricultural land.

Current land use:
On site: Nature Conservation.
Surrounding area: Primarily wheat and sheep production.

Disturbances or threats:
Current: Increased inundation has degraded the condition of the low elevation rises that support eucalypt Woodlands and shrublands dominated by *Melaleuca* spp (M. Lyons, pers. comm.).
Potential: No information.

Conservation measures taken:
The site is contained within the Kondinin Salt Marsh Nature Reserve which was gazetted in 1974.

Management authority and jurisdiction:
The nature reserve is managed by the Western Australian Department of Conservation and Land Management for the Conservation Commission of Western Australia. CALM Regional Office located at Narrogin.

Compiler and date:
Compiled by Sue Elscot, Western Australian Department of Conservation and Land Management, Busselton, in July 2005.

References:
Beecham, B. and Danks, A. (2001). Mallee 2 (MAL2 – Western Mallee subregion). Pp. 435-465 in: May, J. and McKenzie, N.L. (Eds.). (2002*). A Biodiversity Audit of Western Australia's Biogeographical Subregions in 2002.* Department of Conservation and Land Management, Perth.

Pinder, A. M., Halse, S.A., McRae, J.M. and Shiel, R.J. (2004). Aquatic invertebrate assemblages of wetlands and rivers in the Wheatbelt region of Western Australia. *Records of the Western Australian Museum*, **67**:7-37.

M. Lyons. Research Scientist, Western Australian Department of Conservation and Land Management, Woodvale.

2.7 WA127 Lake Willson

Name of Wetland:
Lake Willson

Reference number:
WA127

Location:
19°22'31" S and 128°16'54" E, approximately 140 km southeast of Halls Creek. Nearby wetlands: Lewis Creek Floodout (Creeks, Springs and Floodout of the Gardner and Denison Ranges) is 30 km northeast; Lake Gregory is 130 km southwest.

Bioregion:
Tanami

Shire:
Shire of Halls Creek

Area:
Approximately 10,000 ha (the main wetland basin is c. 200 ha)

Elevation:
Approximately 200 m AHD

Other wetlands in the same aggregation:
The Lewis and Slatey Creek systems (Creeks, Springs and Floodout of the Gardner and Denison Range) may have an ecological connection with the lake (Pearson, 2005), which is possibly a terminal drainage basin for the system in exceptional flood years (Coate et al., 1998).

Wetland types:
B6

Criteria for inclusion:
1, 3

Site description:
The site includes Lake Willson to the limit of its flooded extent.

Physical features:
Landform: Mesoscale ovoid lake. Geological setting: The lake is situated in the Canning Basin and lies in a depression of quaternary sand silt clay of alluvial and lacustrine origin. The flat to gently undulating sand plain consists of quaternary mainly aeolian sands. The surrounding area contains occasional low rocky out crops, mesas, buttes, hills and ridges.

Climate: Median and mean annual rainfall at Balgo Hills are 281 mm and 307 mm respectively, mostly falling in December-March; annual evaporation is c. 3900 mm.

Hydrological features:
Water Supply: Drainage channels are evident at the northwest, southeast and southwest corners of the wetland but it is unclear whether these are inlets or outlets (Pearson, 2005). Inundation: Lake Willson seldom dries completely and according to station people in the vicinity, the lake can flood out for 1-2 km from the shoreline in a good season (Coate et al., 1998). Extensive stands of flooded *Eucalyptus* sp. and possibly *Acacia* sp. found during an aerial survey of the lake in July 2004 indicate that the water levels were higher than normal at that time (Pearson, 2005). The lake was filled to exceptional levels in 1993 and 1994 but was almost dry in 1996 (Coate et al., 1998). The lake filled again following exceptionally heavy rainfall in 1997 (Coate et al., 1998).

Ecological features:
Lake Willson is a small, semi-permanent wetland with fringing *Melaleuca glomerata* woodland extending eastwards from the southern end around to the northeastern shore (Coate et al., 1998). Extensive areas of shallow water indicate suitable habitat for small wading birds and extensive areas of intermittently flooded woodland provide nesting habitat for common species such as ibises (Plataleidae), ducks (Anatidae), crakes and rails (Rallidae) and cormorants (Phalacrocoracidae) (Coate et al., 1998; Pearson, 2005).

Significance:
The lake is a good example of a small, semi-permanent, freshwater wetland with fringing *Melaleuca glomerata* woodland which is uncommon within the bioregion. The lake supports a high diversity of waterbirds (48 species recorded) and is a significant breeding area for waterbirds in an otherwise arid environment (16 species recorded breeding) (Coate et al., 1998).

Notable flora:
Threatened Species: None known. Composition: A dense grassland of *Eragrostis desertum* growing to a height of about 50 cm surrounds the lake and extends out into *Melaleuca glomerata* woodlands. On the northern and eastern fringes of the lake are extensive stands of *M. glomerata*, ranging from small to about 7 m. *Abutilon octocarpum* and *Sesbania cannabina* are plentiful in the grassland. Around the southern side of the lake the samphire *Halosarcia indica leiostachya* is common. Away from the lake, in depressions flooded when the lake overfills, are thickets of multi-stemmed *M. glomerata* and *M. lasiandra* growing to a height of about 3 m. A small white-barked *Eucalyptus* sp. is also sometimes associated with these depressions (Coate et al., 1998).

Notable fauna:
Threatened Species: None known. Composition: A total of 48 species of waterbirds have been recorded using Lake Willson, of which 12 are listed under international treaties (11 under JAMBA and 11 under CAMBA) (Coate et al., 1998). These include 9 ducks and allies (Anatidae), 3 grebes (Podicipedidae), 4 cormorants (Phalacrocoracidae), and 6 herons and egrets (Ardeidae) (Coate et al., 1998). A total of 18 species of waders and

shorebirds, including 7 sandpipers and allies (Scolopacidae), 2 Stilts (Recurvirostridae), 5 Plovers (Charadriidae) and 3 gulls and terns (Laridae) have also been recorded, some of which are rarely recorded inland however all have been observed in low numbers only (Coate et al., 1998). Numbers: A total of 1356 waterbirds of 30 species were recorded during an aerial survey of the lake undertaken during July 2004 (Pearson, 2005). Exceptionally high water levels in 1993 and 1994 attracted spectacular numbers of waterbirds (Coate et al., 1998). Thousands of Eurasian Coot *Fulica atra* were present in September 1993 and April 1994, and in May 1997 up to 1000 Grey Teal *Anas gracilis* and more than 2000 Hardhead *Aythya australis* were recorded (Coate et al., 1993). More than 500 Plumed Whistling Duck *Dendrocygna eytoni* were recorded in May 1997, and flocks of up to 200 Black Swan *Cygnus atratus* and Australasian Grebe *Tachybaptus novaehollandiae* have been recorded on several occasions (Coate et al., 1998). Breeding: A total of 19 species of waterbirds have been recorded breeding at Lake Willson, with large numbers of nests observed following exceptional flooding in April 1994 and May 1997 (Coate et al., 1998). Thousands of Pink-eared Ducks *Malacorhynchus membranaceus* built nests on old disused Coot nests in August 1993 and April 1994. Hundreds of Darter *Anhinga melanogaster* and Little Black Cormorants *Phalacrocroax sulcirostris* and thousands of Little Pied Cormorants *Phalacrocorax melanoleucos* nested in April 1994 (Coate et al., 1998). Large Harvester Termite mounds *Nasutitermes* sp. that had collapsed well away from the normal lake edge provided nesting platforms for Black-winged Stilt *Himantopus himantopus*, Masked Lapwing *Vanellus miles* and Black Swan *Cygnus atratus* when the lake was filled to exceptional levels in 1993 and 1994 (Coate et al., 1998).

Other fauna:
Threatened Species: None known. Composition: Thousands of Little Red Flying Fox *Pteropus scapulatus* were colonising a dense area of partly submerged *M. glomerata* in August 1993. Dingoes *Canis lupus dingo*, feral Horses *Equus caballus*, Donkeys *Equus asinus* and Camels *Camelus dromedarius* (all introduced species) have been recorded around the lake (Coate et al., 1998). A total of 81 species of terrestrial birds have been recorded using Lake Willson and its immediate surrounds, of which at least 29 species have been recorded breeding (Coate et al., 1998).

Social and cultural values:
Historical values: Lake Willson was named during a 1966 army field check of the area, after Sapper B.H. Willson, a member of the survey team (Coate et al., 1998).

Land tenure:
On site: Unallocated Crown Land
Surrounding area: Unallocated Crown Land. Sturt Creek Station homestead is approximately 25 km to the north-west of the lake.

Current land use:
On site: None.
Surrounding area: Limited pastoral grazing.

Disturbances or threats:
Current: Grazing and trampling by feral camels, donkeys, horses and possibly cattle.
Potential: No information.

Conservation measures taken:
The site is included within an area recommended to form the Gardner Range Nature Reserve (Coate et al., 1998).

Management authority and jurisdiction:
The Western Australian Department of Planning and Infrastructure is responsible for managing Unallocated Crown Lands although the Department of Conservation and Land Management has partial responsibility for the management of fire, feral animals and weeds.

Compiler and date:
Compiled by Sue Elscot, Western Australian Department of Conservation and Land Management, Busselton, in August 2005.

References:
Coate, K.H., Johnstone, R.E. and Lodge, G.A. (1998). Birds of the Gardner and Denison Ranges, and Lake Willson area, south-east Kimberley, Western Australia. *Western Australian Naturalist* 22(1):25-55.

Pearson, G.B. (2005). Report on aerial survey of wetlands of the Ord Victoria Plain (OVP), Tanami (TAN) and Dampierland (DL) IBRA regions. Unpublished report prepared by the Department of Conservation and Land Management, Wildlife Research Centre, Woodvale.

2.8 WA128 Nurina Cave

Name of Wetland:
Nurina Cave

Reference number:
WA128

Location:
32°00'28" S and 127°02'29" E, approximately 15 km southeast of Madura.

Bioregion:
Hampton

Shire:
Shire of Dundas

Area:
Approximately 1600 ha, the full extent of the cave system and catchment is currently unknown.

Elevation:
Approximately 25 m AHD

Other wetlands in the same aggregation:
None.

Wetland types:
B19

Criteria for inclusion:
1, 3, 5

Site description:
The site encompasses all of the subterranean passages, both dry and phreatic (submerged), of Nurina Cave (Australian Speleological Federation Nullarbor cave number N46), and all of the land area and terrestrial vegetation above the cave system, the roots of which, in part, drive the ecosystem below.

Physical features:
Landform: Nurina Cave is a joint-controlled maze-type limestone cave system developed close to the present water table (Eberhard, 1999). Its typical passage cross-section comprises an air-filled section overlying a waterfilled section which is accessible only by diving (Eberhard, 1999). The cave contains fragile features which are susceptible to damage or disturbance, including speleogens (phreatic spongework sculpture) and

speleothems (actively forming and fossil calcite raft features), sediments and fragile crusts (Eberhard, 1999). Geological Setting: The site occurs on the Roe Plain, which is a depositional surface formed on the Pliocene to Pleistocene Roe Calcarenite (Davey et al., 1992). This area was inundated by the sea following subsidence during the early Cretaceous, with the first limestones formed about 45 million years ago in the middle Eocene. At least two periods of marine recessions occurred during the Oligocene, followed by uplift during the Middle Miocene about 15 million years ago. Another marine transgression occurred during the Late Pliocene to early Pleistocene when the sea level reached about 30 m above its current level. This transgression eroded the Roe Plains and the Hampton Scarp to the north is the old sea cliff of Late Pliocene age. Geological Significance: Nurina Cave contains calcite-coated passages and is actively depositing calcite at present making it feasible to study its deposition and establish its speleogenetic importance (Davey et al., 1992). Climate: Mean annual rainfall at Madura is 268.9 mm, median is 254.5 mm, annual evaporation is c. 1600 mm.

Hydrological features:
Water Supply: Nurina Cave intersects the regional saline water table. Water Depth: The maximum known depth of the phreatic passages is 7 m below the surface of the water table while the depth of water within most of the phreatic passages is approximately 1.5 to 2 m. Lengths of submerged passages exceed 400 m. Water Salinity and Chemistry: The salinity and chemical composition of the water is essentially the same as seawater except that it is enriched with calcium (Bradbury and Eberhard, 2000). Water salinity of 31.7 ppt TDS in 1987 (Davey et al., 1992). Saline, stasohaline.

Ecological features:
Nurina Cave has special environmental and habitat characteristics that are unlike most of the caves on the Nullarbor and Roe Plains (Eberhard, 1999). The internal environment of Nurina Cave is characteristic of the deep cave zone, with complete darkness, near constant temperature, high relative humidity, low evaporation potential and little air movement (except in the vicinity of the entrance), with little or no year-round variation in these parameters (Eberhard, 1999). The extensive network of flooded passages and lakes acts as a reservoir to maintain the humid conditions (Eberhard, 1999). Other than caves N1327 and N327, few caves on the Nullarbor and Roe Plains contain deep zone environmental conditions so close to the surface, if at all (Eberhard, 1999). The deep zone conditions in Nurina Cave, which exist because of the high degree of insulation from the surface environment afforded by its naturally small entrance, are ideal for troglobitic fauna (species which are obligate cave dwellers), which are dependent on the water in the cave maintaining the humid environment (Eberhard, 1999). The fauna in most Nullarbor and Roe Plain caves is non-troglobitic and consists of the less cave-adapted trogloxenes (species which spend only part of their life-cycle underground), guanophiles (species which rely on bat guano as a food source) and troglophiles (species which spend their entire life-cycle underground) (Eberhard, 1999). The occurrence of troglobitic fauna may also be limited in Nullarbor and Roe Plain caves by the scarcity of food sources such as tree roots which can easily penetrate the humid passages above the shallow water table on the low-lying Roe Plain (Hampton Bioregion), unlike on the elevated and treeless Hampton tableland (Nullarbor Bioregion) where the water table may be up to 110 m

below the surface (Eberhard, 1999). Nurina Cave contains deposits of very old bat guano which has been degraded to a fine amorphous powder, as bats have long since abandoned the cave and the guanophile community has died out (Eberhard, 1999). It has been suggested that the degraded bat guano is the food base for the troglobites however Eberhard (1999) stated that this remains to be verified as tree roots also occur in the section of the cave where most troglobites occur. A localised food source of plant and animal material enters the cave's open vertical entrance series and Eberhard (1999) noted that the troglobitic, aquatic melitid amphipod *Nurina poulteri* is most abundant in the pool directly below the entrance series, although it occurs in lower densities in other submerged parts of the cave.

Significance:
Nurina Cave is a good example of a shallow limestone cave system developed close to the present water table which contains both air-filled and phreatic passages combined with a very small entrance which result in deep-zone environmental conditions unusually close to the surface. The invertebrate fauna of Nurina Cave comprises 29 species, of which seven (24%) are troglobitic species which is in contrast to the fauna of most Nullarbor and Roe Plain caves where troglobites are extremely rare or more usually entirely absent (Eberhard, 1999; Eberhard and Moulds, 2007). The troglobitic fauna of Nurina Cave is one of the most diverse and abundant known from the Nullarbor and Roe Plain caves (7 species from 7 disparate groups) and, as troglobites are highly specialised relictual fauna that are generally very restricted in their distribution, Nurina Cave is highly significant for its biological conservation value (Eberhard, 1999). Nurina Cave is the type location for a new species of aquatic troglobite, the melitid amphipod *Nurina poulteri*, which is one of only three aquatic troglobites (all amphipods) known from the Nullarbor and Roe Plain caves (Eberhard, 1999). The other two aquatic troglobites occur only within caves on pastoral leases. Nurina Cave supports a troglobitic spider, the Nurina Cave Spider *Tartarus nurinensis* (Sr), which is considered to be rare and is specially protected at a state level.

Notable flora:
No information.

Notable fauna:
Threatened species: The troglobitic Nurina Cave Spider *Tartarus nurinensis* (Sr), which weaves webs so delicate they are damaged by the slightest air currents caused by the movement of people, breath or body heat, is specially protected by the Western Australian Wildlife Conservation Act (1950). Composition: The diverse invertebrate fauna of Nurina Cave comprises 29 species from 29 genera, including 17 arachnids, six insects and three crustaceans (Eberhard and Moulds, 2007). At least seven species of troglobitic fauna, including one aquatic troglobite (a melitid amphipod) occur in Nurina Cave (Eberhard, 1999). Only three aquatic troglobites are known from the Nullarbor and Roe Plain caves (all amphipods), and the other two occur only in Cave N1327 (located on Madura pastoral lease). A new genus and species of an aquatic, troglobitic melitid amphipod, *Nurina poulteri*, was first discovered in Nurina Cave in 1982 and is known only from Nurina Cave and nearby Cave N1327 (Bradbury and Eberhard, 2000). *Nurina*

poulteri is most likely to be a relictual marine species that has evolved in isolation on the Roe Plain following one of the previous marine transgression and recession episodes that have shaped the geology of the Roe and Nullarbor Plains (Bradbury and Eberhard, 2000). Other troglobitic fauna include an as-yet undescribed new species of ?Oniscidae isopod, an undetermined copepod *Speloephria* sp., two Theridiid spiders *Achaeranea* sp., *Icona* sp., a cockroach *Trogloblatella nullarborensis*, a carabid beetle *Speothalpius grayi*, and a centipede *Cryptops roeplainsensis* (Davey et al., 1992; Eberhard, 1999; Eberhard and Moulds, 2007). The Nurina Cave carabid beetle is the most cave-modified invertebrate yet recorded from Australia, and its extreme troglomorphic modifications are comparable only with the northern hemisphere ice-age beetle troglobites, yet the Nurina Cave troglobitic fauna is likely to be of late Pleistocene age or younger (Davey et al., 1992).

Other fauna:
Threatened species: The Western Barred Bandicoot *Peremeles bougainville* (Sr, Ne), and the Burrowing Bettong *Bettongia lesuer* (Sr, Nv), which are both now regionally extinct and specially protected under the Western Australian Wildlife Conservation Act (1999) and the Commonwealth Environment Protection and Biodiversity Conservation Act (1999), have been recorded from sub-fossil deposits in the cave, along with the extinct Crescent Nail-tailed Wallaby *Onychogalea lunata* (Davey et al., 1992). Composition: Other vertebrates recorded from sub-fossil deposits in Nurina Cave include the Common Brushtail Possum *Trichosurus vulpecula* and the Chocolate Wattled Bat *Chalinolobus morio* (Davey et al., 1992).

Social and cultural values:
Nurina Cave is recognised by cave divers to be a world-class cave diving site because of the shallowness of the surrounding water table on the Roe Plain, which allows there to be significant lengths of large diameter (approximately 2 – 3 m) phreatic (submerged) passages at shallow depths, easily accessible to divers (Trimix Divers, 2005). The maximum depth is a 7 m bedding plane and the length of underwater passage explored so far is more than 400 m (Trimix Divers, 2005).

Land tenure:
On site: Unallocated Crown Land
Surrounding area: Unallocated Crown Land

Current land use:
On site: Limited recreational caving and cave diving.
Surrounding area: None.

Disturbances or threats:
Current: Because of its proximity to the Madura Pass Roadhouse, Nurina Cave is easily accessed by locals, tourists and cavers, some of whom have degraded the entrance doline by fossil digging and possibly degraded the cave through thoughtless caving activities (Davey et al., 1992). The movement of diving parties and the transport of heavy diving equipment along the passage leading to the Lunch Room, where diving currently commences, has already impacted this section of the cave (Eberhard, 1999).

Potential: There exists a proposal to promote the site as a cave diving destination for members of the Cave Divers Association of Australia, which may increase the rate of visitation to the site and accelerate the rate of cave degradation if divers are not suitably experienced in minimum impact caving techniques (Eberhard, 1999).

Conservation measures taken:
Nurina Cave is within an area proposed for addition to Nuytsland Nature Reserve. The Nullarbor caves have been identified as highly significant refugia for biological diversity because they provide refuge for many evolutionary relictual species (Morton et al., 1995). In order to protect a section of the cave which contains a rich terrestrial troglobitic fauna, the location of these passages was not shown on a 1987 survey map by Poulter and Edwards of the Western Australian Speleological Research Group Inc. In addition, the group has installed an explanatory sign at the start of the fauna passage, which is relatively near to the cave entrance but difficult to access through some awkwardly small passages, requesting that visitors do not proceed further (Eberhard, 1999). A review of the biological significance of Nurina Cave has recommended that the bushland overlying the caves should be adequately protected to ensure that it is not cleared, and intense bushfires should be suppressed, because the tree roots provide a food source for the troglobitic community (Eberhard, 1999). The review also recommended that, should diving continue in Nurina Cave, those divers should be suitably experienced in minimum impact caving techniques such as specified by the Minimum Impact Caving Code (1995) of the Australian Speleoological Federation (Eberhard, 1999). The site is within a much larger area identified for listing as a World Heritage Area (Natural Heritage category) because of the significance of its landforms, particularly karst features, and their associated biota, notably the unique troglobitic fauna, which are of outstanding international importance (Davey et al., 1992).

Management authority and jurisdiction:
The Western Australia Department of Planning and Infrastructure is responsible for managing all Unallocated Crown Lands although the Department of Conservation and Land Management has partial responsibility for the management of fire, feral animals and weeds.

Compiler and date:
Compiled by Sue Elscot, Department of Conservation and Land Management, Busselton, in August 2005, with minor additions in 2009.

References:
Bradbury, J.H. and Eberhard, S. (2000). A new stygobiont melitid amphipod from the Nullarbor Plain. *Records of the Western Australian Museum* **20**:39-50.

Davey, A.G. Gray, M.R., Grimes, K.G., Hamilton-Smith, E., James, J.M. and Spate, A.P. (1992). World Heritage significance of karst and other landforms in the Nullarbor region. Report prepared by the Applied Ecology Research Group, University of Canberra, for the Commonwealth Department of The Arts, Sport, The Environment and Territories, Canberra.

Eberhard, S. (1999). The Biological Significance of Caves N46, N327 and N1327 on the Nullarbor Plain. Unpublished report to the Speliological Research Group of Western Australia Inc. and the Department of Conservation and Land Management (South Coast Region), Albany.

Eberhard, S. and Moulds, T. (2007). Subterranean Biodiversity of the Nullabor Karst Desktop Study. Report prepared by Subterranean Ecology Scientific Environmental Services, Greenwood, for the Department of Environment and Conservation, Perth.

Morton, S.R., Short, J. and Barker, R.D. (1995). Refugia for Biological Diversity in Arid and Semi-arid Australia. Biodiversity Series, Paper No. 4, Biodiversity Unit. Department of Environment, Sport and Territories, Canberra.

Trimix Divers (2005). Nurina Cave. Accessed online at: http://www.trimixdivers.com/Navigate.do;jsessionid=2D83E93622A869854B470F2DCF154487 . 21/8/05.

2.9 WA129 Paperbark Swamp

Name of Wetland:
Paperbark Swamp

Reference number:
WA129

Location:
32°24'58" S, 118°5'52" E, approximately 25km southeast of Corrigin.

Bioregion:
Mallee

Shire:
Shire of Corrigin

Area:
Approximately 60 ha, main wetland basin is approximately 42.5 ha.

Elevation:
Approximately 285 m AHD

Other wetlands in the same aggregation:
None.

Wetland types:
B14

Criteria for inclusion:
1, 3

Site description:
The site includes Paperbark Swamp, an ephemeral freshwater wetland within Paperbark Nature Reserve.

Physical features:
Landform: The site includes a small fresh seasonal wetland that comprises a number of small irregular basins (1-1.5m deep when full) that are interconnected by slightly shallower broad channels (Cale et al., 2004). There is a dam on the lakebed at the north end where surface water persists for several months after the rest of the swamp has dried (Cale et al., 2004). Geological Setting: The wetland sits on an impervious heavy clay which is two to three metres thick. The clay is light coloured, causing the water to become white and opaque when the swamp is inundated. Below this clay layer lies the

palaeodrainage channel of alluvial sands. Climate: Mean annual rainfall at Corrigin is 375.5 mm, mostly falling between June – August, annual evaporation is c. 1800 mm.

Hydrological features:
Water Supply: Surface inflow enters at the southern end of the wetland from undefined channels that drain farmland to the south and south-west (Cale et al., 2004). Outflow, when it occurs, empties into a saline chain of lakes known collectively as the Bendering Lakes, which lie 2-3 km north of the swamp (Cale et al., 2004). Water Depth: September: mean 0.85 m, median 0.95 m, maximum 1.53 m (n = 18), dry in 1985, 87 and 97. November: mean 0.69 m, median 0.75 m, maximum 1.21 m (n = 19), dry in 1985, 87 and 98 (Lane et al., 2004). Water salinity: Fresh, stasohaline. September: mean 0.26 ppt, median 0.23 ppt, range 0.14-0.50 ppt (n = 15). November: mean 0.51 ppt, median 0.36 ppt, range 0.25-1.84 ppt (n = 16) (Lane et al. 2004). Water pH: range 6.30-9.10 (n = 38) (CALM, unpublished data). Water Colour: 51 TCU in October 1997, 130 TCU in October 1999 and 91 TCU in Octber 2003 (CALM, unpublished data). Turbidity: Water is frequently turbid because of the clay substrate (Cale et al., 2004). 51 NTU in October 1997, 1400 NTU in October 1999 and 35 NTU in October 2003 (CALM, unpublished data). Groundwater: Maximum depth to groundwater in January 2000 ranged between 3.1 and 5.7 m and groundwater was always more saline than the surface water (Cale et al., 2004).

Ecological features:
The wetland basin is dominated by *Melaleuca strobophylla*, with an understorey of *Melaleuca phoidophylla* towards the margin. The wetland fringe includes *Eucalyptus loxophleba* and *E. yilgarnensis* woodland over *Melaleuca lateriflora* thickets.

Significance:
One of the best examples of a wooded swamp dominated by *Melaleuca strobophylla* remaining in good condition within the Mallee and Avon-Wheatbelt bioregions, where this wetland type has been extensively degraded and destroyed by clearing and dryland salinity (M. Lyons, pers. comm.).

Notable flora:
Threatened Species: None known. Composition: The overstorey is dominated by healthy, mature *Melaleuca strobophylla* overstorey, with *M. phoidophylla* forming a sparse, seasonally inundated understorey through the centre and southern parts of the wetland. At the northern end, *M. latiflora* and *M. phoidophylla* grow over an understorey that includes *Enchylaena tomentosa, Atriplex semibaccata, Maireana brevifolia, Grevillia acuaria, Lomandra effusa* and *Chenopodium* spp (Cale et al., 2004). Plants present at the wetland edge include *Juncus subsecundus, Lythrum wilsonii, Centipeda crateriformis* and *Marsilea drummondii* (M. Lyons, pers. comm.).

Notable fauna:
Threatened species: None known. Composition: A total of 10 species of waterbirds have been recorded using Paperbark Swamp, with greatest species richness occurring in autumn, after the lake had flooded extensively (Cale, 2004; Cale et al., 2004). Breeding:

Five waterbird species have been recorded breeding in low numbers at Paperbark Swamp: Grey Teal *Anas gracilis*, Pacific Black Duck *Anas superciliosa*, White-necked Heron *Ardea pacifica*, Eurasian Coot *Fulica atra* and Pink-eared Duck *Malacorhynchus membranaceus* (Cale, 2004). White-necked Heron were breeding at the swamp in October 1999 (Cale et al., 2004). Numbers: During biennial surveys carried out between 1999 and 2003, the abundance of waterbirds ranged from 100-600 individuals, and was strongly dominated by Grey Teal *Anas gibberifrons* (Cale, 2004).

Other fauna:
A total of 114 species of aquatic invertebrates have been recorded within Paperbark Swamp (Cale et al., 2004; A. Pinder, pers. comm.). Species composition is dominated by insects (39 species or 52% of the fauna, Cale et al., 2004). There are 16 taxa of coleopteran beetle, including *Hyderodes* sp., which is typically collected from vegetated swamps with turbid or coloured water. Hemipterans and Dipterans are also well represented (7 and 16 taxa respectively). The most numerically abundant insect species were the Dipterans *Chironomus tepperi*, *Chironomus* aff. *Alternans* and Stratiomyidae. A total of 22 species of crustaceans (29% of the fauna) were collected and, while not as species rich as the insects, they were numerically dominant, with the anostracan *Branchinella lyrifera* and the ostracod *Bennelongia barangaroo* both recorded at densities in excess of 10,000 individuals per sample (50m sweep sample with a 250 micron D-framed pond-net). Two species of conchostracans, *Lynceus* sp. and *Caenestheriella* sp., were also collected in large numbers. Paperbark Swamp has considerable conservation importance for aquatic invertebrates, particularly conchostracans and anostracans which rely on a dessication-resistant stage to persist at Paperbark Swamp between filling cycles (Cale et al., 2004). These species would be compromised by changes in the hydrological cycle or water quality (Cale et al., 2004).

Social and cultural values:
No information.

Land tenure:
On site: Paperbark Nature Reserve (Reserve 12900).
Surrounding area: Freehold farmland.

Current land use:
On site: Nature Conservation.
Surrounding area: Agriculture, predominantly wheat production and sheep grazing.

Disturbances or threats:
Current: A large drainage inlet has been constructed within the southern section of the reserve opposite a paddock with evidence of waterlogging and erosion (Gurner et al., 1999). Vegetation on the southern boundary of the nature reserve shows symptoms of waterlogging and salinity stress (Gurner et al., 1999). In 2001/2002, there was an increase in soil salinities at the swamp which has caused the death of individuals of some tree species, and a decrease in the number of some salt sensitive understorey species (Kabay, 2002).

Potential: Secondary salinisation and increased inundation.

Conservation measures taken:
The site is within Paperbark Nature Reserve (Reserve 12900). Paperbark Swamp is one of 25 'biological monitoring' wetlands within the Wheatbelt which are monitored by the Western Australian Department of Conservation and Land Management under the State Salinity Strategy. Three permanent vegetation transects have been established at the site to monitor the health of the vegetation on a triennial basis (Gurner et al., 1999). Waterbirds, aquatic invertebrates and groundwater are also monitored biennially (Cale et al., 2004), while depth, salinity and water quality are measured each September and November (Lane et al., 2004).

Management authority and jurisdiction:
The nature reserve is managed by the Western Australian Department of Conservation and Land Management for the Conservation Commission of Western Australia. Wheatbelt regional office located at Narrogin.

Compiler and date:
Compiled by Sue Elscot, Department of Conservation and Land Management, Busselton, in July 2005.

References:
Cale, D.J. (2004). Paperbark Swamp Waterbirds. Summary pamphlet produced by the Department of Conservation and Land Management, Perth.

Cale, D.J., Halse, S.A. and Walker, C.D. (2004). Wetland monitoring in the Wheatbelt of south-west Western Australia: site descriptions, waterbird, aquatic invertebrate and groundwater data. *Conservation Science Western Australia* **5(1)**:20-135.

Kabay, E.D. (2002). Salinity Action Plan Wetland Vegetation Monitoring 2001/2002 Report. Unpublished report prepared by Kabay Consultants for the Department of Conservation and Land Management, Perth.

Lane, J.A.K., Pearson, G.B., Clarke, A.C., Winchcombe, Y.C. and Munro, D.R. (dec.). (2004). Depths and Salinities of Wetlands in South-western Australia: 1977-2000. Department of Conservation and Land Management, Perth.

Gurner, R., Froend, R., and Ogden, G. (1999). Salinity Action Plan Wetland Vegetation Monitoring 1998/1999. Department of Conservation and Land Management, Perth.

A. Pinder. Research Scientist, Department of Conservation and Land Management, Woodvale Wildlife Research Centre.

M. Lyons. Research Scientist, Western Australian Department of Conservation and Land Management, Woodvale.

2.10 WA130 Walcott Inlet and Munja Lagoon

Name of Wetland:
Walcott Inlet and Munja Lagoon

Reference number:
WA130

Location:
16°25’ S, 124° 50’ E, approximately 150 km north-east of the town of Derby.

Bioregion:
Northern Kimberley

Shire:
Shire of Derby/West Kimberley

Area:
Approximately 30,000 ha

Elevation:
Sea level.

Other wetlands in the same aggregation:
None.

Wetland type:
A6, A7, A9, A11, A12, B1, B4

Criteria for inclusion:
1, 2, 3, 5, 6

Site description:
The site includes Walcott Inlet, Munja Lagoon (at the north-eastern end of the Inlet) and the lower reaches of the Isdell, Calder, and Charnley Rivers. Nearby wetlands: Big Springs (WA114) is 90 km south-west; Yampi Sound Training Area (WA115) is 80 km west north-west; and the Prince Regent River (WA064) is 125 km north-east.

Physical features:
Landform: Megascale, elongate estuary; Walcott Inlet extends approximately 60 km eastwards from Collier Bay to the mouths of the Calder and Charnley Rivers; at its widest point, Walcott Inlet spans approximately 11 km. Munja Lagoon is located at the north-eastern end of Walcott Inlet. Geological Setting: Walcott Inlet is the broad, shallow, drowned river valley which, in a previous era, followed a structural joint between the Carson Volcanic and King Leopold Sandstone strata, which is why there are contrasting

landforms on either side of the Inlet (Kenneally and Edinger, 1993). To the north and north-east of the Inlet are undulating lowlands, with dendritic drainage off the gentle slopes of the isolated hills and ridges, which is typical of volcanic country. To the south of the Inlet are rugged, boulder-strewn valleys and ranges typical of King Leopold Sandstone. Tidal mudflats, up to five kilometres wide, fringe the central and eastern parts of the Inlet and are variably inundated by the tides which have an average effective rise and fall of 11 m (Kenneally and Edinger, 1993). Around the landward edge of the mudflat there are extensive alluvial plains, including dark alluvial soils, occasional large fresh water lagoons and, where small streams flow out of the sandstone, small swampy areas of deep, sandy soil stained by organics. Rocky slopes rise steeply from the mangroves and rocky shores at the mouth of Walcott Inlet, terminating in a plateau which in places is bordered by cliffs. Here the Warton and Pentecost Sandstones overlie the Carson Volcanics and produce similar topography to that of the King Leopold Sandstone, which also forms the Artesian Range between the Isdell and Charnley Rivers south-east of Walcott Inlet. Dark grey Hart Dolerite intrudes on all these rock types and produces a characteristic black band on many hillsides where scree slopes have been produced by weathering (Kenneally and Edinger, 1993). Climate: Median and mean annual rainfall at Kuri Bay are 1292 mm and 1320 mm respectively, mostly falling in December-March; annual evaporation is c. 3000 mm.

Hydrological features:
Walcott Inlet is strongly tidal, with tidal amplifications of up to 11 m at the mouth of Collier Bay. Tides penetrate approximately 6 km into the Calder River and 3 km into the Charnley River from the confluences of the rivers with Walcott Inlet (Chapman et al., 1993). The Charnley, Calder and Isdell Rivers all discharge fresh water into the Inlet. Munja Lagoon is the largest of many freshwater swamps and lagoons that occur inland of the tidal meadows on Munja Plain, on the north-eastern side of Walcott Inlet.

Ecological features:
The site is characterised by highly diverse habitats and a number of distinct wetland types including estuary, river, river floodplain, and scarp-foot seepage rainforests (on the south side of the estuary). Munja Lagoon, located on the north-eastern side of the estuary, is a very open feature which contains the largest known swamps of *Eleocharis dulcis* in the Northern Kimberley bioregion (T. Willing, personal communication).

Extensive tidal embayments and alluvial flats support dense stands of mangroves. Alluvial plains support extensive grasslands dominated by *Eucalyptus tectifica, Corymbia greeniana, C. confertiflora, Terminalia canescens, Gardenia megasperma* and *Erythrophleum chlorostachys*, with the occasional Boab *Adansonia gregorii*. The ground layer is dominated by Spear Grass *Heteropogon contortus* and Plains Wanderrie Grass *Eriachne festucacea* (Kenneally and Edinger, 1993).

Alluvial banks adjacent to the rivers support *Corymbia clavigera, Glochidion sumatranum, Bauhinia cunninghamii,* White Cedar *Melia azedarach, Homolanthus novo-guineensis, Terminalia bursarina, Brachychiton diversifolius* and the climbers *Luffa cylindrica, Merremia gemella* and *M. umbellata* (Kenneally and Edinger, 1993).

Gallery forests extend along the banks of creeks and adjacent to the outcropping sandstone. These permanently damp areas support the tree species *Melaleuca leucadendra, Eucalyptus houseana, Terminalia ferdinandiana, T. platyphylla, Cordia dichotoma, Ficus coronulata, Nauclea orientalis, Syzygium eucalyptoides, S. nervosum, S. suborbiculare, Thespesia thespesioides, Timonius timon* and *Carallia brachiata* (Kenneally and Edinger, 1993). Dense groves of *Pandanus spiralis* occur with fern beds dominated by Mangrove Fern *Acrostichum speciosum*, Climbing Swamp Fern *Stenochlaena palustris*, *Cyclosorus interruptus,* the rarely collected *Helminthostachys zeylanica, Cressa cretica, Drosera indica, Limnophila fragrans, Marsilea hirsuta, M. mutica, Mitrasacme hispida* and *Cyanthillium cinereum* (Kenneally and Edinger, 1993).

Patches of rainforest occur on the steep slopes below the sandstone escarpments, in narrow gorges, in hollows on the upper slopes of some hills and in swampy areas behind tidal mudflats often merging with gallery forests. Rainforest species include the trees *Aidia racemosa, Aglaia elaeagnoidea, Albizia lebbeck, Alstonia linearis, Alphitonia excelsa, Bombax ceiba, Canarium australianum, Celtis philippensis, Cryptocarya cunninghamii, Ficus virens, F. racemosa, Ganophyllum falcatum, Grewia breviflora, Gyrocarpus americanus, Ilex arnhemensis, Miliusa brahei, Mimusops elengi, Polyalthia australis, Polyaulax cylindrocarpa, Pouteria sericea,* and *Wrightia pubescens*. The vines include *Abrus precatorius, Adenia heterophylla, Ampelocissus acetosa, Canavalia papuana, Capparis sepiaria, Flagellaria indica, Ichnocarpus frutescens, Pachygone ovata, Parsonia velutina, Pisonia aculeata* and *Secamone timoriensis* (Kenneally and Edinger, 1993). The epiphytic orchid *Dendrobium affine* occasionally occurs.

Rivers and creeks flowing through sandstone are fringed by Cadjeputs *Melaleuca leucadendra* over thickets of Screw Palm *Pandanus spiralis* (Kenneally and Edinger, 1993).

Semi-permanent or permanent swamps or billabongs are found in the area, the largest example being Munja Lagoon. These wetlands are dominated by the Blue Waterlily *Nymphaea violacea* and are often fringed with dense beds of the sedge *Eleocharis dulcis*. The grass *Pseudoraphis spinescens* is common as are the submerged aquatics *Blyxa aubertii* and *Najas tenuifolia* (Kenneally and Edinger, 1993).

Walcott Inlet and Munja Lagoon support a very diverse avian fauna comprising at least 131 species, including 52 waterbird species (of which 17 are listed under international treaties), due to the high diversity of habitat types within a small area (Chapman et al., 1993).

Significance:
Unlike other large inlets in the Northern Kimberley bioregion that are fringed by mangroves only, Walcott Inlet is fringed by extensive alluvial, black soil plains that support gallery forests, rainforest, savanna and permanent freshwater wetlands, notably Munja Lagoon, which is one of few permanent, freshwater swamps in the bioregion (Kenneally and Edinger, 1993).

The site's vegetation communities are especially important. Three areas of rainforest within the site are listed as a Threatened Ecological Community (TEC), 'Assemblages of Walcott Inlet', which is specially protected by the Western Australian *Wildlife Protection Act 1950* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.* These rainforest patches, although only small in size, are biologically very significant. Munja Lagoon, located on the north-eastern side of the estuary, is a very open feature which contains the largest known swamp of *Eleocharis dulcis* in the Northern Kimberley bioregion (T. Willing, personal communication).

The site supports very high numbers of waterbirds of at least 52 species (Chapman et al. 1993, K. Coate, unpublished data), and contains important nesting habitat for the Saltwater Crocodile *Crocodylus porosus* which is specially protected by the Western Australian *Wildlife Protection Act 1950* (T. Willing, personal communication).

The Walcott Inlet and Munja Lagoon area contains many sites of significance to Aboriginal people including art and burial sites, and contemporary Aboriginal people retain strong ties to the area (CALM, no date).

Notable flora:
Threatened species: None. Composition: Three areas of rainforest within the site are listed as a Threatened Ecological Community (TEC), 'Assemblages of Walcott Inlet', which is specially protected by the Western Australian *Wildlife Protection Act 1950* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.* The three occurrences of this TEC were first described during the Kimberley Rainforests Survey (McKenzie et al., 1991, patches 18/4, 19/2 and 21/4). Stoneman et al. (1991) described patch 19/2 in detail. This rainforest swamp, located on the south side of Walcott Inlet, near the Isdell River, is fed by streams from sandstone hills and appears to be part of a broad watercourse. In June 1987, there was water entering the swamp from the south and draining towards the tidal mudflats located to the north and there was standing water to at least 30cm deep in the central part of the swamp. Higher ground with tall *Melaleuca* forest occurs in the centre of the swamp. The soils are generally highly organic and in places are composed of layers of different textures. The vegetation comprises closed canopy rainforest to 30m in height, and is dominated by *Ficus* spp., *Nauclea orientalis* and *Celtis philippensis* over 1-3m high *Acrostichum speciosum* ferns. During the Kimberley Rainforests survey, which examined 95 Kimberley rainforest patches, the tree *Cordia subcordata* was recorded only once, at patch 19/2 on the southern side of Walcott Inlet.

A number of species present appear to be restricted to the site and its immediate surrounds: *Borya subulata* (Anthericaceae), *Monochoria vaginalis* (Pontederiaceae), *Merremia gemella* (Convolvulaceae), *Kalanchoe crenata* (Crassulaceae), *Decaisnina biangulata* (Loranthaceae), *Acacia froggattii* (Mimosaceae) and *Syzygium nervosum* (Myrtaceae)(Kenneally and Edinger, 1993).

Notable fauna:
Threatened species: None known. Composition: A total of 52 waterbird species have been recorded using Walcott Inlet and the lower reaches of the Isdell, Calder and Charnley Rivers, including 17 listed under international treaties (17 under CAMBA and 13 under JAMBA) (Chapman et al., 1993; K. Coate, unpublished data). These include 10 herons and egrets (Family Ardeidae), 16 waders and shorebirds (including six Charadriidae and eight Scolopacidae), six gulls and terns (Family Laridae) and five ibises and spoonbills (Family Threskiornithidae). Some waterbirds, particularly herons, ibises, egrets and Australian Pelicans are much more abundant on the Calder than the Charnley River, which may be due to the greater tidal penetration into the Calder River (*ca* 6 km of tidal reaches compared to *ca* 3 km in the Charnley River) (Chapman et al., 1993). Additionally, the Calder River has larger areas of 'tidal meadows', which are narrow margins of semi-aquatic grasslands that are inundated by the high tides (Chapman et al., 1993). Numbers: No systematic waterbird counts have been undertaken in Walcott Inlet or Munja Lagoon. More than 500 Brolga *Grus rubicundus,* 500 Magpie Goose *Anseranas semipalmata,* and large numbers of Glossy Ibis *Plegadis falcinellus,* Australian White Ibis *Threskiornis molucca* and Straw-necked Ibis *Threskiornis spinicollis* were observed on Munja Lagoon at dusk during a fleeting visit in June 1999 (P. Masters, pers comm.).

Other fauna:
Threatened species: The Golden Bandicoot *Isoodon auratus,* which is specially protected by the Western Australian *Wildlife Protection Act 1950* (Sr) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Nv), has been recorded within a vine thicket in rainforest along the Charnley River (Chapman, 1993). One group of five Gouldian Finch *Erythrura gouldiae,* which are also specially protected by the Western Australian *Wildlife Protection Act 1950* (Sr) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Ne), were recorded in savannah woodland near the mouth of Neville Creek on the Calder River (Chapman et al., 1993). The site includes important nesting habitat for the Saltwater Crocodile *Crocodylus porosus* which is specially protected by the Western Australian *Wildlife Protection Act 1950* (Sr) (T. Willing, personal communication). Composition: At least 79 species of birds (in addition to the 52 waterbird species) have been recorded using the site, with insectivores and frugivores being the most common birds (Chapman et al., 1993). Species recorded only in the rainforest and vine thickets were the Pied Imperial Pigeon *Ducula bicolor,* Emerald Dove *Chalcophaps indica,* Sacred Kingfisher *Todiramphus sanctus,* Yellow Oriole *Oriolus flavocinctus* and Spangled Drongo *Dicrurus bracteatus* (Chapman et al., 1993). Notable bird records include the Rufous Fantail *Rhipidura phasiana,* Red-chested Button Quail *Turnix pyrrhothorax,* and White-browed Robin *Poecilodryas superciliosa* (K. Coate, pers. comm.). A total of seventeen native and four introduced mammals have been recorded from the Walcott Inlet and Munja Lagoon area (Chapman, 1993). The seventeen native mammals include the Short-beaked Echidna *Tachyglossus aculeata,* the rarely sighted Scaly-tailed Possum *Wyulda squamicaudata,* the Common Wallaroo *Macropus robustus,* five bat species and three native rats and mice (Chapman, 1993). The four introduced species are the Cat *Felis catus,* Horse *Equus caballus,* One-humped Camel *Camelus dromedarius* and the Cow *Bos taurus* (Chapman, 1993). While the cat, horse and camel were recorded in low

numbers only, approximately 200-300 cattle were observed along the rivers and swamps of the Munja Plain. During the Kimberley Rainforests survey, which examined 95 Kimberley rainforest patches, the camaenid snail *Torresitrachia sp*. was recorded only once, at patch 19/2 on the southern side of Walcott Inlet (Solem, 1991).

Social and cultural values:
Historical value: Walcott Inlet was named after Pemberton Walcott (1834-1883), a collector of natural history and botanical specimens and inspector of pearl fisheries in Broome, by the surveyor F.S. Brockman in July 1901 (Kenneally and Edinger, 1993). The first pastoral lease in the vicinity was established in 1924, and in 1927 the State Government purchased the leases and, together with the remaining Crown land from the northern side of the inlet to the ocean, established an Aboriginal Reserve (No. 19563) and cattle station at Munja. In 1949, the Presbyterian Church took over the station and in 1951 the Presbyterian mission was closed and moved to Wotjulum (on the mainland near Cockatoo Island). Aboriginal Reserve No. 19563 was cancelled in 1958. Cultural value: The Walcott Inlet and Munja Lagoon area contains many sites of significance to Aboriginal people including art and burial sites, and contemporary Aboriginal people retain strong ties to the area (CALM, date unknown).

Land tenure:
On site: The site is currently Unallocated Crown Land (UCL) and although it has been proposed to form the Walcott Inlet National Park, this has not yet occurred.
Surrounding area: Walcott Inlet is surrounded almost entirely by UCL. Pantijan Station, which is leased by the Federal Government for the Mowanjum Aboriginal Community, adjoins the north-eastern end of the inlet. Land adjoining the south-eastern corner of the inlet, between the Isdell and Charnley Rivers, was formerly Charnley pastoral lease, but was subsequently secured by CALM for conservation in 1992. The south-western side of the Inlet (west of Mount Page) is Reserve 1011 (unvested) for the purpose 'Townsite and Landing'.

Current land use:
On site: The site is currently Unallocated Crown Land that is proposed to form Walcott Inlet National Park. Currently, the area can only be accessed via roads crossing pastoral leases, namely Mt Elizabeth Station, Beverley Springs Station and Pantijan Station. Permission to use these tracks must be obtained from the pastoral lessees prior to arrival at the stations (CALM, date unknown). Several commercial tour operators provide guided nature-based and fishing tours to the Inlet. Some temporary camping takes place at Munja during stock mustering from nearby Pantijan Station (Kenneally and Edinger, 1993).
Surrounding area: Most of the Inlet is surrounded by Unallocated Crown Land. Pantijan Station adjoins the north-eastern corner of the Inlet.

Disturbances or threats:
Current: Feral stock are present in limited numbers and the vegetation is in reasonably good condition (Kenneally and Edinger, 1993).
Potential: Whilst the presence of feral pigs has not been confirmed in the Walcott Inlet and Munja Lagoon area, concerns have been raised about increasing pig numbers

throughout the Kimberley and pigs have been known to damage rainforest patches (G. Graham, pers. comm.).

Conservation measures taken:
The area has been proposed to form the Walcott Inlet National Park (Burbidge et al., 1991).

Management authority and jurisdiction:
The Western Australian Department of Planning and Infrastructure is responsible for management of all unvested reserves and Unallocated Crown Land although the Department of Conservation and Land Management has partial responsibility for the management of weeds, fire and feral animals within Unallocated Crown Land.

Compiler and date:
Compiled by Sue Elscot, Western Australian Department of Conservation and Land Management, Busselton, in June 2005.

References:
Burbidge, A.A., McKenzie, N.L. and Kenneally, K.F. (1991). Nature Conservation Reserves in the Kimberley. Department of Conservation and Land Management, Perth.

CALM. (No date). A Guide to the Walcott Inlet Area of the North-west Kimberley. Brochure produced by the Department of Conservation ad Land Management, Kununurra, and Mt Elizabeth Station, Beverley Springs Station, and Pantijan Station.

Chapman, A. (1993). Mammals of the Munja-Walcott Inlet area, West Kimberley, Western Australia. *The Western Australian Naturalist,* **19(2)**: 140-146.

Chapman, A., Harold, G. and Milewski, T. (1993). Birds of the Munja-Walcott Inlet Area, West Kimberley, Western Austalia. *The Western Australian Naturalist,* **19(2)**:147-161.

Kenneally, K.F. and Edinger, D.C. (1993). A botanical survey of Walcott Inlet, Kimberley, Western Australia. *The Western Australian Naturalist,* **19(2)**:84-139.

McKenzie, N.L., Johnstone, R.B. and Kendrick, P.G. (Eds.) (1991). Kimberley Rainforests of Australia. Surrey Beatty and Sons, Chipping Norton, in association with the Western Australian Department of Conservation and Land Management, Perth, and the Department of Arts, Heritage and Environment, Canberra.

Solem, A. (1991). Land snails of Kimberley rainforest patches and biogeography of all Kimberley land snails. Pp 145-246 in: McKenzie, N.L., Johnstone, R.B. and Kendrick, P.G. (Eds.) *Kimberley Rainforests of Australia.* Surrey Beatty and Sons, Chipping Norton, in association with the Western Australian Department of

Conservation and Land Management, Perth, and the Department of Arts, Heritage and Environment, Canberra.

Stoneman, T.C., McArthur, W.M. and Walsh, F.J. (1991). Soils and landforms of Kimberley rainforests, Western Australia. Pp 53-87 in: McKenzie, N.L., Johnstone, R.B. and Kendrick, P.G. (Eds.) *Kimberley Rainforests of Australia.* Surrey Beatty and Sons, Chipping Norton, in association with the Western Australian Department of Conservation and Land Management, Perth, and the Department of Arts, Heritage and Environment, Canberra.

T. Willing, former Regional Botanist, Department of Conservation and Land Management, Kimberley Region, personal communication.

K. Coate, former Vice-President of the Western Australian Naturalist's Club and Kimberley Wildlife Tour Operator, unpublished data.

G. Graham, Regional Leader Nature Conservation, Department of Conservation and Land Management, Kimberley Region, personal communication.

P. Masters, Derby Visitors Centre, personal communication.

2.11 REFERENCES USED FOR THE TEN NEW NATIONALLY IMPORTANT WETLAND DESCRIPTIONS

Beecham, B. and Danks, A. (2001). Mallee 2 (MAL2 – Western Mallee subregion). Pp. 435-465 in: May, J. and McKenzie, N.L. (Eds.). (2002*). A Biodiversity Audit of Western Australia's Biogeographical Subregions in 2002.* Department of Conservation and Land Management, Perth.

Beecham, B. and Danks, A. (2001). Mallee 2 (MAL2 – Western Mallee subregion). Pp. 435-465 in: May, J. and McKenzie, N.L. (Eds.). (2002*). A Biodiversity Audit of Western Australia's Biogeographical Subregions in 2002.* Department of Conservation and Land Management, Perth.

Birds Australia (2003). Atlas of Australian Birds. Birds Australia, Melbourne.

Bowler, J.M. (1976). Aridity in Australia: age, origins, and expression in aeolian landforms and sediments. *Earth – Science Review* **12**:279-310.

Bradbury, J.H. and Eberhard, S. (2000). A new stygobiont melitid amphipod from the Nullarbor Plain. *Records of the Western Australian Museum* **20**:39-50.

Burbidge, A.A., McKenzie, N.L. and Kenneally, K.F. (1991). Nature Conservation Reserves in the Kimberley. Department of Conservation and Land Management, Perth.

Cale, D.J. (2004). Bennetts Lake Waterbirds. Summary pamphlet produced by the Department of Conservation and Land Management, Perth.

Cale, D.J. (2004). Paperbark Swamp Waterbirds. Summary pamphlet produced by the Department of Conservation and Land Management, Perth.

Cale, D.J., Halse, S.A. and Walker, C.D. (2004). Wetland monitoring in the Wheatbelt of south-west Western Australia: site descriptions, waterbird, aquatic invertebrate and groundwater data. *Conservation Science Western Australia* **5(1)**:20-135.

CALM. (No date). A Guide to the Walcott Inlet Area of the North-west Kimberley. Brochure produced by the Department of Conservation ad Land Management, Kununurra, and Mt Elizabeth Station, Beverley Springs Station, and Pantijan Station.

Chapman, A. (1993). Mammals of the Munja-Walcott Inlet area, West Kimberley, Western Australia. *The Western Australian Naturalist,* **19(2)**: 140-146.

Chapman, A., Harold, G. and Milewski, T. (1993). Birds of the Munja-Walcott Inlet Area, West Kimberley, Western Austalia. *The Western Australian Naturalist*, **19(2)**:147-161.

Coate, K.H., Johnstone, R.E. and Lodge, G.A. (1998). Birds of the Gardner and Denison Ranges, and Lake Willson area, south-east Kimberley, Western Australia. *Western Australian Naturalist* **22(1)**:25-55.

Davey, A.G. (1978). Rescource Management of the Nullarbor Region, WA. A report to the Environmental Protection Authority by the Australian Speliological Federation.

Davey, A.G. Gray, M.R., Grimes, K.G., Hamilton-Smith, E., James, J.M. and Spate, A.P. (1992). World Heritage significance of karst and other landforms in the Nullarbor region. Report prepared by the Applied Ecology Research Group, University of Canberra, for the Commonwealth Department of The Arts, Sport, The Environment and Territories, Canberra.

Dell, J. and How, R.A. (1984). IV Vertebrate Fauna. Pp. 57-81 in: Biological Surveys Committee. The Biological Survey of the Eastern Goldfields of Western Australia, Part 2. Widgiemooltha – Zanthus Study Area. *Records of the Western Australian Museum, Supplement Number 18*.

Doepel, J.J.G. and Lowry, D.C. (1970). Zanthus. Geological Survey of Western Australia 1:250,000 Geological Series Explanatory Notes.

DPI. (2005). Western Australian *Navigable Waters Regulations 1958.* Accessed online at: http://www.dpi.wa.gov.au/imarine/rec_boating/pdfs/REG_Navwater_All_Report.rtf (accessed 29/8/05).

Eberhard, S. (1999). The Biological Significance of Caves N46, N327 and N1327 on the Nullarbor Plain. Unpublished report to the Speliological Research Group of Western Australia Inc. and the Department of Conservation and Land Management (South Coast Region), Albany.

Eberhard, S. and Moulds, T. (2007). Subterranean Biodiversity of the Nullabor Karst Desktop Study. Report prepared by Subterranean Ecology Scientific Environmental Services, Greenwood, for the Department of Environment and Conservation, Perth.

Gurner, R. Froend, R., Ogden, G., and Franke, B. (2000). Wetland Vegetation Monitoring, 1999/2000 (Salinity Action Plan). Unpublished report prepared for the Department of Conservation and Land Management by the Centre for Ecosystem Management, Edith Cowan University, Perth.

Gurner, R., Froend, R., and Ogden, G. (1999). Salinity Action Plan Wetland Vegetation Monitoring 1998/1999. Department of Conservation and Land Management, Perth.

Kabay, E.D. (2002). Salinity Action Plan Wetland Vegetation Monitoring 2001/2002 Report. Unpublished report prepared by Kabay Consultants for the Department of Conservation and Land Management, Perth.

Kenneally, K., Edinger, D., Coate, K. and How, R. (1999). *Craters and Creatures of the Tanami Desert 1998*: Landscope Expedition Report No. 27. Department of Conservation and Land Management, Perth.

Kenneally, K.F. and Edinger, D.C. (1993). A botanical survey of Walcott Inlet, Kimberley, Western Australia. *The Western Australian Naturalist*, **19(2)**:84-139.

Lane, J.A.K., Pearson, G.B., Clarke, A.C., Winchcombe, Y.C. and Munro, D.R. (dec.). (2004). Depths and Salinities of Wetlands in South-western Australia: 1977-2000. Department of Conservation and Land Management, Perth.

Lowry, D.C. (1970). Geology of the Western Australian part of the Eucla Basin. Geological Survey of Western Australia: Bulletin 122.

McKenzie, N.L., Johnstone, R.B. and Kendrick, P.G. (Eds.) (1991). Kimberley Rainforests of Australia. Surrey Beatty and Sons, Chipping Norton, in association with the Western Australian Department of Conservation and Land Management, Perth, and the Department of Arts, Heritage and Environment, Canberra.

Morton, S.R., Short, J. and Barker, R.D. (1995). Refugia for Biological Diversity in Arid and Semi-arid Australia. Biodiversity Series, Paper No. 4, Biodiversity Unit. Department of Environment, Sport and Territories, Canberra.

Newbey, K.R. (1984). II Physical Environment. Pp. 29-40 in: Biological Surveys Committee. The Biological Survey of the Eastern Goldfields of Western Australia, Part 2. Widgiemooltha – Zanthus Study Area. *Records of the Western Australian Museum, Supplement Number 18*.

Pearson, G.B. (2005). Report on aerial survey of wetlands of the Ord Victoria Plain (OVP), Tanami (TAN) and Dampierland (DL) IBRA regions. Unpublished report prepared by the Department of Conservation and Land Management, Wildlife Research Centre, Woodvale.

Phillimore, R., Stack, G. and Brown, A. (2002). Lake King Eremophila (*Eremophila subteretifolia* ms): Interim Recovery Plan 2002-2005. Western Australian Threatened Species and Communities Unit, Department of Conservation and Land Management, Woodvale.

Pinder, A. M., Halse, S.A., McRae, J.M. and Shiel, R.J. (2004). Aquatic invertebrate assemblages of wetlands and rivers in the Wheatbelt region of Western Australia. *Records of the Western Australian Museum*, **67**:7-37.

Pinder, A.M., Halse, S.A., Shiel, R.J. and McRae, J.M. (2000). Granite outcrop pools in south-western Australia: foci of diversification and refugia for aquatic invertebrates. *Journal of the Royal Society of Western Australia*, **83**:149-161.

Singor, M. (1999). Hooded Plover Report No. 2: 1996-1999. Supplement to *Western Australian Bird Notes*, No. 90, June 1999.

Solem, A. (1991). Land snails of Kimberley rainforest patches and biogeography of all Kimberley land snails. Pp 145-246 in: McKenzie, N.L., Johnstone, R.B. and Kendrick, P.G. (Eds.) *Kimberley Rainforests of Australia.* Surrey Beatty and Sons, Chipping Norton, in association with the Western Australian Department of Conservation and Land Management, Perth, and the Department of Arts, Heritage and Environment, Canberra.

Stoneman, T.C., McArthur, W.M. and Walsh, F.J. (1991). Soils and landforms of Kimberley rainforests, Western Australia. Pp 53-87 in: McKenzie, N.L., Johnstone, R.B. and Kendrick, P.G. (Eds.) *Kimberley Rainforests of Australia.* Surrey Beatty and Sons, Chipping Norton, in association with the Western Australian Department of Conservation and Land Management, Perth, and the Department of Arts, Heritage and Environment, Canberra.

Trimix Divers (2005). Nurina Cave. Accessed online at: http://www.trimixdivers.com/Navigate.do;jsessionid=2D83E93622A869854B470F2DCF154487 . 21/8/05.

Watkins, D. and Jaensch, R. (1997). Wetlands of the Hampton and Nullarbor Bioregions: Collation of data on wetlands for potential listing in the Directory of Important Wetlands in Australia. A report to the Western Australian Department of Conservation and Land Management by Wetlands International – Oceania, Canberra.

Watkins, D. and McNee, S. (1987). A survey of wetlands in and adjacent to Dunn Rock and Lake Bryde Nature Reserves. Unpublished report prepared for the Wheatbelt Region of the Department of Conservation and Land Management.

Wetlands International (2002). Waterbird Population Estimates (Third Edition). Wetlands International Global Series Number 12. Wageningen, the Netherlands.

Personal Communications

A. Clarke, Senior Technical Officer, Western Australian Department of Conservation and Land Management, Woodvale.

K. Coate, former Vice-President of the Western Australian Naturalist's Club and Kimberley Wildlife Tour Operator, unpublished data.

G. Graham, Regional Leader Nature Conservation, Department of Conservation and Land Management, Kimberley Region, personal communication.

M. Lyons. Research Scientist, Western Australian Department of Conservation and Land Management, Woodvale.

P. Masters, Derby Visitors Centre, personal communication.

A. Pinder. Research Scientist, Western Australian Department of Conservation and Land Management, Science Division, Woodvale.

T. Willing, former Regional Botanist, Department of Conservation and Land Management, Kimberley Region, personal communication.

3 IMPROVED DOCUMENTATION OF EXISTING DIRECTORY SITES

This section of the report provides details on the improvments made to 25 existing Directory site reports that were updated as part of this project, primarily as a result of a review of literature and information that had become available since the previous updates were completed in 1999/2000. Therefore, the descriptions for these sites include new information that became available from 1999, and are current up to June 2005. New information and changes to these sites beyond June 2005 has not been included. References used to update each site were not added to each site description in the electronic version of the access database as the exiting references field in the database simply says "refer to the Western Australian references list". A list of all references used to update the existing site descriptions is included in section 3.2 of this report, and an electronic version of the reference list is provided on the thumb drive that accompanies this report (File name Refs used to update existing site descriptions).

3.1 Changes Made to Existing Site Descriptions

WA036 Lake Logue - Indoon System

- Conservation measures taken (NHT rehab and catchment management project, Shire of Carnamah, 2002; wetland vegetation monitoring, Kabay 2002, Gurner et al. 1999)
- Disturbances or threats (past/present, impacts of 1999 floods on vegetation health, Kabay 2002; 1999 wetland vegetation monitoring, Gurner et al. 1999; feral animals – at the request of Jodie Watts)
- Other fauna (new species of tubificid known only from this location, Pinder and Halse 2002; addition of SAP aquatic invertebrate monitoring data, Cale et al., 2004)
- Land tenure (updates based on advice from Graham Hoare, CALM Information Management Branch, 2005)

WA014 Rock Pools of the Walter James Range

- Changes made at the request of the Ngaanyatjarra Council to site description, social and cultural values, current land use, disturbance or threat, conservation measures taken and the management authority and jurisdiction (R. Edwards, Ngaanyatjarra Council representative, pers. comm.)
- Conservation measures taken (declaration of the IPA, Anon 2003; Thomas and Clews 2000)
- Current land use (addition of nature conservation)
- Land Tenure (declaration of the IPA)

WA035 Hutt Lagoon System

- Social and cultural values – research (Brine hydrochemistry, Arakel and Moulton 1986)
- Disturbances or Threats (uncontrolled vehicle access, illegal grazing and weed encroachment at Utcha swamp, incompatible land use, inappropriate fire regimes, A.Chant, CALM, pers. comm.)

WA044 Yeo Lake/Lake Throssell

- Physical features (addition of Beard 2002 ref only)
- Social and cultural values – research (palaeogeography and drainage evolution Beard 2002)
- Notable flora (removal of pigface from outlying pans)
- Notable fauna (species names updated)
- Potential threats (rabbits, camels and altered fire regimes)

WA052 Lake Disappointment – Savory Creek System

- Social and cultural values – research (palaeogeography and drainage evolution, Beard 2002)
- Hydrological features (added August 2004 water chemistry info, CALM, unpublished data)
- Notable fauna (birds on Savory Creek in August 1997, Webster 1997; Banded Stilt Breeding attempt, Clarke et al. 2004; birds on Savory Creek, Fuller and Burbidge 2002, Van Leeuwen 1997)
- Notable flora (significant revision – replaced text with B. Muir's new descriptions, CALM unpublished data)
- Other fauna (reptiles, frogs, mammals, terrestrial birds, Fuller and Burbidge, 2002; Start 2002; Kendrick 2002; addition of preliminary aquatic invertebrate id's, CALM, unpublished data; comments on the most numerically abundant aquatic invertbrates, A. Clarke, CALM, pers. comm..).
- Taxon Info (added all species listed in Clarke et al 2004, Fuller and Burbidge 2002, Start 2002, and Kendrick 2002)
- Threats (feral donkeys and camels on Savory Creek (Start 2002)
- Conservation measures (proposed Wild River, Environment Australia 1998)

WA039 Lake Gruszka

- Hydrological features (inundation the result of rain-bearing depressions)
- Social and cultural values – research (palaeogeography and drainage evolution, Beard 2002)
- Land use (surrounding area – exploration for base metals and diamonds, Trench 2002)

WA038 Gibson Desert Gnamma Holes

- Social and cultural values – research (palaeogeography and drainage evolution, Beard 2002)
- Land use (surrounding area – exploration for base metals and diamonds, Trench 2002)

WA111 Gladstone Lake

- Social and cultural values (history/naming of the lake, Dell 2003)
- Disturbances or threats (cattle damage, Dell 2003)
- Land tenure (reserved for "Public Purposes", Dell 2003)
- Significance (birds listed under international treaties)
- Ecological features (total numbers of bird species, Dell 2003)
- Notable Fauna (considerable revision, Dell 2003)
- Other fauna (revision, Dell 2003)
- Notable Flora (other species present, Dell 2003)
- Conservation measures taken (negotiations to add to the conservation estate, G. Graham, CALM, pers. comm..)
- Taxon Info (added extra bird species from Dell 2003)

WA112 Lake Bryde – East Lake Bryde

- Conservation measures taken (soil-landscape mapping, Griffin et al. 2002; South Lake Bryde Focus Catchment Group, Hamilton-Brown 1999; photogrammetric mapping/ digital elevation model, Kevron Aerial Surveys 2000; surface water management study, Farmer et al. 2002; wetland vegetation monitoring, Ogden and Froend 1998, Franke et al. 2001; Thorny Lignum Interim Recovery Plan, Phillimore et al., 2003; Register of the National Estate, Raines 1995)
- Hydrological features (depth to groundwater, Cale et al. 2004)
- Notable fauna (Threatened species, waterbird diversity and abundance, Cale et al. 2004)
- Physical features (catchment area, Kevron Aerial Surveys 2000)
- Notable flora (addition of understorey species and extra Melaleucas identified by Ecoscape et al. 2001)
- Disturbances or threats (recent wetland vegetation monitoring results, Franke et al. 2001)

WA096 Lake Gregory System

- Notable fauna (addition of Grant Pearson's July 2004 waterbird counts, CALM unpublished data)
- Other fauna (minor change, Halse, Shiel and Williams, 1998)
- Hydrological features (minor change to salinities at Lake Mulan, Halse, Shiel and Williams, 1998)
- Conservation measures taken (identified as a refugia for biological diversity in arid Australia, Morton et al. 1995; declaration of the IPA, DEH 2005)

- Land tenure (Paruku IPA, subject to the Tjurabalan native title claim, Van Osterzee et al. 2001)
- Social and Cultural Features (Cultural values, info about Paruku traditional owners and native title claim, Van Osterzee et al. 2001)
- Management authority and jurisdiction (revision, Van Osterzee et al. 2001)
- Current land use (limited tourism, Van Osterzee et al. 2001)

WA055 Lake Grace System

- Hydrological features (Lake Altham, depth to groundwater, Cale et al. 2004)
- Notable fauna (Lake Altham, waterbird diversity in 1998/2000, Cale et al. 2004)
- Notable flora (section revised, added Gurner et al. 2000)
- Social and Cultural features (minor addition to research, State Salinity Strategy)

WA064 Prince Regent River System

- Notable flora (new species of tropical triggerplant, Lowrie and Kenneally 1996)
- Other fauna (addition of threatened species, G. Graham, pers. comm.; addition of other native mammals, G. Graham, pers. comm..)
- Conservation measures taken (indigenous management plan, Wunambal-Gaambera Aboriginal Corporation 2000)
- Land tenure (native title claim, Wunambal-Gaambera Aboriginal Corporation 2000)

WA063 Mitchell River System

- Conservation measures taken (indigenous management plan, Wunambal-Gaambera Aboriginal Corporation 2000, declaration of the Mitchell River NP in 2000)
- Other fauna (Threatened fauna – Golden Bandicoot along tributaries, G. Graham, pers. comm.).
- Land tenure (native title claim, Wunambal-Gaambera Aboriginal Corporation 2000)

WA013 Windjana Gorge

- Social and cultural values (Social value, importance of Windjana Gorge Devonian reef fish fossils, Long 2000)
- Conservation measures taken (identified as a Refugia for Biological Diversity, Morton et al. 1995)

WA041 Lake Dora (Rudall River) System

- Other fauna (addition of aquatic invertebrate data, CALM unpublished data)

WA037 Murchison River (Lower Reaches)

- Notable flora (addition of DRF *Stachystemon nematophorus*)

- Conservation measures taken (identified as a Refugia for Biological Diversity, Morton et al. 1995)
- Disturbances or Threats (current – feral pigs and goats, uncontrolled vehicle access, at the request of Kelly Gillen, CALM Midwest DM).
- Land tenure (addition of townsite reserve info)
- Management authority and jurisdiction (addition of Shire of Northampton reserves)

WA019 Thundelarra Lignum Swamp

- Significance (outstanding ornithological importance, Raines et al. 1995)
- Conservation measures taken (nominated for listing on the Register of the National Estate, Raines et al. 1995)
- Disturbance or threats (large passage about soil erosion and siltation added, D. Blood, pers. comm..)

WA015 Rowles Lagoon System

- Conservation measures taken (management plan for the conservation park and nature reserve, key management issues, section 16A agreement proposal and purchase of Canegrass Lagoon, declaration of an 'Environmentally Sensitive Area', CALM 2000; 2015 pastoral lease excision details).
- Notable fauna (10,000 coots in May 1996, potential numbers following a major inundation event, CALM, 2000)
- Notable flora (significant revision of the fringing veg description, CALM 2000)
- Hydrological features (estimate of catchment area – 85,000 ha, CALM 2000; removal of comment that the lagoon may be near permanent)
- Physical features (significant revision, CALM 2000)
- Current land use (recreational facilities provided at Rowles Lagoon, CALM 2000)
- Disturbances or threats (present – signs of excessive grazing, potential – weed invasion)

WA062 Drysdale River

- Significance (add information about the Ramsar criterion that the site meets – endemic fishes, Jaensch and Watkins, 1999).
- Notable fauna (added number of birds listed under international treaties, 3, Woinarski and Start 1997; presence of Gouldian Finch, G. Graham, CALM, pers. comm..)
- Other fauna (added distribution of endemic fishes, Jaensch and Watkins, 1999; Threatened fauna – Salt water crocs below Solea Falls, G. Graham, CALM, pers. comm..).
- Other fauna (added Woinarski and Start reference only)
- Disturbances or threats (added changed fire regimes and feral animals at the request of G. Graham, CALM)
- Conservation measures taken (addition of Donkey culling at the request of G. Graham, CALM).

WA054 Lake Cronin

- Management authority and jurisdiction (Mallee Aboriginal Corp native title claim – finalised and dismissed)
- Hydrological features (info on the summer rather than winter filling of the lake, supplied by Greg Durell, Narrogin CALM DM)
- Other fauna (changes to the name and status of the Lake Cronin snake, Keogh et al., 2000 and Western Australian Museum, 2003).
- Social and cultural values (exploration along the green stone belt is still occurring…, info on current mining in catchment from Greg Durell, Narrogin CALM DM)
- Current land use (nickel mining added)
- Current and potential threats (WANL nickel mining added)

WA053 Pools of the Durba Hills

- Hydrological features (addition of 2004 water chem. Results, CALM, unpublished data)
- Other fauna (addition of preliminary aquatic invertebrate id's, CALM, unpublished data; comments on the most numerically abundant aquatic invertbrates, A. Clarke, CALM, pers. comm..)
- Notable flora (considerable revision – use of B. Muir's vegetation descriptions, CALM unpublished data)

WA033 Windich Springs

- Land tenure (removal of reserve 5280 – on advice from Graham Hoare, CALM Information Management Branch, 2005)
- Management authority and jurisdiction (changes to reflect current status)

WA110 Wagga Wagga Salt Lake

- Disturbances or threats (changes in plant cover and composition resulting from grazing, D. Blood, CALM, pers. comm..)

WA032 Lake Carnegie System

- Current or potential threats (cattle, camels, rabbits, altered fire regimes and weed invasion added)

ALL SITES

All sites have had changes made to the management authority and jurisdiction section to reflect changes in Agency structures and legislation since the last edition of the Directory was published. Since these updates were completed in 2005, the Department of Conservation and Land Management (CALM) has been renamed the Department of Environment and Conservation (DEC), however the reports for the above sites (and all WA sites within the Directory, and WA's Ramsar site documentation) still refer CALM.

Rectification of this will need to occur in a consistent manner across all WA Directory and Ramsar sites listed within the Australian Wetlands Database.

3.2 REFERENCES USED TO UPDATE EXISTING DIRECTORY SITE DESCRIPTIONS

Anon (2003). Australia's largest protected area declared in WA. *Australian Farm Journal BUSH, April 2003,* 14-15.

Arakel, A.V. and Moulton, T. (1986). Hydrochemistry of surficial brines in Hutt Lagoon, Western Australia. *Palaeogeography, Paleoclimatology, Palaeoecology*, 54:261-282.

Beard, J.S. (2002). Palaeogeography and drainage evolution in the Gibson and Great Victoria Deserts, Western Australia. *Journal of the Royal Society of Western Australia* 85:17-29.

CALM. (2000). Rowles Lagoon Conservation Park and Clear and Muddy Lakes Nature Reserve management plan 2000 – 2010. Department of Conservation and Land Management for the National Parks and Nature Conservation Agency, Perth.

Cale, D.J., Halse, S.A. and Walker, C.D. (2004). Wetland monitoring in the Wheatbelt of south-west Western Australia: site descriptions, waterbird, aquatic invertebrate and groundwater data. *Conservation Science Western Australia* 5(1):20-135.

Clarke, A.C., Muir, B., Elscot, S. and Lane, J. (2004). Banded Stilt breeding attempt at Lake Disappointment. *The Stilt* 46:39.

Dell, J. (2003). Lake Gladstone, an important Kimberley bird habitat: with notes on birds recorded during the W.A. Naturalist's club excursion on 12 July 2003. *The Western Australian Naturalist* 24(2):89-100.

DEH. (2005). Paruku – Indigenous protected area. Department of Environment and Heritage, Canberra. www.deh.gov.au/indigenous/ipa/declared/paruku.html

Ecoscape (Australia) Pty Ltd, Land Assessment Pty Ltd. (2001). Vegetation survey of reserves in the Lake Bryde recovery catchment: prepared for the Western Australian Department of Conservation and Land Management, Perth.

Environment Australia (1998). Conservation Guidelines for the Management of Wild River Values. Environment Australia, Canberra.

Farmer, D., Stanton, D. and Coles, N.A. (2002). Lake Bryde recovery catchment: surface water assessment and recommendations. Prepared by the Engineering Water Management Group of the Department of Agriculture Western Australia for the Western Australian Department of Conservation and Land Management, Perth.

Franke, B., Gurner, R. and Froend, R. (2001). Wetland Vegetation Monitoring 2000/2001. Prepared for the Department of Conservation and Land Management by the Centre for Ecosystem Management, Edith Cowan University, Perth.

Fuller, P.J. and Burbidge, A.A. (2002). Birds of the South-western Little Sandy Desert. Pp. 85-99 in: Van Leeuwin, S. (Ed.) Biological survey of the south-western Little Sandy Desert: National Reserve System Project N706, final report, June 2002. Department of Conservation and Land Management, Perth.

Gurner, R., Froend, R.H. and Ogden, G. (1999). Salinity Action Plan Wetland Vegetation Monitoring 1998/99. Prepared for the Department of Conservation and Land Management by the Centre for Ecosystem Management, Edith Cowan University, Perth.

Griffin, T., Verboom, B., Schoknecht, N., Goulding, P. and Cacetta, P. (2002). Lake Bryde recovery catchment soil-landscape mapping. A report prepared for the Western Australian Department of Conservation and Land Management, Perth by the Natural Resource Management Branch of the Department of Agriculture, Western Australia.

Gurner, R. Froend, R. Ogden, G. and Franke, B. (2000). Wetland Vegetation Monitoring 1999/2000 (Salinity Action Plan). Western Australian Department of Conservation and Land Management, Perth.

Halse, S.A., Shiel, R.J., and Williams, W.D. (1998). Aquatic invertebrates of Lake Gregory, northwestern Australia, in relation to salinity and ionic composition. *Hydrobiologia, 381*.

Hamilton-Brown, S. (1999). Lignum and samphire freshwater wetlands. *Landscope* 14(3):48.

Jaensch, R. and Watkins, D. (1999). Nomination of additional Ramsar wetlands in Western Australia. Report to the Department of Conservation and Land Management, Perth by Wetlands International – Oceania, Canberra.

Kabay, E.D. (2002). Salinity Action Plan: Wetland Vegetation Monitoring 2001/2002. Report prepared for the Western Australian Department of Conservation and Land Management, Perth.

Kendrick, P.G. (2002). The Herpetofauna of the South-western Little Sandy Desert. Pp. 65-84 in Van Leeuwin, S. (Ed.). Biological survey of the south-western Little Sandy Desert: National Reserve System Project N706, final report, June 2002. Department of Conservation and Land Management, Perth.

Keogh, J., Scott, I.A.W. and Scanlon, J.D. (2000). Molecular phylogeny of viviparous Australian elapid snakes: affinities of Echiopsis atriceps (Storr, 1980) and

Drysdalia coronata (Schlegel, 1873), with descriptions of a new genus. J. Zool. (Lond.) 252:317-326.

Kevron Aerial Surveys (2000). Consultancy: Contour mapping in the Lake Bryde/East Lake Bryde wetland chain. Report prepared for the Western Australian Department of Conservation and Land Management, Perth.

Long, J. (2000). Old Fossils: Windjana Gorge National Park. *Landscope* 16(1):28-34.

Lowrie, A. and Kenneally, K.F. (1996). Stylidium fimbriatum (Stylidiaceae), a new species of triggerplant from the Kimberley, Western Australia. *Nuytsia* 10(3):425-427.

Morton, S.R., Short, J. and Barker, R.D. (1995). Refugia for Biological Diversity in Arid and Semi-arid Australia. Biodiversity Unit, Department of the Environment, Sport and the Territories, Canberra. Biodiversity Series, Paper No. 4.

Ogden, G. and Froend, R.H. (1998). Salinity Action Plan: Wetland Vegetation Monitoring 1997/98. Report prepared for the Department of Conservation and Land Management, Perth, by the Centre for Ecosystem Management, Edith Cowan University, Perth.

Phillimore, R., Giraudo, M., and Brown, A. (2003). Remote Thorny Lignum (*Meuhelenbeckia horrida* subsp. *Abdita*) Interim Recovery Plan: 2003-2008. Western Australian Threatened Species and Communities Unit, Department of Conservation and Land Management, Woodvale.

Pinder, A.M. and Halse, S.A. (2002). Two new species of *Ainudrilus* (Clitellata: Tubificidae), with notes on *Ainudrilus nharna* Pinder and Brinkhurst. *Records of the Western Australian Museum*, 21:1-7.

Raines, J.A., Yung, F.H. and Burbidge, A.H. (1995). Wetlands of outstanding importance for the Register of the National Estate in south-west Western Australia. Report to the Australian Heritage Commission, June 1995.

Shire of Carnamah (2002). Lake Indoon Catchment Management Group Rehabilitation Project. Unpublished Natural Heritage Trust Final Project Report.

Start, A.N. (2002). Mammals of the South-western Little Sandy Desert. Pp. 100-114 in Van Leeuwin, S. (Ed.). Biological survey of the south-western Little Sandy Desert: National Reserve System Project N706, final report, June 2002. Department of Conservation and Land Management, Perth.

Thomas, R. and Clews, M. (2000). Common Ground. *Landscope* 15(4):10-16.

Trench, G. and Dugdale, A.L. (2002). Assessment of mineral potential of Gibson Desert nature Reserve (A34606): an update for EV 141. Geological Survey of Western Australia, Perth.

Van Leeuwin, S. (1997). Biological survey of the southern Little Sandy Desert: Project N706, final report December 1996. Department of Conservation and Land Management, Perth.

Van Oosterzee, P., Preece, N. and Bell, J. (2001). Paruku (Lake Gregory) Indigenous Protected Area Management Plan: A plan for the Tjurabalan mob to look after their country. Unpublished report prepared for the Kimberley Land Council on behalf of the Tjuabalan Traditional Owners of Paruku.

Webster, M. (Ed) (1997). List of Birds Sighted by the Busselton Naturalist's Club on a Canning Stock Route/Rudall River Trip in August 1997. Unpublished bird list compiled from sightings made by six members of the Busselton Naturalist's Club.

Western Australian Museum. 2003. FaunaBase [online] http://www.museum.wa.gov.au/faunabase/prod/index.htm. Accessed 22/8/2005.

Willing, T. and Kenneally, K. (2002). Under a regent moon. *Landscope* 17(4):48-53.

Woinarski, J. and Start, T. (1997). Comparison of fauna recorded at two sites in Drysdale River National Park, 1975 and 1997. Unpublished report of the Department of Conservation and Land Management, Perth.

Wunambal-Gaambera Aboriginal Corporation (2000). Land of Wandjina and Wungurr: Ngaunudu management plan, Wunambal people, Mitchell Plateau, north-west Australia. Wunambal-Gaambera Aboriginal Corporation and the Kimberley Land Council, Broome.

Personal Communications and other citations

D. Blood, Senior Operations Officer (Pastoral), Western Australian Department of Conservation and Land Management, Geraldton.

A. Chant, Nature Conservation Officer, Western Australian Department of Conservation and Land Management, Geraldton.

A. Clarke, Senior Technical Officer, Western Australian Department of Conservation and Land Management, Wildlife Research Centre, Woodvale.

G. Graham, Regional Leader Nature Conservation, Western Australian Department of Conservation and Land Management, Kununurra.

CALM, unpublished data