

Information Sheet on Ramsar Wetlands (RIS)

Categories approved by Recommendation 4.7, as amended by Resolution VIII.13 of the Conference of the Contracting Parties.

1. Name and address of the compiler of this form:

Compiled by the Western Australian Department of Conservation & Land Management (DCLM) in 1990 and updated by Roger Jaensch, Wetlands International - Oceania, on behalf of DCLM in 1998, and by DCLM staff in 2000 and 2003.

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Designation date

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Site Reference Number

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2. Date this sheet was completed/updated:

November 2003

3. Country:

Australia

4. Name of the Ramsar site:

Peel – Yalgorup System, Western Australia

5. Map of site included:

Refer to Annex III of the *Explanatory Note and Guidelines*, for detailed guidance on provision of suitable maps.

a) **hard copy** (required for inclusion of site in the Ramsar List): *yes*

b) **digital (electronic) format** (optional): *yes*

6. Geographical coordinates (latitude/longitude):

Latitude: 32° 32' S to 33° 06' S

Longitude: 115° 37' E to 115° 47' E

7. General location:

Peel-Yalgorup System is in the City of Mandurah and the Shires of Murray, Waroona and Harvey (local authorities) in the State of Western Australia (population ca. 1.95 million in 2003). It is immediately south of the City of Mandurah (population ca. 50,000 in 2003).

The Ramsar Site as originally nominated in February 1990 comprised: Peel Inlet (south of the old Mandurah Estuary Bridge) and Harvey Estuary; Nature Reserves (4990, 24036, 28087 and 2707) adjoining the eastern and southern sides of Peel Inlet; Nature Reserves (2738, 24739, 23756 and 36126) adjoining the eastern and southern sides of Harvey Estuary; most of Lake McLarty (Nature Reserve 39404, which is contiguous with 24739); Lake Mealup (partly in Nature Reserve 6627 and partly freehold owned by the Lake Mealup Preservation Society); and the waters (principally Lakes Clifton, Preston, Boundary, Pollard, Martins Tank, Yalgorup, Hayward and Newnham) and lands of Yalgorup National Park.

The Site was extended in 2001 to include seven additional areas, most of which were recent additions to the conservation reserve system (see maps):

- Extension 1: an addition to Nature Reserve 4990 which includes brackish-saline marsh and shrub-swamp connected by a drain to Peel Inlet at Robert Bay;
- Extension 2: the Nature Reserve 44978 which comprises the western margins and southern part of Lake McLarty;

- Extension 3: an addition to Reserve 11710 (part of Yalgorup National Park) which is dryland that widens the buffer zone for part of the eastern side of Lake Preston;
- Extension 4: an addition to Reserve 11710 (part of Yalgorup National Park) which includes some of the north-western shore of Lake Clifton and also dryland that widens the buffer zone for the north-western side of Lake Clifton;
- Extension 5: the south-eastern part of Reserve 12189 (also part of Yalgorup National Park) which widens the buffer zone for part of the north-eastern side of Lake Clifton;
- Extension 6: Erskine Conservation Park (Nature Reserve 43690), which has two parts and includes shore and associated marshes on the north-western side of Peel Inlet near “The Chimneys”.
- Extension 7: an area of salt marsh north of Creery Island ceded to the Crown (and subsequently to be made a conservation reserve) by Cedar Woods Properties Limited as part of the Mariners Cove Development at Mandurah.

Of these components, Extensions 1, 2, 6 and 7 include substantial areas of wetland. The others include shoreline at the edge of the Ramsar Site as originally nominated and/or dryland that provides a buffer zone for the wetlands.

8. Elevation: (average and/or max. & min.)
Approximately at sea level

9. Area: (in hectares)
26 530 ha

10. Overview:

A large system of shallow estuary and saline, brackish and freshwater lakes. Many tens of thousands of waterbirds, including large numbers of migrant shorebirds from the northern hemisphere, use the estuary and lakes each year. There is also a particularly unusual occurrence of thrombolites, a primitive life form superficially resembling stromatolites.

11. Ramsar Criteria:

Circle or underline each Criterion applied to the designation of the Ramsar site. See Annex II of the *Explanatory Notes and Guidelines* for the Criteria and guidelines for their application (adopted by Resolution VII.11).

The Criteria under which Peel – Yalgorup System was originally nominated as a Ramsar Site were:

- 1a (It is a particularly good example of a specific type of wetland, characteristic of its region).
- 2d (It is of special value for its endemic plant or animal species or communities).
- 3a (It regularly supports 20,000 waterfowl).
- 3c (Where data on populations are available, it regularly supports 1% of the individuals in a population of one species or a subspecies of waterfowl).

Since that time, the Criteria have been further developed and re-numbered by Ramsar Conferences of Contracting Parties. The Criteria now applicable to the Site are:

- 1 (It contains a representative, rare or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region).
 - 3 (It supports populations of a plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region).
 - 5 (It regularly supports 20,000 or more waterbirds).
 - 6 (It regularly supports 1% of the individuals in a population of one species or subspecies of waterbird).
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12. Justification for the application of each Criterion listed in 11. above:

Provide justification for each Criterion in turn, clearly identifying to which Criterion the justification applies (see Annex II for guidance on acceptable forms of justification).

- 1: The Site includes the largest and most diverse estuarine complex in South-Western Australia and also particularly good examples of coastal saline lakes and freshwater marshes.

- 3: The Site is one of only two locations in south-western Australia and one of very few in the world where living thrombolites (a type of microbialite, superficially similar in appearance to stromatolites) occur in hyposaline water.
- 5: The Site comprises the most important area for waterbirds in south-western Australia, supporting in excess of 20,000 waterbirds annually, with greater than 150,000 individuals recorded at one time (February 1977).
- 6: The Site regularly supports 1% of the population of at least six shorebirds: Red-necked Avocet *Recurvirostra novaehollandiae*, Red-necked Stint *Calidris ruficollis*, Red-capped Plover *Charadrius ruficapillus*, Banded Stilt *Cladorhynchus leucocephalus*, Caspian Tern *Sterna caspia* and Fairy Tern *Sterna nereis*.

13. Biogeography (required when Criteria 1 and/or 3 and /or certain applications of Criterion 2 are applied to the designation):

Name the relevant biogeographic region that includes the Ramsar site, and identify the biogeographic regionalisation system that has been applied.

a) biogeographic region:

Swan Coastal Plain

b) biogeographic regionalisation scheme (include reference citation):

Interim Biogeographic Regionalisation for Australia (IBRA) Version 5.1 (Cummings and Hardy 2000)

14. Physical features of the site:

Peel Inlet and Harvey Estuary form a shallow estuarine system connected to the sea via a narrow, natural channel at the northern end of Peel Inlet, and a man-made channel (the Dawesville Channel) at the northern end of Harvey Estuary that was opened in 1994. The Murray and Serpentine Rivers drain into the north-eastern corner of the Inlet; the Harvey River enters the Estuary at its southern end. Several major drains from agricultural land empty into the eastern side of the Estuary and Inlet.

A large proportion of Peel Inlet and the southern end of Harvey Estuary contains water less than 0.5 m deep; the maximum depth of water is only about 2 metres. Salinity varies according to season and location in the system but, in general terms, varies from 10 ppt in winter to 45 ppt TDS in summer. Tidal flushing in summer is not great enough to prevent evaporation making the water more concentrated than seawater. The opening of the Dawesville Channel in 1994 increased the tidal range in both estuaries (from a maximum spring tide range of about 12.3% to 48% of the ocean tide for Peel Inlet and from 11.6% to 55% of the ocean tide for Harvey Estuary) resulting in increased tidal flushing and rapid re-establishment of marine salinities after winter rains (D.A. Lord & Assoc. 1998). The intertidal area is now greater than prior to the opening of the Dawesville Channel.

The Yalgorup lakes vary from about 1-4 metres in depth and are saline (although they are principally supplied by fresh groundwater and precipitation) because of long-term concentration of salt by evaporation; they never overflow. The hydrology of the Yalgorup lakes is extremely interesting: several types of salinity regime occur in lakes with similar physiognomy that are supplied by the same underground aquifer. Lake Clifton has extensive areas of groundwater seepage, which result in pronounced horizontal salinity gradients; away from the shoreline the salinity varied from about 8 to 32 ppt during the 1980s however, salinity measurements from the late 1990s ranged from 25 to 49 ppt (Knott et al. In press). Large quantities of calcium carbonate precipitate out of seepage water as it enters Lake Clifton and Lake Pollard. Lake Hayward reaches about 200 ppt TDS in summer but is remarkable for exhibiting vertical stratification of salinity in winter when it is only about 2 metres deep. Surface water contains about 70 ppt, while bottom water contains 180 ppt. This results in an inverse thermal stratification with water at the

bottom of the lake reaching 35°C and, because of prolific growth of cyanophyta, reaching 2 000% oxygen saturation at times.

Median and mean annual rainfall at Mandurah are 879 mm and 885 mm respectively, mostly falling in May-August. Annual evaporation is c. 1900 mm.

15. Physical features of the catchment area:

Describe the surface area, general geology and geomorphological features, general soil types, general land use, and climate (including climate type).

The Site is situated in the Perth Basin, on the Swan Coastal Plain. Peel Inlet and Harvey Estuary are separated from Lakes McLarty and Mealup and the Yalgorup Lakes by vegetated sand ridges 1-5 km wide and up to 60 m high. The catchment of Peel Inlet and Harvey Estuary is 11 300 km², which is mostly cleared.

16. Hydrological values:

None recognised.

17. Wetland Types

a) presence:

Circle or underline the applicable codes for the wetland types of the Ramsar "Classification System for Wetland Type" present in the Ramsar site. Descriptions of each wetland type code are provided in Annex I of the *Explanatory Notes & Guidelines*.

Marine/coastal: A • B • C • D • E • F • G • H • I • J • K •
Zk(a)

Inland: L • M • N • O • P • Q • R • Sp • Ss • Tp Ts • U •
Va •
Vt • W • Xf • Xp • Y • Zg • Zk(b)

Human-made: 1 • 2 • 3 • 4 • 5 • 6 • 7 • 8 • 9 • Zk(c)

b) dominance:

List the wetland types identified in a) above in order of their dominance (by area) in the Ramsar site, starting with the wetland type with the largest area.

F, Q, O, Ts, G, H, W, Xf, Tp.

18. General ecological features:

Provide further description, as appropriate, of the main habitats, vegetation types, plant and animal communities present in the Ramsar site.

Parts of Peel Inlet and Harvey Estuary and some of the lakes in the Yalgorup chain are fringed by samphire flats. Behind the samphire, or sometimes adjacent to the water where samphire is absent, rushes and sedges occur. Beyond this is a zone of trees which are tolerant of seasonal water-logging while the higher ground away from the lake supports open forest. Large parts of the shoreline throughout the Peel-Yalgorup system have been cleared, mostly for agriculture, thus altering or eliminating the tree zones.

Samphire vegetation around Peel Inlet and Harvey Estuary is dominated by *Halosarcia halocnemoides* and *H. indica* (dominant on the more saline high marsh) and *Suaeda australis* and *S. quinqueflora* (dominant on the intertidal marsh). The dominant species of sedges are *Bolboschoenus caldwellii*, and *Juncus kruassii* (McComb et al. 1995). The water's edge is fringed by low trees of *Melaleuca raphiophylla* and *M. hamulosa* around the eastern side of the Inlet or *M. cuticularis* and *M. raphiophylla* along the Estuary. *Melaleuca* is sometimes replaced by *Acacia saligna* and *Eucalyptus rudis* farther from the water. As the ground begins to rise the vegetation changes to open forest dominated by *Eucalyptus gomphocephala* and *Agonis flexuosa* on the western side of the system or *E. marginata* and *E. calophylla* on the eastern side. *Halophila ovalis* is the dominant seagrass in both

estuaries, present in the deeper bays, while significant stands of *Ruppia megacarpa* occur in Austin Bay, and *Heterozoster tasmanica* is present in the Dawesville Channel and the Sticks Channel (D.A. Lord & Assoc. 1998).

The vegetation around the Yalgorup lakes is virtually the same as occurs around Peel Inlet and Harvey Estuary. Around hypersaline lakes there is a narrow belt of samphire, behind which clumps of *Juncus kraussii* and *Gabnia trifida* occur. Hyposaline lakes lack samphire but have a dense belt of *Melaleuca cuticularis* and *M. rhapsiophylla* in the case of hyposaline lakes; samphire and rushes are replaced by *M. cuticularis* and *Acacia cyclops* in the case of hypersaline ones. The surrounding woodland is dominated by *Eucalyptus gomphocephala* and *Agonis flexuosa*.

A total of 86 species of waterbirds have been recorded in Peel Inlet and Harvey Estuary, including five darters and cormorants, 12 herons and allies, 12 ducks and allies, five rails, 35 shorebirds and nine gulls and terns; 35 species are listed under the Japan – Australia Migratory Bird Agreement (JAMBA) and the China – Australia Migratory Bird Agreement (CAMBA) and are specially protected by the Commonwealth Environment Protection and Biodiversity Conservation Act (1999). Peel Inlet and Harvey Estuary support very large numbers of waterbirds, regularly in excess of 20 000 individuals (see item 20). It was conservatively estimated that 12 000-15 000 ducks and swans used the area each year between 1981-85; to a maximum of 36 000 in 1976-77. Particularly abundant species of duck are:

Black Swan	<i>Cygnus atratus</i>	8 060 1976-77
Australian Shelduck	<i>Tadorna tadornoides</i>	5 650 Dec 1984
Pacific Black Duck	<i>Anas superciliosus</i>	3 000 Feb 1982
Grey Teal	<i>A. gracilis</i>	25 070 1976-77
Australasian Shoveler	<i>A. rhynchotis</i>	500 Feb 1982
Blue-billed Duck	<i>Oxyura australis</i>	1 200 Jul 1983
Musk Duck	<i>Biziura lobata</i>	490 1976-77
Pink-eared Duck	<i>Malacorhynchus membranaceus</i>	440 1976-77

Highest numbers of many species in south-western Australia have been recorded in the Peel Inlet and Harvey Estuary system, including the Little Egret *Egretta garzetta* and Royal Spoonbill *Platalea regia*, which are uncommon in the region. Species recorded in large numbers include:

Hoary-headed Grebe	<i>Poliiocephalus poliocephalus</i>	10 340 1976-77
Little Pied Cormorant	<i>Phalacrocorax melanoleucos</i>	4 650 1976-77
Pied Cormorant	<i>Phalacrocorax varius</i>	4 290 1976-77
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>	4 790 1976-77
Australian Pelican	<i>Pelecanus conspicillatus</i>	2 100 1976-77
White-faced Heron	<i>Egretta novaehollandiae</i>	470 1976-77
Eurasian Coot	<i>Fulica atra</i>	17 040 1976-77
Black-winged Stilt	<i>Himantopus himantopus</i>	2 460 1976-77
Banded Stilt	<i>Cladorhynchus leucocephalus</i>	63 000 1976-77
Red-necked Avocet	<i>Recurvirostra novaehollandiae</i>	2 440 Dec 1996
Bar-tailed Godwit	<i>Limosa lapponica</i>	430 1976-77
Common Greenshank	<i>Tringa nebularia</i>	390 1976-77
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>	2 120 Jan 1983
Red-necked Stint	<i>C. ruficollis</i>	16 440 Dec 1998
Curlew Sandpiper	<i>C. ferruginea</i>	6 260 1976-77
Red Knot	<i>C. canutus</i>	1 360 1976-77
Caspian Tern	<i>Sterna caspia</i>	300 1998-99
Fairy Tern	<i>Sterna nereis</i>	260 1998-99

Peel Inlet – Harvey Estuary waterbird count data are from Royal Australasian Ornithologists Union (now Birds Australia) and Western Australian Department of Conservation and Land

Management ground/aerial surveys 1981-91; Jaensch et al. 1988; Storr and Johnstone 1988; Lane and Pearson 2002; Lane et al 2002a, 2002b.

Many waterbird species also occur in the Yalgorup lakes, including large numbers of ducks, swans and waders. Over 2 200 Musk Duck *Biziura lobata* were counted in Lake Clifton in March 1986; the Yalgorup lakes are the most important drought refuge for this species in WA. The system is a major moulting area for Australian Shelduck *Tadorna tadornoides*; over 11 000 were recorded at Lake Clifton in November 1986, while 8 000 – 9 400 Australian Shelduck were observed at Lake McLarty in October 1997, many of which were moulting and flightless (Craig 1997; Kirkby 1998). Over 190 Great Crested Grebe *Podiceps cristatus*, an uncommon species, were observed at Lake Clifton in March 1988, and 28 were recorded at Lake McLarty in January 1983.

A total of 72 species of waterbirds have been recorded at Lake McLarty, including 36 species of waders (Burbidge and Craig 1996; Craig et al. 2001). Waders recorded in significant numbers between 1990-2000 include:

Marsh Sandpiper	<i>Tringa stagnatilis</i>	142
Common Greenshank	<i>T. nebularia</i>	204
Wood Sandpiper	<i>T. glareola</i>	112
Red-necked Stint	<i>Calidris ruficollis</i>	11 500
Sharp-tailed Sandpiper	<i>C. acuminata</i>	4 144
Curlew Sandpiper	<i>C. ferruginea</i>	3 000
Black-winged Stilt	<i>Himantopus himantopus</i>	2 439
Banded Stilt	<i>Cladorhynchus leucocephalus</i>	1 000
Red-necked Avocet	<i>Recurvirostra novaebollandiae</i>	5 468
Red-capped Plover	<i>Charadrius ruficapillus</i>	1 500
Black-fronted Dotterel	<i>C. melanops</i>	100
Red-kneed Dotterel	<i>Erythrogonys cinctus</i>	90

Areas added to the Site in 2001 enhance the conservation values of the Site through the inclusion of important shorebird feeding habitat (Extensions 1, 6 and 7), inclusion of the remainder of Lake McLarty (which is used consistently by large numbers of waterbirds including migratory shorebirds), and provision/widening of protected buffer zones for the Site's wetlands.

Peel Inlet and Harvey Estuary contain at least 55 species of fish, including the commercially important Cobbler *Gnidoglanis macrocephalus*, Tailor *Pomatomus saltatrix*, Mulloway *Argyrosomus hololepidotus*, Whiting species and Mullet species. Commercially important crustaceans include Blue Manna Crabs *Portunus pelagicus*, Western King Prawn *Penaeus latisulcatus* and Greasy-back Prawns *Metapeneas dalli*. The area supports the largest professional and amateur estuarine fishery in Western Australia.

More than 20 taxa of benthic invertebrates have been recorded in Peel Inlet and Harvey Estuary, and the natural outlet channel of Peel Inlet supports 50 Foraminiferans. At least 60 invertebrate taxa occur within the samphires, including 12 Dipterans, 17 Crustaceans and 8 Arachnids (McComb et al. 1995).

Twenty taxa of aquatic metazoans have been identified living in association with the thrombolites (see item 19) of Lake Clifton. The most numerous fauna are crustaceans (predominantly amphipods and isopods) and polychaetes, less common fauna include foraminiferans, ostracods, nematodes and possibly four new species of harpacticoid copepod (Konishi et al. 2001).

19. Noteworthy flora:

Lake Clifton is one of only two sites known in the world where living "stromatolite-like" microbialite structures (thrombolites) occur in hyposaline water. They are organosedimentary structures formed by calcium carbonate precipitating out of freshwater seepage and being incorporated in the mucilage secreted by the cyanophyta growing on the bottom of the lake.

The substantial samphire areas at Peel Inlet and Harvey Estuary are significant because much of this community type has been lost from other estuaries in the bioregion. In addition, the samphire *Halosarcia indica* subspecies *leiostachya* is unique to the Creery Wetlands (D.A. Lord & Assoc. 1998). At least one sedge species (*Schoenus natans*) that is of conservation concern (“Priority 4”) at State level is also found at the Site.

20. Noteworthy fauna:

Provide additional information on particular species and why they are noteworthy (expanding as necessary on information provided in 12. Justification for the application of the Criteria) indicating, e.g., which species/communities are unique, rare, endangered or biogeographically important, etc., including count data. *Do not include here taxonomic lists of species present – these may be supplied as supplementary information to the RIS.*

In terms of total numbers, Peel Inlet and Harvey Estuary comprise the most important area for waterbirds in south-western Australia, regularly supporting in excess of 20 000 waterbirds: over 150 000 were recorded in February 1977 (Lane and Pearson 2002), 51 000 were recorded in December 1996, and 42 000 were recorded in December 1998 (Lane et al. 2002a, 2002b). Total numbers of waterbirds using Peel-Harvey Estuary during 1976-77, 1996-97 and 1998-99 were at least 176 000, 61 000 and 45 000 respectively (Lane and Pearson 2002; Land et al. 2002a, 2002b).

Peel Inlet and Harvey Estuary support more than 1% of the population (Watkins 1993, Rose and Scott 1997) of at least six waterbird species (Lane et al. 2002a, 2002b):

Red-necked Avocet	<i>Recurvirostra novaehollandiae</i>	2 443 Dec 1996
Red-necked Stint	<i>Calidris ruficollis</i>	16 436 Dec 1998
Red-capped Plover	<i>Charadrius ruficapillus</i>	1 754 Dec 1998
Banded Stilt	<i>Cladorhynchus leucocephalus</i>	6 954 Feb 1997
Caspian Tern	<i>Sterna caspia</i>	298 Feb 1999
Fairy Tern	<i>Sterna nereis</i>	262 Feb 1997

Lake McLarty also regularly supports more than 20 000 waterbirds, with counts by Birds Australia of 39 250 in December 2002 and 31 250 in January 2003. Other counts in excess of 20 000 individuals include 26 690 in February 1996, 34 104 in February 1997 and 30 177 in January 1998 (Craig et al. 2001). Five species occurred in internationally significant numbers between 1990 – 2000 (more than 1% of the flyway population, or more than 1% of the national population in the case of resident species; Craig et al. 2001):

Red-necked Stint	<i>C. ruficollis</i>	11 500
Sharp-tailed Sandpiper	<i>C. acuminata</i>	4 144
Curlew Sandpiper	<i>C. ferruginea</i>	3 000
Red-necked Avocet	<i>R. novaehollandiae</i>	5 470
Red-capped Plover	<i>C. ruficapillus</i>	1 500

More than 15 000 Red-necked Stint *C. ruficollis* were observed at Lake Preston in December 1999 (which is more than 3% of the population of this species – Rose and Scott 1997; Russell 2000). The very large numbers of Stint and other waders at this time may have been due in part to very high water levels at Lake McLarty and Harvey Estuary restricting the availability of suitable habitat (Russell 2000).

Over 18 000 Banded Stilt *C. leucocephalus* were counted on the Yalgorup Lakes during February 2003 (Davis 2003; which is nearly 6% of the population of this species, Wetlands International 2002).

21. Social and cultural values:

The major social values of Peel Inlet and Harvey Estuary are fishing, both commercial and recreational, and other aquatic activities. The estuary system supports the largest professional and amateur estuarine fishery in Western Australia, producing an annual catch of 600-900 tonnes worth more than \$1 million (D.A. Lord & Assoc. 1998). The majority of recreational fishers

(more than 80%) target blue swimmer crabs *Portunus pelagicus*, and the recreational catch of crabs exceeds that taken by professional fishers (Malseed and Sumner 2001).

There are several important Aboriginal heritage sites around Peel Inlet and Harvey Estuary which are protected by the Western Australian Aboriginal Heritage Act (1972) including campsites at the Serpentine River mouth and Island Point, and a ceremonial site at Egg Island (O'Connor et al. 1989).

22. Land tenure/ownership:

(a) within the Ramsar site: See item 13. The Nature Reserves and National Park are all vested in the Conservation Commission of Western Australia. The purpose of most of the Nature Reserves is "Conservation of Flora and Fauna": an exception is Reserve 43690 which is "Conservation Park". The purpose of the Reserves that comprise Yalgorup National Park is "National Park".

(b) in the surrounding area: Surrounding areas are mostly freehold (privately owned) land or Unallocated Crown Land and there are some other local/State government reserves.

23. Current land (including water) use:

(a) within the Ramsar site: Peel Inlet and Harvey Estuary are used extensively for public recreation, especially fishing, and commercial fishing also occurs. The Yalgorup lakes are in a National Park and are used only for passive recreation associated with their natural values. The remaining areas are used for nature conservation.

(b) in the surroundings/catchment: The town of Mandurah is on the northern edge of the Inlet and there are several housing developments along the shores of the Inlet and the north-western part of the Estuary. The area to the east is used principally for cattle farming and there are many farmlets and holiday homes on the western side of the Estuary. Much of the land surrounding the Yalgorup lakes has been cleared for cattle farming and an area on the north-eastern shore of Lake Clifton has been sub-divided for housing.

24. Factors (past, present or potential) adversely affecting the site's ecological character, including changes in land (including water) use and development projects:

(a) within the Ramsar site: A major management problem formerly existed in Peel Inlet and Harvey Estuary. Large amounts of phosphate leached from surrounding agricultural land into the estuarine system caused the system to become eutrophic, causing massive production of benthic and planktonic algae (mainly *Cladophora*, *Nodularia* and *Ulva* spp.), which resulted in a variety of biological problems. There was intensive investigation into ways of managing the system and the Peel Inlet Management Authority has been implementing a management plan produced in 1982.

One of the management tools used extensively since the late 1970s has been direct harvesting of macroalgae from the shallows and beaches at a number of sites within the system, using front-end loaders and other heavy machinery. A recent study suggests that the disturbance caused by harvesting is temporary (in the order of days to weeks), and in the long-term may mimic the natural flushing of beaches, preventing the detrimental effects of algal accumulation and producing faunal assemblages not unlike those found at beaches without algal accumulations (Lavery et al. 1999).

To alleviate problems caused by eutrophication, the Dawesville Channel, an artificial channel connecting Harvey Estuary to the sea, was opened in April 1994. This was intended to improve water circulation and reduce algae problems in the estuary. Since the opening, tidal flushing of both estuaries (particularly Harvey) has increased, resulting in marine salinities for much of the year. Water quality has improved, particularly in Harvey Estuary where periods of stratification and deoxygenation have become shorter and less frequent. No *Nodularia* blooms have occurred since the opening, phytoplankton biomass has decreased and turbidity has improved (decreased)

in spring. In contrast to pre-channel years, water quality in both estuaries is now very similar (Wilson, Hale and Paling 1997). The more stable salinity regime and improved water quality have increased the diversity of aquatic flora and fauna, particularly those requiring marine salinities, and the estuary is now more like a sheltered marine embayment. Macroalgal biomass has declined, while seagrass distribution and productivity have increased in Peel Inlet and the northern Harvey Estuary; in the southern Harvey Estuary macroalgae still predominate (Wilson, Latchford and Paling 1997). A significant decline in tree health along the lower Harvey River and the death of fringing vegetation along western shore of Harvey Estuary is thought to be a result of changes to the salinity and tidal regime, however the fringing vegetation along the eastern side of the estuary has not been similarly affected (the reason for this is unclear) (Monks and Gibson 2000, Gibson 2001). The vegetation of the important freshwater wetlands adjoining Austin Bay, which includes the rare sedge *Schoenus natans* (see item 19), has also not been affected (Monks and Gibson 2000). Further changes in the fringing vegetation of the lower Harvey River and Harvey Estuary can be expected (Monks and Gibson 2000). Waterbird numbers and diversity have remained very high (though not as high as 1976-77) and post-Dawesville, the system is still one of the most important habitats for waterbirds in Western Australia, continuing to meet the two waterbird criteria for which it was nominated to the Ramsar list in 1990 (Lane et al. 2002a, 2002b; see item 20). Waterbird distribution has remained similar, with the greatest number of birds occurring in south-eastern Peel Inlet (Austin and Robert Bays), the southern end of Harvey Estuary and north-central Peel Inlet (Lane et al. 2002a, 2002b). One successful Pelican breeding site, Nirimba Cay, was lost through inundation, however numbers appear to be maintained by breeding on Boundary Island (although increased human disturbance may impact this colony) (Lane et al. 1997). Numbers of the main commercial fish species appear unchanged or have increased in abundance and more marine species are now present. Prawns and crabs now recruit to Harvey Estuary earlier, and stay longer, however, commercial catches of Western King Prawns are lower as large numbers emigrate through the channel where strong currents prevent the use of commercial fishing gear. An unexpected consequence of the channel has been an increase in toxic phytoplankton blooms (cyanophytes and dinoflagellates) in the lower reaches of the Murray and Serpentine Rivers. This may be due to increased nutrient loading, however stratification resulting from increased tidal exchange has led to anoxic conditions in the lower reaches of the river which allow the release of sediment phosphorus. It is likely that conditions favourable to phytoplankton blooms may now occur regularly in both rivers. The channel has also resulted in increased numbers of mosquitos (particularly *Aedes vigilax* – a vector of Ross River Virus), despite a large increase in aerial larvicide use (D.A. Lord & Assoc. 1998). Monitoring of the impacts of the channel is ongoing.

In 1987, the thrombolite reef at Lake Clifton was found to be partially covered by the alga *Cladophora vagabonda* which has the potential to hinder the thrombolite forming processes. Extraction of groundwater and interference with seepage near new small-rural holdings, and increased nutrient input (from agricultural fertilisers) could change conditions that favour the growth of the thrombolites (Rosen 1996; Shams 1999). Research on the impact of vegetated buffer zones on nutrient inflow into Lake Clifton suggests that existing buffer zones, particularly those classified as small (less than 50 m wide) are inadequate to limit nutrient inputs to the lake (Davies and Lane 1996).

The Tuart *Eucalyptus gomphocephala* forest in the Yalgorup National Park has suffered a severe insect attack that has caused serious crown deterioration and tree mortality since 1997 (Bradshaw 2000). The primary agent of the attack is the Tuart Borer *Phoracantha impavida*, although the Bullseye Borer *Phoracantha acanthocera* is also present. The exact stimulus of the insect outbreak is not known as present, although there are several theories including lowered water table and long periods without fire. There is concern because there is an apparent lack of natural regeneration of Tuart within the Park. A number of recommendations have been made to enhance the natural regeneration of the Tuart forests in the areas (Bradshaw 2000).

(b) in the surrounding area: Urban (housing, including canal estate) development has continued to expand in the immediate vicinity of the Site. Canal development could potentially impact on water quality through the disturbance of acid sulphate soils and damage to fringing vegetation if not appropriately managed. The already substantial urban population adjacent to many parts of the Ramsar Site is expected to increase markedly. The resulting increase in recreational use of the estuary may lead to greater disturbance of waterbirds and damage to habitat. Increased population in the surrounding area will also increase exposure to mosquito borne diseases including Ross River Virus, which in turn may increase public demand for mosquito control, particularly the use of chemical insecticides (which may impact on waterbirds) and habitat modification (e.g. runnelling and draining of samphire flats). Similarly, urban development around the Yalgorup lakes should be approached cautiously, especially in the case of Lake Clifton where it may interfere with the groundwater seepages producing the thrombolites. Furthermore, intensive human activity on the shore of Lake Clifton would result in severe damage to these comparatively delicate structures.

25. Conservation measures taken:

There is a series of Nature Reserves around Harvey Estuary and Peel Inlet (2990, 23756, 24739, 2738, 2707, 2436, 4990, 28087) and there is a Shire reserve where the Murray River enters Peel Inlet. Yalgorup lakes are all within Yalgorup National Park. Since the Site was originally nominated, several new Nature Reserves on or near the edge of Peel Inlet and Harvey Estuary have been declared (44978, 11710, 12189, 43690) and Yalgorup National Park has been extended (some of this is now included in the Site following extensions to the Site in 2001). A management plan exists for Yalgorup National Park (CALM 1995). The conservation value of the “Creery Marshes” (salt marsh immediately north of Creery Island) has been recognised, and the area was ceded to the Crown and reserved in 2002. This area was included in the extensions to the Site made in 2001.

Maintenance of environmental quality (particularly water quality), appropriate land use and development within the catchment of Peel Inlet and Harvey Estuary is regulated by the Western Australian Environmental Protection Authority’s statutory Draft Environmental Protection (Peel-Harvey) Policy (1999). A management plan was prepared for Peel Inlet and Harvey Estuary in 1982, and a new management strategy for the system was endorsed by the Minister for the Environment in 1989 (EPA 2003). The Peel-Harvey Catchment Council has been established to facilitate integrated catchment management by bringing together government agencies and stakeholders in the area (EPA 2003).

The Coastal and Lakelands Planning Strategy provides land use planning guidelines for the catchment of the Yalgorup Lakes, with the protection of water quality and associated environmental values of the lakes as a primary objective (Western Australian Planning Commission 1999). The Western Australian Environmental Protection Authority has produced specific guidelines for development within the catchment of Lake Clifton to protect water quality and the hydrological balance of the lake (EPA 1997, 1998).

The Department of Conservation and Land Management listed the thrombolite reef at Lake Clifton as a critically endangered Threatened Ecological Community (TEC - “Stromatolite-like freshwater community of coastal brackish lakes”) in 2002. In 2002, the Department established a recovery team consisting of relevant stakeholders. The recovery team has produced and is implementing an interim recovery plan for the TEC.

26. Conservation measures proposed but not yet implemented:

A Water Quality Improvement Plan for the Peel –Harvey Estuary System is to be developed (EPA 2003).

Subject to consultation with stakeholders and, where necessary, resolution of land tenure, it may be possible to add other areas to the Ramsar Site in the future, for example the reserve, vested in

the Shire of Murray, which comprises the deltaic islands situated where the Murray River enters Peel Inlet.

27. Current scientific research and facilities:

Extensive research has been, and currently is being, conducted by State Government Agencies and universities on the management of Peel Inlet and Harvey Estuary, particularly monitoring of the impacts of the Dawesville Channel (D.A. Lord & Assoc. 1998), and nutrient inflows and accumulation within the system (Water and Rivers Commission 2000; McComb et al. 1998; Gerritse et al. 1998; Summers et al. 1999).

Research is also being conducted on the lakes of the Yalgorup system, where the University of Western Australia operates the Neville Stanley Research Station (Knott et al. In press, Konishi et al. 2001, Rosen et al. 1996, Shams 1999).

28. Current conservation education:

An education program is being developed by Department of Conservation and Land Management.

29. Current recreation and tourism:

Peel Inlet and Harvey Estuary are used extensively for recreational fishing and boating. There is limited use of Yalgorup National Park for passive recreation.

30. Jurisdiction:

Territorial: The State Government of Western Australia.

Functional: The Nature Reserves and Yalgorup National Park – The Conservation Commission (vesting) and the Western Australian Department of Conservation & Land Management (management on behalf of the Conservation Commission); The waters and shores of Peel-Harvey Estuary – Peel Inlet Management Authority.

31. Management authority:

The Swan Coastal District (based in Wanneroo and with an office also in the City of Mandurah) of the Swan Region, Western Australian Department of Conservation & Land Management, and the Mandurah office of the Department of Environment.

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