Chapter 2 Use of Wetlands for Wastewater Treatment

2.1 Use in Australia

About 40 constructed wetlands have been installed in Australia, mostly within the last ten years (refer to **Table 2.1: Inventory of Australian Wetlands**). The majority of existing wetlands are Free Water Surface (FWS) systems, ranging in size from 400 m^2 to 85 ha. Wetland configurations vary from single ponds or channels to multiple ponds up to 15 in number. A typical configuration has between 3 to 6 ponds.

Table 2.1 Inventory of Australian Wetlands

Operator	Treatment Plant	Type (see Note)	Size	Year Built	Disposal/Reuse
Queensland					
Cairns City Council	Edmonton	FWS Pilot	1 900 m^2 (3 ponds)	1994	Discharge to estuary
Hinchinbrook Shire	Ingham	FWS Pilot	7 600 m^2 (3 ponds)	1993	Discharge to river
Blackall Shire	Blackall	FWS Full	3 450 m^2 (4 ponds)	1993	Irrigate golf course
Townsville City Council	Mt St John	FWS Pilot	1 450 m^2 (4 ponds)	1993	Discharge to Town Common (wetland)
Livingstone Shire	Emu Park	FWS Pilot	600 m^2 (5 ponds)	1993	Irrigate to land
Goondiwindi Town	Goondiwindi	FWS Full	2 150 m^2 (4 ponds)	1994	Pasture irrigation
Brisbane City Council	Oxley Creek	SSF Pilot	420 m^2 (4 beds)	1995	Ground soakage
Noosa Shire	Cooroy	FWS Full	25 000 m^2 (4 ponds)	1995	Discharge to creek
Ipswich City Council	Rosewood	FWS/SSF Full	4 000 m^2 (4 ponds)	1995	Irrigate golf course & discharge to creek
Winton Shire Council	Winton	FWS Full	7 000 m^2 (4 ponds)	1997	Irrigate to park
Tambo Shire Council	Tambo	FWS Full	5 400 m^2 (3 ponds)	1996	Irrigate to oval
Woodford Correctional Centre	Correctional Centre	FWS Full	3 ponds	1996	Discharge to river
Roma Town Council	Roma	FWS Full	11 000 m^2 (1 channel)	1999	Irrigate to lucerne
Bowen Shire Council	Bowen	FWS Pilot	1 600 m^3 (2 ponds)	1995	Irrigate to park
Caloundra City Council	Landsborough	FWS Full	5 300 m^2 (7 ponds)	1998	Discharge to sea
Logan City Council	Queens Road	FWS Pilot	21 m^2 (3 cells)	1996	Return to treatment plant
New South Wales					
Albury City Council	Albury	FWS Full	850 000 m^2 (7 ponds)	1997	Used for storage.
Byron Bay Shire Council	West Byron Bay	FWS Full	100 000 m^2 approx	1992	Discharge to creek
Byron Bay Shire Council	Ocean Shores	FWS Full	6 000 m^2 approx	1995	Discharge to river
Hunter Water Corporation	Paxton	FWS Full	3 000 m^3 (6 cells)	1991	Discharge to creek

Continued next page.

Operator	Treatment Plant	Type (see Note)	Size	Year Built	Disposal/Reuse
Hunter Water Corporation	Minmi	FWS & SSF Full	2 500 m^3 (6 cells)	1989	Discharge to natural wetland
Hunter Water Corporation	Cessnock	FWS Full	500 m long (1 pond)		Discharge to creek
Hunter Water Corporation	Kearsley	FWS Full	20 000 m^3 (2 ponds)	1990	Discharge to creek
Casino Shire Council	Casino	FWS Full	22 000 m^2 (2 ponds)	1990	Discharge to river
Lismore City Council	South Lismore	FWS Full	130 000 m^2 (5 cells)	1998	Discharge to creek & irrigate tea tree plantation
Blayney Shire Council	Blayney	FWS Pilot	30 000 m^2 (5 ponds)	1993	Discharge to river
Moree Plains Shire Council	Mungindi	FWS Full	7 000 m^2 (4 ponds)	1997	Reuse by irrigation
Hawkesbury City Council	McGraths Hill	FWS Full	60 000 m^2 (15 ponds)	1997	Irrigate to lucerne and woodlots.
Sydney Water	Rouse Hill	FWS Full	50 000 m^2	1994	Discharge to creek
Crookwell Shire Council	Crookwell	FWS Full	9 390 m^2 (6 ponds)	1996	Discharge to river
Victoria					
Yarra Valley Water	Upper Yarra	FWS Full	30 000 m^2 (6 ponds)	1998	Discharge to river
East Gippsland Water	Bairnsdale	SSF Full	120 000 m^2 (3 ponds)	1999	Discharge to Macleod Morass (wetland)
Portland Coast RWB	Portland	SSF Full	60 000 m^2 (12 ponds)	1999	Discharge to ocean
Central Highlands Water	Maryborough	FWS Pilot	1 600 m^3 (3 cells)	1996	Discharge to creek
Tasmania					
George Town Council	George Town	SSF Full	1 000 m^2 (6 cells)	1993	Discharge to river
West Tamar Council	Beaconsfield	SSF Full	3 300 m^2 (1 pond)	1993	Discharge to creek
Derwent Valley Council	New Norfolk	FWS Full	Approx 10 000 m^2	1994	Discharge to river
Western Australia					
Water Corporation	Pemberton	FWS Full		1994	Irrigate to oval in summer. Overflow discharge to river in winter.
Water Corporation	Mundaring	FWS Full	2 500 m^2 (1 pond)	1996	Infiltration through soakage trench.
Water Corporation	Busselton	FWS Full	85 000 m^2 (1 pond)	2000	Irrigate to golf course. Overflow discharge to drain.

Note: FWS = Free Water Surface Wetland
SSF = Sub Surface Flow Wetland
Pilot = Wetland used for monitoring of treatment performance
Full = Wetland commissioned and used for wastewater treatment.

The main treatment uses of constructed wetlands include:

- effluent polishing by the reduction of biochemical oxygen demand and suspended solids
- nutrient removal, particularly nitrogen
- algal removal, particularly from pre-treatment processes such as oxidation and maturation lagoons.

Constructed wetlands offer other beneficial uses which may be achieved in association with the treatment functions of the wetland. These additional uses include:

- reuse of the wetland effluent as irrigation water
- production of vegetation for commercial use, eg Lemna for stock feed
- creation of a bird and wildlife habitat
- establishment of an educational or research facility, and
- creation of an aesthetic feature within public open space.

Irrigation reuse is practiced at about 30% of Australian constructed wetlands. This commonly involves the irrigation of open space (golf courses, ovals and parks), lucerne and woodlots.

Constructed wetland technology originated in Europe over 40 years ago. More than 500 wetlands are operational in Europe and the majority are sub-surface flow systems. This trend has evolved because wetlands have been added to wastewater facilities that provide only basic levels of primary or secondary treatment. Because of the potential for creating nuisance conditions in wetlands that receive poor quality wastewater, the European design preference has been to use sub-surface flow through soil or sand planted with common reed.

In North America, more than 200 constructed wetlands are operational. Most are FWS systems.

2.2 Queensland Pilot Trials

Background

In 1992, the Queensland Government established an Artificial Wetlands for Water Pollution Control Research Program with funding from the then National Landcare Program. The basis of the research was to provide information on design suitability and management options for constructed wetlands in Queensland. One of the driving forces for this program was that most of the wetlands that had been installed up to that point were in cold and temperate climates, and little experience was available in tropical and arid environments.

Between October 1992 and July 1995, ten pilot wetlands were constructed as State Government joint projects. Nine FWS wetlands were designed and built to treat secondary effluent from treatment plants. One wetland was constructed as a Sub-Surface Flow (SSF) system to treat all the domestic household effluent from one house.

The FWS wetlands were constructed in Mossman, Edmonton near Cairns, Ingham, Logan, Townsville, Mackay, Blackall, Emu Park and Goondiwindi with the majority of information coming from the Mossman, Edmonton, Ingham, Logan, Townsville, Mackay and Blackall systems.

Appendix A contains a report summarising the pilot wetland program.

Objectives

In summary, the main aims of the program included generating information that would enable design of wetlands to satisfy the following treatment objectives:

- effluent polishing, in terms of BOD and SS removal or reduction
- nutrient reduction, in terms of nitrogen and phosphorus
- disinfection, in terms of faecal coliforms or *Ecoli*
- sediment removal; and
- algal removal, particularly from upstream processes such as oxidation ponds or maturation lagoons.

The above objectives are in the interest of complying with discharge standards, preserving water quality, enabling reuse, maintaining public health standards and ecological sustainability.

Data Generated from the Pilot Program

Data sets of varying extent and quality were generated through the pilot program. The data gathered generally included flowrate, temperature, pH, dissolved oxygen, BOD, COD, SS, ammonia, total nitrogen, nitrate, nitrite, filterable reactive phosphorus, total phosphorus and indicator bacteria counts.

The main conclusions to be drawn from the analysis of the data include:

- Given that there is significant water loss through the wetland systems, the best indicator of performance is removal on a mass basis rather than on a concentration basis.

- Wetlands can consistently achieve an effluent standard of 20 mg/L BOD and 30 mg/L SS on an 85th percentile basis provided that macrophyte establishment is achieved. It should also be noted that during an initial period of operation, the BOD and SS levels could be substantially above these levels.
- Where the influent BOD and SS concentrations are very good and less than 5 to 10 mg/L, some degradation on a concentration basis can be expected. This conclusion is often reported in the literature.
- Where the influent nitrogen to wetlands is predominantly nitrate and low dissolved oxygen concentrations are maintained, very efficient nitrogen removal can be achieved.
- Where the influent nitrogen is predominantly ammonia and with concentrations of 5 to 10 mg/L, the effluent ammonia may follow or lag behind the influent with limited removal on a mass basis. This conclusion is drawn from limited information.
- Where the influent ammonia is greater than 10 mg/L, the effluent ammonia profile generally follows the influent profile with some reduction in ammonia concentration. This conclusion is drawn from limited information.
- COD is not seen as a good design variable or indicator of performance as the percentage of the influent COD that is soluble and non-biodegradable is often high in effluent from other processes. Hence removal performance will inherently be low and often the degradation products from wetland treatment may increase the COD of the effluent.
- Removal of phosphorus from influent with FRP in the range of 3 to 8 mg/L can be expected in the early period of wetland operation, as the macrophytes become established. After establishment, poor removal performance, if any, can be expected.
- There were no on-going problems with mosquitoes associated with the pilot wetlands.
- Firm conclusions regarding disinfection can not be easily drawn from consideration of the available faecal coliform and faecal streptococci data. One conclusion drawn from a particular site was that, if the detention time is increased, the removal performance on a concentration basis improves. Under most circumstances at least a one log removal can be expected.
- Wetlands operated and designed with significant dark cover from emergent or floating macrophytes can be expected to operate at a low dissolved oxygen concentration. Therefore under most circumstances, supplementary aeration may be required if a positive effluent dissolved oxygen concentration is required.
- The pilot study has shown that a wide variety of Australian native macrophytes are suitable to be used in constructed wetlands.
- The ability of FWS wetlands to treat municipal sewage to high standards should not be overstated. The pilot studies have demonstrated that constructed wetlands have an application, but they are unable to produce an effluent similar to that produced by an advanced treatment technology.

Comparison of Constructed Wetland Performance

A significant amount of treatment performance data for wetland systems is available in the North American Wetland Treatment System Database or NADB (Knight, 1994). Data has been compiled on 120 FWS wetlands throughout the United States and Canada and includes both natural and constructed systems. The median percentage removal for the NADB listed FWS wetlands is provided in **Table 2.2: NADB Treatment Performance Summary**.

The median values of percentage removal estimated for the Queensland pilot wetlands (refer Appendix A) are also shown in Table 2.2. Direct comparisons between the NADB and Queensland pilot data cannot be fully made due to incompatibility between wetland types, loading rates, influent concentration and other factors.

Some general trends are present including a similarity of removal performance between NADB and Queensland pilot wetlands for BOD and SS. Queensland median removal of ammonia and total nitrogen tend to be higher than NADB values, but are lower for filterable reactive phosphorus and total phosphorus.

The range of percentage removal values for the Queensland pilot wetland data is also given in Table 2.2. This highlights the erratic performance of constructed FWS wetlands, demonstrating a capability for moderate to high removal rates but also periods of poor performance.

Performance data for FWS constructed wetlands treating domestic wastewater is also available for five pilot systems installed at Richmond, near Sydney (Sakadevan et al, 1995). Each wetland was identical in size (30 m x 5 m) and planted with three macrophyte species. A range of influent loading conditions was used to test treatment performance. On a mass basis, the total nitrogen removal varied from 57 to 94% and the total phosphorus removal varied from 35 to 62%. The upper limits of the measured nutrient removal are consistent with values from the Queensland pilot wetland data (refer Table 2.2).

Table 2.2: NADB Treatment Performance Summary

Parameter	NADB Median Removal (%)	Queensland Pilot Wetlands	
		Median Removal (%)	Removal Range (%)
BOD	71	64	-9 to 79
SS	68	60	11 to 90
Ammonia	38	72	-36 to 100
Total Nitrogen	55	77	26 to 97
Filterable Reactive Phosphorus	41	28	-38 to 61
Total Phosphorus	34	25	-38 to 62

Note: Percentage removal values are mass based for FWS wetlands.