DPI

QUEENSLAND
DEPARTMENT OF
PRIMARY INDUSTRIES

WATER
RESOURCES

INTERIM GUIDELINES ON THE PLANNING, DESIGN AND MANAGEMENT OF ARTIFICIAL WETLANDS *IN QUEENSLAND*

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INTERIM GUIDELINES ON THE PLANNING, DESIGN AND MANAGEMENT OF ARTIFICIAL WETLANDS

1.00 SCOPE:

This publication is a revision of interim guidelines first released in August 1994. It is in a condensed form and the intention is to provide assistance to those contemplating wetland technology as a means of polishing municipal effluent, at the planning and design stages, or those with existing wetlands seeking guidance on operational and management aspects.

The content of these guidelines has largely been based on the experiences and information obtained to date on the Artificial Wetlands for Water Pollution Control Research Program in Queensland.

The main thrust of these guidelines is centred around open-surface flow wetlands since 8 of the 10 research projects are based on this mode of operation. The remaining projects are dual surface and sub-surface flow systems. For a list and summary information on these research projects refer to **Appendix 1.** This list includes two non municipal effluent wetlands more recently established in North Queensland.

It is intended that final guidelines are produced on the completion of the artificial wetlands research program, projected for late 1996.

2.0 PLANNING, TREATMENT OBJECTIVES AND SITE INVESTIGATIONS:

2.1 CONCEPTUAL PLANNING

It is imperative that the proposed site is designated or zoned for sewage treatment purposes, under the Local Government town planning regulations. Other treatment options should have been investigated and the benefits, problems and economics of all the options evaluated. Wetlands are generally a viable and cost effective option but like any natural system they can have their limitations and the performance can be variable. It should be recognised that the main performance limitation is the consistent removal of phosphorus.

It is most important that the treatment and project objectives are clearly established early in the planning stage and prior to the site investigation stage. These are discussed in **Section 2.2.**

Wetlands can be located in low lying areas that one would normally associate with the presence of natural wetlands. The wetland system should be surrounded by a suitable buffer area and some allowance should be made for future expansion.

2.2 TREATMENT AND PROJECT OBJECTIVES

Treatment objectives adopted in Queensland to date include:

(1) effluent polishing, in terms of biochemical oxygen demand (BOD) and suspended solids (SS) removal or reduction;

(2) nutrient reduction, in terms of total Nitrogen (Total N) and total Phosphorous (Total P);

(3) disinfection, in terms of faecal coliforms or E.coli die-off;

(4) sediment removal, in terms of the particulate content and the association with nutrients; and

(5) algal removal, particularly from pretreatment unit processes as oxidation and maturation lagoons.

The above treatment objectives are in the interests of complying with discharge standards, preserving water quality, resource reuse and maintaining public health standards.

There are likely to be additional objectives to be met concurrently with the treatment objectives. These are project objectives and they may be based around beneficial uses such as:

- reuse of the wetland effluent for vegetation and pasture irrigation;
- 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 a parkland.

2.3 SITE INVESTIGATIONS

Aspects that should be considered in site investigations include the following:

- groundwater levels;
- soil profiles, including their suitability for construction, retaining liquid and as a wetland substrate;
- existing and projected sewage flows and quality of pretreated sewage, if appropriate;
- aquatic plant species prevailing in the area;
- surface drainage patterns and flood levels;
- possible wetland configurations;
- effluent standards; and
- final effluent usage.

3.0 WETLAND DESIGN:

Unless the treatment and project objectives are clearly thought out and understood it will not be possible to develop an appropriate design for the wetland system. Hence, the design objectives generally evolve from the determination of the treatment and project objectives.

3.1 DESIGN OBJECTIVES

A primary design objective may well be to aim for a wetland system which fulfils all the project and treatment objectives at minimal capital and management costs.

Associated design objectives could be:

- to ensure the system is flexible, in terms of the mode of operation, flows and water levels;
- to ensure the operation and maintenance is simple but effective;
- to ensure there is a contingency plan to cater for a gross overload or extreme climatic event; and
- to consider the system can be readily monitored and flows can be recorded, in the interests of performance evaluation.

3.2 DESIGN CONSIDERATIONS

The following aspects should be considered in the preliminary and final design of a wetland system:

- land availability confirmation and town planning consent;
- quality of influent;
- wetland type and configuration;
- aquatic plant (macrophyte) species in the area;
- surface drainage control;
- hydraulic, organic and solids loading rates;
- soil types and permeability;
- existing and projected populations;
- mosquito control measures, including native fishes habitats;
- final effluent quality and proposed usage;
- construction costs; and
- management requirements, as the control of excess aquatic plant growth and noxious weed eradication.

3.3 DESIGN CRITERIA

The principal process design criteria for open-surface flow wetlands are detention time, water depth, organic loading rate, solids loading and aspect ratio. The wetlands research program in Queensland is expected to produce more comprehensive data for the selection of planning, design and management criteria. This information is not expected to be available until late 1996. In the meantime, based on the limited design and operating experience to date, the following design criteria is considered appropriate to surface flow wetlands in Queensland conditions:

- ❑ detention time - in North Queensland, 5 to 7 days for BOD and SS reduction.

  - other areas, 7 to 10 days for BOD and SS reduction and 18 days for nutrient reduction with no guarantee on P reduction. The longer detention times are likely to be more conducive to effective disinfection and nutrient reduction.

Note: *These detentions times could be viewed as being somewhat conservative. Times as low as 3 days have resulted in good standards of treatment, in surface flow and sub-surface wetlands in Queensland. What is needed is a further 12 months of monitoring.*

- ❑ water depths - 350 to a maximum of 500mm.

- ❑ water level control - there must be provision for the adjustment of water levels to cater for high flows, rainfall events and sample collection.

- ❑ loading unit rate - is a method for sizing wetlands for preliminary designs only. For polishing purposes, 5 to 6 m2 per equivalent population (EP) for North Queensland and 6 to 9 m2 per EP for other areas. (the lower figures are related to higher all year and day/night temperatures)

- ❑ aspect ratios - 3:1 (length:width) as a minimum. There does not appear to be any point in exceeding 20:1 unless a long narrow trench system is being considered.

- ❑ configurations - to avoid the problem of short-circuiting trench or U-shaped systems have been favoured. This is not always the most economic use of available land. Rectangular wetlands have performed satisfactorily if multiple inlet and outlets have been installed, to minimise short-circuiting.

- ❑ batter slopes - steeper batters are to be avoided since they do not create a suitable environment for establishing most macrophytes. Maximum slope 2:1, depending on the soil characteristics. More gently slopes do, however, encourage mosquito breeding. Ensure that macrophyte growth is controlled to encourage the migration and movement of fishes and other predators.

- ❑ substrate - allow at least a depth of 100 mm of organic soil for establishing aquatic plants.

- ❑ construction material - the base and embankments constructed from impermeable clays.

- ❑ wetland orientation - to aid system management, eg. in the direction of prevailing winds for harvesting floating plants by drawoff.

- ❑ free-board - allow a minimum of least 300 mm or greater in the case of areas effected by monsoon events.

- ❑ selection of plant species - a very important design aspect. More guidance is given in **Section 4.1** on wetland planting and commissioning.

In the interim, the above suggested design criteria could be checked against the formulae suggested for detention times, BOD removal and SS removal, as reported by Crites (1992), Reed *et al* (1988), and Manual of Practice (1990). Some allowance should be made for the climatic differences between the North American and other overseas experiences and Queensland. The warmer conditions in many parts of Queensland definitely enhances the growth of macrophytes and it is suspected that this is related to increased treatment performance rates.

Other design aspects include the importance of flow and level control, constructing cells/trenches in parallel for operational flexibility, allowing adequate distance between cells for access and maintenance, locating systems above flood influence levels and clear of groundwater, and considering localised surface drainage. It is very important that wetlands are fenced to prevent stock access. Cattle have been known to damage batters and graze on the macrophytes.

It is very important that the project objectives are addressed in both the design and management of the wetland.

4.0 WETLAND ESTABLISHMENT, OPERATION AND MANAGEMENT:

4.1 WETLAND PLANTING AND COMMISSIONING

It is imperative that wetland plants are selected from species that currently prevail in the particular area under study. While native species are to be preferred, the use of naturalised species is acceptable in Queensland. In general, the naturalised species, suitable for water bodies and wetlands, are widespread in Queensland and their use is therefore not likely to lead to further distribution. They are also likely to readily survive in an artificial or constructed wetland or water body environment.

In the absence of publications on aquatic plants in Queensland the Department of Environment and Heritage (Queensland Herbarium) has issued a list *"Plants Suitable for Use in Artificial Water Bodies and Wetlands in Queensland"*, (February 1995 revision). This is attached as **Appendix A.** Reference can also be made to Sainty and Jacobs (1994).

Professional advise should be sought on the suitability, availability and growth characteristics of aquatic plants, including their ability to oxygenate and remove nutrients. This expertise is being generated within the DPI, DEH (Queensland Herbarium) and various universities in Queensland.

Experience in Queensland has shown that rhizome transplanting has been successful. The root systems should be as complete as possible and the time between procurement and transplanting be as short as possible. It has been reported by Sainty and Jacobs (1994) that propagation from local seed and cuttings is best. Direct seeding with fertiliser has been tried on Horn Island (gold mine wetland) and planting cuttings has been trialed in the Burdekin (agricultural drainage wetland).

It is important that the natural habitat is studied by considering the soil type, frequency and depth of inundation, edge slopes, presence of aerobic/anaerobic conditions, soil/water pH, climatic characteristics, extent of the growing season, weed potential and tendencies for the area to dry out. In essence, blend the natural habitat conditions with the engineering design.

Planting in Queensland has taken place in saturated soil or in soil covered with a depth of water varying between 100 to 300 mm. Transplanting in clay or poor quality soil must be avoided. It has been suggested by Sainty and Jacobs (1994) that the soils should be tested for nutrient levels, pH and conductivity. During the initial planting phase particular care should be taken to ensure that emergent species are not starved of oxygen or drowned. Experience with wetland planting in Queensland has shown that the shallower margins (edges) of open surface wetlands are the more responsive zones for transplanting.

In the case of a trench configuration, it is felt that, should the edge zones become well established, the central zones will eventually do likewise. Often different species should be selected for the edge zones as compared with those selected for the central or deeper zones. This is due to the varying tolerances of species. For the purpose of specifying a density basis has been used. Typical edge zone densities may vary from 2 to 5 plants per m^2, depending on the species and the project budget. Typical centre zone densities are 1 to 2 plants per m^2.

4.2 WETLAND OPERATION

The treatment performance is improved when the contact between the effluent and the plants is maximised. It is important to maintain good circulation and even distribution. Stagnant areas are to be avoided. The literature has suggested a 75% coverage of the surface area by plants for optimum treatment efficiency.

Queensland experience has shown that dense planting, preferably the emergent type, at the inlet zones of wetlands is beneficial. The same applies to the outlet zone where a mix of emergent and floating species is suggested to act as a final filter. The system should also contain smaller clear water zones where the vegetation can be either controlled or absent.

Other operational aspects have been covered in **Section 4.4.**

4.3 MONITORING

Monitoring of wetlands can be time-consuming and expensive but it is an essential part of the establishment and on-going processes. It is very important that a monitoring program is linked to the design and project objectives, meaningful parameters are selected for measurement, the program is well designed with a statistical basis and the best use is made of the available resources and funding. Reference can be made to **Table 1** for guidance on monitoring parameters that are appropriate to the particular treatment and project objectives. This will help to ensure that:

(1) performance evaluations of the wetland system can be made;
(2) compliance with discharge licence standards and conditions can be determined; and
(3) whether desired effluent reuse and health standards are being achieved.

Guidance on sampling and monitoring is given in the proceedings of the *"Artificial Wetlands Workshop on Sampling, Monitoring and Management"*, 28 February - 1 March 1994. Copies are available from the DPI - Water Resources, GPO Box 2454, Brisbane 4001. (These proceedings also outline some of the wetland management experiences in Queensland over the past two years). At this wetland development stage in Queensland professional advice on monitoring should be sought.

Table 1 - Suggested On-Going Monitoring Parameters

TREATMENT OBJECTIVES	PARAMETERS[1]	FREQUENCY
Effluent Polishing	BOD, SS (COD optional)	*i* As per discharge licence *ii* Monthly
Nutrient reduction	Total N (TKN, Oxidised N, NH_4 -N) Total P (Filterable P optional)	*i* As per discharge licence *ii* monthly (minimum)
Disinfection	E.coli[2] (or faecal coliforms)	*i* As per discharge licence *ii* monthly (minimum)
PROJECT OBJECTIVES		
For example[3]: Irrigation by effluent reuse	Salinity, SAR	Quarterly or half-yearly

1 Measurement of inflow and outflow on sampling days is critical for performance assessment.
2 Quantify actual numbers of organisms.
3 This is in addition to the initial evaluation covered in the effluent reuse feasibility study.

Experience has shown that it is sound practice to periodically monitor the wetland vegetation. Nuisance species may have invaded the system or plant health problems may have developed. This should be undertaken by a trained Botanist.

4.4 MANAGEMENT

To date, experience in Queensland has shown that wetlands require varying degrees of maintenance. It is evident from some of the experimental projects that they may require substantial maintenance. Examples in North Queensland have shown that if the wetlands are left to their own devices they become overgrown and infested with nuisance weeds. It is felt that the wetland performance may be affected in the long term if the macrophytes are not actively managed. Vegetation maintenance mainly entails the removal of noxious or nuisance weed species, the control of excessive or rank growth, and harvesting of the floating species. Based on experience, this amounts to not more than 3-4 hours per person per week.

The need to harvest plants has been the subject of much debate over recent years. A study by Sharma, Griffith, NSW, indicated that only 12% of the nutrients are in the stems and leaves, the balance is in the rhizomes or roots.

Until such time as predators are established and the wetland becomes a balanced ecosystem, mosquitoes could be a problem. There are several species of native fishes that eat mosquito larvae. Advice on suitable fish species should be sought from the DPI-Land Use and Fisheries. Mosquito fish should not be introduced because of their known aggression towards native fishes and their doubtful ability to control mosquitoes.

Other routine management procedures include:

- water level control, particularly prior to and during heavy rainfall;
- maintenance of flow recording systems;
- bank and batter erosion control;

- ❑ bank vegetation control;
- ❑ maintaining wetland operational records; and
- ❑ wetland monitoring.

The need for regular upkeep of a wetland system is to be stressed.

Wetland treatment is gaining more recognition as a viable and economic method of effluent polishing. It is important that all the available knowledge base is utilised when planning, designing, commissioning and managing an artificial wetland system. These guidelines should be of some assistance in the interim. Further assistance can also be sought from the following Department of Primary Industries regional offices:

North Region	PO Box 1085 **TOWNSVILLE QLD 4810** Phone: (077) 78 2688 Fax: (077) 78 3634
South Region	PO Box 102 **TOOWOOMBA QLD 4350** Phone: (076) 31 4200 Fax (076) 34 7421
South East Region	PO Box 5165 **NAMBOUR QLD 4560** Phone: (074) 76 0277 Fax: (074) 76 0570
Central Region	PO Box 1834 **ROCKHAMPTON QLD 4700** Phone: (079) 31 9016 Fax (079) 31 9007
West Region	PO Box 519 **LONGREACH QLD 4730** Phone: (076) 58 4400 Fax: (076) 58 4433

REFERENCES

Crites, R W : Design Criteria and Practice for Constructed Wetlands, *Proc's International Specialist Conference, Wetland Systems in Water Pollution Control,* 30 November - 3 December 1992, Sydney.

Reed, S C, Middlebrooks, E J and Crites, R W, 1988 : *Natural Systems for Waste Management and Treatment*, McGraw-Hill Book Co.

Sainty, G R and Jacobs, S W L, 1994 : *Waterplants in Australia.* (A Field Guide) - third edition.

Manual of Practice FD-16, 1990 : *Natural Systems for Wastewater Treatment*, WPCF.

APPENDIX 1

SUMMARY INFORMATION OF ARTIFICIAL WETLAND RESEARCH PROJECTS - (MUNICIPAL WASTEWATER)

Project	Location/ Council and Contact	Construct. Date	Treatment Objectives	Wetland Type	Effluent Usage/ Discharge
1.	Mossman, Douglas Shire Peter Cymbala	Project delayed	* a, b, c	open-surface	Golf course irrigation
2.	Edmonton Mulgrave Shire Peter Robbins	April 1994	* a, b, c	open-surface	Estuarine inlet discharge
3.	Ingham, Hinchinbrook Shire Keith Phillips	February 1993	* a, b, c	open-surface	River discharge
4.	Mt St.John, Townsville Mark Langford	March 1993	* a,b,c,	open-surface	Town Common discharge
5.	Mt Bassett, Mackay Ian Angus	May 1994	* a, b, c	open-surface	Riparian zone discharge + estuary
6.	Yeppoon, Livingstone Shire Mike Paine	October 1994	* a, b, c	shallow melaleuca system	
7.	Emu Park, Livingstone Shire Mike Paine	January 1994	* a, b	open-surface	Land disposal + estuary discharge
8.	Blackall, Blackall Shire Laurie Doonar	February 1993	* a	open-surface	Golf course irrigation
9.	Wamuran, Caboolture Shire Frank Fornasier	October 1992	* d	dual gravel bed + surface	Ground soakage and plant irrigation
10.	Goondiwindi John McCormick	June 1994	* a, b	gravel bed + open-surface	Pasture irrigation

ADDITIONAL WETLAND PROJECTS (post 1993)

Project	Location	Construct.Date	Treatment Objectives	Wetland Type
A.	Horn Island, Torres Strait	January 1994	Improve Gold Mine leachate	Combined sub-surface and surface flow
B.	Burdekin Agricultural College, Ayr (LWRRDC project)	May 1994	Improve quality of Agricultural runoff waters * b, e	Riparian open-surface

* a denotes effluent polishing (BOD and SS removal)
b denotes nutrient reduction
c denotes disinfection
d denotes secondary standard of treatment
e denotes sediment removal.

Queensland Department of Environment

A selection of plants considered suitable for use in Artificial Wetlands used for the treatment of waste water in Queensland May 1997

Note: Not all of these species will be suitable for all areas of Queensland and professional advice should be sought as to their suitability for any particular area.

Scientific Name[A]	Common Name	Habit[B]
Acrostichum speciosum [2]	mangrove fern	shrub (fern)
Azolla spp. [1]	azolla	floating
Baeckea diosmifolia [2]	fringed baeckea	shrub
Baeckea stenophylla [2]	weeping baeckea	shrub
Banksia robur [2]	broad leaved banksia	shrub
Baumea articulata [2]	jointed twigrush	emergent (sedge)
Baumea rubiginosa [2]	soft twigrush	emergent (sedge)
Baumea teretifolia [2]		emergent (sedge
Blechnum camfieldii [2]		emergent (fern)
Blechnum indicum	swamp water fern	emergent (creeping fern)
Blyxa spp.		submerged
Bolboschoenus fluviatilis [2]		emergent (sedge)

Note: The weediness of a species may reflect the water quality in which it is growing. It is important to ascertain the likely weediness of any species in your local area or conditions before use. Both native and introduced species can act as weeds under certain circumstances.

A SCIENTIFIC NAME - KEY TO GROWTH STATUS

1. native species that may act as a weed under certain circumstances or from time to time
2. edge plant or plant for damp areas
3. introduced species - species that acts/may act as a weed under certain conditions
4. introduced/non-native species

B KEY TO HABIT

Floating
- a plant that is free floating and not attached to any substrate.

Submerged
- a plant that is attached to the substrate or free floating but whose leaves and stems are permanently submerged. It includes plants whose flowers may be emergent.

Emergent
- a plant that is attached to the substrate and whose leaves and stems either float on the surface or protrude above the surface. It includes plants that are periodically or seasonally as well as permanently inundated.

Herbaceous
- a plant consisting mainly of soft non-woody growth that may be growing in damp situations or in areas that are periodically or permanently inundated.

Shrub
- a plant with a woody shrubby habit of growth, often multistemmed, which grows in damp situations or where it is periodically or seasonally inundated.

Grass or Grass Like
- a plant that is a grass or grass like that grows in damp situations or areas that are periodically inundated.

Tree
- a plant with a woody habit of growth, usually (but not always) with one stem that grows in areas that are seasonally inundated.

Scientific Name[A]	Common Name	Habit[B]
Boronia falcifolia		shrub
Boronia parviflora	swamp boronia	shrub
Caldesia oligococca	caldesia	emergent
Callistemon pachyphyllus [2]	wallum bottlebrush	shrub
Callistemon viminalis [2]		tree
Carex fascicularis	tassel sedge	emergent (sedge)
Ceratophyllum demersum [1]	hornwort	submerged
Ceratopteris thalictroides	water fern	emergent
Chara spp.	a stonewort	submerged
Colocasia esculenta [3]	taro	emergent
Comesperma defoliatum [2]		shrub
Cyperus alopercuroides		emergent
Cyperus concinnus		emergent
Cyperus difformis [1]	rice sedge	emergent (sedge)
Cyperus exaltatus	tall flat sedge	herbaceous (sedge)
Cyperus haspan		herbaceous (sedge)
Cyperus lucidus		herbaceous (sedge)
Cyperus papyrus [4]	papyrus	emergent (sedge)
Cyperus pilosus		herbaceous (sedge)
Cyperus platystylis		emergent (sedge)
Cyperus polystachyos	bunchy sedge	emergent
Cyperus procerus [2]		herbaceous (sedge)
Cyperus trinervis [2]		herbaceous (sedge)
Cyperus unioloides		emergent (sedge)
Damasonium minus	starfruit	emergent
Diplachne fusca	brown beetle grass	grass
Echinochloa colona [3]	awnless barnyard grass	grass
Echinochloa crus-galli [3]	barnyard grass	grass
Echinochloa inundata	marsh millet	grass
Eclipta prostrate [1]	white eclipta	herbaceous
Egeria densa [4]	dense waterweed	submerged
Eleocharis cylindrostachys		herbaceous
Eleocharis dulcis		herbaceous
Eleocharis equisetina		herbaceous
Eleocharis ochrostachys		emergent
Eleocharis philippinensis		emergent
Eleocharis plana	ribbed spikerush	emergent
Eleocharis sphacelata	tall spikerush	herbaceous

Scientific Name[A]	Common Name	Habit[B]
Eleocharis spiralis		herbaceous
Eriocaulon scariosum		herbaceous
Eriocaulon setaceum	eriocaulon	submerged
Eucalyptus robusta [2]	swamp messmate	tree
Fimbristylis dichotoma	common fringerush	emergent
Fuirena ciliaris		herbaceous
Fuirena umbellata		herbaceous (emergent)
Gahnia sieberiana	red fruited sawsedge	shrub
Glochidion ferdinandii [1,2]	cheese tree	tree
Hibbertia salicifolia [2]		shrub (emergent)
Hibiscus diversifolius	swamp hibiscus	tree
Hibiscus tiliaceus [2]	cotton tree	tree
Hydrilla verticillata	hydrilla	submerged
Hymenachne acutigluma	native hymenachne	emergent
Ipomoea aquatica [1]		emergent
Isolepis inundata	swamp club rush	emergent (sedge)
Juncus aridicola	tussock rush	herbaceous (sedge)
Juncus continuus		herbaceous (sedge)
Juncus polyanthemos		herbaceous (sedge)
Juncus prismatocarpus	branching rush	herbaceous (sedge)
Juncus usitatus	common rush	herbaceous (sedge)
Juncus usitatus	common rush	emergent
Leersia hexandra	swamp ricegrass	emergent
Lemna spp. [1]	duckweeds	floating
Lepidosperma longitudinale	pithy sword sedge	emergent (sedge)
Lepironia articulata		emergent (sedge)
Leptocarpus tenax		herbaceous (sedge)
Leptospermum juniperinum [2]		shrub
Leptospermum liversidge [2]*i*		shrub
Leptospermum semibaccatum [2]		shrub
Limnophila indica		submerged
Lophostemon suaveolens [2]	swamp mahogany	tree
Ludwigia adscendens	white water primrose	emergent
Ludwigia octovalvis	willow primrose	herbaceous
Ludwigia peploides subsp. *montevidensis* [1]	water primrose	emergent
Marsilea drummondii		
Marsilea mutica	nardoo	emergent
Melaleuca alternifolia		shrub

Scientific Name[A]	Common Name	Habit[B]
Melaleuca leucadendra	paperbarked tea tree	tree
Melaleuca quinquenervia [1]	paperbarked tea tree	tree
Melastoma affine [2]	blue tongue	shrub
Monochoria cyanea	monochoria	emergent
Muehlenbeckia cunninghamii	lignum	shrub
Myriophyllum verrucosum [1]	red water milfoil	emergent
Najas tenuifolia	water nymph	submerged
Nelumbo nucifera	lotus	emergent
Nephrolepis biserrata		emergent
Nitella spp.	a stonewort	submerged
Nymphaea spp. (native species only)	water lilies	emergent
Nymphoides crenata	wavy marshwort	emergent
Nymphoides indica	water snowflake	emergent
Ottelia alismoides		submerged
Ottelia ovalifolia	swamp lily	emergent
Paspalum distichum [1]	water couch	grass
Paspalum scrobiculatum [1]	ditch millet	grass
Pennisetum alopecuroides [3]	swamp foxtail	grass
Persicaria attenuata	a smart weed	emergent
Persicaria barbata	a knot weed	emergent
Persicaria decipiens	slender knotweed	emergent
Persicaria hydropiper	water pepper	emergent
Persicaria lapathifolia	a smart weed	emergent
Persicaria orientalis	Prince's feather	emergent
Persicaria prostrate	creeping knotweed	emergent
Persicaria strigosa	a smart weed	emergent
Persicaria subsessilis	a smart weed	emergent
Philydrum lanuginosum [1]	frogsmouth	emergent
Phragmites australis [1]	common reed	grass
Phragmites kakka [1]		grass
Phyla nodiflora [1,2]	Condamine couch	
Potamogeton crispus [1]	curly pondweed	submerged
Potamogeton javanicus	pondweed	emergent
Potamogeton pectinatus [1]	sago pondweed	submerged
Potamogeton perfoliatus [1]	clasped pondweed	submerged
Potamogeton tricarinatus [1]	floating pondweed	emergent
Pseudoraphis spinescens	spiny mudgrass	grass
Pultenaea paleacea [2]		shrub

Scientific Name[A]	Common Name	Habit[B]
Ranunculus inundatus	river buttercup	emergent
Ricciocarpus natans	a liverwort	floating
Rorippa nasturtium-aquaticum [4]	water cress	emergent
Rumex brownii [1]	swamp dock	herbaceous
Sagittaria graminea [3]	sagittaria	emergent
Schoenoplectus litoralis		emergent (sedge)
Schoenoplectus mucronatus [1]		emergent (sedge)
Schoenoplectus validus		emergent (sedge)
Schoenus apogon [2]	fluke bogrush	herbaceous
Schoenus brevifolius		emergent
Scleria poiformis		emergent
Sphaerolobium vimineum		emergent
Spirodela spp. [1]	a duck weed	floating
Todea barbara	southern king fern	shrub (fern)
Triglochin procera	water ribbons	submerged
Triglochin striata	streaked arrow grass	emergent
Typha domingensis [1]		
Typha orientalis [1]	cumbungi	emergent
Utricularia aurea	a bladderwort	submerged
Utricularia gibba	yellow bladderwort	submerged
Utricularia stellaris	a bladderwort	submerged
Vallisneria gigantea	ribbon weed	submerged
Villarsia exaltata		emergent
Wolffia spp. [1]	a duckweed	floating