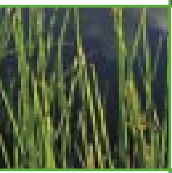
Constructed Wetland Systems

Design Guidelines for Developers

Version 3, November 2005

Victoria
The Place To Be

Melbourne Water



Constructed Wetland System
Design Guidelines for Developers

Contents

Acknowledgments

This document is a review of the document published in July 2003. This review has been undertaken to reflect the increasing knowledge and understanding of constructed wetland systems. The original document was produced in consultation with the Co-operative Research Centre (CRC) for Catchment Hydrology and the Association of Land Development Engineers (ALDE). Major contributions from Coomes Consulting Pty Ltd, WBM Oceanics Australia and Australian Ecosystems were gratefully accepted.

1. Introduction

Melbourne Water is committed to improving water quality in our waterways and receiving environments. An important part of this commitment is to reduce nitrogen loads to the Port Phillip Bay, and as identified in the Healthy Bay Initiative, Melbourne Water will contribute to the reduction target of 1000 tonnes (annual average load).

The current major sources of nitrogen entering the bay are from our waterways, stormwater drains and sewage treatment facilities. With increasing urban development within Melbourne, it is imperative that reductions from these existing loads are matched by reductions from new developments.

The State Environment Protection Policy (SEPP) for the Water's of Victoria sets out base statutory requirements for the quality of stormwater runoff. To assist in achieving these objectives the Best Practice Environmental Management Guidelines for Urban Stormwater describes the level of stormwater treatment necessary to comply with the SEPP requirements. The objectives from these guidelines are incorporated into this document.

A key treatment in stormwater management is constructed wetlands, which provide treatment for the removal of nitrogen, phosphorus, suspended solids and heavy metals from stormwater. The purpose of this document is to provide Melbourne Water's design requirements for the construction of wetland systems. It offers specific requirements for Melbourne Water systems in addition to those detailed design methods outlined in the technical manual "WSUD Engineering Procedures: Stormwater".

This document should be read in conjunction with:

- Melbourne Water's Land Development Manual http://ldm.melbournewater.com.au
- Urban Stormwater: Best Practice Environmental Management Guidelines 1999.
- WSUD Engineering Procedures: Stormwater. Technical Manual, MWC, 2005

2. Wetland Performance Objectives

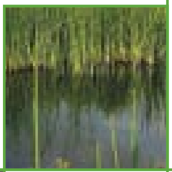
The aim of stormwater quality treatment is to reduce typical pollutant loads from urban areas to Best Management Practice (BMP) as defined in Table 1.

Table 1 Target pollutant reduction criteria for new development

Pollutant	Performance Objective
Suspended solids	80% reduction from typical urban load
Total phosphorus	45% reduction from typical urban load
Total nitrogen	45% reduction from typical urban load
Litter	70% reduction from typical urban load

Source: (Urban Stormwater: Best Practice Environmental Management Guidelines – Victorian Stormwater Committee, 1999)

It is important to understand that the above table describes the minimum requirement for treatment. The design of the wetland may be required to address other local environmental objectives requiring a higher level of performance or for removal of other contaminants. Any objectives above BMP will be identified in a Melbourne Water Drainage Strategy/Scheme, other appropriate reports or during feasibility discussion. The design intent (see Section 3.1) must capture wetland performance requirements.



3. Design Process

The design process has three distinct components: the Design Intent, Functional Design, and Detailed Design.

3.1 Design Intent

In addition to improving stormwater quality, constructed wetlands can also satisfy other urban design and conservation objectives. These additional aspects to the design should be documented in the Design Intent.

The Design Intent is a critical component that guides the design of the wetland. The Design Intent should describe the treatment performance required by the wetland, any local flora and fauna protection or enhancement objectives, landscaping objectives and recreational use objectives. The Design Intent should be created in consultation with all key stakeholders and be undertaken before the functional design. For drainage scheme wetlands, Melbourne Water will supply specific design criteria. The developer and Melbourne Water should then work together to prepare a Design Intent, which may capture broader recreational and landscaping objectives. For Melbourne Water instigated projects, a Design Intent will be supplied. A sample Design Intent may be found in Appendix 1.

3.2 Functional Design

A Functional Design must be prepared and approved prior to a detailed design. The Functional Design addresses the issues identified in the Design Intent and demonstrates an understanding of the wetland performance objectives and basic design principles. Appendix 2 provides the basis of a Functional Design with a Calculation Summary Checklist.

3.3 Detailed Design

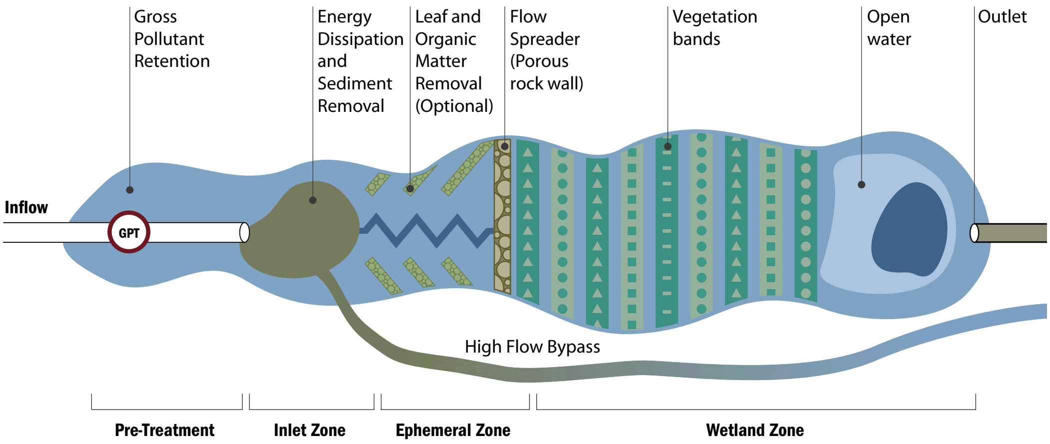
The Detailed Design of the wetland outlines the specifications of all works associated with the wetland and, upon approval will be used for construction of the wetland. Appendix 3 provides an outline of the Detailed Design report.

4. Constructed Wetlands

Although constructed wetland systems have been the most common treatment measure used to reduce concentrations of fine particulate and dissolved pollutants, they should be considered as one component within a treatment train of Water Sensitive Urban Design (WSUD) options. In many situations, they are not the most cost effective method of mitigating stormwater pollution. Melbourne Water's WSUD website can provide more information on alternative options. Please visit www.wsud.melbournewater.com.au for further details.

In laying out the wetland system and its components, consideration must be given to ease of maintenance with allowance for access to ponds and structures. The wetland system should be able to be taken off line to enable critical maintenance activities. Figures 1 and 2 provide a conceptual design of a wetland system indicating the main elements in their order.

Figure 1 – Schematic representation of a typical constructed wetland



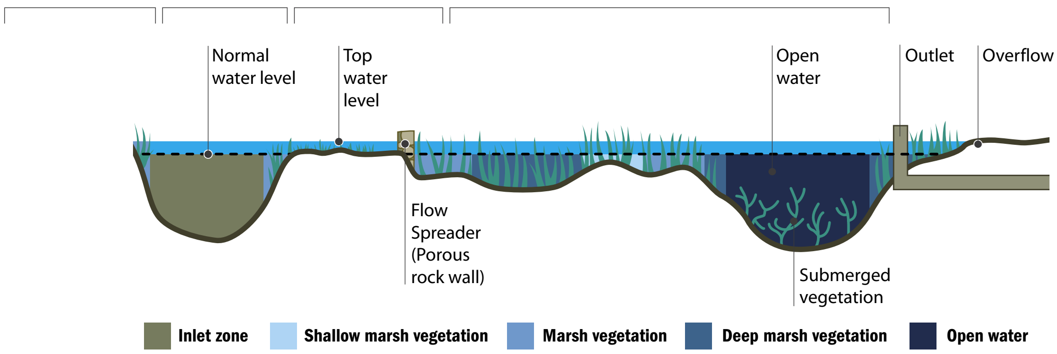
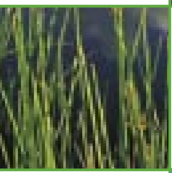
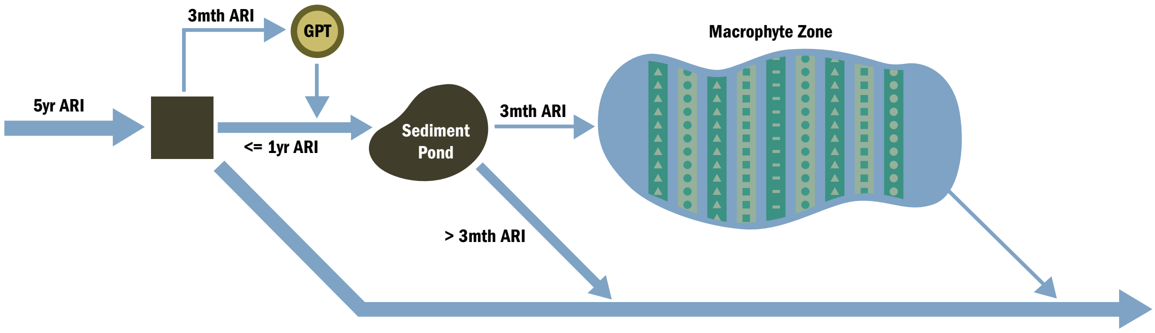


Figure 2 – Long section schematic representation of a typical constructed wetland system (above)



The various components of a wetland system also have different hydraulic loading capabilities. Figure 3 illustrates the basic hydrology and tolerance. All components should be designed in accordance with the technical manual "WSUD Engineering Procedures: Stormwater", MWC, 2005.

Figure 3 – Conceptual hydrology of a typical constructed wetland



4.1 Pre-Treatment (gross pollutant retention)

To minimise the onerous task of removing litter from vegetation throughout the wetland, a litter trapping capability is required upstream of the wetland. The intention of the litter trap is to remove litter and coarse organic matter from inflows to allow simple collection by maintenance crews. It should be noted that if flows are too high to allow the incorporation of a litter trap, then a strategy to remove litter closer to the source via distributed treatments in the upstream drainage system will be required.

Specific design requirements for the pre-treatment include:

1. A pre-treatment litter trap should be capable of retaining litter items of a size greater than 20mm for all flows up to the 3-month Average Recurrence Interval (ARI) flow.
2. The litter trap should have a storage capacity to reduce the cleaning frequency to less than 4 times per year.

4.2 Inlet Zone (energy dissipation and sedimentation)

Coarse sediment or excessive velocities can damage, smother or dislodge sensitive wetland vegetation. Removal of coarse sediment can be achieved by either:

- Installing a sediment trap as part of the pre-treatment; or
- Using the inlet zone pond as a coarse sediment trap (in addition to its energy dissipation role).

Regardless of which method is used, 95% of all suspended sediment down to a particle size of at least 125 µm shall be removed for peak design flows. An ability to retain collected sediment for a period of up to 5 years between maintenance is a minimum requirement.

Specific design requirements for the inlet zone include:

1. Hard stand areas must be provided adjacent to the inlet zone to allow for the maintenance and cleanout of this zone. The hard stand should be at least 3 metres wide and designed to be capable of supporting a 20 tonne excavation plant. Multiple areas should be considered where the pond is greater than 7 metres wide. Adequate space for dewatering must be provided.
2. Access ramps and tracks into ponds cells and to all hard stand areas are required and must be capable of supporting a 20 tonne excavation plant for maintenance.
3. A method for identifying the base of the sedimentation pond when cleaning out collected sediment (eg. concrete base or identifiable sand) must be provided.
4. The pond is to have a maximum width of 14 m to allow access with the maintenance plant, unless approval is provided for long reach excavators or the construction of access ramps into pond.

4.3 Ephemeral Zone (leaf/organic matter trap)

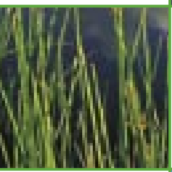
An ephemeral marsh leaf trap may be considered to trap leaf and other organic material prior to entering the wetland zone where the litter trap device cannot meet the design flow. Ephemeral zones may be more useful in areas where significant carbon loads such as residential catchments with established deciduous trees. The ephemeral zone enhances the likelihood of the aerobic decomposition of organic matter in the wetland.

4.4 Wetland Zone (fine particulate and dissolved contaminant retention)

The intention of a wetland zone is to remove sediment particles less than 125 μm through to sub micron particles and dissolved pollutants.

Specific design requirements for the wetland zone include:

1. The batters of the wetland should be smoothed off to ensure no small reservoirs remain that provide breeding habitat for mosquitoes. Please visit www.melbournewater.com.au>publications>fact sheets>drainage>mosquitoes and wetlands for further information.
2. Deep marsh areas and sediment ponds should have a means to isolate and drain under gravity to allow maintenance activities.
3. Where ephemeral benches are used to aid uniform distribution of flows across the wetland, allowance shall be made for low flow bypass and drainage for maintenance by the provision of appropriate pipework or porous rocked drains through the benches.
4. All pits and structures shall be subject to a due diligence and safety audit.
5. Materials used for all fixtures and controls shall be durable and essentially vandal proof. All covered pits are required to have approved lids, and all uncovered outlet structures areas require to have approved grilles/grates.
6. The use of any electrical controls or automated gate or valve systems are not encouraged.
7. Constructed access ramp must be provided into the wetland zone capable of supporting 20 tonne maintenance plant to allow of the maintenance of the wetland zone.
8. A minimum of 80 percent emergent macrophyte (vegetated marsh) zone is to be arranged in bands across the flow path. The remaining area, up to a maximum of 20 percent, shall be allowed for submerged marsh and or open water areas (pools deeper than 1.2 metres).
9. The macrophyte zone should have a sequence and mix of submerged, shallow, deep and ephemeral marsh zones that reflect the quantity of the water from the receiving catchment. The zones should be arranged in a banded manner and be perpendicular to the flow (see Figure 1). The wetland margins should be planted densely with robust sedges and rushes.
10. A minimum of 150 mm of topsoil is required throughout the wetland cells and adjacent fringing ephemeral areas with a minimum of 5 percent organic content to assist the establishment of aquatic macrophytes.
11. The outlet performance is required to provide a hydraulic regime to allow the establishment of shallow marsh vegetation in addition to ephemeral and deep marsh species. Riser or siphon outlets are best suited to provide the range of depths required. Allowances in the orifices shall also consider the variance in the seasonal base flow rates.
12. Outlet structures should be designed and located so that they are maintainable, with inlets to orifices submerged to minimise clogging with debris.
13. A wetland vegetation and weed maintenance program shall be established for a period of at least 24 months after the initial planting of the wetland.
14. Invasive plants and animals can be introduced to wetlands during construction and establishment. Equipment should always be washed down before being used on site and the suppliers of aquatic plants must demonstrate that their stock is free of mosquito fish and unwanted aquatic weeds.
15. The wetland and sedimentation pond system shall have a complimentary landscaping plan to the satisfaction of Melbourne Water and/or the Council.
16. Any hard landscaping features or recreational facilities used in the site shall not be the management responsibility of Melbourne Water and shall be subject to maintenance agreement with the Council.



4.5 Managing High Flows

Constructed wetland systems generally require a diversion (high flow by-pass) for flood flows to avoid mobilisation of collected pollutants, and damage to vegetation within the wetland system. Generally the bypass will come into use once the wetland has been filled to the event standing water level and there is a need to divert the incoming waters away from the wetland.

The high flow by-pass needs to be capable of passing flows above the design flow for the wetland through to a 5 year ARI storm. Flows greater than 5 year may overtop the wetland, but only at velocities below 1.0 m/s. Where site constraints limit the construction of a high flow bypass then a system that passively overtops the wetland for all flows at velocities well below 1.0 m/s may be considered.

5. Wetland Safety Considerations

Melbourne Water advises that the construction of any water body must include a risk assessment to be undertaken by a qualified professional. The risk assessment shall consider the risk to the public during the construction and operational stages of the water body. Please refer to "The Royal Life Saving Society Australia, Guidelines for Water Safety in Urban Water Developments (2004)" for detailed information on safety issues. The following design criteria may be considered:

- A minimum offset of 15m, from the edge of waters to any allotment boundaries where there are back fences without private access provision or 25-30 m where there is access provision.
- The edge of any deep open water should not be hidden or obscured by embankment or terrestrial planting unless measures precluding access are incorporated.
- Approach batter slopes should be no steeper than 1:5 Vertical to Horizontal (V:H) unless there is special landscape edge treatment that will provide appropriate safety measures.
- All boardwalks, piers, bridges and/or structurally treated edges installed and maintained by others are to have heights and or railings in accordance with design codes and satisfy inundation and safety criteria.
- No formal access to water shall be invited unless there is appropriate safety benching.
- Details and safety requirements for batter slopes on approaches and immediately under the permanent water level are provided in "WSUD Engineering Procedures: Stormwater" document.
- In the case of open water bodies greater than 0.9 m deep a secondary safety bench may be required at 0.9 m. This is dependent on the batter slopes from the initial safety bench and depth of the deeper open water.
- Interim fencing may be required between the construction and vegetation establishment where any component of the waterbody is deeper than 350 mm.
- Permanent fencing and/or combined fencing and dense impenetrable plantings should be used adjacent to zones of deep water (greater than 350 mm at NTWL), areas where safety benches do not meet the width criteria, adjacent to potentially unsafe structures, areas where high velocities may be encountered or batters are steeper than 1:5 (V:H).
- Maintenance access areas shall be signed, fenced and gated to discourage access where the basic safety measures above are not met.
- Non-maintenance access to the top of weirs, orifice pits and outlet structures shall be restricted by appropriate safety fences and other barriers.
- No public access is to be permitted into the wetland site during the construction phase. Appropriate fencing and signage must be provided during this phase.

6. Integrating with Ecological and Landscape Setting Benefits

The primary objective for constructed wetlands is to provide stormwater treatment, however where possible secondary benefits, such as amenity (landscape setting) or habitat creation should be explored. It is important to note that sometimes the primary objective can compromise the ecological value as the impacts of catchment derived pollutants maybe deleterious to the wetland ecology.

If carefully designed there may be options to integrate the two objectives, for example, small off-line wetlands filled seasonally by direct rainfall and local catchments of open space can be provided adjacent to the main water quality treatment wetland. Such ephemeral wetlands can provide a refuge for mobile species from temporary high pollutant loads from a storm event and provide breeding opportunity for species that are susceptible to predation from mosquito fish.

It should be noted that constructed waterbodies can attract flocking birds that may be a concern to airports. Further information should be sought from the relevant airport and planning authority.

The following points can be considered in the design of constructed wetlands to maximise their landscape setting and ecological value within the constraints presented by their water quality treatment function.

- Retention, enhancement and interpretation of existing ecological, landscape and cultural values, such as trees and other native vegetation and sites of archeological significance should be considered. These are valuable assets that will be of interest to the local community and help to create a unique sense of place.
- Water bodies should be created that simulate important physical characteristics of natural wetlands such as shape, depth, edge gradients and wetting/drying cycles. The shaping and gradient of wetland edges are very important in creating good habitats for plant growth. Shallow edge gradients maximise the width of planting benches and also provide natural conditions when water levels draw down over summer.
- The use of locally indigenous species in wetland plantings ensures that plants are adapted to local environmental conditions and that the character of the wetland is 'in keeping' with the surrounding landscape.
- Creation of structural complexity in riparian and wetland vegetation is important for ecological diversity and landscape amenity. A range of plant life forms should be included in the planting schedule. These life forms include emergent, submerged and floating plants.
- Terrestrial planting of appropriate indigenous tree, shrub and groundcover species provide additional habitat requirements necessary for some wetland animals, such as nesting sites for birds and over-wintering shelter for frogs.
- Rocks or logs (which can be salvaged from the land development process) placed in or around a wetland provide shelter, perches and basking areas for native wildlife. Logs must be suitably anchored to avoid movement in high flows.
- Where possible the creation of refuge areas, such as islands, and screening vegetation to reduce disturbance of wildlife can be considered.
- Sensitive placement of paths, roads, power-lines and other infrastructure should be considered. Power-lines in particular pose a serious threat to water birds when they are taking off or landing. If a wetland must be placed near power-lines it should oriented to be parallel to them. Dense screening vegetation should be planted between the wetland and the power-lines to discourage birds from using this area as a flight path.
- Integrated control of the impact of aquatic and terrestrial weeds is required. Weed control should be carried out by specialist contractors with a proven ability to identify indigenous and weed species. If performed correctly weed control will maximize the regeneration of indigenous species, providing a dense growth of plants for wildlife habitat.
- The impact of domestic animals, especially dogs need to be managed. In habitat wetlands, unleashed dogs can have significant direct and indirect impacts on native wildlife. Fencing and/or regulatory signage may be required (See Section 9).
- The ability to provide habitat for regionally important values (eg Platypus, Dwarf Galaxias and Warty Bell Frog) should be investigated in the design of habitat wetlands. These "flagship" species may have particular habitat requirements that could be incorporated into the wetland design. Examples of such requirements are deep open water and fringing rocks for the Warty Bell Frog.

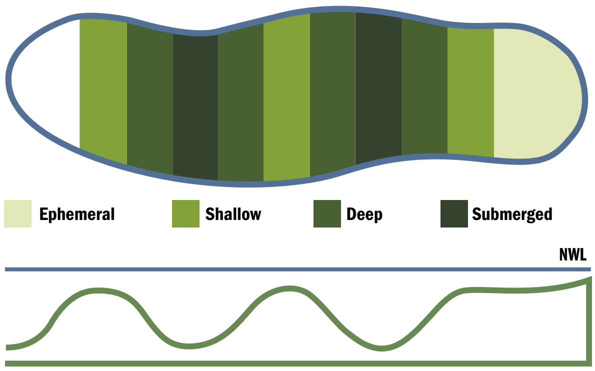
7. Vegetation

Vegetation within the wetland can be broken up into zones perpendicular to the flow. These zones refer to the depth of water and appropriate species to be selected to optimise the success of the system. For a comprehensive list of appropriate macrophyte species for wetlands please refer to Appendix 6.

All species used in vegetation, including both aquatic and terrestrial, should be indigenous and local provenance.

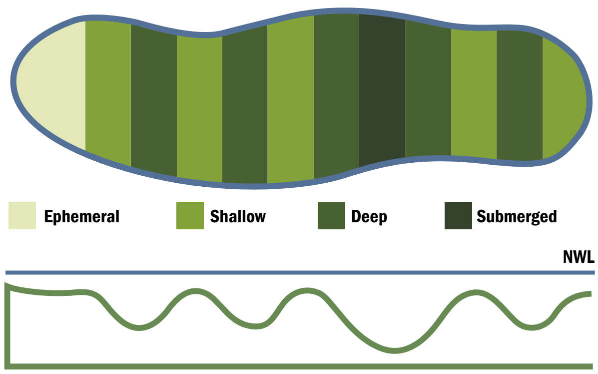
In areas of predictable low rainfall patterns and where there is also a high evaporative loss due to wind sheer, the wetland should use a vegetation sequence such that there is sustainable water depths in deep and submerged marsh areas during drawn down, as illustrated in figure 4.

Figure 4 – Conceptual Vegetation Sequence in low rainfall areas.



In areas of more favourable rainfall distribution a sequencing of deep and shallow marsh bands may be used with occasional use of submerged marsh pools and or ephemeral marsh bands, illustrated in Figure 5.

Figure 5 – Conceptual Vegetation Sequence in high rainfall areas.



8. Construction and Maintenance

To ensure the successful and sustainable operation of the wetland system, a Maintenance Plan must be prepared by the developer that clearly identifies all maintenance tasks and frequency, and allocates maintenance responsibilities to the relevant authority.

The Maintenance Plan must include a clearly labelled schematic layout of the site identifying all structures, plantings, open space, water bodies and paths. A Schedule of Responsibilities must be prepared that specifies the maintenance requirements and responsible authority for each component of wetland and surrounding area identified in the layout plan. The Maintenance Plan must be prepared in consultation with the relevant stakeholders and signed off prior to the completion of the detailed design.

The agreed wetland maintenance plan must be implemented for a period of three (3) years, at a cost to the developer, and to the satisfaction of the local municipality and Melbourne Water as applicable. This will ensure that the sediment trap is maintained for optimum performance during the development stage prior to hand over to the ultimate management agency. Collected sediment within the trap or inlet zone of a wetland is to be removed immediately prior to hand over.

Within the 3-year maintenance plan, a range of defect liability periods will apply to constructed wetlands;

- Civil assets – 3 months.
- Soft engineering – 12 months.
- Landscape vegetation & wetland plantings – 24 months.

A sample maintenance plan and typical schedule of responsibilities is included in Appendix 5.

9. Signage

Advisory and interpretive signage may be designed in consultation with the authority that will be responsible for the management of the wetland system. If the wetland will become a Melbourne Water asset, approval must be obtained from Melbourne Water. Signage should comply with all Australian standards, be non-obtrusive and highly resistant to vandalism.

The sign design should ideally incorporate the following elements:

- The purpose of the wetland.
- The physical and biological processes.
- Identifying any significant environmental features (such as habitat for a particular species).
- Appropriate safety warnings.
- Appropriate agency identification.

10. Use of Conceptual Modelling Software

Melbourne Water currently supports and uses MUSIC (Model for Urban Stormwater Improvement Conceptualisation). MUSIC is produced by the Co-operative Research Centre (CRC) for Catchment Hydrology / eWater and is used to model wetlands and other water quality treatment measures to determine performance.

The use of MUSIC is recommended by Melbourne Water in order to optimise the conceptual design and to demonstrate its performance against Best Management Practice targets. To assist developers in using MUSIC, Melbourne Water has prepared guidelines on the input parameters for MUSIC. These guidelines can be downloaded from the Melbourne Water website. www.melbournewater.com.au >Water Cycle>Drainage & Stormwater >The Drainage System

MUSIC is available through the CRC for Catchment Hydrology at Monash University.

http://toolkit.net.au/products/music/

11. Further Reading

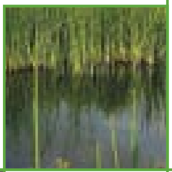
Department of Land and Water Conservation New South Wales (1998).
The Constructed Wetlands Manual. Department of Land and Water Conservation New South Wales

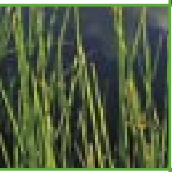
Stormwater Committee (1999).
Urban Stormwater: Best Practice Environmental Management Guidelines. CSIRO Publishing Australia.

The Institution of Engineers Australia (2003).
Australian Runoff Quality (Draft). The Institution of Engineers Australia.

Wong, T.H.F., Breen, P.F., Somes, N.L.G. and Lloyd, S.D.
Managing Urban Stormwater using Constructed Wetlands, Industry Report 98/7, Cooperative Research Centre for Catchment Hydrology (1998)

WSUD Engineering Procedures: Stormwater. Technical Manual, MWC (2005)





Appendix 1 – Example Design Intent

Spring Valley Wetland

Catchment details:

Catchment size: 89ha.

The catchment is predominantly agricultural grazing with a small area (<10ha) of industrial factories.

1. Wetland Performance and design information

Reduction in Nitrogen 300 kg/year
Reduction in Phosphorus 50 kg/year
Reduction in suspended solids 10,000 kg/year
Number of inlets 1
GPT treatment 3 month ARI
Design flow for Sediment Pond 1 year ARI
Inlet flow to wetland 3 month ARI
Wetland High flow bypass 1 year – 5 year ARI
Flood flows > 5 years overtop at < 1m/s
Sediment pond target 95% of particles down to 125μm

2. Site Constraints

The known site constraints include:

- Sewer – An existing sewer does impact on the proposed wetland. The wetland must either be shaped to avoid excavation problems or the sewer can be relocated.
- Existing vegetation – The wetland must be constructed around the mature Red Gum trees.

Works must ensure no damage to the trees or their root systems and that their long term health is protected.

- There are no known site contamination issues.
- There are no known cultural aboriginal sites.

3. Flora and Fauna considerations:

A sustainable population of Warty Bell frogs has been identified in the Darebin Creek approximately 1 km north of this proposed wetland (refer to DNRE report). This wetland is to be designed to maximise the habitat opportunity for this species, whilst achieving treatment performance.

Curley Sedge (Carex tasmanica) is present on the site and in the Darebin Creek tributary adjacent to the proposed wetland. This species is listed under the Flora and Fauna Guarantee Act, and listed as Vulnerable under ANZECC. A detailed environmental assessment is required to identify all remnant populations for protection. This wetland will be designed to extend the population of this plant. Seed collection will need to be investigated.

4. Open space and Landscape considerations

This wetland will be designed to visually blend with the surrounding public open space. The wetland will be an environmental feature along the shared bike track and will have interpretative signage to explain its role in treating stormwater and protection of the Warty Bell frog and Curley Sedge. Generally the site is characterised by small to medium sized rocky outcrops of granite, which extend over the entire development site. This wetland and immediate open space will attempt to preserve this feature where possible and attempt to replace this landscape feature through final landscaping works. All landscaping plants will be indigenous and will be local provenance.

5. Water Safety

The wetland will be designed to minimise risk to the general public and where they are encouraged to engage with the wetland (viewing platforms) fencing that complies with Australian Standards will installed. An appropriate safety audit will be undertaken.

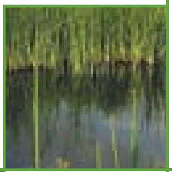
6. Maintenance & access

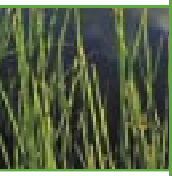
The wetland's primary maintenance access will be located on the western side and will be integrated into the bike path. The bike path will be capable of trafficking heavy machinery. Hard stand access will be provided to the sediment pond. The pedestrian path network will consider the required temporary closing of this path for maintenance and alternative routes will be provided. The wetland will be designed so that it can be fully drawn down for maintenance purposes and all control structures will be vandal proof.

7. Stakeholders

Stakeholders in this wetland include:

- Melbourne Water – Design and approval.
- Council – Landscaping and open space design.
- Department of Sustainability and Environment – Protection and management of threatened species.





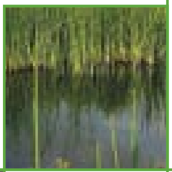
Appendix 2 – Functional Design

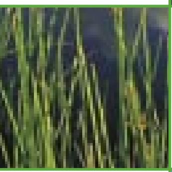
The Functional Design report should include but not be limited to the following;

- Topographical survey of the site identifying any physical constraints and opportunities on the site, including an obstruction search of all existing and proposed services. In particular local drainage lines and floodplains must be identified to ensure that the design does not cause adverse flooding of the area.
- Preliminary geotechnical investigation to assess any potential issues relating to constructability, dispersion, permeability, acid sulphate soils, disposal costs and contamination. -
- Identify environmental issues that may arise as a result of the works and propose a method of resolution.
- Preliminary layout of proposed works outlining: inlet configuration, pond configuration, internal structures, outlet configuration, known site constraints, trees to be removed/retained. The layout should clearly show all key water levels at base and stormwater event levels.
- Hydraulic modelling of the preferred concept to verify the hydraulic performance.
- Water Quality modelling of the preferred design to verify the water quality performance.
- Estimate bulk earthworks required for construction with a preliminary cost estimate (optional)
- The basis of the proposed maintenance agreement (see Section 8).

	Constructed Wetland	**CALCULATION SUMMARY**		
	CALCULATION TASK	OUTCOME		CHECK
1	**Identify design criteria**			
	Design ARI Flow for inlet zone		year	
	Target sediment size for inlet zone		mm	
	Notional detention period for macrophyte zone		hrs	
	Design ARI flow for bypass spillway		year	
	Extended detention volume		m^3	
2	**Catchment characteristics**			
	Residential		Ha	
	Commercial		Ha	
	Fraction impervious			
	Residential			
	Commercial			
3	**Estimate design flow rates**			
	Time of concentration			
	Estimate from flow path length and velocities		minutes	
	Identify rainfall intensities			
	Station used for IFD data:			
	100 year ARI		mm/hr	
	1 year ARI		mm/hr	

	Design runoff coefficient			
	C1			
	C100			
	Peak design flows			
	Q1		m^3/s	
	Q100		m^3/s	
4	**Inlet zone**			
	Refer to sedimentation basin calculation checksheet			
5	**Macrophyte zone Layout**			
	Extend detention depth		m	
	Area of macrophyte zone		m^2	
	Aspect ratio		L:W	
	Hydraulic efficiency			
	Length		m	
	Top width (including extended detention)		m	
	Cross section batter slope		V:H	
6	**Macrophyte zone outlet structures**			
	Maintenance drain			
	Diameter of maintenance valve		mm	
	Drainage time		hrs	
	Riser			
	Linear storage-discharge relationship for riser			
	Discharge pipe			
	Discharge capacity of discharge pipe		m^3/s	
7	**Connection between inlet zone and macrophyte zone**			
	Discharge capacity of connection culvert		m^3/s	
8	**Bypass weir**			
	Discharge capacity of bypass weir		m^3/s	





Appendix 3 – Detailed Design

The detailed design report should include but not be limited to the following:

- Detailed design of the approved proposal and all associated civil works such as the inlet and outlet structures, bypass flow path, embankment and all associated structures and pipework.
- Further geotechnical study. Where there is a likelihood of either groundwater discharge or high seasonal water tables, a hydrogeological investigation may be required to describe the interactions and potential issues.
- Detailed design drawings for the construction of the wetland and retarding basin.
- Detailed design of required relocation and/or alterations to existing services, as required, in consultation with the relevant authorities and their subsequent agreement in writing.
- Consideration should be given for subdivision requirements, set backs from roads, maintenance access, etc.
- Detailed construction cost estimate, fully priced against a schedule of quantities.
- Project Specification, Schedule of Prices and associated Drawings. The Specifications are to be based on the use of the Australian Standard Conditions of Contract, AS2124.
- Completed Maintenance Plan for the wetland's key structures and any other special features.
- The Plan should identify all activities and frequency to ensure optimal operation of the wetland.
- Detailed Design summary report at the completion of the project with all hydraulic calculations for each structure, overall wetland operation and incorporates the deliverables outlined above. The design report detailing the final design basis for the proposed works.

Please refer to "The Royal Life Saving Society Australia, Guidelines for Water Safety in Urban Water Developments (2004)" for detailed information on safety issues.

Wetland Design Assessment Checklist						
Wetland Location:						
Hydraulics	Minor flood: (m³/s)		Major flood: (m³/s)			
Area	Catchment area (ha):		Wetland area (ha)			
Treatment					**Yes**	**No**
Treatment performance verified					❑	❑
Inlet zone					**Yes**	**No**
Inlet pipe/structure sufficient for maximum design flow (Q5 or Q100)?					❑	❑
Scour protection provided at inlet?					❑	❑
Configuration of inlet zone (aspect, depth and flows) allows settling of particles >125 µm?					❑	❑
Bypass weir incorporated into inlet zone?					❑	❑
Bypass weir and channel sufficient to convey >Q1 <= maximum inlet flows?					❑	❑
Bypass weir crest at macrophyte permanent pool level + extended detention depth?					❑	❑
Bypass channel has sufficient scour protection?					❑	❑
Structure from inlet zone to macrophyte zone enables energy dissipation/flow distribution?					❑	❑

Inlet zone permanent pool level above macrophyte permanent pool level?	❑	❑
Maintenance access allowed for into base of inlet zone?	❑	❑
Public access to inlet zone prevented through vegetation or other means?	❑	❑
Gross pollutant protection measures provided on inlet structures (both inflows and to macrophyte zone)	❑	❑
Macrophyte zone	**Yes**	**No**
Extended detention depth >0.25 m and <0.75 m?	❑	❑
Vegetation bands perpendicular to flow path?	❑	❑
Vegetation bands of near uniform depth?	❑	❑
Sequencing of vegetation bands provides continuous gradient to open water zones?	❑	❑
Vegetation appropriate to selected band?	❑	❑
Aspect ratio provides hydraulic efficiency >0.5?	❑	❑
Velocities from inlet zone <0.05 m/s or scouring protection provided?	❑	❑
Batter slopes from accessible edges shallow enough to allow egress?	❑	❑
Maintenance access provided into areas of the macrophyte zone (especially open water zones)?	❑	❑
Public access to macrophyte zones restricted where appropriate?	❑	❑
Safety audit of publicly accessible areas undertaken?	❑	❑
Freeboard provided above extended detention depth?	❑	❑
Outlet structures	**Yes**	**No**
Riser outlet provided in macrophyte zone?	❑	❑
Orifice configuration allows for a linear storage-discharge relationship for full range of the extended detention depth?	❑	❑
Riser diameter sufficient to convey Q1 flows when operating as a 'glory hole' spillway?	❑	❑
Maintenance drain provided?	❑	❑
Discharge pipe from has sufficient capacity to convey the maintenance drain flows or Q1 flows (whichever is higher)?	❑	❑
Protection against clogging of orifice provided on outlet structure?	❑	❑

Appendix 4 – Construction Inspection Checklist

Wetlands	SITE:	CONSTRUCTED BY:	
INSPECTED BY:		DATE:	TIME:
WEATHER:	CONTACT DURING VISIT:		

DURING CONSTRUCTION

Items inspected	Checked			
Preliminary works	**Yes**	**No**	Satisfactory	Unsatisfactory
1. Erosion and sediment control plan adopted	☐	☐	☐	☐
2. Limit public access	☐	☐	☐	☐
3. Location same as plans	☐	☐	☐	☐
4. Site protection from existing flows	☐	☐	☐	☐
5. All required permits in place	☐	☐	☐	☐
Earthworks				
6. Integrity of banks	☐	☐	☐	☐
7. Batter slopes as plans	☐	☐	☐	☐
8. Impermeable (eg. clay) base installed	☐	☐	☐	☐
9. Maintenance access to whole wetland	☐	☐	☐	☐
10. Compaction process as designed	☐	☐	☐	☐
11. Placement of adequate topsoil	☐	☐	☐	☐
12. Levels as designed for base, benches, banks and spillway (including freeboard)	☐	☐	☐	☐
13. Check for groundwater intrusion	☐	☐	☐	☐
14. Stabilisation with sterile grass	☐	☐	☐	☐
Structural components				
15. Location and levels of outlet as designed	☐	☐	☐	☐
16. Safety protection provided	☐	☐	☐	☐
17. Pipe joints and connections as designed	☐	☐	☐	☐
18. Concrete and reinforcement as designed	☐	☐	☐	☐
19. Inlets appropriately installed	☐	☐	☐	☐
20. Inlet energy dissipation installed	☐	☐	☐	☐
21. No seepage through banks	☐	☐	☐	☐
22. Ensure spillway is level	☐	☐	☐	☐
23. Provision of maintenance drain(s)	☐	☐	☐	☐
24. Collar installed on pipes	☐	☐	☐	☐
25. Low flow channel rocks are adequate	☐	☐	☐	☐
26. Protection of riser from debris	☐	☐	☐	☐
27. Bypass channel stabilised	☐	☐	☐	☐
28. Erosion protection at macrophyte outlet	☐	☐	☐	☐
Vegetation				
29. Vegetation appropriate to zone (depth)	☐	☐	☐	☐
30. Weed removal prior to planting	☐	☐	☐	☐
31.Provision for water level control during establishment	☐	☐	☐	☐
32. Vegetation layout and densities as designed	☐	☐	☐	☐
33. Provision for bird protection	☐	☐	☐	☐
34. By-pass channel vegetated	☐	☐	☐	☐

FINAL INSPECTION				
Items inspected	Checked			
	Yes	**No**	Satisfactory	Unsatisfactory
1. Confirm levels of inlets and outlets	❑	❑	❑	❑
2. Confirm structural element sizes	❑	❑	❑	❑
3. Check batter slopes	❑	❑	❑	❑
4. Vegetation planting as designed	❑	❑	❑	❑
5. Erosion protection measures working	❑	❑	❑	❑
6. Pre-treatment installed and operational	❑	❑	❑	❑
7. Maintenance access provided	❑	❑	❑	❑
8. Public safety adequate	❑	❑	❑	❑
9. Check for uneven settling of banks	❑	❑	❑	❑
10. Evidence of stagnant water, short circuiting or vegetation scouring	❑	❑	❑	❑
11. Evidence of litter or excessive debris	❑	❑	❑	❑
12. Provision of removed sediment drainage area	❑	❑	❑	❑
13. Evidence of debris in high flow bypass	❑	❑	❑	❑
14. Macrophyte outlet free of debris	❑	❑	❑	❑

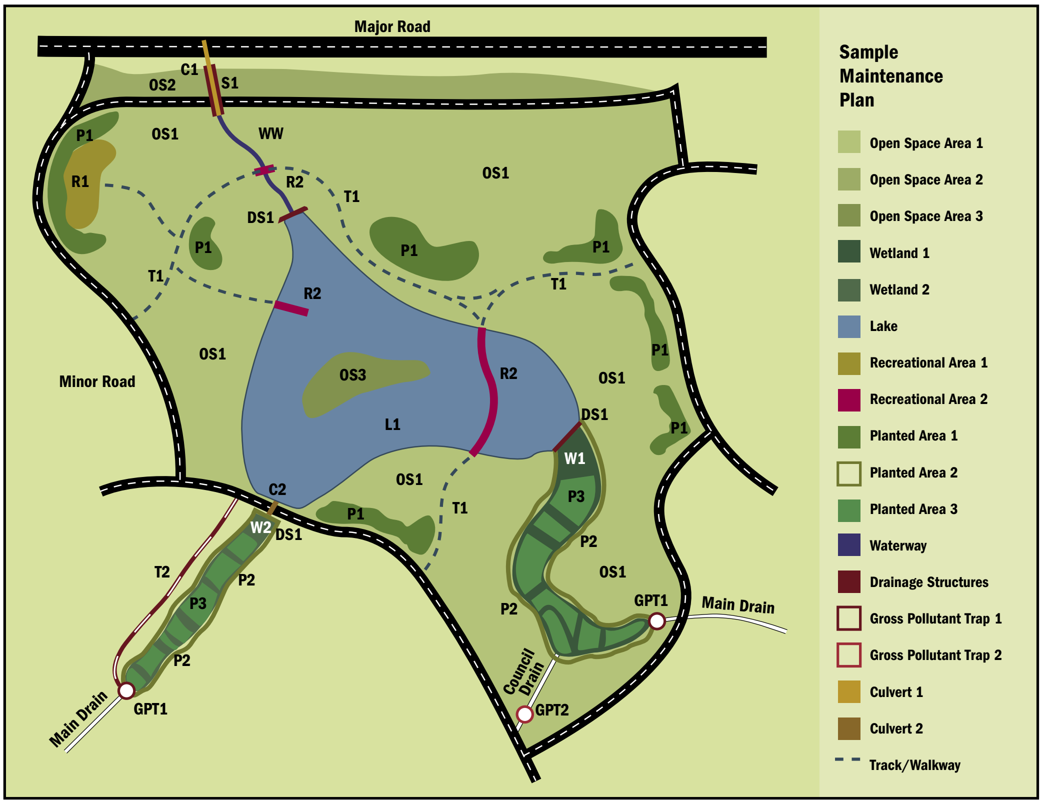
COMMENTS ON INSPECTION

ACTIONS REQUIRED
1.
2.
3.
4.
5.
6.

Inspection officer signature:

Appendix 5 – Sample Maintenance Plan & Schedule of Responsibilities

The maintenance plan shall include a schedule of tasks, responsibilities and timing. An example of a plan, indication the level and detail required is shown below.



Below is an example of part of a schedule of responsibilities relating to the maintenance plan above.

It should be noted that this table is incomplete and should be no means be taken as a fully completed Schedule of Responsibilities.

CODE	DESCRIPTION	ASSET	MAINTENANCE/LEVEL OF SERVICE	RESPONSIBLE AUTHORITY
OS1	Open space area 1	Parkland north of lake	Monthly mowing at X height, removal of litter	Council
OS2	Open space area 2	Retarding basin embankment	Monthly mowing at X height, removal of litter	Maintenance – Council Owner – Melbourne Water
P1	Planted area 1	Garden beds adjacent to and within OS1	Yearly tree pruning. Weeding every 6 months. Plant and mulch replacement as required. Vandalism Check every month.	Council
P2	Planted area 2	Edge planting of wetlands	Edge treatment as required. Plant replacement as required to keep a good coverage of marginal plantings. Weeding every 6 months until full establishment	Melbourne Water

W1	Wetland 1	East wetland	Removal of litter twice a year, as a minimum. Sediment to be cleaned out when accumulation is within 500mm of normal water surface.	Melbourne Water
Continue until all assets are listed…				

Wetland Maintenance Checklist				
Inspection frequency: 3 monthly	**Date of visit:**			
Location:				
Description:				
Site visit by:				
Inspection items	**Yes**	**No**	**Action required (details)**	
Sediment accumulation at inflow points?	❑	❑		
Litter within inlet or macrophyte zones?	❑	❑		
Sediment within inlet zone requires removal (record depth, remove if >50%)?	❑	❑		
Overflow structure integrity satisfactory?	❑	❑		
Evidence of dumping (building waste, oils etc.)?	❑	❑		
Terrestrial vegetation condition satisfactory (density, weeds etc.)?	❑	❑		
Aquatic vegetation condition satisfactory (density, weeds etc.)?	❑	❑		
Replanting required?	❑	❑		
Settling or erosion of bunds/batters present?	❑	❑		
Evidence of isolated shallow ponding?	❑	❑		
Damage/vandalism to structures present?	❑	❑		
Outlet structure free of debris?	❑	❑		
Maintenance drain operational (check)?	❑	❑		
Resetting of system required?	❑	❑		
Comments:				

Appendix 6 – Suggested Macrophyte Species for Wetlands

Suggested macrophyte species for different soil types have been provided for wetlands constructed on Silurian and Basalt derived soils, and Saline and Sandy soils. These are general lists only and the recommended species have been proven to be suited to constructed wetlands. Other species may be appropriate depending on the local soil characteristics, water chemistry and wetting and drying regimes.

The dominant species are shown in bold and should comprise of 70% of the total plant numbers.

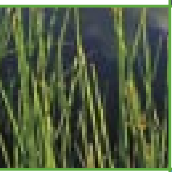
The remaining species should comprise of the other 30%. The planting densities recommend an appropriate coverage to ensure establishment and reduce the invasion of weed species. Please note the follow recent name changes;

- *Schoenoplectus validus* has been changed to *Schoenoplectus tabernaemontani*
- *Vallisneria spiralis* has been changed to *Vallisneria Americana*

Provisional Listing for Silurian Soils

Submerged Marsh	0.4 – 0.9 m below normal top water level	
	Potamageton crispus	**Curly Pondweed**
	Potamageton ochreatus	**Blunt Pondweed**
	Vallisneria americana	**Eel-grass**
	The recommended plant density is **2 plants per square metre.**	
Deep Marsh	0.2 – 0.4 m below normal top water level	
	Eleocharis sphacelata	**Tall Spike-rush**
	Potamageton tepperi	Floating Pondweed
	Potamageton ochreatus	Blunt Pondweed
	Schoenoplectus tabernaemontani	**River Club-rush**
	Triglochin procerum	**Water Ribbons**
	Ottelia ovalifolia	Swamp Lily
	Vallisneria americana	Eel-grass
	The recommended plant density is **4 plants per square metre** (planted in bands perpendicular to flow).	
Shallow Marsh	0 – 0.2 m below normal top water level	
	Alisma plantago- aquatica	Water Plantain
	Baumea articulate	**Jointed Twig-rush**
	Bolboschoenus medianus	**Marsh Club-rush**
	Cyperus gunnii	Flecked Flat-sedge
	Eleocharis acuta	Common Spike-sedge
	Juncus procerus	Tall Rush
	Glyceria australis	Austral Sweet-grass
	Myriphyllum crispatum	Upright Milfoil
	Myriphyllum varrifolium	Variable Milfoil
	Ranunculus inundatus	River Buttercup

	Schoenoplectus tabernaemontani	**River Club-rush**
	The recommended plant density is **6 plants per square metre** (planted in bands perpendicular to flow).	
Ephemeral Marsh	Above normal water level, temporally inundated during high flows	
	Carex appressa	**Tall Sedge**
	Carex gaudichaudiana	Fen Sedge
	Crassula helmsii	Swamp Crassula
	Cyperus lucidius	Leafy Flat-sedge
	Eleocharis acuta	Common Spike-sedge
	Juncus amabilis	**Hollow Rush**
	Juncus gregiflorus	**Green Rush**
	Juncus sarophorus	**Broom Rush**
	Melaleuca ericifolia	**Swamp Paperbark**
	Persicaria decipens	Slender Knotweed
	Poa ensiformis	Sword Tussock-grass
	Poa labillardierei	Common Tussock-grass
	Persicaria praetermissa	Spotted Knotweed
	Gratiola peruviana	Brooklime
	The recommended plant density is **6 plants per square metre**.	
Ephemeral Wetland	*(for vegetative/organic matter removal)*	
	Above normal water level, temporally inundated during high flows	
	Carex appressa	**Tall Sedge**
	Carex fasicularis	**Tassell Sedge**
	Crassula helmsii	Swamp Crassula
	Juncus amabilis	Hollow Rush
	Juncus gregiflorus	Green Rush
	Juncus pauciflorus	Loose-flowered Rush
	Juncus sarophorus	Broom Rush
	Melaleuca ericifolia	**Swamp Paperbark**
	Leptospermum lanigerum	Woolly Tea-tree
	Persicaria decipens	Slender Knotweed
	Persicaria praetermissa	Spotted Knotweed
	Gratiola peruviana	Brooklime
	The recommended plant density is **6 plants per square metre**.	
Wetland Margin	***Carex appressa***	**Tall Sedge**
	Carex fasicularis	**Tassell Sedge**
	Carex gaudichaudiana	Fen Sedge

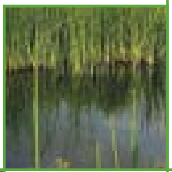
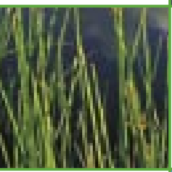


Crassula helmsii	**Swamp Crassula**
Cyperus lucidius	Leafy Flat-sedge
Eleocharis acuta	Common Spike-sedge
Isolepis inundata	Swamp Club-rush
Juncus amabilis	**Hollow Rush**
Juncus gregiflorus	**Green Rush**
Juncus sarophorus	**Broom Rush**
Juncus vaginatus	**Rush**
Melaleuca ericifolia	Swamp Paperbark
Neopaxia australasica	White Purslane
Persicaria decipens	Slender Knotweed

The recommended plant density is **6 plants per square metre**.

Provisional Listing for Basaltic Soils

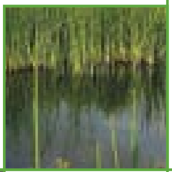
Submerged Marsh	0.4 – 0.9 m below normal top water level	
	Potamageton ochreatus	**Blunt Pondweed**
	Vallisneria americana	**Eel-grass**
	The recommended plant density is **2 plants per square metre**.	
Deep Marsh	0.2 – 0.4 m below normal top water level	
	Eleocharis sphacelata	**Tall Spike-rush**
	Ottelia ovalifolia	Swamp Lily
	Potamageton tepperi	Floating Pondweed
	Potamageton ochreatus	Blunt Pondweed
	Schoenoplectus tabernaemontani	**River Club-rush**
	Triglochin procerum	**Water Ribbons**
	Vallisneria americana	Eel-grass
	The recommended plant density is **4 plants per square metre**. (planted in bands perpendicular to flow).	
Shallow Marsh	0 – 0.2 m below normal top water level	
	Amphibromus nervosus	Common Swamp Wallaby-grass
	Alisma plantago- aquatica	Water Plantain
	Baumea articulata	**Jointed Twig-rush**
	Bolboschoenus caldwellii	**Sea Club-rush**
	Bolboschoenus medianus	**Marsh Club-rush**
	Eleocharis acuta	Common Spike-sedge
	Juncus semisolidus	Rush
	Marsilea drummondii	Common Nardoo
	Myriphyllum crispatum	Upright Milfoil
	Myriphyllum simulans	Amphibious Milfoil
	Ranunculus inundatus	River Buttercup
	Schoenoplectus pungens	**Sharp Club-rush**
	Schoenoplectus tabernaemontani	**River Club-rush**
	The recommended plant density is **4 plants per square metre**. (planted in bands perpendicular to flow).	
Ephemeral Marsh	Above normal water level, temporally inundated during high flows	
	Carex tereticaulis	**Basket Sedge**
	Carex bichenoviana	Sedge
	Crassula helmsii	Swamp Crassula
	Eleocharis acuta	**Common Spike-sedge**
	Juncus semisolidus	Rush
	Juncus subsecundus	Finger Rush
	Juncus flavidus	Yellow Rush

	Leptospermum lanigerum	**Woolly Tea-tree**
	Lobelia pratioides	Poison Lobelia
	Haloragis aspera	Rough Raspwort
	Poa labillardierei	**Common Tussock-grass**
	The recommended plant density is **6 plants per square metre**.	
Ephemeral Wetland	(for vegetative/organic matter removal) Above normal water level, temporally inundated during high flows	
	Austrodanthonia duttoniana	Brown-backed Wallaby-grass
	Carex appressa	**Tall Sedge**
	Carex tereticaulis	**Basket Sedge**
	Juncus semisolidus	**Rush**
	Juncus subsecundus	Finger Rush
	Juncus flavidus	Yellow Rush
	Leptospermum lanigerum	Woolly Tea-tree
	Lobelia pratioides	Poison Lobelia
	Haloragis aspera	Rough Raspwort
	Poa labillardierei	Common Tussock-grass
	The recommended plant density is **6 plants per square metre**.	
Wetland Margin	***Carex appressa***	**Tall Sedge**
	Carex bichenoviana	Sedge
	Carex tereticaulis	**Basket Sedge**
	Crassula helmsii	**Swamp Crassula**
	Eleocharis acuta	Common Spike-sedge
	Hydrocotyle sibthorpiodes	Shiny Pennywort
	Juncus semisolidus	**Rush**
	Juncus flavidus	**Yellow Rush**
	Marsilea drummondii	**Common Nardoo**
	Leptospermum lanigerum	Woolly Tea-tree
	Lobelia pratioides	Poison Lobelia
	Neopaxia australasica	White Purslane
	Persicaria decipens	Slender Knotweed
	The recommended plant density is **6 plants per square metre**.	

Provisional Listing for Sandy Soils
(Derived from Tertiary Sediments or Quaternary Sands)

Submerged Marsh	0.4 – 0.9 m below normal top water level	
	Myriphyllum salsugineum	**Lake Milfoil**
	Potamageton crispus	**Curly Pondweed**
	Potamageton ochreatus	**Blunt Pondweed**
	Potamageton pectinatus	**Fennel Pondweed**
	The recommended plant density is **2 plants per square metre**.	
Deep Marsh	0.2 – 0.4 m below normal top water level	
	Baumea articulata	**Jointed Twig-rush**
	Eleocharis sphacelata	**Tall Spike-rush**
	Potamageton pectinatus	Fennel Pondweed
	Potamageton tepperi	Floating Pondweed
	Schoenoplectus tabernaemontani	**River Club-rush**
	Triglochin procerum	**Water Ribbons**
	The recommended plant density is **4 plants per square metre**. (planted in bands perpendicular to flow).	
Shallow Marsh	0 – 0.20 m below normal top water level	
	Amphibromus nervosus	Common Swamp Wallaby-grass
	Baumea arthrophylla	**Fine Twig-rush**
	Baumea articulata	**Jointed Twig-rush**
	Bolboschoenus medianus	**Marsh Club-rush**
	Eleocharis acuta	Common Spike-sedge
	Myriphyllum salsugineum	Lake Milfoil
	Myriphyllum simulans	Amphibious Milfoil
	Ranunculus amphitrichus	Small River Buttercup
	Schoenoplectus validus	**River Club-rush**
	Villarsia reniformis	**Running Marsh-flower**
	The recommended plant density is **4 plants per square metre**. (planted in bands perpendicular to flow).	
Ephemeral Marsh	Above normal water level, temporally inundated during high flows	
	Carex appressa	Tall Sedge
	Carex gaudichaudiana	Fen Sedge
	Centella cordifolia	Centella
	Crassula helmsii	Swamp Crassula
	Cyperus lucidius	Leafy Flat-sedge
	Eleocharis acuta	Common Spike-sedge
	Juncus amabilis	**Hollow Rush**
	Juncus australis	**Austral Rush**
	The recommended plant density is **6 plants per square metre**.	



Ephemeral Wetland	(for vegetative/organic matter removal) Above normal water level, temporally inundated during high flows	
	Carex appressa	**Tall Sedge**
	Carex tereticaulis	**Basket Sedge**
	Centella cordifolia	Centella
	Juncus amabillis	**Hollow Rush**
	Juncus australis	**Austral Rush**
	Juncus pallidus	Pale Rush
	Leptospermum lanigerum	Woolly Tea-tree
	Melaleuca ericifolia	**Swamp Paperbark**
	Persicaria decipens	**Slender Knotweed**
	The recommended plant density is **6 plants per square metre**.	
Wetland Margin	***Baumea arthrophylla***	**Fine Twig-rush**
	Carex appressa	**Tall Sedge**
	Carex fasicularis	**Tassell Sedge**
	Carex tereticaulis	Basket Sedge
	Crassula helmsii	**Swamp Crassula**
	Eleocharis acuta	Common Spike-sedge
	Isolepis inundata	Swamp Club-rush
	Juncus amabilis	Hollow Rush
	Juncus australis	**Austral Rush**
	Juncus pallidus	Pale Rush
	Neopaxia australasica	White Purslane
	Persicaria decipens	Slender Knotweed
	The recommended plant density is **6 plants per square metre**.	

Provisional Listing for Saline Soils, Wetland Salinity (2000 to 10000 ppm)

Submerged Marsh	0.4 – 0.9 m below normal top water level	
	Myriphyllum salsugineum	**Milfoil**
	Potamageton pectinatus	**Fennel Pondweed**
	Ruppia polycarpa	Slender Widgeon-grass
	Lepilaena cylindrocarpa	Long-fruited Water-mat
	Lepilaena preissii	Slender Water-mat
	The recommended plant density is **2 plants per square metre**.	
Deep Marsh	0.2 – 0.4 m below normal top water level	
	Baumea articulata	**Jointed Twig-rush**
	Potamageton pectinatus	Fennel Pondweed
	Schoenoplectus tabernaemontani	**River Club-rush**
	Triglochin procerum	**Water Ribbons**
	The recommended plant density is **4 plants per square metre**. (planted in bands perpendicular to flow).	
Shallow Marsh	0 – 0.2 m below normal top water level	
	Baumea arthrophylla	**Fine Twig-rush**
	Baumea articulata	**Jointed Twig-rush**
	Bolboschoenus caldwellii	Sea Club-rush
	Cladium procerum	Leafy Twig-rush
	Eleocharis acuta	Common Spike-rush
	Lilaeopsis polyantha	Creeping Crantzia
	Mimulus repens	Creeping Monkey-flower
	Myriphyllum salsugineum	Lake Milfoil
	Myriphyllum verrucosum	Red Water-milfoil
	Schoenoplectus pungens	**Sharp Club-rush**
	The recommended plant density is **4 plants per square metre**. (planted in bands perpendicular to flow).	
Ephemeral Marsh	Above normal water level, temporally inundated during high flows	
	Crassula helmsii	**Swamp Stonecrop**
	Juncus flavidus	Yellow Rush
	Juncus krausii	**Sea Rush**
	Distichilis disticophylla	**Australia Salt-grass**
	Poa labillardierei	**Common Tussock-grass**
	Poa poiformis	Blue Tussock-grass
	Samolus repens	Creeping Brookweed
	Selliera radicans	**Shiny Swamp-mat**
	Triglochin striatum	Streaked Arrow-grass
	Leptinella reptans	Creeping Cotula

	Lobelia irrigua	Salt Pratia
	Ranunculus diminutus	Dwarf River Buttercup
	Ranunculus papulentis	Large River Buttercup
	The recommended plant density is **6 plants per square metre**.	
Ephemeral Wetland	(for vegetative/organic matter removal) Above normal water level, temporally inundated during high flows	
	Carex tereticaulis	**Basket Sedge**
	Juncus flavidus	**Rush**
	Juncus kraussii	**Sea Rush**
	Distichilis disticophylla	Australia Salt-grass
	Melaleuca ericifolia	Swamp Paperbark
	Poa labillardierei	Common Tussock-grass
	Poa poiformis	Blue Tussock-grass
	Selliera radicans	Shiny Swamp-mat
	Triglochin striatum	Streaked Arrow-grass
	The recommended plant density is **6 plants per square metre**.	
Wetland Margin	***Baumea arthrophylla***	**Fine Twig-rush**
	Baumea juncea	Bare Twig-rush
	Carex tereticaulis	**Basket Sedge**
	Juncus subsecundus	Finger Rush
	Juncus flavidus	Yellow Rush
	Juncus kraussii	**Sea Rush**
	Selliera radicans	Shiny Swamp-mat
	Triglochin striatum	Streaked Arrow-grass
	The recommended plant density is **6 plants per square metre**.	

Who we are

Melbourne Water is owned by the Victorian Government. We manage Melbourne's water supply catchments, remove and treat most of Melbourne's sewage, and manage rivers, creeks and major drainage systems in the Melbourne region.

We are a significant business, managing $8.1 billion of natural and built assets.

An independent Board of Directors is responsible for the governance of Melbourne Water. The responsible Minister is the Minister for Water.

Our people have diverse skills and expertise and we place a high priority on building strong partnerships and relationships with the community and all our other stakeholders. Our customers include the metropolitan retail water businesses, other water authorities, local councils and the land development industry.

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For information on Melbourne's water resources in languages other than English, call 131 722 or visit www.melbournewater.com.au and click on the Community Languages link.