



Wetland Design Manual - Supporting Document: Form & Function Manual

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1. Purpose

The purpose of this document is to provide detail about the form and function of wetlands.

2. Scope

The scope of this document are all assets outlined through the wetland design manual documents.

3. Water Sensitive Urban Design

Water Sensitive Urban Design (WSUD) integrates water cycle management with urban planning and design, and utilises natural processes to help mitigate the impacts of stormwater runoff on waterways and bays.

The key principles of WSUD outlined in the *Urban Stormwater: Best Practice Environmental Management (BPEM) Guidelines* (Victorian Stormwater Committee, 1999) are to:

- Protect and enhance natural water systems within urban environments;
- Integrate stormwater treatment into the landscape, maximising the visual and recreational amenity of developments;
- Improve the quality of water draining from urban developments into receiving environments;
- Reduce runoff and peak flows from urban developments by increasing local detention times and minimising impervious areas; and
- Minimise drainage infrastructure costs of development due to reduced runoff and peak flows.

3.1 Protection of Waterways

Stormwater management, through the adoption of WSUD principles, helps to protect urban waterways so they remain valuable community assets that enhance community liveability and support the ecosystems that rely on them.

The physical characteristics and catchment properties within a region, such as land use, amount of impervious area, and rainfall characteristics, strongly influence the amount of stormwater that is generated and the subsequent impacts on waterway health.

3.2 Management of Stormwater in Urban Landscapes

The management of stormwater in the landscape using WSUD initiatives (e.g. stormwater treatment, harvesting and reuse systems) reduces the volume and frequency of stormwater runoff and increases the quality of stormwater before it is discharged to downstream waterways.

The management of stormwater in urban landscapes may also include:

- Integrated management with groundwater, potable water and wastewater to protect water related environmental, recreational and cultural values;

- Storage, treatment and beneficial use of stormwater runoff; and
- Use of vegetation for improving stormwater quality, providing water efficient landscaping and enhancing biodiversity.

3.3 Provision of Multiple Benefits

The adoption of WSUD principles can provide a range of other benefits such as alternative water supply, improved landscape amenity, and contribution to enhanced liveability by highlighting natural features such as waterways and the surrounding open spaces.

The use of WSUD treatment systems can also help to minimise drainage infrastructure development costs by reducing pipe sizes and potentially replacing large scale reticulated water systems with local solutions where appropriate.

4. Natural Wetlands

The term 'wetland' is used to describe places within the landscape that are inundated with water for all, or at least part, of the year. Natural wetlands encompass a diverse range of aquatic ecosystems, ranging from permanently inundated environments (such as freshwater lakes and estuaries) to variably inundated environments (such as freshwater marshes/swamps and salt marshes).

Shallow freshwater wetlands (less than two meters deep) are present throughout Australia and are defined on the basis of wetting and drying cycles (referred to as the wetland water regime - timing, frequency, duration, extent and depth of inundation). Many shallow freshwater wetlands are highly ephemeral, often comprising of large shallow areas that regularly dry out during summer, and pockets of deeper permanent water. A major feature of shallow freshwater wetlands is the presence of aquatic plants, commonly known as macrophytes.

Shallow freshwater wetlands are characterised by a diverse range of physical, chemical and biological processes that are dependent upon the wetland water regime, wetland soils, microbial processes and the types of aquatic vegetation present.

Freshwater wetlands are generally characterised by the presence of highly organic, reduced (anoxic) sediments due to regular inundation of the wetland soils. Wetlands play an important role in nutrient cycling, acting as a sink for phosphorus and providing conditions where organic carbon, nitrogen and sulphur is transformed to gaseous forms and released back into the atmosphere.

The aquatic plants that grow in wetlands have adapted to survive both wet and dry conditions. The biochemical, molecular and morphological adaptations of aquatic plants to inundation include tolerance to anoxia (metabolic regulation), the presence of aerenchyma (air spaces which extend throughout the plant and allow the plant to supply oxygen to submerged tissues) and the ability to elongate inundated shoots (to renew contact with the aerial environment).

5. Constructed Wetlands

This document refers to wetlands that are designed with the primary objective of stormwater pollutant removal but may also provide other WSUD benefits.

The capacity of wetlands to remove pollutants (nutrients, suspended solids and metals) from water has led to the widespread use of wetlands to improve the quality of stormwater runoff from urban catchments.

Wetlands are typically shallow, extensively vegetated freshwater bodies that use enhanced sedimentation, fine filtration, chemical and biological uptake processes to remove pollutants from stormwater runoff.

As complex and highly active biological systems, wetlands rely heavily upon microbial processes to intercept, transform and remove pollutants from stormwater. Wetlands are robust and dynamic systems that can cope with large variations in flow and water quality. The presence of emergent aquatic plants within wetlands is crucial to the long term performance of the wetland system, as the plants play a major role in the uptake of nutrients, and the health of the wetland sediments and microbial communities. Wetlands therefore need to be carefully designed to provide the best conditions for plant growth to ensure the long term performance of the wetland.

A well-designed wetland can remove pollutants under varying hydraulic conditions. If a wetland is not designed appropriately, the wetland vegetation may fail to establish, sediment/microbial health will be poor, and the wetland may provide limited treatment of pollutants, or actually become a source of pollutants itself.

Wetlands are commonly used for stormwater treatment by developers and councils due to their amenity and recreational value to the community. They also provide a range of benefits such as wildlife habitat, management of stormwater runoff volumes and frequency, stormwater harvesting and reuse opportunities, and minimal maintenance requirements once established.

5.1 Stormwater Treatment Mechanisms

Wetlands are commonly used to treat stormwater to best practice standard by removing:

- Gross pollutants
- Sediments
- Nitrogen
- Phosphorus

Stormwater treatment wetlands are also known to be efficient at removing a number of other pollutants associated with urban stormwater runoff including:

- Metals
- Pathogens (e.g. E Coli)
- Organic compounds

The key treatment mechanisms associated with constructed stormwater treatment wetlands are summarised as follows:

Physical removal

- Sediment capture vegetation in the wetland facilitates enhanced sedimentation of particles down to the fine colloidal fractions

- Adsorbed pollutant removal – a high proportion of adsorbed pollutants are removed through capture of fine particles
- The presence of vegetation minimises the likelihood of widespread re- entrainment of trapped sediments

Biological and chemical uptake

- Dissolved pollutants uptake – epiphytic biofilms present on the surface of the aquatic vegetation uptake dissolved pollutants
- Chemical adsorption of pollutants to fine suspended particles are removed through enhanced sedimentation and adhesion facilitated by macrophytes and biofilms

Pollutant transformation

- The regular wetting and drying cycle within wetlands leads to more stable sediment fixation of contaminants (such as phosphorus and metals) in the substratum
- Microbial processes such as nitrification and denitrification result in nitrogenous pollutants such as ammonium and nitrate being converted to nitrogen gas and being dispersed into the atmosphere
- UV treatment in open water areas provides disinfection

5.1.1 Components of a Typical Wetland

Treatment wetlands comprise of three major components: sediment pond, macrophyte zone and bypass route (channel or pipe). Figure 1 and Figure 2 show an indicative plan view and section of a typical wetland layout. All inflows enter a sediment pond and are subsequently split between the macrophyte zone and bypass route. These three components are important for all wetlands, even if some or all of the wetland sits within a retarding basin.

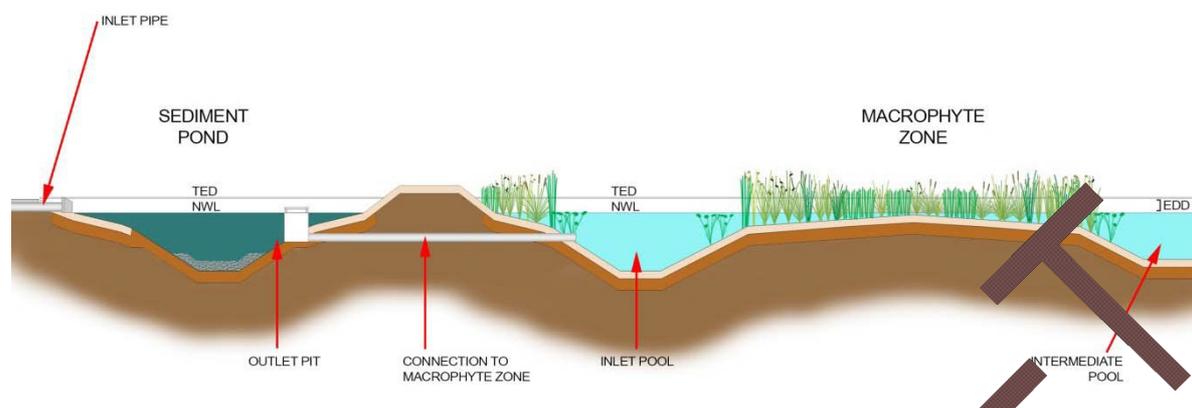


Figure 1: Indicative selection of a typical wetland layout

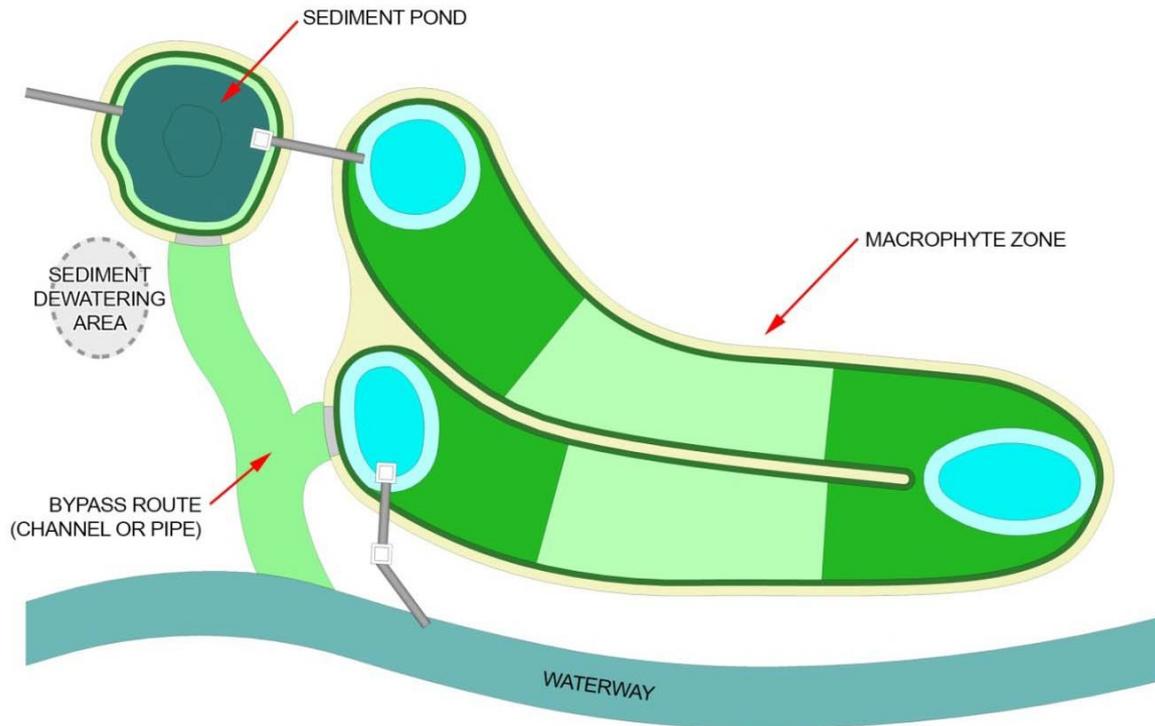


Figure 2: Indicative plan view of a typical wetland layout

Sediment Pond

The sediment pond is an open water body where stormwater runoff enters the wetland system (refer to Figure 4). The sediment pond reduces the velocity of inflows, traps coarse sediments and generally protects the macrophyte zone.

Stormwater enters the sediment pond via a drainage inlet pipe or a waterway/drainage channel. The sediment pond is sized to promote settling to capture coarse sediments.

Generally, gross pollutants are removed using gross pollutant traps located in the catchment upstream of the sediment pond. In cases where no upstream gross pollutant traps are present, the inlet pipes to the sediment pond may be fitted with litter traps. Please note, most gross pollutant traps are located within local drainage systems which are managed by councils. Some councils do not accept gross pollutant traps and therefore an early conversation with the local council is recommended to understand their standards and requirements.

The sediment pond is connected to the macrophyte zone by a connection sized to pass the three month Average Recurrence Interval (ARI) flow. This protects the vegetation and deposited fine particulates in the macrophyte zone from scour. Isolation of the sediment pond from the macrophyte zone is important, as this enables the water level within the sediment pond to be reduced during maintenance without impacting on the water level in the macrophyte zone.

When flows entering the sediment pond exceed the three month ARI flow, or the extended detention depth of the macrophyte is full, stormwater is discharged from the sediment pond via an overflow weir into the bypass channel. The bypass channel

conveys high flows around the macrophyte zone. The key features of a sediment pond are shown in Figure 3 and Figure 4.



Figure 3: Example sediment pond (Banyan Reserve, Carrum Downs):

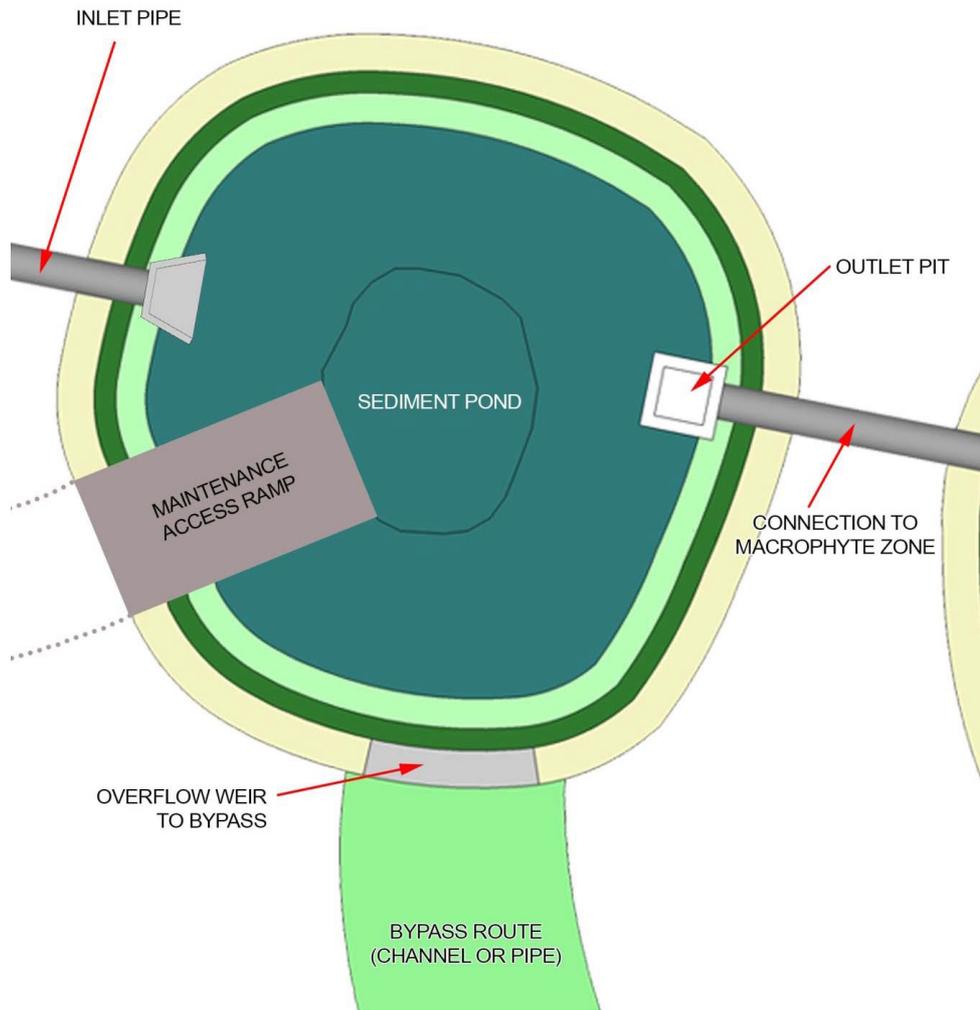


Figure 4: Indicative plan view of a typical sediment pond layout

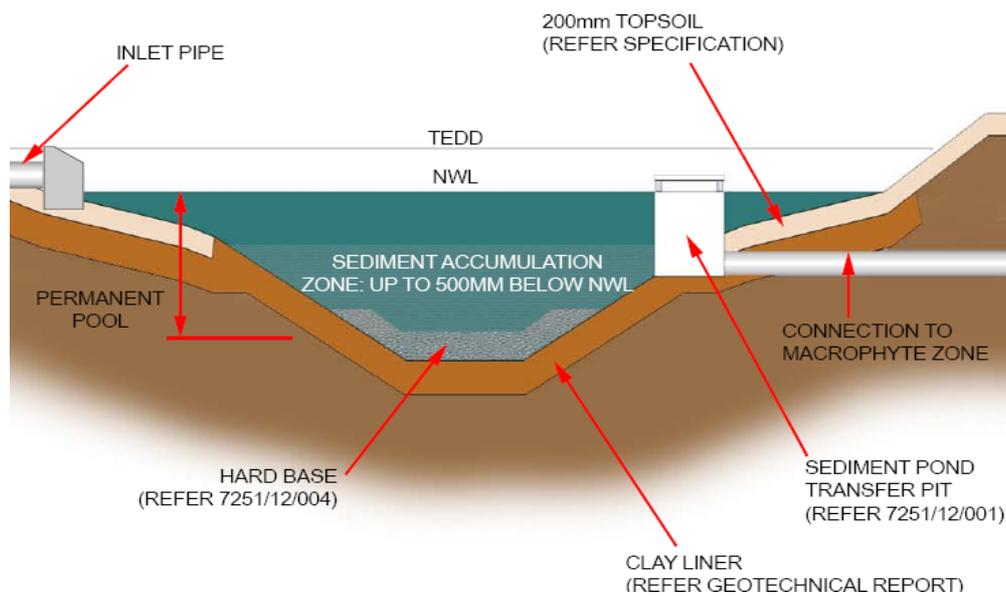


Figure 5: Indicative section of a typical sediment pond

A maintenance access track to the base of the sediment pond is required for vehicular access during sediment cleanout events. A sediment dewatering area must be provided adjacent to the sediment pond. The accumulated sediment removed from the sediment pond is stockpiled on the sediment dewatering area to allow dewatering to occur prior to removal from the site. The sediment dewatering area is considered an asset and is a significant part of the overall wetland system. The sediment dewatering area must be located and sized for purpose, without impacting on the wetland function, operation and maintenance plus without impacting on recreational features of the surrounding open space area (i.e. shared path network; seats and playgrounds).

Sediment ponds are maintained as open water systems, however emergent aquatic plants (macrophytes) are normally planted around the shallow margins of the sediment pond to assist with bank stability, improve visual amenity and to discourage public access.

5.1.2 Macrophyte zone

The macrophyte zone consists of one or more densely planted linear cells (refer to Figure 7).



Figure 6: Densely planted macrophyte zone (Narre Warren North)

The function of the macrophyte zone is to provide a low velocity environment where the smaller suspended particles are able to settle out of suspension or adhere to the vegetation. Soluble pollutants, such as nutrients, are adsorbed onto the surfaces of suspended solids and entrained within the wetland sediments, or biologically absorbed by the biofilms (algae, bacteria) present on the macrophytes-or by the macrophytes themselves. Microbial activity within the biofilms or within the sediment helps to

decompose organic matter and is crucial to the transformation and export of carbon, nitrogen and sulphur (in gaseous forms) from the wetland.

The presence of macrophytes is also important in maintaining positive redox potential in the sediments, thereby controlling the release of phosphorus from the sediments. The macrophyte zone also provides a valuable habitat for aquatic fauna such as invertebrates, waterbirds and amphibians.

It is important that the macrophyte zone is protected from high flows so that the biofilms present upon the macrophytes are not removed. Fine sediments accumulated within the wetland and the macrophytes themselves can also be scoured from the wetland by high flows.

Stormwater enters the macrophyte zone inlet pool where energy is dissipated and the velocity of inflowing stormwater is reduced. The bathymetry of macrophyte zones is designed so that stormwater passes through a sequence of densely vegetated marsh zones (shallow, deep and submerged) prior to exiting the macrophyte zone via the outlet pool. The key features of a macrophyte zone are shown in Figure 7.

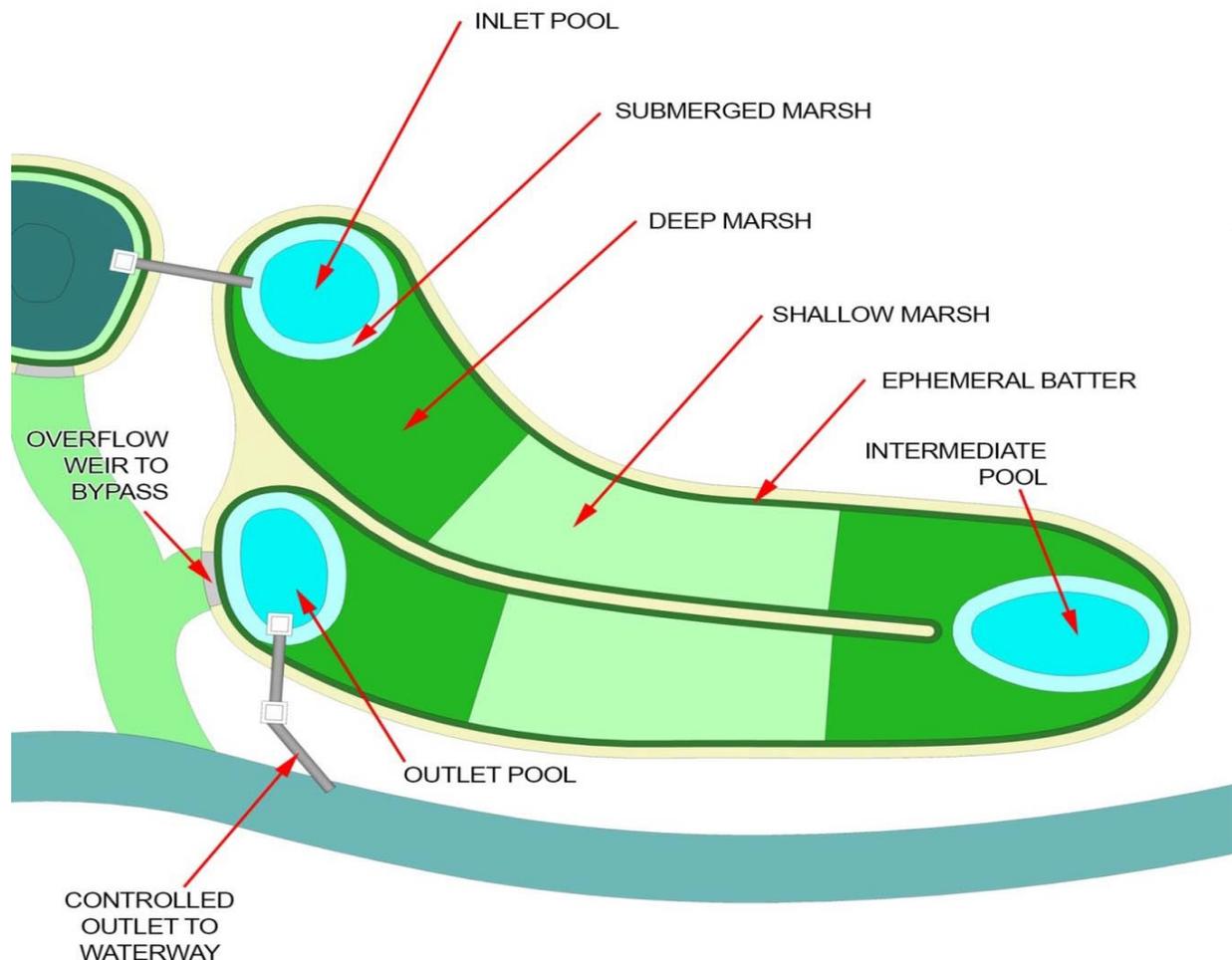


Figure 7: Indicative plan view of a typical macrophyte zone layout

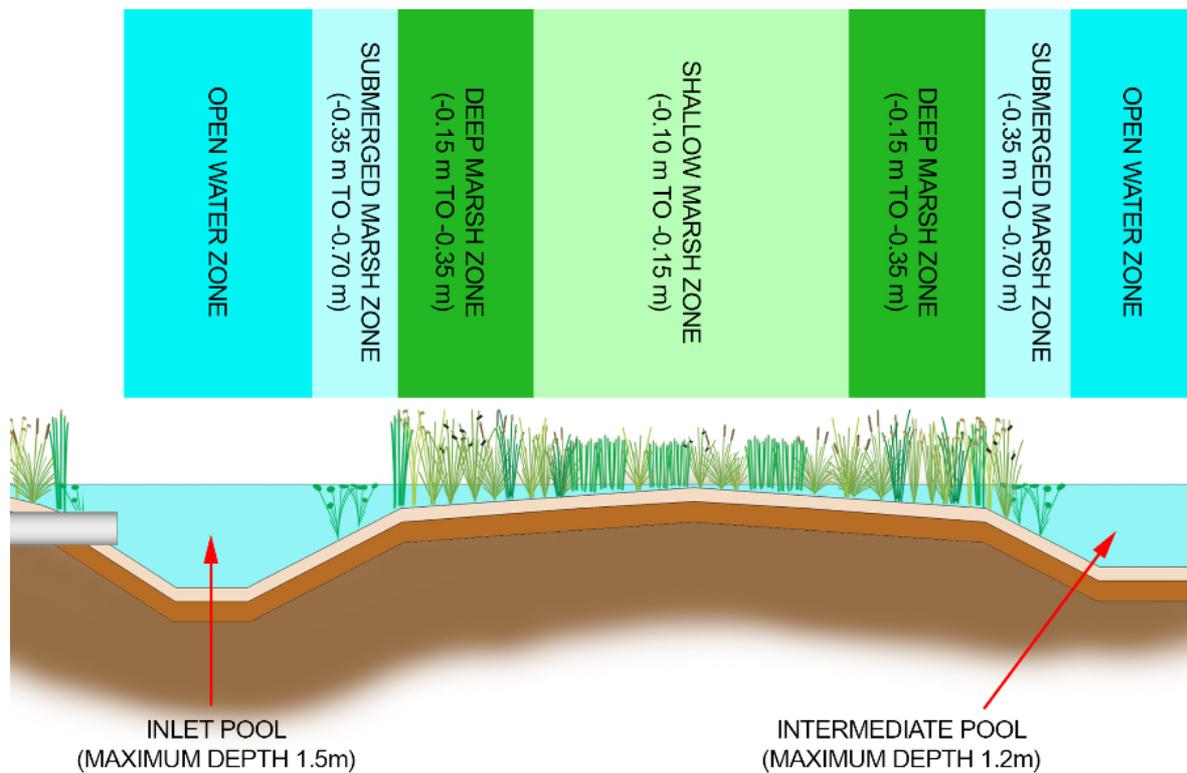


Figure 8: Indicative section of a typical macrophyte zone

The marsh zones are arranged in a banded manner, perpendicular to the flow direction, so that stormwater can flow evenly through the macrophyte zone vegetation, and interact with the biofilms present upon the surfaces of the macrophyte stems. The treatment performance of the wetland is highly dependent upon flows passing through dense vegetation distributed across the entire macrophyte zone. Clumped vegetation and open water flow paths result in the short circuiting of flows within the wetland and reduced treatment performance.

Open water areas (including areas of submerged marsh) should not exceed more than 20% of the wetland area. Open water areas should be provided as inlet and outlet pools, and as intermediate pools in larger wetlands.

The distribution of wetland vegetation is typically determined by inundation depth, frequency and duration. In wetlands, these features are determined by the permanent pool depth of the various macrophyte zones (submerged marsh, deep marsh, shallow marsh, ephemeral marsh) and the amount of time inflows engage the extended detention.

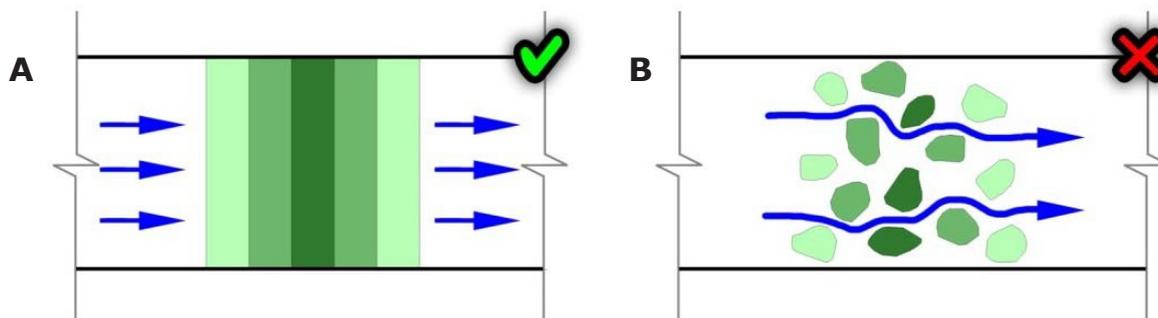


Figure 9: Treatment performance of the wetland is highly dependent upon the presence of dense vegetation

- A) Good performance - dense vegetation and even flow path through the wetland
B) Poor performance - clumped vegetation and multiple open water flow paths

The vegetation planted within the macrophyte zone should be selected based on predicted water levels relative to the height of the plant species. Emergent macrophytes are sensitive to excessive inundation depths and durations. Macrophyte species planted within the shallow and deep marsh zones should be sufficiently robust to cope with the expected hydrologic regime within the macrophyte zone.

The macrophyte zone (and planted margins of the sediment pond) must be lined with topsoil ([as per Melbourne Water specification](#)) to enable plants to grow and protect the wetland liner (generally compacted clay) from erosion.

Outflows from the macrophyte zone are regulated by a twin chamber outfall pit located within, or adjacent to, the outlet pool. The controlled outlet sets the normal water level within the macrophyte zone and is configured so that stormwater will take a maximum of three days to pass through the system (residence time). The controlled outlet is also configured to enable the water level in the macrophyte zone to remain at NWL during the establishment phase to assist with the establishment of the macrophytes.

The controlled outlet generally comprises of a twin chamber outfall pit (containing a side winding penstock valve) or weir. Only water that has been treated in the wetland for a maximum of three days is released through the controlled outlet and conveyed via an outlet pipe to the downstream waterway.

When the top of extended detention depth (TEDD) of the macrophyte zone is exceeded, all further inflows are discharged from the macrophyte zone via an overflow pit or overflow weir, or the overflow weir located in the sediment pond (via feedback from the macrophyte zone). In many cases, the outlet pit is configured to house the controlled outlet and also act as an overflow pit. Large wetlands may also have a dedicated overflow pit located within the outlet pool.

5.1.3 Bypass route

The bypass route allows flows to be diverted around the macrophyte zone when the water level is at TEDD. The bypass route protects the macrophyte zone from scour during high flow

events, and enables the wetland to be temporarily taken off-line for maintenance or water level regulation (i.e. it may be beneficial to dry the wetland out periodically to stimulate plant regeneration).

The bypass generally consists of a vegetated channel, but could also involve pipes, culverts, etc. For wetlands within retarding basins, the bypass operates until the bypass itself is inundated by water filling up the retarding basin.

6. Document History

Date	Reviewed/ Actioned By	Version	Action
December 2020	Senior Asset Practitioner – Water Quality	2	Updated template and links