Constructed (treatment) wetlands

This fact sheet is one of a series which provides advice to extension officers and land managers on the use of constructed (treatment) wetlands to improve farm run-off water quality, specific to coastal agriculture in the wet/dry tropics region between central and Far North Queensland.

Constructed wetlands

Wetlands can be constructed for many different purposes. This fact sheet addresses constructed treatment wetlands which are densely vegetated and are designed to facilitate fine filtration, enhanced sedimentation and biological uptake to remove pollutants from farm run-off.

These constructed wetlands can also be very effective at treating irrigation tail-water.

The functional elements of a constructed treatment wetland consist of a:

- sediment basin (see accompanying fact sheet)
- macrophyte (reed and sedge) zone, and
- high flow bypass channel.

Constructed (treatment) wetland. Photo: Peter Breen

Treatment processes

Constructed treatment wetlands provide treatment for drainage flows through a number of different processes. These are described in Table 1.

Wetland vegetation plays a vital role in these treatment processes, as well as:

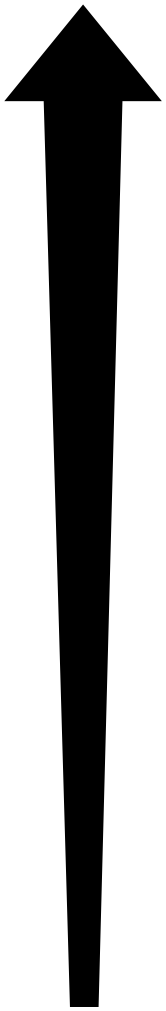
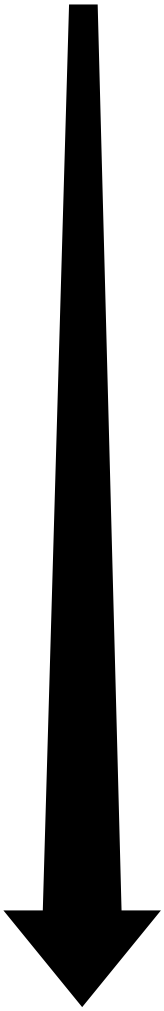
- influencing hydrology and hydraulics by promoting even flows through the wetland
- decreasing erosion by reducing wave action and flow velocities (speeds) while binding soil particles with their root systems, and
- providing shade and reducing light availability for algal photosynthesis and aquatic weeds.

Sometimes the vegetation may also improve biodiversity by providing a basis for wetland food chains and creating habitat for invertebrates, amphibians, fish, reptiles, birds and mammals. The design considerations outlined in this fact sheet are for treatment wetlands. If habitat is a primary objective for a wetland, different design features may need to be considered and the treatment capacity may be reduced accordingly.

The area planted with dense emergent macrophytes should be maximised in constructed (treatment) wetlands and the amount of open water should be kept to a minimum (to improve water quality outcomes and reduce the risk of algal blooms and weed colonisation).

A ratio of open water to macrophytes of at least 1:5 is recommended.

Table 1 – Summary of wetland treatment processes

Pollutant Size / Type	Treatment Performance of Wetland Sediment Basin[1]	Treatment Performance of Wetland Macrophyte Zone	Description of Constructed Wetland Treatment Process
Coarse to medium sized pollutants (e.g. sediments)			The sediment basin component of the wetland provides for settling of coarse to medium sized pollutants. These pollutants are not the target pollutants for the macrophyte zone as these can smother the vegetation.
Fine particulates (e.g. fine sediments and particulate nutrients)			The wetland macrophyte zone is designed to facilitate enhanced sedimentation of fine particles, down to the fine silts. These fine particles trapped in the wetland may retain or absorb pollutants. The presence of vegetation also reduces the widespread re-suspension of trapped sediments.
Dissolved pollutants (e.g. nutrients, chemicals and pesticides)			Wetland vegetation provides surfaces for epiphytic biofilms (e.g. bacteria and other microorganisms) which take up dissolved pollutants. Wetland vegetation also directly takes up dissolved nutrients. The regular wetting and drying of the macrophyte zone sediments progressively leads to less reversible sediment fixation of pollutants in the sediments. Wetland vegetation also inhibits the release of nutrients from the sediments by pumping oxygen into the soils.

[1] See sediment basin factsheet for more details on sediment basin treatment processes.

Use of constructed wetlands on farms to manage run-off

Constructed wetlands can be used as part of an overall farm drainage strategy to improve run-off water quality provided best practice farm management practices are implemented and a number of key design considerations are addressed. Planning treatment elements should also consider their position in the catchment and whether the location is suitable.

Sizing

The size of the constructed wetland and the area to be treated will influence the treatment performance. Treatment performance is also linked to the surface area of macrophytes and detention times.

Recent modelling results suggest that the optimal size for a constructed treatment wetland, when combined with best farming practices, is in the order of 5-7% of the upstream catchment assuming in-block best management practices are adopted.

If best management farming practices are not adopted, wetlands would need to be larger, around 10% or more of the upstream catchment area.

Site constraints

Wetlands are not ideally suited to sites with:

- Undulating and steep topography - a site with more than a 2m cross-fall will result in high embankments and deep excavation which limits the wetland feasibility. A smaller vegetated sediment basin may be required for these steep site situations (see sediment basin fact sheet).

- Flat topography: there needs to be at least 0.5m available between the invert of the upstream drain and the water level in the downstream system at the proposed site to allow for water retention to occur during flow events e.g. 0.5m extended detention.

- Limited space:
  - If there is less than 100m^2 available for the wetland construction, the combination of width, depth and edge profile will prevent the flow being uniformly distributed and instead the flow will be dominated by edge effects.
  - If the area available is less than 5% of the upstream catchment, performance might be compromised, through insufficient detention time and high velocities causing scour or vegetation damage.

Wetlands can also be difficult to construct if there is shallow bedrock, high water tables and sandy soils. In low lying coastal areas any form of excavation can expose acid sulfate soils.

These site characteristics don't preclude the use of wetlands, but it would require additional design considerations with potential cost implications.

Constructed wetlands should not remove or damage existing natural wetlands or riparian vegetation. Design needs to take into account natural water flows and avoid changing the hydrology in natural wetlands and waterways.

Position and role in a stormwater treatment train

The adoption of in-block best management practices and other treatment train elements will reduce the size requirements for the constructed wetland.

Wetlands should be designed as the last element in a treatment train (Figure 1), although re-use of treated water may occur after the wetland.

Sediment basins are an essential part of the wetland design to capture coarse to medium sized sediments (see sediment basin fact sheet). A high flow bypass is also critical to protect the wetland plants from being smothered or scouring during high flow events. Buffer strips and vegetated swales/drains can also be located upstream of the constructed wetland to provide additional pre-treatment of flows by removing sediments as well as some nutrients.

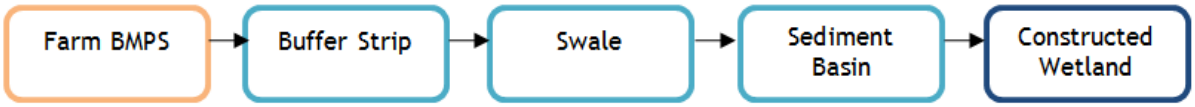


Figure 1 – Location of constructed (treatment) wetland in farm run-off treatment train

Design, construction and maintenance

Design requirements

Constructed wetlands should have the following design features (Figure 2):

Sediment basin

The sediment basin acts as a sediment trap as well as controls flows entering the wetland (see sediment basin fact sheet for design requirements).

Deep pools

Deep open water zones are designed to retain water for the entire dry season to provide habitat for mosquito predators and assist with wet season colonisation of the macrophyte zone. These areas should be 2m deep.

Macrophyte zone

The densely vegetated deep marsh zone will be seasonally inundated and are designed to dry out periodically, although dry periods should not exceed 60 days at a time. The depth of these areas will depend on the rainfall, but will generally be between 0.6-0.8m deep.

Additional design considerations:

Wetland hydraulics

The shaping of the wetland should ensure that flows pass through the wetland in a uniform manner, ensuring no short-circuiting of flows.

Provision for bypass of high flows

The high flow bypass should be configured so that after the wetland is full, flows spill past the wetland and not through it. It may not be possible to position the wetland away from the flow path of extreme storms. In these cases, high flow velocities through the wetland should not exceed 2m/sec.

Weed management

Trees can shade out weeds and densely vegetated emergent macrophytes along littoral zones and can make it difficult for weeds to establish by occupying the habitat (Figure 2).

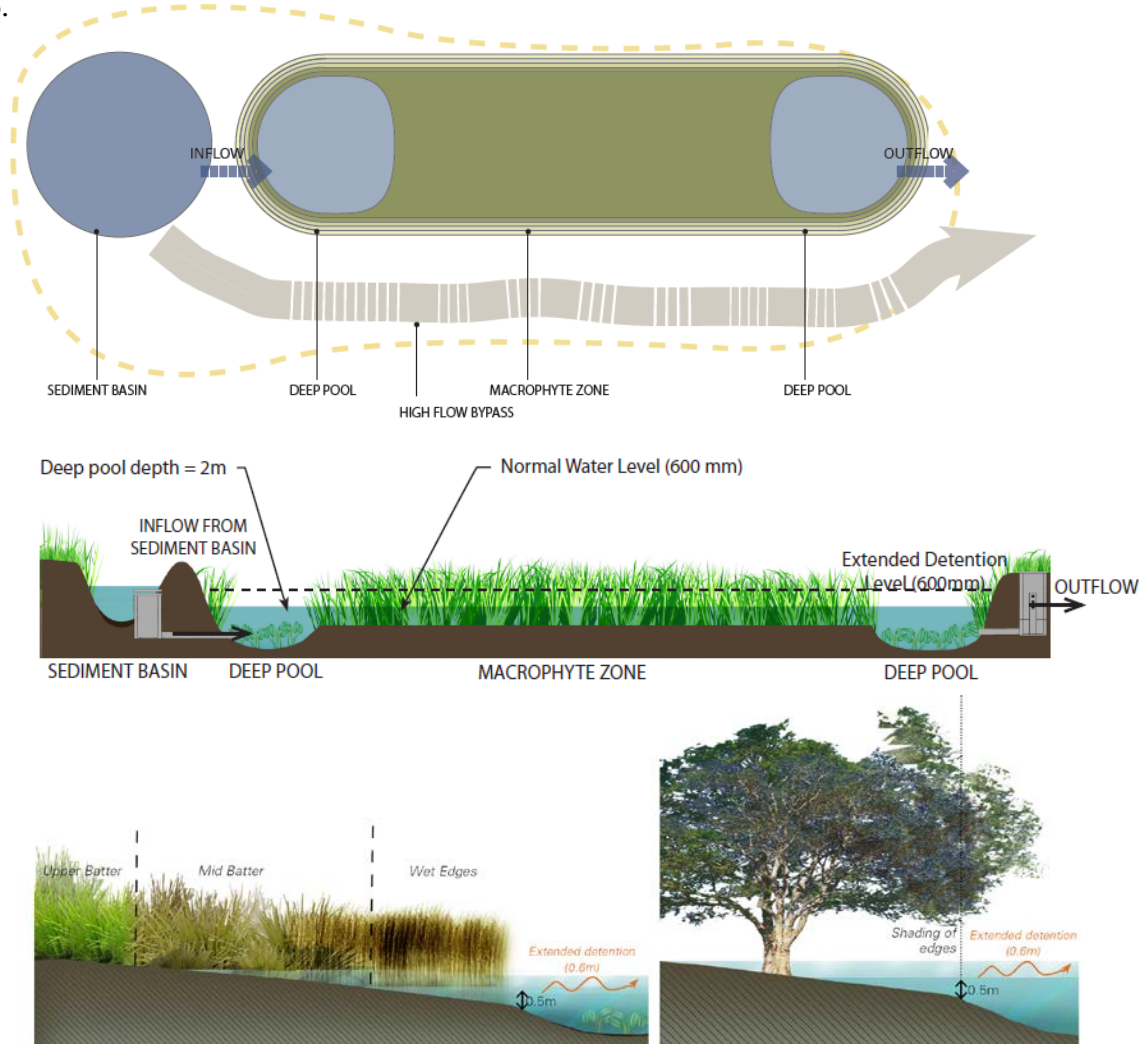


Figure 2 - Wetland plan view (top) and cross section (middle) and potential edge treatments for weed management (bottom).

Typical construction issues

Existing vegetation/wetlands

Constructed wetlands should be located away from natural wetlands and existing native vegetation and should not affect the drainage to these natural features. If there is existing vegetation which needs to be removed for the construction of the wetland, clearance approval may be required.

Earthworks within the vicinity of an area mapped as a wetland protection area may trigger an approval process. Other approvals may also apply, so advice should be sought from the regional NRM or catchment groups and from local and state governments.

Earthworks

Constructed wetlands require considerable and potentially detailed earthworks to create the required shaping. An engineer should be engaged to provide technical advice on the earthworks required to achieve the wetland design requirements for a specific site.

Earthworks should occur during the dry season to minimise sediment loss.

Planting and establishment

Constructed wetlands require large numbers of new plants. These should be sourced as early as possible at the start of the project to ensure plants are available and planting plans adjusted according to availability.

Local guidelines for plant selections should be used where available. Natural vegetated systems such as waterways, wetlands and riparian zones can be used as a regional reference from which to create a possible species template for the constructed wetland.

Before planting is undertaken the suitability of the soils for vegetation establishment should be tested.

The establishment of the vegetation may require irrigation and weed management until it is fully established. This can take up to two years.

To improve the success of vegetation plantings, time them to allow for adequate establishment/root growth before the wet season. Planting early in the year (April-May) means you can take advantage of available soil moisture. Some irrigation may be required during the dry season to help with establishment.

During the early stages of wetland establishment water birds can be a nuisance by pulling out recently planted tube stock. To avoid this, interlocking planting systems e.g. where several plants are grown together in a single container such as ‘floral edges’ can be used.

To maximise the chances of successful emergent macrophyte establishment and to minimise the risk of the plants being drowned out, the water level of the wetland system may need to be manipulated in the early stages of vegetation growth and during prolonged wet seasons. This can be achieved by closing off the connection between the sediment basin and the macrophyte zone and bypassing additional flows around the wetland.

Cost implications/risk

Wetland vegetation, specifically macrophytes, can be expensive. The risk of not achieving the desired design planting densities is poor treatment performance and the risk of weed colonisation.

If cost is an issue, potential staging options should be considered. It is recommended that smaller, well vegetated wetland compartments be delivered in a staged approach rather than a single large wetland with limited vegetation cover.

Macrophytes are an essential component of constructed (treatment) wetlands. Photo: QDAFF

Maintenance

Maintaining healthy vegetation and adequate flow conditions in a constructed wetland are the key maintenance objectives.

The most intensive period of maintenance is during the plant establishment period in the first two years when weed removal and replanting may be required to ensure design densities of plants are achieved.

Typical maintenance of wetlands will involve:

- Irrigating the vegetation during dry periods to maximise establishment success.
- Removing weeds before they set seed and spread is of critical importance. Any herbicide spraying needs to ensure it does not kill the wetland vegetation, and the type of herbicide needs to be suitable for aquatic areas.
- Draining and de-silting the sediment basin when capacity is less than 0.5m or when sediment has filled up half the capacity of the basin. If in-block best management practices are adopted and the sediment basin is appropriately sized, this de-silting should only be required every 5 years. Removed sediments should be placed in a location where it can de-water away from drainage lines and natural waterways (ideally upstream of the sediment basin so flows can drain back into it). Once sediments are dried, they should be removed and can be used back in the blocks.
- Repairing any erosion, especially if it has created isolated pools in the batters.
- Removing blockages and repairing erosion at inlets and outlets.
- Replacing plants that have died with plants of equivalent size and species as detailed in the planting schedule.

Wetlands should be inspected every six months or after every major rain event.

The majority of the maintenance can be done by hand, however machinery and access will be required for de-silting the sediment basin.

Further information

This fact sheet is part of a series on run-off treatment systems, as listed below. The Wetland Management Handbook provides more detail on treatment structures and general farm management to improve water quality leaving farms.

These resources and other wetland management tools and guides are available at http://wetlandinfo.ehp.qld.gov.au/wetlands/management/wetland-management/

Number	Publication Title
Fact sheet 1	Farm runoff treatment systems—toolkit
Fact sheet 2	Buffer strips
Fact sheet 3	Vegetated swales and drains
Fact sheet 4	Sediment basins
Fact sheet 5	Constructed (treatment) wetlands

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The Queensland Wetlands Program supports projects and activities that result in long-term benefits to the sustainable management, wise use and protection of wetlands in Queensland. The tools developed by the Program help wetlands landholders, managers and decision makers in government and industry. The Program is a joint initiative of the Australian and Queensland governments.

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or visit www.wetlandinfo.ehp.qld.gov.au

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