Maintaining water sensitive urban design elements

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Contents

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Maintaining water sensitive urban design elements

One of the barriers to greater adoption of water sensitive urban design (WSUD) for stormwater treatment is uncertainty about the maintenance that will be needed after construction. This manual is designed to give council staff and developers the information to help plan, cost and schedule for WSUD.

WSUD elements can harvest, treat and store stormwater, saving drinking water and reducing pollutants in urban stormwater runoff. WSUD elements can be designed to manage and treat stormwater in a wide range of urban situations, from individual allotments to whole neighbourhoods.

This manual describes the maintenance methods used in Australia and overseas for the most commonly used WSUD elements, and spells out what to look out for on site for each element. It also provides checklists that can be used on site and kept as records of the work needed and carried out.

Asset managers need to note that some faults listed during site inspections may require substantial redesign work to be rectified. Design faults need to be identified and addressed before site handover.

DESIGN CONSIDERATIONS

This manual should be used hand-in-hand with the *WSUD Engineering Procedures: Stormwater Manual* (Melbourne Water 2005), which contains detailed information about the design and construction of WSUD elements.

The way WSUD elements are constructed will directly affect how they can be maintained. Maintenance needs to be considered early in the design process and those who will be responsible for maintenance should be identified and consulted during this time. The main things to consider are outlined below.

Access

Maintenance staff need easy access to all parts of WSUD elements:

- Access tracks should be designed to cater for the type of equipment that will be used to remove sediment or do other maintenance work.
- In bioretention systems, inspection openings at the end of perforated pipes need to be part of the initial design. This allows maintenance staff to check sediment build-up and water level fluctuations. Infiltration tests should be undertaken periodically.
- Ensure that inspection openings have been angled to allow jetting to occur into accumulated sediment which will then wash back down the pipe (rather than jetting from behind built-up sediment).

Vegetation management

It takes two summers and a subsequent autumn season to establish vegetation. After that, vegetation management is required for the life of the WSUD asset, and needs to be scheduled accordingly.

Where dense planting is required, it is generally best to use a combination of ground covers and other plants. For information on using specific plant species, refer to Appendix A of the *WSUD engineering procedures: Stormwater manual*.

It is also important to select vegetation appropriate to the equipment available for maintenance and to carry out planting accordingly.

In ponds and wetlands, plants can be used to stabilise banks and may need to be included in designs where there is the potential for erosion. In inlet zones, dense planting around the waterline can make public access difficult, and as such, can minimise the risks of drowning. It can also make the landscape more attractive and screen basins which can be typically turbid.

Wetland and pond management

Often wetlands and ponds are designed with a number of objectives supplementary to stormwater management, such as providing habitats or improving local amenity.

To protect wetlands and ponds, it is critical to undertake regular maintenance on the upstream sediment basin. Any build-up of coarse sediments in wetlands is generally caused by poor design or poor maintenance of the sediment basin.

The design also needs to accommodate fluctuations in water levels.

To avoid the occurrence of algal blooms, ponds and wetlandss should be designed to have a proper flowthrough of water. Design considerations to minimise the risk of algal blooms are outlined later in this manual and in Melbourne Water's *Constructed shallow lake systems – Design guidelines for developers*.

The size of the weltand or pond needs to relate to the size of the catchment to ensure adequate flushing and turnover of water. Smaller elements are cheaper to maintain but the element must still be 1–2 per cent of the catchment it is treating to be effective.

To minimise the potential for mosquito breeding, refer to the *WSUD Engineering Procedures Stormwater Manual*.

Sediment

All wetlands, ponds and sediment basins should be designed to have an area for stockpiling wet material that is removed during maintenance. Removing dry material is much cheaper than wet material.

Mulch

If there are plans to mulch swales or bioretention systems, designs need to make sure that run-off does not wash these mulches into drains where they could create blockages. Good design, as well as avoiding mulches that float, can make sure the mulch stays on site.

Street tree pits

The most important design considerations are selecting the right species for the site and the best filter material to ensure the appropriate infiltration rate of water through the media. It is also useful to identify existing services located near the site.

ASSET HANDOVER

Before taking on ownership responsibility of a WSUD element or series of elements (known as a 'treatment train') the proposed owner should perform an asset handover inspection. Use Table 1 below to evaluate the general maintenance issues common to all WSUD elements. Deficiencies should be rectified before asset handover.

It is important to identify who will be responsible for maintenance and allow for expected costs in budgets. Some maintenance staff may be need to be trained if they are unfamiliar with WSUD treatments.

Inspection frequency

In most cases, newly constructed components of WSUD elements will need inspection after rainfall to ensure they are working properly. After settling-in, all elements should be inspected every three to six months. This frequency seems to be the most cost-effective without sacrificing environmental effectiveness. Areas of high litter loads may need more regular inspection.

In particular, inlets should be regularly checked and cleared to prevent debris and sediment build-up. For example, if building sites in a catchment are poorly managed, the stormwater running off these sites will carry a great deal of debris and sediment into nearby ponds, wetlands, raingardens or vegetated swales. Built-up debris and sediment can smother plants, damage filtering capabilities and reduce the volume of water that can be stored or treated. It can block inlets or outlets, making sites smelly, unattractive and ineffective.

Raingardens, wetlands and vegetated swales will need more maintenance while their plants are becoming established (the first two summers followed by a subsequent autumn season). Weed removal and replanting may be required.

Maintenance checklists have been developed as part of the WSUD Engineering Procedures. They are included in this manual on the inside back cover. Photocopy these checklists to use when inspecting WSUD sites so you build a record of their condition and the quantity of pollutants removed over time.

Table 1: Maintenance considerations for asset handover.

Maintenance	Yes	No
Are maintenance plans provided for each asset?		
Has inspection and maintenance been undertaken as specified by the maintenance plan?		
Are inspection and maintenance forms provided?		
Has the asset been inspected for defects?		

This table is derived from the full Asset Handover Checklist in the *WSUD engineering procedures manual*, page 43.

SEDIMENT BASINS

Main tasks

- Make sure the erosion protection (plants, rocks or other) around the inlet is operating as designed.
- Check for and remove any built-up sediment.
- Make sure the outlet zone is clear of vegetation and debris.

Primary target

- Sediment

Secondary targets

- Organics
- Litter

On site

Soon after construction, inspect the inlet zone after storms to make sure the erosion protection is working properly.

Sediment should be removed about every five years, but this depends on the nature of the catchment. As a general guide, sediment should be removed once the sedimentation basin is half full.

In catchments where there is a lot of construction work, large loads of sediment can be washed into the stormwater system unless it is properly controlled on each building site. In these areas, sediment basins will need to be cleared out more frequently.

Remove organic and inorganic debris and litter whenever you see them on the site.

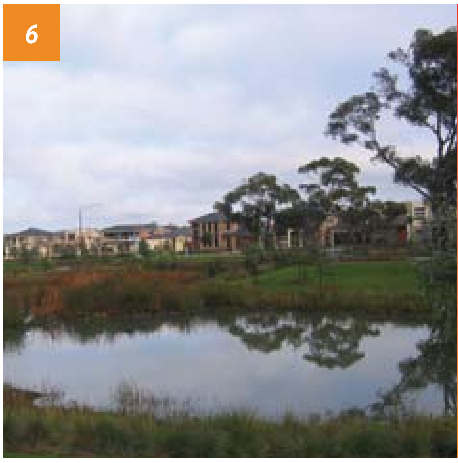
Maintenance costs

Ponds, sediment traps and sedimentation basins typically cost between three and six per cent of the construction cost to maintain each year.

Generally, there is a very strong correlation between typical annual maintenance costs and the surface area of the basin. Put simply: smaller basins are cheaper to maintain.

Maintenance costs are low in most years, but higher when desilting is done or aquatic weeds need to be removed.

[Source: Wegland et al. (1986), Schueler (1987), SWRPC (1991), Livingston et al (1997),Weber (2001 and 2002) in Taylor & Wong (2002), The Centre for Watershed Protection (CWP, 1998) and US EPA (2001)].



PONDS AND LAKES

Main tasks

- Check for endangered species.
- Inspect the inlet zone for scour after large storms.
- Unclog outlets.
- Remove litter and debris.
- Control weeds and pests.
- Replant edging plants where needed.

Primary targets

- Fine sediment
- Metals

On site

For ponds and lakes, most of the maintenance work is needed around the inlet zone. Remove litter, weeds and debris whenever you see them on the site. Replant edging plants as necessary.

Maintenance costs

Dealing with algal bloooms is essentially a design and management issue, rather than a maintenance one. For further information on algal blooms, refer to the comprehensive document *Design guidelines for shallow lake systems*, produced by Melbourne Water and available from its library on its website at:

www.melbournewater.com.au/content/library/rivers_and_creeks/wetlands/Design_Guidelines_For_Shallow_Lake_Systems.pdf

Ponds, sediment traps and sedimentation basins typically cost between three and six per cent of the construction cost to maintain each year.

Generally, there is a very strong correlation between typical annual maintenance costs and the surface area of the basin or pond. Put simply: smaller ponds are cheaper to maintain.

[Source: Wegland et al (1986), Schueler (1987), SWRPC (1991), Livingston et al (1997),Weber (2001 and 2002) in Taylor & Wong (2002), The Centre for Watershed Protection (CWP, 1998) and US EPA (2001)].

WETLANDS

Main tasks

- Inspect the inlet zone for scour after large storms.
- Unclog any outlets; remove vegetation litter, debris and sediment.
- Control pests and weeds.
- Replant edging plants if needed.
- Check and maintain water plants.
- Manage vegetation.
- Remove litter.

Primary targets

- Fine-to-medium sediments
- Nutrients
- Metals
- Bacteria.

On site

The maintenance tasks for wetlands are similar to ponds and lakes.

However in wetlands, maintenance staff also need to look out for any build-up of coarse sediments. The inlet zone of a wetland needs the same maintenance as a sedimentation basin. Scour and erosion at the inlet can also create problems, so it is important to inspect all inlets after large storms.

The most intensive maintenance effort will be needed during the first two summers and subsequent autumn season while plants are becoming established. This will involve weed control and replanting where necessary. When checking plant densities, aim to have 70–80 per cent of the ground covered after two growing seasons (two years).

To help wetland plants establish, keep the water level shallow and constant for the first six to eight weeks. After that, the plants should be strong enough to survive in deeper water, so the wetland can be gently filled to its normal operating water level.

Large wetland systems will need tailor-made detailed maintenance schedules, which include a brief explanation of how the wetland operates and a list of main items or areas to check during each inspection.

Maintenance costs

To cost wetlands, the treatment device includes an inlet zone sediment basin/ pond and macrophyte zone, without a gross pollutant trap.

Wetlands typically cost between two and six per cent of the construction cost to maintain each year. Generally, there is a very strong correlation between Typical Annual Maintenance costs and the surface area of the wetland. Put simply: smaller wetlands are cheaper to maintain.

Maintenance costs increase where:

- there are introduced aquatic weeds
- sediments are contaminated
- upstream control of sediment is poor
- access is difficult
- dewatering areas are limited.

[Source: Wegland et al (1986), Schueler (1987),SWRPC (1991), Livingston et al (1997), Taylor & Wong (2002) The Centre for Watershed Protection (CWP, 1998), Weber (2001) and US EPA (2001).]

SWALES OR BUFFER SYSTEMS

Main tasks

- Control weeds and pests.
- Make sure water flows into, and through the system.
- Prevent or remove channelisation.
- Remove any accumulated sediment.
- Remove litter and debris.

Primary targets

- Coarse sediments
- Some nutrients (total phosphorous)
- Litter
- Organics

On site

To operate successfully, the plants in a swale or buffer system need to be well-established and dense, and managed well to prevent erosion.

The plants need to be grouped close together so any runoff water will flood or seep through, rather than establishing little flow channels (known as rills) which might erode the swale surface.

Maintaining the health and density of vegetation is vital, particularly in the early stages. New plantings will need to be maintained for at least 6 months. Tasks include regular watering, weeding, replacing dead plants, monitoring and controlling pests, and removing rubbish.

Any scour at inlets (if the swale does not have distributed inflows) needs to be monitored closely. Litter, debris and sediment can build up at the inlet points. Litter and debris also need to be removed from the surcharge pits.

Check overflow pits for structural faults. Check the pits are functioning properly.

Grass clippings need to be disposed in green waste or compost systems.

Areas damaged by wheel ruts need be restored to re-establish contours.

Maintenance costs

Maintenance costs tend to be higher in the first five years, while the swale or buffer is becoming established.

- Grassed swales cost about \$2.50–\$3.13/m^2/year to become established (but if residents mow regularly, there is less cost to local authorities).
- Vegetated swales cost about \$9/m^2/year.

After five years, the cost for grass swales decreases to roughly \$0.75–\$1.50/m^2/year.

[Source: Lloyd et al (2002), Beecham (2002)]

RAINGARDENS (Bioretention systems and swales)

Main tasks

- Make sure water flows into, and through the system during storms.
- Prevent or remove channelisation.
- Remove weeds and replace dead plants.
- Remove accumulated sediment, litter and debris.
- Remove clogged filtration material and replace with new material.
- Test filtration capacity if visible problem or every five years.
- Check drainage pipes.

Primary targets

- Fine-to-medium sediment
- Nutrients
- Organics
- Metals

On site

To operate successfully, the plants in a bioretention system need to be well-established and dense.

The plants need to be grouped close together so any runoff water will flood or seep through, rather than establishing little flow channels (known as rills) which might erode the surface. Mulch should prevent erosion.

Maintaining the health and density of vegetation is vital, particularly in the early stages. High-density planting will also ensure a uniform root zone in bioretention systems.

New plantings will need to be maintained for at least six months. Tasks include regular watering, weeding, replacing dead plants, monitoring and controlling pests, and removing rubbish.

Any scour at inlets needs to be monitored closely. Litter, debris and sediment can build up at inlet points. Litter and debris also need to be removed from surcharge pits.

Check overflow pits for structural faults. Check the pits are functioning properly.

If the fitration capacity is reduced significantly, the filter material should be replaced, along with new plants and mulch.

Maintenance costs

The Typical Annual Maintenance cost for a bioretention system is approximately five to seven per cent of the construction cost. Maintenance costs are likely to be higher in the first few years due to the intensive effort needed to establish the system.

The maintenance cost for mature bioretention systems is similar to swales: \$2.50/m^2 for grassed systems and \$9/m^2 for vegetated systems using native vegetation.

[Source: SWRPC (1991), Taylor & Wong (2002), The Centre for Watershed Protection (CWP, 1998) and US EPA (2001), Fletcher et al (2005).]].

STREET TREE PITS (Bioretention systems)

Main tasks

- Remove leaves, litter and fine sediment from surface.
- Remove caked sediment from surface.
- Prune tree as necessary.
- Test filtration capacity if visible problem, or every five years.

Primary targets

- Fine-to-medium sediment
- Nutrients
- Organics
- Metals
- Litter

On site

Street trees can be used as small-scale bioretention system in streetscapes where there is limited vegetation or landscaping for linear swales or larger-scale rain gardens. This is particularly relevant for town centres where space is limited and hard stand areas dominate the landscape.

Check the pits are functioning properly.

Check inlets for scour and sediment. Remove litter and debris.

Over time, the filter media will accumulate fine sediments. It should be replaced when its infiltration capacity is reduced significantly. If the filter material becomes clogged, the tree will be unable to thrive.

It is also important to check there is enough filter material in the tree pit.

Maintenance costs

The typical annual maintenance cost of a tree pit is five to seven per cent of the total construction costs.

INFILTRATION SYSTEMS

Main tasks

- Ensure pre-treatment is operating effectively.
- Maintain plants if present.

Primary targets

- Fine-to-medium sediment
- Nutrients
- Metals

On site

Infiltration systems differ from raingardens in that water infiltrates into the surrounding soil, rather than entering the piped stormwater systems. Infiltration systems may have plants or simply use an infiltration medium such as sand. The most important aspect of maintaining infiltration systems is to make sure the WSUD element used for pre-treatment is operating effectively.

Check that sediment is not clogging the system. Surfaces need to be cleared of debris and sediment periodically to maintain system functions.

Check the infiltration rates to make sure the system is functioning properly.

Maintenance costs

Typical Annual Maintenance costs for infiltration systems can range from approximately five to 20 per cent of the construction cost. There is a strong correlation between the Total Annual Maintenance cost and the total acquisition cost. Put simply, the more these systems cost to build, the more they cost to maintain.

[Source: The Centre for Watershed Protection (CWP, 1998) and US EPA (2001), Taylor & Wong (2002).]

ANNUAL MAINTENANCE COSTS

Until recently, detailed data about actual costs incurred by owners of these elements has not been available. We now have the results of a number of studies into maintenance costs. The costing estimates in this manual are the best that could be generated given the information available collected from around Australia. For some measures such as buffer strips, bioretention systems and infiltration systems, the data is very limited.

These estimates will be refined over time as local governments and developers record detailed costs involved in maintaining WSUD elements.

To minimise costs, managers could investigate the potential of working with community groups on maintenance tasks.

All figures and calculations used in this manual are derived from real data for maintenance costs loaded into the computer software called MUSIC (Model for Urban Stormwater Improvement Conceptualisation), developed by the CRC (Cooperative Research Centre) for Catchment Hydrology's Urban Stormwater Quality Program. The rates can also be found in the Users Guide to MUSIC at www.toolkit.net.au.

Table 2: Typical maintenance costs for various WSUD stormwater treatment devices.

Treatment devices	Typical annual maintenance (TAM) cost	Correlation
Constructed wetlands	TAM ($2004) = 6.831 x (A)0.6435	R2= 0.76; p< 0.01; n= 21
Vegetated swales	TAM ($2004) = 48.87 x (TAC)0.4407	R2= 0.94; p= 0.03; n= 4
Buffer strips	TAM ($2004) = 48.87 x (TAC)0.4410	R2= 0.94; p= 0.03; n= 4
Bioretention systems	TAM ($2004) = 48.87 x (TAC)0.4410	R2= 0.94; p= 0.03; n= 4
Ponds and sediment basins	TAM ($2004) = 185.4 x (A)0.4780	R2= 0.92; p= 0.04; n= 4
Infiltration systems	TAM ($2004) = 30.15 x (TAC) 0.4741	R2= 0.80; p= 0.04; n= 5

Note: the size/cost relationships for TAM, TAC and RC are derived from a combined data set involving vegetated swales, buffer strips and bioretention systems. There is insufficient data to analyse swales on their own.

A = surface area of treatment zone/ basin/ infiltration system in m2.

TAC = total acquisition cost.

R2 = explanation of variance

p = significance

n = number of samples p is derived from.

SEDIMENT BASINS maintenance checklist

INSPECTION ITEMS	YES	NO	ACTION NEEDED (details)
Is there litter within inlet or open water zones?			
Is there sediment in the inlet zone that needs removal? (Record depth. Remove if it fills >50% of basin.)			
Is the overflow structure integrity satisfactory?			
Is there evidence of dumping (building waste, oils, etc.)?			
Is the condition of terrestrial vegetation satisfactory (record density, weeds, etc.)?			
Are there weeds needing removal from within basin?			
Is there settling or erosion of bunds/batters?			
Is there damage or vandalism to structures?			
Is the outlet structure free of debris?			
Is the maintenance drain operational?			
Comments:			

Source: WSUD Engineering Procedures: Stormwater CSIRO 2005

PONDS maintenance checklist

INSPECTION ITEMS	YES	NO	ACTION NEEDED (details)
Is there litter within inlet or open water zones?			
Is there sediment within the inlet zone that needs removal? (Record depth. Remove if it fills >50% of basin.)			
Is the overflow structure integrity satisfactory?			
Is there evidence of dumping (building waste, oils etc.)?			
Is any replanting required?			
Does any of the submerged or floating vegetation need to be removed or harvested?			
Is there settling or erosion of bunds/batters?			
Is there damage or vandalism to structures?			
Is the outlet structure free of debris?			
Is the maintenance drain operational?			
Comments:			

Source: WSUD Engineering Procedures: Stormwater CSIRO 2005

CONSTRUCTED WETLANDS maintenance checklist

INSPECTION ITEMS	YES	NO	ACTION NEEDED (details)
Is sediment accumulating at inflow points?			
Is there litter within inlet or macrophyte zones?			
Is there sediment within the inlet zone that needs removal? (Record depth. Remove if it fills >50% of basin.)			
Is the overflow structure integrity satisfactory?			
Is there evidence of dumping (building waste, oils etc.)?			
Is the terrestrial vegetation in satisfactory condition? Record density, weeds, etc.			
Is replanting needed?			
Is there settling or erosion of bunds/batters?			
Is there evidence of isolated shallow ponding?			
Is there damage or vandalism to structures?			
Is the outlet structure free of debris?			
Is the maintenance drain operational?			
Does the system need to be reset?			
Comments:			

Source: WSUD Engineering Procedures: Stormwater CSIRO 2005

SWALES AND BUFFER STRIPS maintenance checklist

INSPECTION ITEMS	YES	NO	ACTION NEEDED (details)
Is sediment accumulating at inflow points?			
Is there litter within the swale?			
Is there erosion at inlet or other structures (eg, crossovers)?			
Has there been damage from traffic?			
Is there evidence of dumping (eg, building waste)?			
Is the vegetation in satisfactory condition (eg, density, weeds)?			
Is replanting needed?			
Is mowing needed?			
Is sediment accumulating at outlets?			
Are drainage points clogged? Record sediment or debris.			
Is there evidence of ponding?			
Is set down from the kerb still possible?			
Comments:			

Source: WSUD Engineering Procedures: Stormwater CSIRO 2005

RAINGARDENS maintenance checklist

INSPECTION ITEMS	YES	NO	ACTION NEEDED (details)
Is sediment accumulating at inflow points?			
Is there litter within the swale?			
Is there erosion at inlet or other structures (eg, crossovers)?			
Has there been damage from traffic?			
Is there evidence of dumping (eg, building waste)?			
Is the vegetation in satisfactory condition (eg, density, weeds)?			
Is replanting needed?			
Is mowing needed?			
Are drainage points clogged? Record sediment or debris.			
Is there evidence of ponding?			
Is set down from the kerb still possible?			
Is there damage or vandalism to structures?			
Is there visible surface clogging?			
Has the drainage system been inspected?			
Does the system need to be reset?			

Comments:

Source: WSUD Engineering Procedures: Stormwater CSIRO 2005

STREET TREE PITS maintenance checklist

INSPECTION ITEMS	YES	NO	ACTION NEEDED (details)
Is sediment accumulating at inflow points?			
Is there litter within the pit?			
Is there erosion at inlet or other structures?			
Has there been damage from traffic?			
Is there evidence of dumping (eg, building waste)?			
Is the vegetation in satisfactory condition?			
Is replanting needed?			
Is there evidence of ponding?			
Is there damage or vandalism to structures?			
Is there visible surface clogging?			
Has the drainage system been inspected?			
Does the system need to be reset?			

Comments:

Source: WSUD Engineering Procedures: Stormwater CSIRO 2005

A4

INFILTRATION SYSTEMS maintenance checklist

INSPECTION ITEMS	YES	NO	ACTION NEEDED (details)
Is there evidence of sediments accumulating in the pre-treatment zone? Does is need removal?			
Is there erosion at inlet or other structures?			
Is there evidence of dumping (eg, building waste)?			
Are there weeds present?			
Are drainage points clogged? Record sediment or debris.			
Is there damage or vandalism to structures?			
Is there visible surface clogging?			
Has the drainage system been inspected?			
Does the system need to be reset?			
Comments:			

Source: WSUD Engineering Procedures: Stormwater CSIRO 2005

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