WATER SENSITIVE SA

Water sensitive urban design (WSUD) assets

Inspection and maintenance guidelines

Biofilters

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Image: City of Unley

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This guideline has been adapted from:

- Blacktown City Council (2019) *Water sensitive urban design (WSUD) inspection and maintenance guidelines.* Developed with assistance from E2Designlab Pty Ltd. A previous version was developed with assistance from Alluvium Consulting Australia Pty Ltd.
- DesignFlow (2022) *Maintenance of WSUD assets* course material, prepared for Water Sensitive SA.
- Water by Design (2012) *Rectifying vegetated stormwater assets (Draft),* Healthy Waterways Ltd developed with assistance from DesignFlow, Brisbane.
- Melbourne Water (2013) *WSUD maintenance guidelines. A guide for asset managers.*
- Stormwater Victoria and E2DesignLab *(2017) WSUD audit guidelines.*

Contents

1 Asset description and functional components

Inspection and maintenance guidelines of biofilters must be read in conjunction with *Water sensitive urban design (WSUD) assets: Inspection and maintenance guidelines | Overview*

Biofilters

Biofilters (also referred to as bioretention systems or raingardens) are engineered garden beds that filter stormwater runoff through a vegetated filter medium (i.e. soil). Treatment of stormwater occurs as the water percolates through the system, where plant roots and microbes in the soil naturally process pollutants. Biofilters can be constructed as basins (in raised beds or planter boxes) or at ground level (swales or medians), and will have the same inspection and maintenance requirements.

Functional components

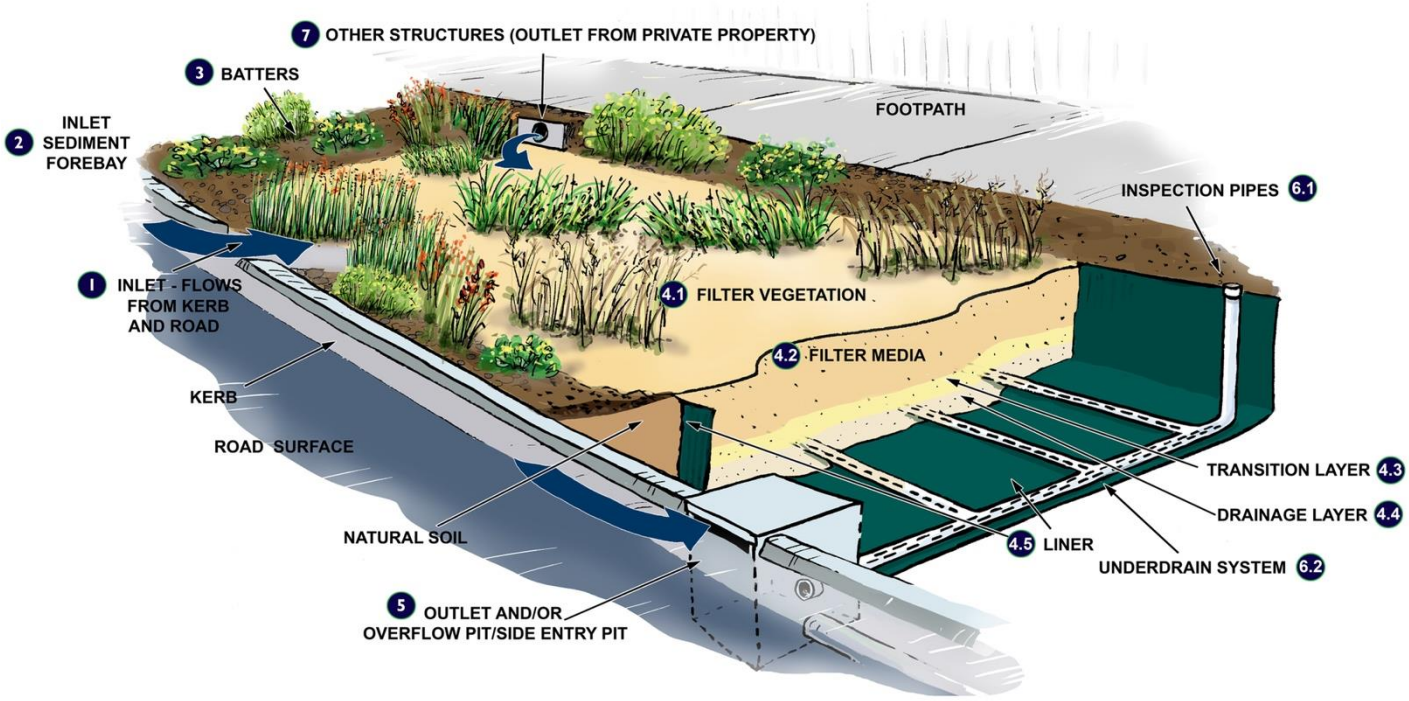

Figure 1.1 Schematic of conventional raingarden integrated into streetscape connected to standard kerb and channel showing key functional elements

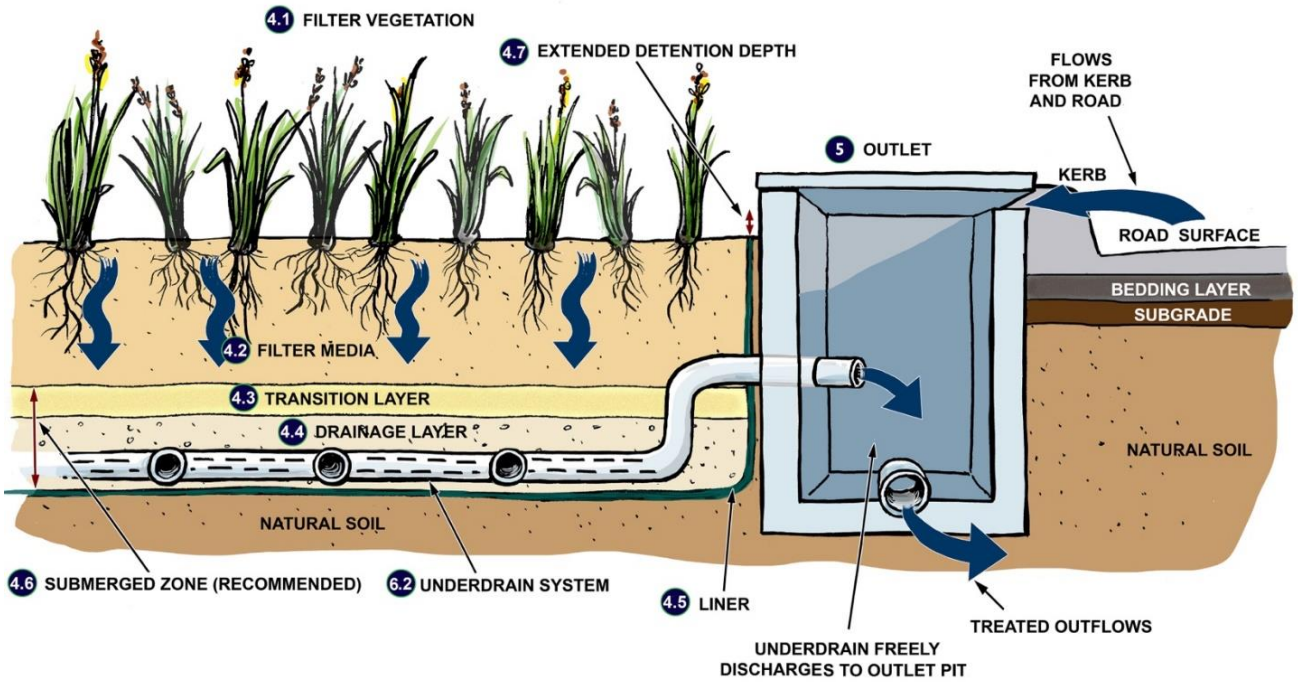

Figure 1.2 Cross section of submerged zone raingarden outlet control

Biofilters comprise the following functional components (Figures 1.1 and 1.2):

1. **Inlet** Conveys stormwater into the raingarden (generally a pipe or kerb cut).
2. **Inlet sediment forebay** Traps and prevents coarse sediment (>1mm) from entering the raingarden and accumulating on the surface of the filter media. Provides an easily accessible area for sediment collection. Can also dissipate inflows to prevent erosion of the filter media surface.
3. **Batters/batter vegetation (optional)** These connect the lower biofilter surface with the surroundings at a safe slope, i.e. grade 1:4 if possible. If this grade cannot be achieved, dense vegetation cover on the batters provides soil stability to prevent erosion, traps litter, and prevents unauthorised access to the raingarden. Alternatively, bioretention systems with steep or no batters may instead have small retaining walls.
4. Biofiltration zone

    4.1 **Filter vegetation** Healthy, actively growing plants are integral to pollutant removal processes and the long-term sustainability of the raingarden. Plants are also a critical component to maintain the infiltration capacity of biofilters. Refer to *A guide to raingarden plant species selection and placement*.

    4.2 **Filter media** Highly permeable sandy-loam mix that enables stormwater to infiltrate the raingarden, facilitates pollutant removal, and supports plant growth.

    4.3 **Transition layer** Clean washed sand that conveys water to the drainage layer while preventing the finer particles migrating from the filter media and clogging the drainage layer.

    4.4 **Drainage layer** Uniformly-sized coarse aggregate that allows the system to drain, either into an underdrain system and outflow point (for lined systems) or infiltration into surrounding soils.

    4.5 **Liner (preferred for South Australian conditions)** An impervious layer constructed of plastic (e.g. 1.5 mm HDPE), bentonite blankets or clay (e.g. 150-300mm of compacted clay of minimum $1x10^{-9}$m/s hydraulic conductivity), used to establish a submerged zone.

    4.6 **Submerged zone (recommended Adelaide/South Australian climate)** Saturated zone = transition layer + drainage layer. An impervious lining on the sides and base to store water between rainfall events with a nominal overall depth of 300-600mm. Designed to retain moisture in the soil for periods between rainfall events. The submerged zone, recommended to sustain raingarden vegetation in South Australian conditions, can improve nitrogen removal and may be beneficial to raingarden plants in drier summer months.

4.7 **Extended detention zone (often referred to as extended detention depth – EDD)** Space above the surface of the raingarden that fills with stormwater during rainfall events, typically 100-300mm above the surface of the system. This temporary stormwater storage provides increased storage volume and increases treatment capacity by allowing stormwater to pond before infiltration.

5. Outlet and/or overflow weir/pit Conveys excess flows away from the raingarden when the capacity of the extended detention zone is full. Generally a grated pit, side entry pit or weir structure. Underdrain pipes often discharge into an overflow pit. The invert level of the overflow structure is typically elevated 100-300mm above the biofilter surface.

6. **Inspection pipes and underdrains**

6.1 **Inspection pipe opening (flushing points)** Usually a capped, vertical PVC pipe for inspecting and cleaning the underdrain system.

6.2 **Underdrain system (required for lined systems)** Network of slotted pipes that convey treated stormwater that percolates through the filter media, from the base of the raingarden. These pipes generally drain to an outlet, then into local waterways or to a reuse storage. Raingardens in sandy soil may not require underdrains as infiltrated flows may discharge directly into the underlying soil.

7. **Other structures**, for example maintenance access ramp (optional, not shown), which is only present in large biofiltration systems, enables access to the sediment forebay for cleaning.

Note 1: Mulch: Rock or organic mulch is not recommended. Jute matting can be used to reduce erosion and weed growth; however, it is preferable to densely plant rather than use mulch.

Expertise required

Biofilter condition inspections can be undertaken by an asset owner. Depending on the outcomes of the inspection, further specialised assessment may be needed to understand the causes of some issues observed, such as clogging or plant loss.

Larger systems may require specialised equipment, such as a high-pressure hose and suction trucks to clean the underground pits and pipes.

During the establishment period, the vegetated components should be inspected more frequently than indicated in sheet ***02a: Condition assessment audit – descriptive reference sheet | Biofilters***, as additional maintenance may be required, e.g. supplementary watering.

2 Inspection and maintenance forms and activities

Routine inspection requirements typically involve:

- Check for sediment and debris build-up in inlets and outlets
- Check for sediment accumulation, litter and debris in filter media area
- Check for permanent bogging/pooled areas following rainfall events
- Check for evidence of erosion
- Check for evidence of preferential flow paths
- Check plant health and cover
- Monitor weed growth within the batters and filter media area
- Check for damage to inspection pipes, inlet and outlet structures, and other structures

Routine (proactive) maintenance requirements typically involve:

Activity	Frequency
▪ Clean blocked inlets and outlets	After significant rain events
▪ Remove litter and debris from the filter media area	After significant rain events
▪ Re-profile in minor eroded areas	As required
▪ Scrape surface crust (fine sediments) in filter media area	As required
▪ Prune plants	Every 8-12 weeks[1]
▪ Replant eroded areas of the batters and filter media area	As required
▪ Weed removal/targeted-use of herbicide	Every 2-3 weeks during high-growth season
▪ Replace damaged/missing inspection pipe caps	As required

[1] Fortnightly during high-growth season for high amenity sites

Rectification activities may involve:

- Re-configure the inlet or outlet structures so the outlet allows ponding over the entire surface of the biofiltration system.
- Enlarge or adjust the sediment forebay area or install additional sediment capture upstream of the asset
- Temporarily removing the vegetation, modifying the filter bed surface level, and re-establishing the vegetation.
- Amend the top 150-200mm of the filter media with organics, compost to increase water holding capacity and nutrients to support vegetation growth

Details of the routine inspection and maintenance activity to maintain the amenity of the biofilter or raingarden can be found in form

01: Inspection and maintenance sheet | Biofilters – routine (proactive)

Routine inspections include the performance of a condition assessment audit to inform asset management planning. The condition assessment score matrices are detailed in forms

02: Condition assessment audit – descriptive reference sheet | Biofilters

Rectification is required if there is a problem with WSUD asset function (e.g. the asset's ability to treat stormwater) that routine maintenance activities cannot address. This guide includes rectification activities to address common design or construction faults in biofiltration assets or other works to address assets that are no longer meeting their functional performance.

03: Rectification activity guide | Biofilters

Trouble shooting

Biofilters are complex systems and need condition assessment audits or major inspections at least every five years to ensure the asset is continuing to function as per the design. This type of audit focuses primarily on the hydraulic function of the biofilter and provides an opportunity to also monitor the routine inspection items. The major condition assessment audits must be conducted by a suitably skilled and experienced in-house WSUD practitioner or outsourced to a subject expert, as appropriate.

If the asset has ceased to perform as designed (e.g. infiltration rate is unacceptably low), guidelines to rectify the problem and return the asset to full functionality is provided in Form *03 – Rectification activity guide | Biofilters.*

01: Inspection & maintenance sheet | Biofilters – routine (proactive)

Date		**Purpose of visit**	**Rainfall conditions**
Location		☐ Routine inspection	☐ Rainfall today (_____mm)
Asset name		☐ Response to complaint	☐ Rainfall in last 3 days (__mm)
Asset ID		☐ Other (specify)	☐ No recent rainfall
Inspected by (name /company)			

INSTRUCTIONS

Prior to maintenance activities occurring, rate asset functional component condition score (from 0 to 5) as per the scoring system below and circle the relevant score.

If score = 0, generate Works Request to refer matter to relevant Council team to decommission the asset or investigate further.
If score = 1, no action is required.
If score = 2, action may be required in some circumstances.
If score = 3, undertake the necessary maintenance and record action taken in right hand side column.
If score = 4 or 5, generate Works Request to refer matter to relevant Council team for rectification works.

Scoring

0 – Asset has been decommissioned, no longer exists or was not able to be rated due to serviceability issues
1 – As new
2 – Working well, PI met
3 – Routine (proactive) maintenance required
4 – Major maintenance/minor rectification works required
5 – Major rectification required

Actions

If further action is required, raise a Works Request for relevant department.
Provide reason for 0 rating/not rated.

Functional component		Performance indicator (PI)	Existing condition score and action(s)
1		**Inlet**	
1a	Blockage	Limited blockage Limited standing water	0 1 2 3 4 5 ☐ Clear accumulated sediment or debris from inlet ☐ Other (provide details):
1b	Damage	Limited damage	0 1 2 3 4 5 ☐ Repair damaged inlet structure ☐ Replace damaged inlet structure ☐ Other (provide details):
1c	Erosion	Limited and localised erosion	0 1 2 3 4 5 ☐ Re-profile eroded areas ☐ Reinforce eroded areas ☐ Replant eroded areas ☐ Other (provide details):
2		**Inlet sediment forebays**	
2a	Blockage	Limited blockage Forebay <25% full of coarse sediment build-up	0 1 2 3 4 5 ☐ Clear accumulated sediment or debris from inlet sediment forebay ☐ Councils' compliance team to enforce erosion and sediment control of construction projects within catchment ☐ Other (provide details):

Functional component		Performance indicator (PI)	Existing condition score and action(s)
3		**Batters**	
3a	Erosion	Limited and localised erosion	0 1 2 3 4 5 ☐ Re-profile eroded areas ☐ Reinforce eroded areas ☐ Other (provide details):
3b	Plant health	Good plant health, free from disease and growing vigorously	0 1 2 3 4 5 ☐ Remove dead or diseased vegetation ☐ Replant dead or diseased areas **Information:** Only use approved plant species, refer to: ▪ Original design specifications, or if not available then ▪ Water Sensitive SA's *A guide to raingarden plant species selection and placement*. ☐ Irrigate stressed vegetation during extended dry periods ☐ Other (provide details):
3c	Plant cover	Good plant cover (80-90%)	0 1 2 3 4 5 ☐ Replant bare areas **Information:** Only use approved plant species, refer to: ▪ Original design specifications, or if not available then ▪ Water Sensitive SA's *A guide to raingarden plant species selection and placement*. ☐ Irrigate stressed plants during extended dry periods ☐ Other (provide details):
3d	Weeds	Limited weeds cover (<10%) No declared invasive weeds	0 1 2 3 4 5 ☐ Remove weeds by hand ☐ Treat weeds with steam, and return within a week to remove by hand ☐ Treat weeds that cannot be removed by hand with targeted-use herbicides **Information: Herbicides must be approved for use in proximity to waterways**. This will minimise potential impact on desirable species and reduce likelihood of chemical residue within soil profile or local waterways. ☐ Other (provide details):
3e	Litter and/or debris (larger than a soft drink can)	1 piece of litter and/or debris/4m^2 Limited impact on aesthetics	0 1 2 3 4 5 ☐ Remove all litter and/or debris **Information:** Contact with sharp objects is a risk when removing litter. All workers must follow WHS practices to reduce risk, including wearing personal protective equipment. Forks and tongs may be used to pick up litter. ☐ Other (provide details):
3f	Vehicle or pedestrian damage	Limited compaction	0 1 2 3 4 5 ☐ Loosen, and re-profile if required, top 100mm of compacted soil ☐ Replace damaged or lost batter plants with large rocks along edges of asset to discourage access ☐ Replace damaged or lost batter plants with bollards along edges of asset to discourage access ☐ Establish a preferred pedestrian route to minimise access to asset ☐ Other (provide details):

Functional component		Performance indicator (PI)	Existing condition score and action(s)
4		**Biofiltration zone**	
4a	Erosion	No erosion/channelisation of flows	0 1 2 3 4 5 ☐ Re-profile minor erosion, limiting damage to adjacent vegetation ☐ Place filter media in minor erosion areas (requiring <1m^3 soil) and re-profile affected area ☐ Place filter media to remediate moderate or significant erosion areas **Information:** If fill is required, refer to design specifications for details of appropriate filter media for biofilter. ☐ Other (provide details):
4b	Plant health	Healthy plants, free from disease and growing vigorously	0 1 2 3 4 5 ☐ Remove dead or diseased vegetation ☐ Replant dead or diseased areas **Information:** Only use approved plant species, refer to: ▪ Original design specifications, or if not available then ▪ Water Sensitive SA's *A guide to raingarden plant species selection and placement*. If bare areas represent >50% of raingarden area, refer to *02: Rectification activity guide | Biofilters*. ☐ To relieve vegetation stress due to lack of water during an extended dry period, especially if there has been more than 70 days of dry weather: ☐ irrigate vegetation ☐ top up submerged zone water level via inspection pipes to fill water storage ☐ Other (provide details):
4c	Plant cover	Good plant cover (80-90% or >6 plants/m^2)	0 1 2 3 4 5 ☐ Replant bare areas **Information:** Only use approved plant species, refer to: ▪ Original design specifications, or if not available then ▪ Water Sensitive SA's *A guide to raingarden plant species selection and placement*. If bare areas represent >50% of raingarden area, refer to *03: Rectification activity guide | Biofilters*. ☐ To relieve vegetation stress due to lack of water during an extended dry period, especially if there has been more than 70 days of dry weather: ☐ irrigate vegetation ☐ top up submerged zone water level via inspection pipes to fill water storage ☐ Other (provide details):
4d	Weeds	Limited weed cover (<10%). No declared invasive weeds	0 1 2 3 4 5 ☐ Remove weeds by hand ☐ Treat weeds with steam, and return within a week to remove by hand ☐ Treat weeds that cannot be removed by hand with targeted-use herbicides **Information: Herbicides must be approved for use in proximity to waterways**. This will minimise potential impact on desirable species and reduce likelihood of chemical residue within soil profile or local waterways. If weed ingress is a persistent problem (i.e. weed coverage is persistently >20%), refer to *03: Rectification activity guide | Biofilters*. ☐ Other (provide details):

Functional component		Performance indicator (PI)	Existing condition score and action(s)
4e	Litter and/or debris (larger than a soft drink can)	1 piece of litter and/or debris/4m^2 Limited impact on aesthetics	0 1 2 3 4 5 ☐ Remove litter and/or debris **Information:** Contact with sharp objects is a risk when removing litter. All workers must follow WHS practices to reduce risk, including wearing personal protective equipment. Forks and tongs may be used to pick up litter. ☐ Other (provide details):
4f	Leaf litter	Limited leaf litter (10-20%) Limited impact on aesthetics	0 1 2 3 4 5 ☐ Remove excessive leaf litter ☐ Other (provide details):
4g	Accumulated sediment (flow path impacts)	Limited accumulated sediment (<10% of surface) No impact on flows through system	0 1 2 3 4 5 ☐ Remove/scrape away clay and fine sediment from around plants **Information:** Dispose of sediment from site appropriately. ☐ Other (provide details):
4h	Surface levels (Annual)	Stormwater being distributed evenly No localised surface depressions Adequate fall from inlet to filter surface (>100mm)	0 1 2 3 4 5 ☐ Re-profile minor depressions or mounds and short circuit pathways, limiting damage to adjacent vegetation ☐ Re-profile moderate to significant depressions, mounds or short circuit pathways in filter media surface, ensuring a flat and even surface ☐ Remove excess filter bed material to re-set filter bed to correct level **Information:** Refer to design specifications to ensure correct surface levels are re-established with appropriate filter media for biofilter. This may involve temporarily removing vegetation, modifying filter bed surface level, and re-establishing vegetation. ☐ Other (provide details):
4i	Extended detention depth (typically 100-300mm) (Annual)	>75% of extended detention depth	0 1 2 3 4 5 ☐ Remove excess filter bed material to re-set the filter bed level to provide the correct extended detention depth, as specified on the Works as Executed plans ☐ Other (provide details):
4j	Permeability and clogging (Annual)	Filter media draining freely Small, isolated ponds of stagnant water Limited fine sediment accumulation or algae Limited surface crusting (<3mm depth) across <10% of filter area In wet conditions, surface ponding (100-300mm) following rainfall is drawn down over 1-2 hours after inflow to system has stopped In dry conditions, water poured on surface infiltrates through surface slowly, ponding clears within minutes	0 1 2 3 4 5 ☐ Loosen/till top 100mm of soil if area is covered in crust of silt and decomposed organic material **Information:** Presence of algae or moss may indicate persistent wetting (e.g. baseflows) or clogging and requires further investigation. ☐ Other (provide details):
5		**Outlet and/or overflow weir/pit**	
5a	Blockage	Limited blockage	0 1 2 3 4 5 ☐ Unblock outlet pipes ☐ Remove sediment from outflow areas ☐ Other (provide details):

Functional component		Performance indicator (PI)	Existing condition score and action(s)
5b	Damage	Limited damage	0 1 2 3 4 5 ☐ Repair damage to overflow weir ☐ Repair damage to overflow pit ☐ Repair damage to rock structures ☐ Other (provide details):
5c	Erosion	Limited and local erosion	0 1 2 3 4 5 ☐ Repair batter erosion caused by flow skirting weir crest ☐ Other (provide details):
6		**Inspection pipes and underdrains**	
6a	Damage (Annual)	Limited damage to aboveground inspection pipes Inspection pipes and underdrains have no visible impact on filter media integrity	0 1 2 3 4 5 ☐ Replace damaged inspection caps ☐ Replace damaged inspection pipe **Information:** Ensure water level within the inspection pipe is consistent with the system design's expected performance, given recent rainfall. ☐ Other (provide details:
7		**Other structures, e.g. handrails, bollards, access ramps, pits, pipes, kerbs, walls**	
7a	Damage to or removal of structure/s (Annual)	Limited damage	0 1 2 3 4 5 ☐ Repair damaged structure/s ☐ Replace significantly damaged or removed structure/s ☐ Other (provide details):

Waste and soil disposal general

Note: Waste and soil disposal procedures must adhere with South Australian EPA and local authorities' requirements.

Functional component		Inspection frequency (months)	Very good (condition score – 1)	Good – Performance indicator (PI) met (condition score – 2)	Fair (condition score – 3)	Poor (condition score – 4)	Very poor (condition score – 5)
1		**Inlet**					
1a	Blockage	3 (and after significant rain events)	No blockage	Limited blockage Limited standing water	Blockage causing minor bypass of flows or restricted inflows Minor amount of standing water	Blockage causing moderate bypass of flows or restricted inflows Moderate amount of standing water	Complete blockage causing total bypass of inflows Significant amount of standing water
1b	Damage	3 (and after significant rain events)	No damage	Limited damage	Minor damage	Moderate damage Minor risk to structural integrity of asset, public safety or asset function	Significant damage Moderate to significant risk to structural integrity of asset, public safety or asset function
1c	Erosion	3 (and after significant rain events)	No erosion	Limited and localised erosion	Minor erosion	Moderate erosion Minor risk to structural integrity of asset, public safety or asset function	Significant erosion Moderate to significant risk to structural integrity of asset, public safety or asset function
2		**Inlet sediment forebays**					
2a	Blockage	3 (and after significant rain events)	No blockage	Limited blockage Forebay <25% full of coarse sediment build-up	Blockage causing minor bypass of flows or restricted inflows Forebay 25-50% full of coarse sediment Evidence of standing water	Blockage causing moderate bypass of flows or restricted inflows and/or minimal damage Forebay 50-90% full of coarse sediment Standing water is draining very slowly	Complete blockage causing total bypass or restriction of inflows and/or significant damage Standing water is not draining

Functional component		Inspection frequency (months)	Very good (condition score – 1)	Good – Performance indicator (PI) met (condition score – 2)	Fair (condition score – 3)	Poor (condition score – 4)	Very poor (condition score – 5)
3		**Batters**					
3a	Erosion	3 (and after significant rain events)	No erosion	Limited and localised erosion	Minor erosion	Moderate erosion Minor risk to structural integrity of asset, public safety or asset function	Significant erosion Moderate to significant risk to structural integrity of asset, public safety or asset function
3b	Plant health	3	Excellent plant health	Good plant health, free from disease and growing vigorously	Fair plant health Minor signs of disease, pests, wilting in <10% of plants	Poor plant health Moderate signs of disease, pests, wilting in 10-25% of plants	Very poor plant health Significant signs of disease, pests, wilting in >25% of plants
3c	Plant cover	3	Excellent plant cover (>90%)	Good plant cover (80-90%)	Moderate plant cover (50-80%)	Poor plant cover (25-50%)	Very poor plant cover (<25%)
3d	Weeds	3	No visible weed cover No declared invasive weeds	Limited weed cover (<10%) No declared invasive weeds	Minor weed cover (10-20%) No declared invasive weeds	Moderate weed cover (20-40%), and/or declared invasive weeds present	Significant weed cover (>40%) and/or declared invasive weeds present
3e	Litter and/or debris (larger than a soft drink can)	3	No litter and/or debris	1 piece of litter and/or debris/4m^2 Limited impact on aesthetics	2-3 pieces of litter and/or debris/4m^2 Minor impact on aesthetics and/or causing visible blockage	4-5 pieces of litter and/or debris/4m^2 Moderate impact on aesthetics and/or causing significant visible blockage	Significant amount of litter and/or debris Significant impact on aesthetics and/or completely blocking flows
3f	Vehicle or pedestrian damage	3	No compaction or vandalism impacting system function	Limited compaction	Minor compaction	Moderate compaction Minor loss of structural integrity of asset	Significant compaction Moderate risk to structural integrity of asset, public safety or asset function

Functional component		Inspection frequency (months)	Very good (condition score – 1)	Good – Performance indicator (PI) met (condition score – 2)	Fair (condition score – 3)	Poor (condition score – 4)	Very poor (condition score – 5)
4	**Biofiltration zone**						
4a	Erosion	3 (and after significant rain events)	No erosion Flows evenly distributed across asset surface	No erosion/channelisation of flows	Minor erosion Minor risk to structural integrity of asset, public safety or asset function	Moderate erosion (e.g. short circuiting of flows) Moderate to significant risk to structural integrity of asset, public safety or asset function	Significant erosion (e.g. short circuiting of flows) Significant risk to structural integrity of asset, public safety or asset function
4b	Plant health	3	Excellent plant health	Good plant health, free from disease and growing vigorously	Fair plant health Minor signs of disease, pests, wilting in <10% of plants	Poor plant health Moderate signs of disease, pests, wilting in 10-25% of plants	Very poor plant health Significant signs of disease, pests, wilting in >25% of plants
4c	Plant cover	3	Excellent plant cover (>90%)	Good plant cover (80-90% or >6 plants/m^2)	Fair plant cover (50-80%)	Poor plant cover (25-50%)	Very poor plant cover (<25%)
4d	Weeds	3	No visible weeds No declared invasive weeds	Limited weed cover (<10%) No declared invasive weeds	Minor weed cover (10-20%) No declared invasive weeds	Moderate weed cover (20-40%) and/or declared invasive weeds present	Significant weed cover (>40%) and/or declared invasive weeds present
4e	Litter and/or debris (larger than a soft drink can)	3	No litter and/or debris	1 piece of litter and/or debris/4m^2 Limited impact on aesthetics	2-3 pieces of litter and/or debris/4m^2 Minor impact on aesthetics and/or causing visible blockage	4-5 pieces of litter and/or debris/4m^2 Moderate impact on aesthetics and/or causing significant visible blockage	Significant amount of litter and/or debris Significant impact on aesthetics and/or completely blocking flows
4f	Leaf litter	3	Insignificant amount of leaf litter (<10% of surface)	Limited leaf litter (10-20%) Limited impact on aesthetics	Minor amount of wet and decaying leaf matter (20-50%) Minor impact on aesthetics	Moderate amount of wet and decaying leaf matter (50-75%). Impacting vegetation growth Moderate impact on aesthetics	Significant amount of wet and decaying leaf matter (>75%) Suppressing vegetation growth Significant impact on aesthetics
4g	Accumulated sediment	3 (and after significant rain events)	No accumulated sediment	Limited accumulated sediment (<10% of surface)	Minor accumulated sediment (10-20% of surface)	Moderate accumulated sediment (20-50% of surface)	Significant accumulated sediment (>50% of surface)

Functional component		Inspection frequency (months)	Very good (condition score – 1)	Good – Performance indicator (PI) met (condition score – 2)	Fair (condition score – 3)	Poor (condition score – 4)	Very poor (condition score – 5)
4h	Surface levels	Annual	No surface depressions or mounds	Limited surface depressions or mounds	Minor number/size of surface depressions or mounds.	Moderate number/size of surface depressions or mounds, or preferential flow paths	Significant number/size of depressions or mounds, or preferential flow paths
			Base is flat with flows evenly distributed through asset surface	Base is mostly flat with flows evenly distributed through most of asset surface	Minor impact on flows through the asset (e.g. emerging signs of short circuiting)	Moderate impact on flows through the asset	Significant impact on flows through asset (e.g. short-circuiting of flows, blocking flows, limited flow distribution)
4i	Extended detention depth (typically 100-300mm)	Annual	Design extended detention depth available	>75% of extended detention depth available	50-75% of design extended detention depth available	<50% of design extended detention depth available	No extended detention depth available
				Adequate fall from inlet to filter surface (>100mm)	The fall from inlet to filter surface is 50-100mm	The fall from inlet to filter surface is 25-50mm	Filter surface is at same level or higher than inlet
4j	Permeability and clogging	Annual	Infiltration/hydraulic capacity of system is preserved No stagnant water ponding on surface	Filter media draining freely Small, isolated ponds of stagnant water	Drainage pattern indicates minor clogging Minor number of ponds of stagnant water	Drainage pattern indicates moderate clogging Moderate number of ponds of stagnant water within filter media area	Drainage pattern indicates significant clogging Significant volume of stagnant water over entire filter media area
			No fine sediment accumulation or visible surface crust, algae or moss on filter surface	Limited fine sediment accumulation or algae Limited surface crusting (<3mm depth) across <10% of filter media area	Minor levels of fine sediment accumulation or surface crusting (3-15mm depth) across <10-20% of filter media area	Moderate levels of fine sediment accumulation or surface crusting (15-20mm depth) across >20% of filter media area	Significant levels of fine sediment accumulation or extensive surface crusting (>20mm depth) across >20% of filter media area
					10-20% surface coverage of algae <10% surface coverage of moss	20-30% surface coverage of algae and/or moss	>30% surface coverage of algae and/or moss on filter surface
			In wet conditions, surface ponding (100-300mm) following rainfall is drawn down over <1 hour after inflow to system has stopped	In wet conditions, surface ponding (100-300mm) following rainfall is drawn down over 1-2 hours after inflow to system has stopped	In wet conditions, surface ponding (100-300mm) following rainfall is drawn down over 2-3 hours after inflow to system has stopped	In wet conditions, surface ponding (100-300mm) following rainfall remains for 3-5 hours after inflow to system has stopped	In wet conditions, surface ponding (100-300mm) following rainfall remains for >5 hours after inflow to system has stopped
			In dry conditions, water poured on surface infiltrates almost immediately	In dry conditions, water poured on surface infiltrates through surface slowly, ponding clears within minutes	In dry conditions, water poured on surface infiltrates through surface slowly, ponding clears within an hour	In dry conditions, water poured on surface infiltrates through surface slowly, ponding clears within hours	In dry conditions, water poured on surface ponds with minimal infiltration

Functional component		Inspection frequency (months)	Very good (condition score – 1)	Good – Performance indicator (PI) met (condition score – 2)	Fair (condition score – 3)	Poor (condition score – 4)	Very poor (condition score – 5)
5		**Outlet and overflow weir/pit**					
5a	Blockage	3 (and after significant rain events	No blockage	Limited blockage	Blockage causing minor obstruction of outflows	Blockage causing moderate obstruction of outflows	Blockage causing significant obstruction of outflows
5b	Damage	3 (and after significant rain events	No damage	Limited damage	Minor damage	Moderate damage Minor risk to structural integrity of asset, public safety or asset function	Significant damage Moderate to significant risk to structural integrity of asset, public safety or asset function
5c	Erosion	3 (and after significant rain events)	No erosion	Limited and localised erosion	Minor erosion	Moderate erosion Minor risk to structural integrity of asset, public safety or asset function	Significant erosion Moderate to significant risk to structural integrity of asset, public safety or asset function
6		**Inspection pipes and underdrains**					
6a	Damage	Annual	No damage to aboveground inspection pipes	Limited damage to aboveground inspection pipes	Minor damage to aboveground inspection pipes (e.g. piece missing from cover cap) Evidence of minor slumping of filter media in association with inspection pipes or underdrains	Moderate damage to aboveground inspection pipes (e.g. missing cover cap) Evidence of moderate slumping of filter media in association with inspection pipes and underdrains	Significant damage to aboveground inspection pipes allowing soil and debris to readily enter pipe Evidence of significant slumping of filter media in association with inspection pipes and underdrains
7		**Other structures, e.g. handrails, bollards, access ramps, pits, pipes, kerbs, walls**					
7a	Damage to or removal of structure/s	Annual	No damage	Limited damage	Minor damage	Moderate damage Minor risk to structural integrity of asset, public safety or asset function	Significant damage Moderate to significant risk to structural integrity of asset, public safety or asset function

03: Rectification activity guide | Biofilters

Rectification is required if there is a problem with function (e.g. the asset's ability to treat stormwater) that maintenance activities cannot address. Examples include:

- A design flaw, such as the levels of the hydraulic structures within the asset are not correct.
- Poor construction, such as an incorrectly placed soil or filter media.
- The collapse of a hydraulic structure.
- Mass plant failure.

Functional component		Rectification response and information
1		**Inlet**
1a	Blockage	**Response:** ▪ Investigate construction and land use activities further up catchment to identify source of excessive loads of sediment or organic matter
1c	Erosion	**Response:** ▪ Install energy dissipators at inlet ▪ Extend length of the apron at inlet ▪ Alter inlet structure to encourage even flow distribution from inlet to the rest of biofiltration system ▪ Re-configure high-flow bypass to ensure that high velocity and damaging flows are prevented from entering biofiltration system **Information:** Typically required after heavy rainfall.
2		**Inlet sediment forebays**
2a	Blockage	**Response:** ▪ Enlarge or adjust sediment forebay area or install additional sediment capture upstream of asset
3		**Batters**
3a	Erosion	**Response:** ▪ Direct lateral flows to small, rock-lined channels that feed down batters to the bioretention system ▪ Re-establish vegetation, using organic mesh, filter cloth or netting to stabilise batters during plant establishment ▪ Remediate soil (e.g. treat sodic soils with additives like gypsum) ▪ Replace batters top soil
3f	Vehicle or pedestrian damage	**Response:** ▪ Rectification works for structural issues to be undertaken immediately ▪ Replace damaged or lost batter plants with rocks, bollard or dense plant species along edges of asset to discourage access ▪ Create a preferred pedestrian route ▪ Install temporary protective barrier while vegetation establishes ▪ Re-profile filter surface if affected **Information:** Refer to Works as Executed plans for structural repairs specifications.
4		**Biofiltration zone**
4b	Plant health	**Benchmark:** Hydraulic conductivity <750mm/hour **Response:** ▪ If hydraulic conductivity of biofiltration system filter media exceeds 750mm/hour then: - amend top 150-200mm of filter media with organics, and compost to increase water holding capacity and nutrients to support vegetation growth - replace vegetation with drought-tolerant species, or - establish a temporary irrigation program
4d	Weeds	**Information:** Composition of plant species in biofilter may change over time and vary from original planting schedule. System should be left to reach its own balance of plant composition (excluding weeds) provided system is functioning as intended. If replanting is required, look at which species are performing well

Functional component		Rectification response and information
		Remove weeds before they flower and seed **Benchmark:** If plant density is <5 plants/m^2 or the vegetation cove is <80% it is likely that vegetation cover is too sparse, allowing weeds to establish **Response:** ▪ Replant to achieve a minimum plant density of 6-10 plants/m^2 ▪ Consider plant species that provide dense cover (e.g. ground covers) akin to a conventional garden bed and/or shade ▪ If weed source is from contaminated fill, replace with appropriate soils **Note:** Use of herbicides may compromise integrity and performance of filter medium. Categories of weeds can be found on the Weeds in South Australia website.
4h	Surface levels	**Response:** ▪ Remove excess filter bed material to re-set filter bed to correct level, or ▪ Re-profile filter surface to ensure a flat and even surface. This may involve temporarily removing vegetation, modifying filter bed surface level, and re-establishing vegetation **Information**: Filter media should be low enough to allow for adequate extended detention depth (typically 100-300mm), i.e. ensure the filter media is NOT filled up to invert level of inlet.
4i	Extended detention depth (typically 100-300mm)	**Response:** ▪ Remove overfilled material and re-level filter surface to include extended detention depth as specified on Works as Executed plans. This may involve temporarily removing vegetation, modifying filter bed surface level, and re-establishing vegetation. ▪ Re-configure inlet or outlet structures so outlet allows ponding over entire surface of the biofiltration system ▪ If grade across system is significant, convert to a terraced system **Information:** Depths of material should meet those specified in Works as Executed plans.
4j	Permeability and clogging	**Benchmark:** Minimum hydraulic conductivity as defined by ASTM F181506 is to be a minimum of 100mm/hour. Permeability and clogging of biofilter surface – in wet conditions, surface ponding (100-300mm) for biofilters following rainfall is drawn down over 3-5 hours after inflow to system has stopped. **Test:** ▪ Option 1 Simple: If filter media is clogged, confirm by scraping back surface of sediment to the filter media and filling void with water to see if it drains ▪ Option 2 Detailed**:** If filter media does not readily drain, investigate sediment sources and undertake an in-situ hydraulic conductivity testing at the surface, middle and bottom of filter media in accordance with *Practice Note1: In-situ Measurement of Hydraulic Conductivity*[1]. If testing finds that low hydraulic conductivity (<10mm/hr) is confined to surface, cause of ponding is most likely surface blinding **Note:** Hydraulic conductivity within most bioretention systems will decrease in first 12-15 months after plants have established but it should recover to within design range. **Response/solutions:** ▪ Enforce erosion and sediment control on construction sites within catchment ▪ If the problem is recurring, enlarge or adjust the sediment forebay area or install additional sediment capture upstream of asset **Information:** Refer to *Water Sensitive SA WSUD Standard Drawing* for best practice sediment forebay designs. ▪ For biofilters with >15mm of fine sediment over filter media, remove as much fine sediment as possible and rake or scarify surface – Note 1: Care should be taken not to rake too close to vegetation with developing roots – Note 2: If rock mulch is present, it may be necessary to remove mulch prior to scarifying (physically breaking up) filter media surface, as fine sediments often accumulate at bottom of rock mulch layer ▪ If algal growth is <10% of filter areas, remove algae by using a shovel to remove top layer of filter media, replace top layer of filter media and replant ▪ Allow existing plants to propagate to break up surface. If vegetation density is <4-6/m^2, plant rushes, grasses, ground covers and trees (if filter media depth is sufficient) to increase plant and root density ▪ If these solutions do not result in improved filtration (>50mm/hr) after 12 months, remove surface layer of sediment, re-install filter media to achieve design surface level and replant

[1] *Hatt B and Le Coustumer S (2008) Practice Note 1: In situ measurement of hydraulic conductivity in: Condition assessment and performance evaluation of bioretention systems. Facility for Advancing Water Biofiltration.*

Functional component		Rectification response and information
		For conditions that fall outside these parameters, refer to *Rectifying vegetated stormwater assets (Draft)* (Water by Design, 2012) for further guidance
5		**Outlet and overflow weir/pit**
5a	Blockage	**Response:** ▪ Unblock outlet pipes. Remove sediment from outflow areas **Information:** Waste must be transported to a waste facility that is appropriately licensed to accept such waste (if there is no opportunity for reuse on-site). A pit is considered a confined space, requiring safety equipment and training.
5b	Damage	**Response:** ▪ Repair damage to overflow pit grate ▪ Repair structural damage to overflow pit or weir, or reconstruct if installed at incorrect level to provide required extended detention
5c	Erosion	**Response:** ▪ To repair erosion around apron or concrete sill of outlet pit: – Dig out eroded sections of bioretention profile, including filter media, transition layer and drainage layer well beyond bounds of erosion. Remove concrete apron or spill. Install a layer of filter cloth to pit and extend it down side of pit into filter media to a depth of 300mm. Refer to *Construction and establishment guidelines: Swales, bioretention systems and wetlands (*Water by Design, 2010) for more information on this technique. – Replace drainage layer, transition layer and filter media in accordance with the *Construction and establishment guidelines: Swales, bioretention systems and wetlands (*Water by Design, 2010). ▪ To repair erosion from locations where flow is skirting weir where weir crest and grouted rock protection does not extend up batters – Reconstruct or modify weir crest to correct configuration – Extend concrete weir crest and grouted rock barriers at least 0.5m along top of batters to “key in” weir ▪ Re-establish vegetation **Information:** Typically required after heavy rainfall.
6		**Inspection pipes and underdrains**
6a	Damage	**Information:** Most underdrain pipes rarely need flushing and some underdrain systems are not connected to an outlet pit, which makes inspection and flushing impossible. Inspection openings are often covered by vegetation, and you may need to refer to Works as Executed plans to find their location. Underdrain pipes can be damaged if water jet is too strong. **Response (rectification):** ▪ Connect and seal underdrains into pit: – Locally excavate bioretention layers adjacent to pit using hand tools to uncover underdrains (dewatering with a pump may be required) – Cut holes into pit at correct level or at base of pit, provided pit base is at or below gravel drainage layer to ensure free drainage (review designs for correct level) – Allow excavated area to drain through holes into pit until it is dry – Connect underdrains into pit and seal around perimeter of underdrains with concrete, grouting or synthetic sealant – Place water in base of excavation to confirm underdrains are sealed – Replace drainage, transition and filter layers in accordance with approved design plans, and re-establish vegetation