Appendix C

Acceptable STF's

Bio-swales

Bio-swales are landscape elements designed to remove silt and pollution from surface runoff water. They consist of a swaled drainage course with gently sloped sides (less than six percent) and filled with filter strip, vegetation, compost and/or riprap.

Depending upon the geometry of land available, a bio-swale may have a meandering or almost straight channel alignment. Biological factors also contribute to the breakdown of certain pollutants.

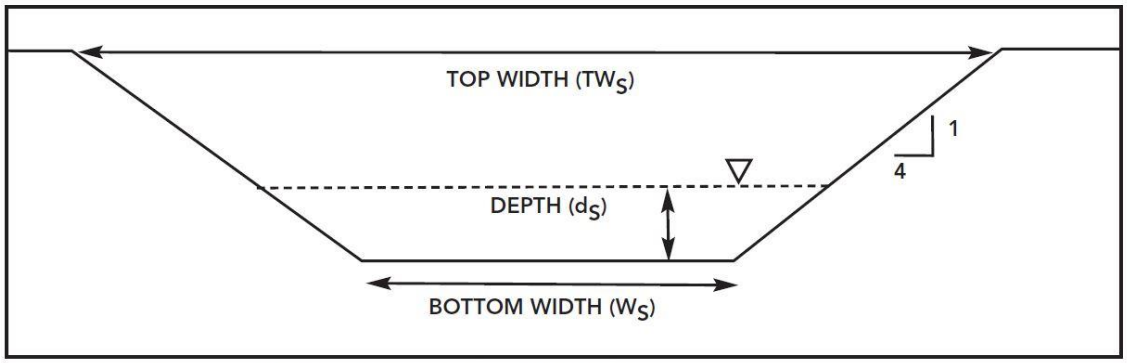


Figure 8-21 Trapezoidal Cross Section with 4:1 Side Slopes

*Drawing from Omaha Regional Stormwater Design Manual Chapter 8

**This drawing is only a template that needs to be adjusted and revised for each project.

MAINTENANCE REQUIRED WHEN:

- Erosion or bare soil is visible in the bottom of the swale or on side slopes.
- Standing water is visible after 24 hours.
- Vegetation is in poor condition or dead.
- Trash, debris and sediment have accumulated within the swale or in front of culverts or over catch basins outlets.
- Foul odor present.

ROUTINE MAINTENANCE:

- Sediment and Debris: Remove accumulated sediment and debris from the mulch or grass surface area of the vegetated infiltration swale.
- Outlet Structure: Keep culverts or drains within the vegetated infiltration swale free from blockage by sediment, debris, trash, mulch or plant material.
- Erosion and Scour: Repair soil erosion or scouring within the swale area or side slopes leading into the vegetated infiltration swale.
- Curb Cuts: Keep curb cuts to the vegetated infiltration swale free from blockage by sediment, debris and trash
- Weeds: Remove weeds and invasive plants from the vegetated infiltration swale.
- Vegetation Management: Inspect plant health seasonally to ensure vigorous growth. Prune plants, particularly shrubs and trees, during the dormant season (fall to early spring).
- Snow Removal: Do not pile or store snow within the vegetated infiltration swale as this will compact the specialized soils and add sediments that may lead to clogging.

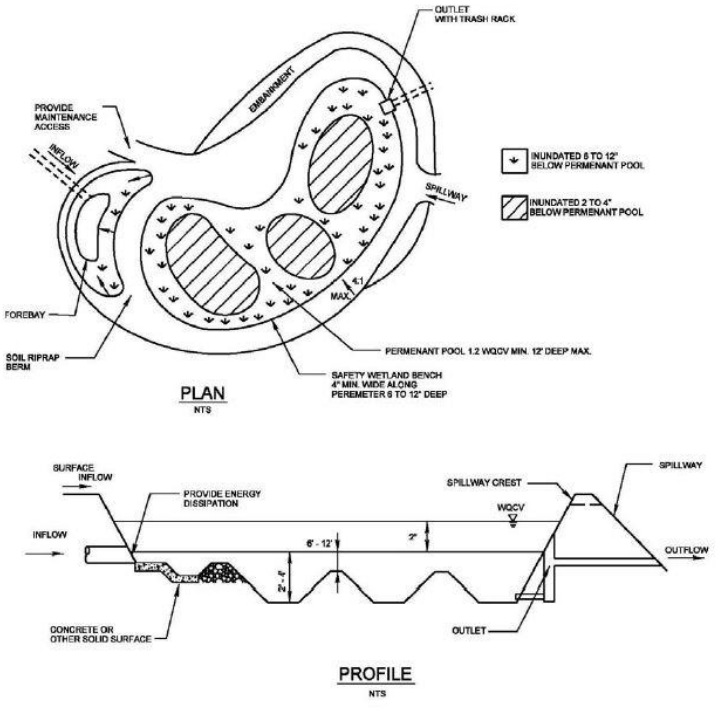
NON-ROUTINE MAINTENANCE:

- Plant Replacement: Replace diseased or dying plants.
- Ponding Water: If ponding water occurs beyond the precipitation event, contact your local community stormwater manager for further consultation.
- Specialized Soil Replacement: Clogging of the specialized soil by fine sediments may require complete replacement of the specialized soil, mulch and plant materials.
- Underdrain Flushing: Some vegetated infiltration swales are constructed with perforated underdrain pipes that drain the infiltration swale's specialized soils. If the underdrains become clogged with fine sediments they may need to be flushed with special equipment or replaced.

Sediment Forebays

A sediment forebay is a settling basin or plunge pool constructed at the incoming discharge points of a stormwater BMP. The purpose of a sediment forebay is to allow sediment to settle from the incoming stormwater runoff before it is delivered to the balance of the BMP. A sediment forebay helps to isolate the sediment deposition in an accessible area, which facilitates BMP maintenance efforts.

FIGURE 8.2 CONSTRUCTED WETLAND



Constructed Wetland - Plan and Cross Section

*Drawing used from the Lincoln Stormwater Best Management Practices Chapter 8

**This drawing is only a template that needs to be adjusted and revised for each project.

MAINTENANCE REQUIRED WHEN:

- Erosion is visible into the forebay.
- Sediment depth marker is no longer visible.
- Sediment is clogging the outfall inlet from properly receiving stormwater.
- Foul odors are present.
- Flooding is taking place after/during a rain event.

ROUTINE MAINTENANCE:

- Adequate access: Must be provided for inspection, maintenance, and landscaping upkeep, including appropriate equipment and vehicles. It is *Recommended* that a maintenance right of way or easement extend to ponds from a public or private road.
- Sediment Removal: It is *Highly Recommended* that sediment removal in the forebay and permanent pool occur every 2 to 7 years or after 50 percent of total forebay or permanent pool capacity has been lost. In areas where road sand is used, an inspection of the forebay and permanent pool should be scheduled after the spring melt to determine if clean-out is necessary.
- Periodic mowing: *Highly Recommended* to mow along maintenance rights-of-way and the embankment. The remaining buffer can be managed as a meadow (mowing every other year), prairie, or forest.

NON-ROUTINE MAINTENANCE:

- Draining: Care should be exercised while draining the pond to prevent rapid release and minimize the discharge of sediments or anoxic water. The approving jurisdiction should be notified before draining a pond.
- Maintenance Timing: It is *Highly Recommended* that the Operation and Maintenance plan include a provision to lower the level of the permanent pool in the late fall, to provide additional retention storage for snowmelt runoff and ensure that some permanent pool storage is available above the ice (the permanent pool should not be completely eliminated nor allowed to freeze through completely).

Rain Gardens

A **rain garden** is a planted depression or a hole that allows rainwater runoff from impervious urban areas, like roofs, driveways, walkways, parking lots, and compacted lawn areas, the opportunity to be absorbed. Rain gardens can cut down on the amount of pollution reaching creeks and streams by up to 30%.

Plant selection

Plants selected for use in a rain garden should tolerate both saturated and dry soil. Using native plants is generally encouraged. This way the rain garden may contribute to urban habitats for native butterflies, birds, and beneficial insects.

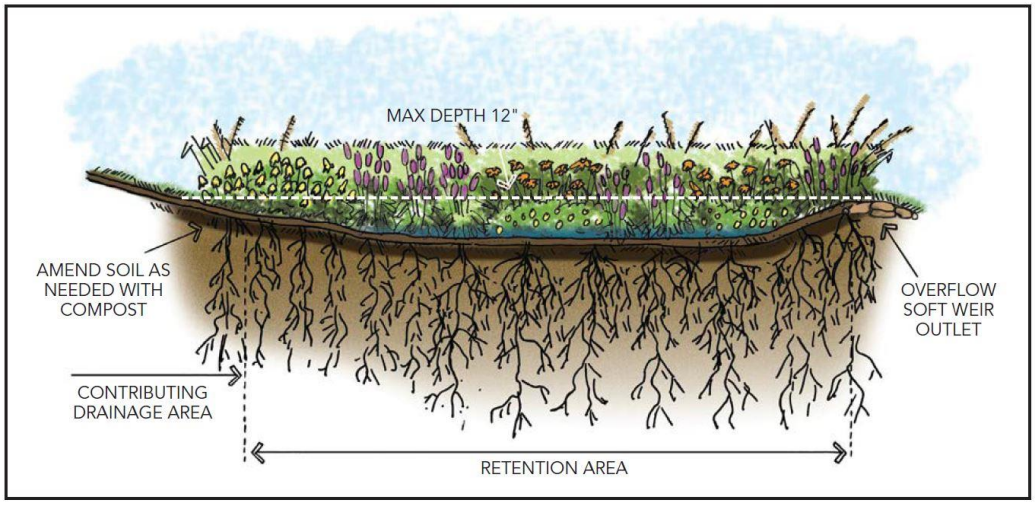


Figure 8-7 Rain Garden Cross Section

*Drawing from Omaha Regional Stormwater Design Manual Stormwater Best Management Practices Chapter 8
**This drawing is only a template that needs to be adjusted and revised for each project.

MAINTENANCE REQUIRED WHEN:

- Standing water is visible 24 hours after a rain event.
- Erosion is visible within the rain garden, on the slopes and inlets leading into the rain garden, or on the berm if present.
- Vegetation, sediment or debris blocking inlets or is excessively present in rain garden.
- Vegetation is wilting, discolored, or dying.
- Foul odors present.
- Mulch cover is inadequate.

ROUTINE MAINTENANCE:

- Sediment and Debris: Remove accumulated sediment and debris from the mulch layer of the rain garden.
- Erosion and Scour: Repair soil erosion or scouring within the rain garden or side slopes leading into the rain garden.
- Mulch: Maintain a 2 to 3-inch depth of hardwood bark mulch layer within the rain garden. If an excessive depth of mulch exists, remove mulch until the mulch layer is 2 to 3 inches in depth.
- Curb Cuts: Keep curb cuts to rain garden free from blockage by sediment, debris and trash.
- Weeds: Remove weeds and invasive plants from rain garden.
- Vegetation Management: Inspect plant health seasonally to ensure vigorous growth. Prune plants, particularly shrubs and trees, during the dormant season (fall to early spring).
- Snow Removal: Do not pile or store snow within the rain garden as this will compact the specialized soils and add sediments from snow melt that may lead to clogging.

NON-ROUTINE MAINTENANCE:

- Plant Replacement: Replace diseased or dying plants.
- Ponding Water: When ponding continues beyond a 24-hour period, contact your local community stormwater manager for further consultation.
- Specialized Soil Replacement: Clogging of the specialized soil by fine sediments may require complete replacement of the specialized soil, mulch and plant materials.

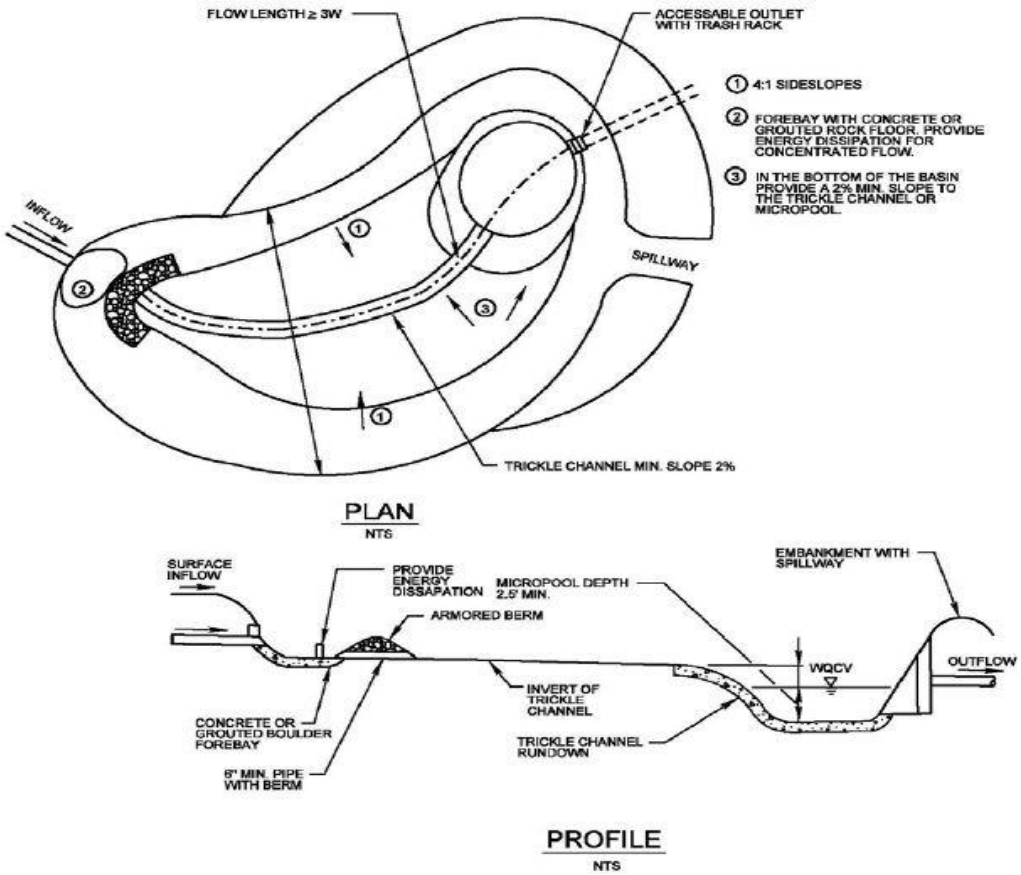
Regional Detention (Dry) Cells

A **Regional Infiltration Detention Cell,** also referred to as an **Extended Dry Detention Basin,** is a vegetated depression located on the site that is designed to collect, store, and infiltrate runoff. Typically includes a mix of amended soils and vegetation. The idea is to hold back the stormwater runoff from reaching the watershed, allowing infiltration and provide treatment. An extended dry detention basin can limit downstream erosion and control of some pollutants such as suspended solids.

Vegetation

Native vegetation should be used to reinforce all earthen structures and be planted along the basin perimeter to prevent erosion. Using vegetation at the inlet will also filter incoming runoff and may reduce inlet velocities. Vegetation surrounding the outlet may serve to reduce runoff impacts on downstream areas so long as it does not promote clogging of the outlet structure.

FIGURE 8.3 EXTENDED DETENTION BASIN



*This image is from the City of Lincoln's Stormwater Best Management Practices Manual Chapter 8

**This drawing is only a template that needs to be adjusted and revised for each project.

MAINTENANCE REQUIRED WHEN:

- Standing water is visible 24 hours after a rain event.
- Outlet is blocked by trash, debris or vegetation.
- Erosion within the emergency spillway, or blocked by debris.
- Erosion of side slopes or dam portion of pond.
- Low flow orifice, forebay, and micro pool are blocked by trash, debris, or sediment.
- Excessive (wetland) vegetation growing within dry pond area.
- Animal burrows within dam portion or side slopes of pond.
- Trees growing on the dam.
- Foul odors present.

ROUTINE MAINTENANCE:

- Outlet Structures: Keep outlets such as principle spillway pipe, water quality orifice pipe and emergency spillway free from blockage by sediment, debris, or trash.

- Dam/Embankment: Mow grassed dam and embankment of dry pond to prevent establishment of woody vegetation.
- Erosion and Scour: Repair soil erosion or scouring on the side slopes leading into the dry pond or within the bottom or forebay of the dry pond.
- Vegetation Management: Remove woody vegetation from ponding area of dry pond.
- Sediment and Debris: Remove accumulated sediment, debris and trash from the dry pond forebay, low flow channel and ponding area. Remove sediments when accumulation reaches 6 inches in depth.

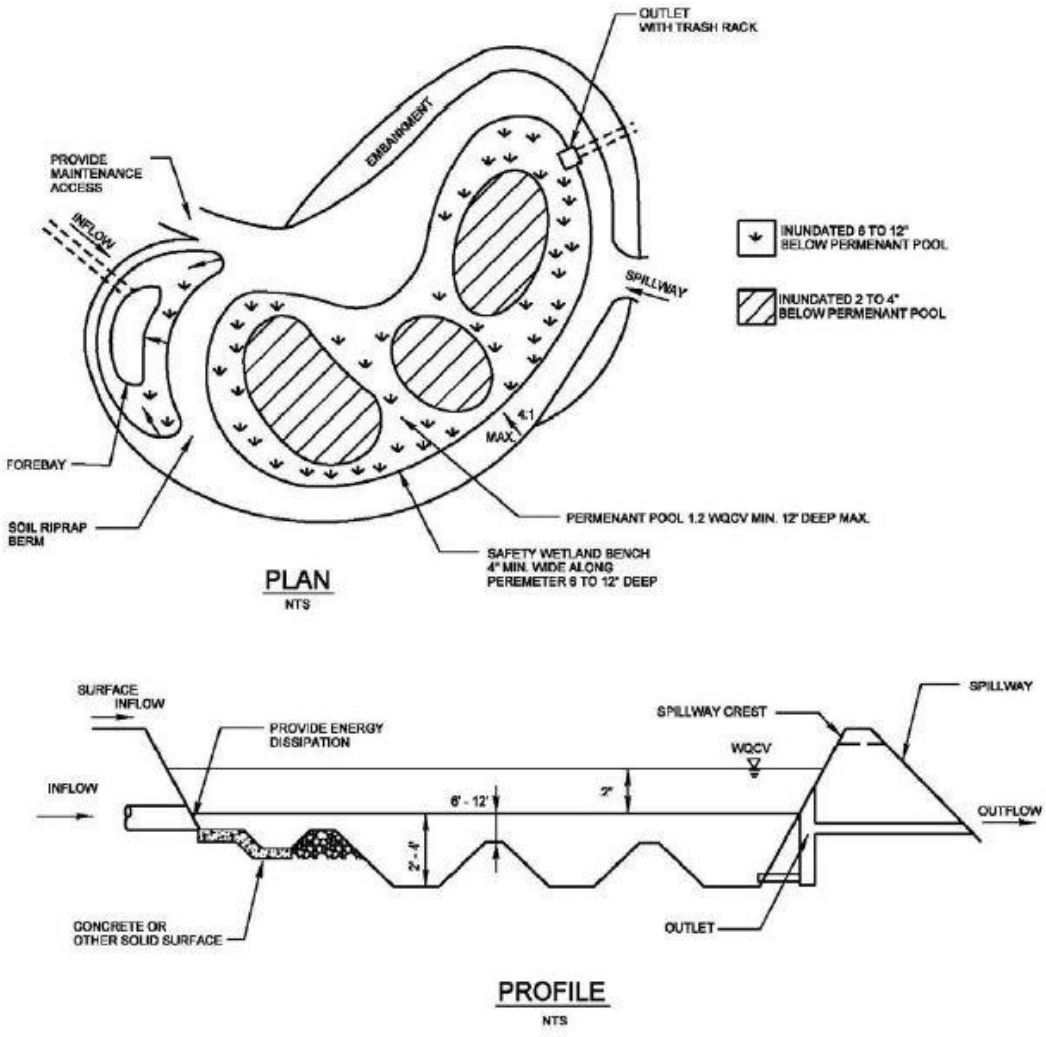
NON-ROUTINE MAINTENANCE*:*

- Excessive Sediment: Remove sediment accumulation from the ponding area prior to 25 percent of the ponding storage volume being lost within the dry pond.
- Invasive Vegetation: Treat and remove invasive vegetation from ponding area, side slopes and emergency spillway.
- Outlet Structure: Repair or replace damaged outlet structure.
- Erosion Protection: Repair or replace riprap or stone protection at pipe inlets, pipe outlets or emergency spillway.
- Dam/Embankment: Seek professional consultation if seepage or leaks appear during ponding or erosion is discovered on the dam or embankment of the dry pond.

Regional Retention (Wet) Cell

The main design difference between a dry detention cell and a wet retention cell is if it has a continuous pool of water- such as a “pond”. The location of the low flow orifice determines the level of the water. Usually, the orifice is part of a riser that is concrete structure. Retention cells have an orifice that is at a higher position than a detention cell, therefore not allowing constant drainage.

FIGURE 8.2 CONSTRUCTED WETLAND



Constructed Wetland - Plan and Cross Section

*Drawings from the Omaha Regional Stormwater Design Manual Chapter Stormwater Best Management Practices 8
**This drawing is only a template that needs to be adjusted and revised for each project

MAINTENANCE REQUIRED WHEN:

- Outlet is blocked by trash, debris or vegetation.
- The emergency spillway is blocked by debris or has signs of erosion.
- Erosion of dam, embankment or side slopes of pond.
- Low flow orifice, forebay, and micro pool are blocked by trash, debris, or sediment.
- Dam or embankment shows signs of visible water seepage.
- There are animal burrows within dam, embankment or side slopes of pond.
- Woody vegetation is growing on the dam.
- Foul odors present.
- Pond depths have been significantly reduced due to sediment accumulation.
- Algae blooms covering over 1/3 of pond surface area occur in the summer.
- Beavers are present in the basin.

ROUTINE MAINTENANCE:

- Outlet Structures: Keep outlets such as principal spillway pipe, water quality orifice pipe and emergency spillway free from blockage by sediment, debris, or trash.
- Dam/Embankment: Mow grassed dam and embankment of wet pond to prevent establishment of woody vegetation.
- Erosion and Scour: Repair soil erosion or scouring on the side slopes leading into the wet pond.
- Vegetation Management: Remove vegetation from at least 10 feet away from the outlet structure.
- Sediment and Debris: Remove accumulated sediment, debris and trash from the wet pond forebay and ponding area. Remove sediments when the pool volume has become significantly reduced or the pond begins to become eutrophic.

NON-ROUTINE MAINTENANCE:

- Excessive Sediment: Remove sediment accumulation from the forebay and ponding area prior to 25 percent of the ponding storage volume being lost within the wet pond.
- Invasive Vegetation: Treat and remove invasive vegetation from ponding area, side slopes and emergency spillway.
- Outlet Structure: Repair or replace damaged outlet structure.

- Erosion Protection: Repair or replace riprap or stone protection at pipe inlets, pipe outlets or emergency spillway.
- Dam/Embankment: Seek professional consultation if seepage, leaks or erosion is discovered on the dam or embankment of the wet pond.

Underground Detention

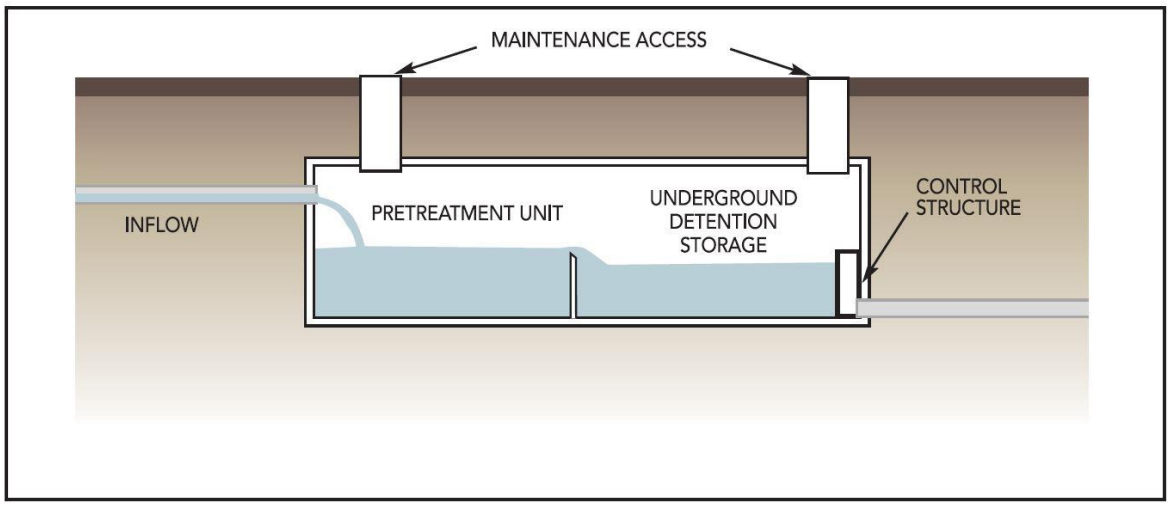


Figure 8-30 Example of Manufactured Storage System

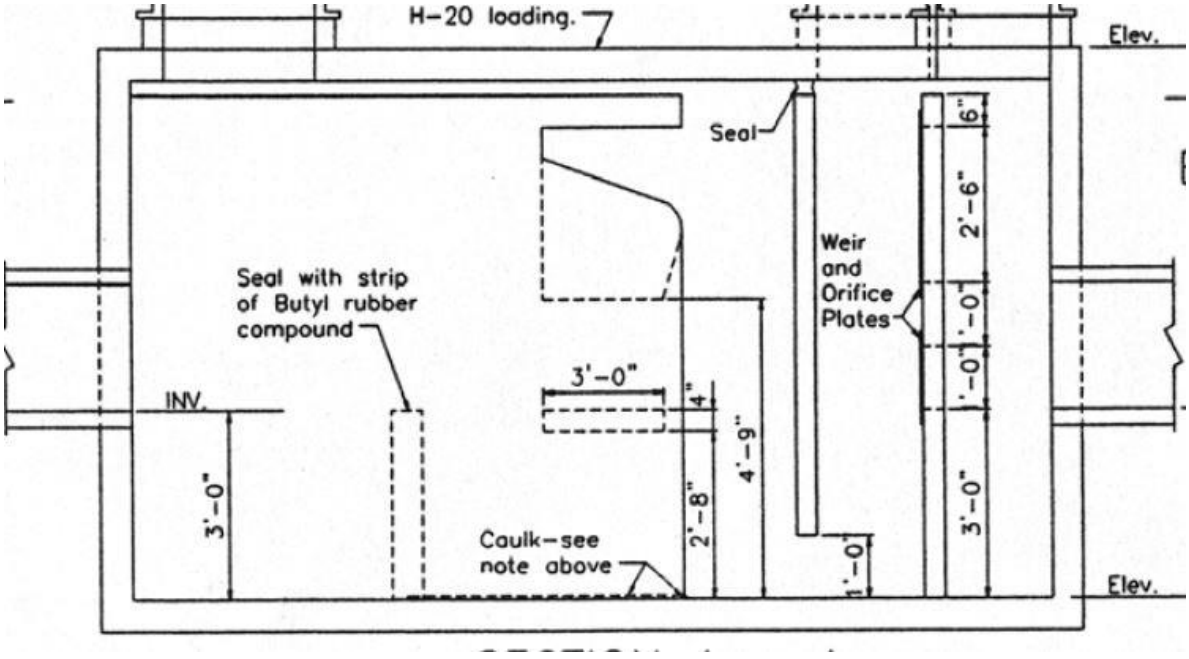


*Image created by the Omaha Regional Stormwater Design Manual Stormwater Best Management Practices Chapter 8
**This drawing is only a template that needs to be adjusted and revised for each project.

MAINTENANCE REQUIRED WHEN:

- Ponding on surface area draining to system.
- Sediment and debris have accumulated at the inlets or outlets of system.
- There is visible damage to the inlets or outlets.
- Inspection of pipes or chambers through inspection port (if present) using a flashlight and stadia rod reveal sediment accumulation that exceeds design criteria.

❖ Do not enter underground detention manholes to inspect system unless Occupational Safety & Health Administration (OSHA) regulations for confined space entry are followed.

❖ Follow inspection and maintenance instructions and schedules provided by system manufacturer and installer.

ROUTINE MAINTENANCE:

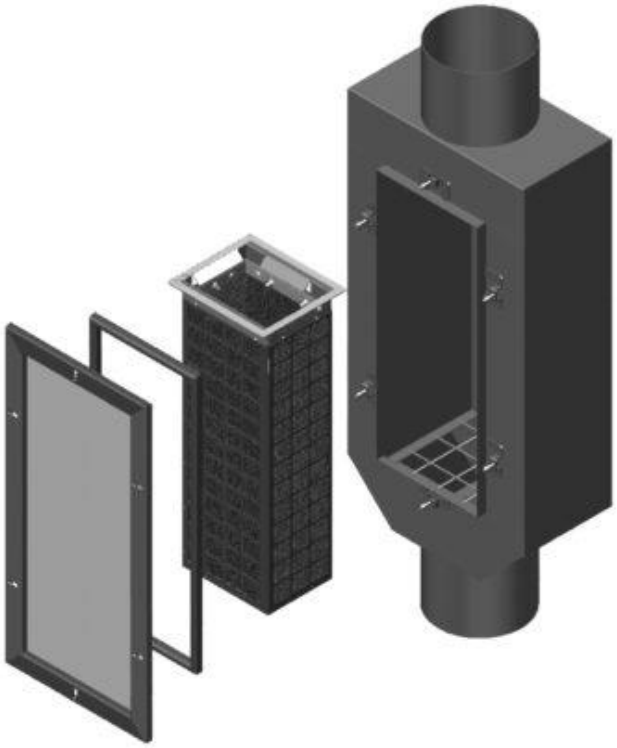
- Sediment and Debris: Remove accumulated sediment, debris and trash from inlets, detention chambers and outlets per manufacturer's specifications.
- Erosion and Scour: Repair soil erosion or scouring at the outlet(s) of the underground detention if overflow is discharged onto ground surfaces.
- Inspection Port: Inspect the monitoring well or inspection port to ensure access by qualified personnel to determine if accumulation of sediment and debris within detention chambers requires removal per manufacturer's specifications.

NON-ROUTINE MAINTENANCE:

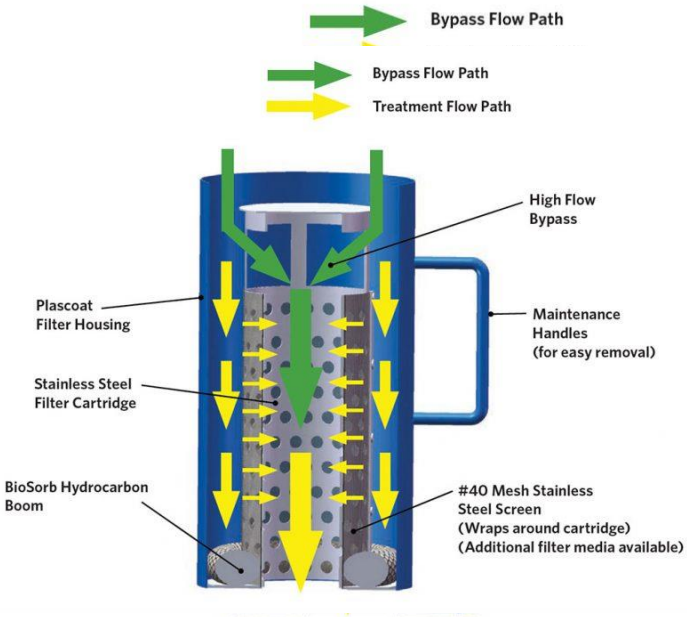
- System Component Repair: Repair or replace damaged system components based on manufacturer's specifications.

* Do not enter underground detention manholes to inspect system unless Occupational Safety & Health Administration (OSHA) regulations for confined space entry are followed.
* Follow inspection and maintenance instructions and schedules provided by system manufacturer and installer.
* Properly dispose of all wastes.

Downspout Filters



*https://oldcastleinfrastructure.com/product/flogard-plus-downspout-filter/



* https://biocleanenvironmental.com/downspout-filter/

**These drawings only represent examples of the types of downspout filters available.

MAINTENANCE REQUIRED WHEN:

- Empty collection basket when filled with debris.
- Ensure adequate connection into and out of filter.
- Replace filter as described by manufacturer.

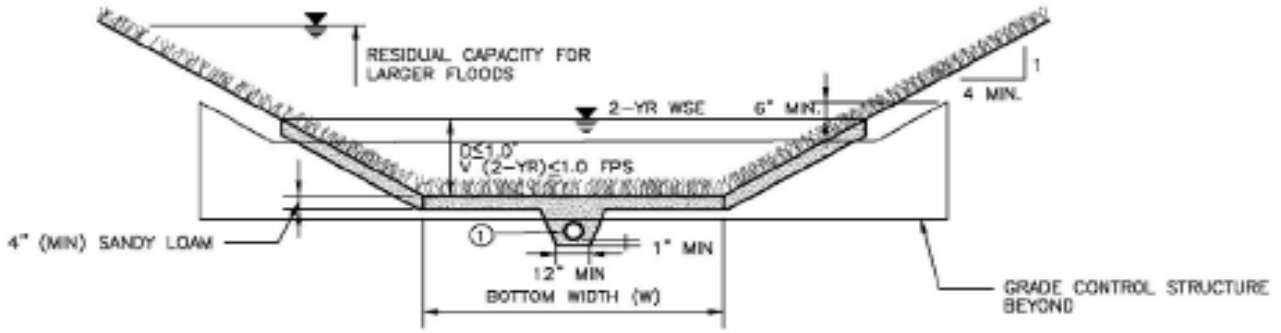
ROUTINE MAINTENANCE:

- Filter Net Inspection: Routinely inspect the filter/collection net to ensure it is not clogged. Empty as needed.
- Connection: Inspect connection to existing downspout for proper efficiency of STF.

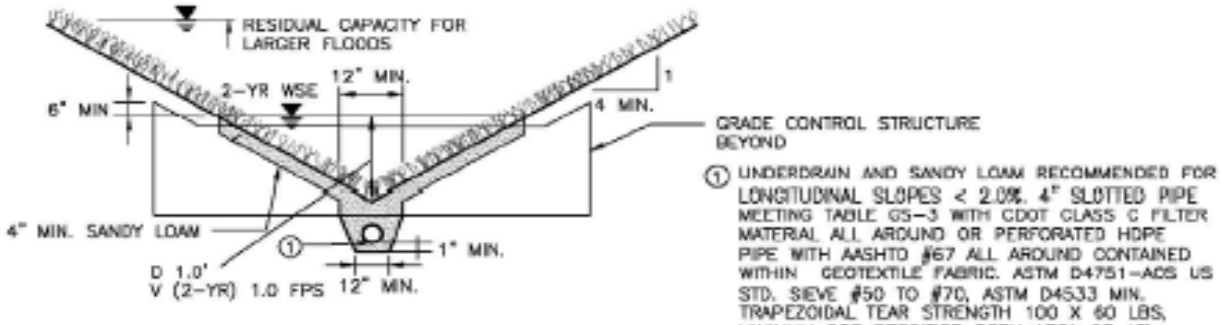
NON-ROUTINE MAINTENANCE:

- Frequency of maintenance: Depends on the conditions of the site and performance of the system.

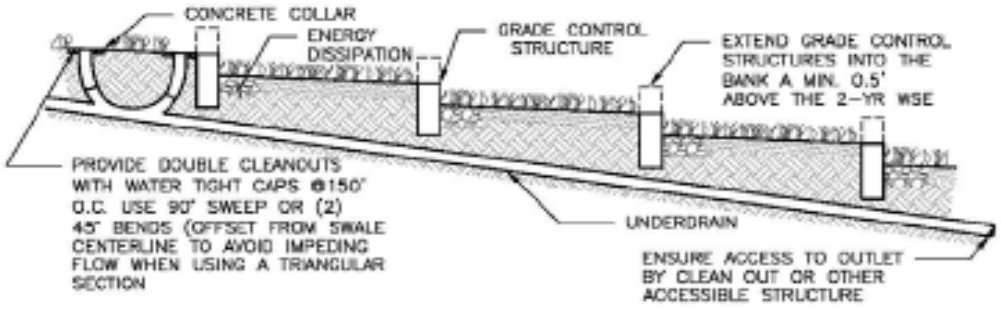
Grass Swale



TRAPEZOIDAL SWALE SECTION
NTS



TRIANGULAR SWALE SECTION
NTS



SWALE PROFILE
NTS

*Drawings courtesy of UDFCD Urban Storm Drainage Manual Volume 3 Chapter 4
**This drawing is only a template that needs to be adjusted and revised for each project.

MAINTENANCE REQUIRED WHEN:

- Erosion is visible within the grass swale.
- Standing water is visible 24 hours after rain event.
- Native grass species are not germinating, discolored, wilting, or dying.
- Four odors present.

ROUTINE MAINTENANCE:

- Sediment and Debris: Remove accumulated sediment, debris and trash from inlets, detention chambers and outlets per manufacturer's specifications.
- Erosion and Scour: Repair soil erosion or scouring at the outlet(s) of the underground detention if overflow is discharged onto ground surfaces.
- Prune and Weed: Cut back and remove previous year's plant material and remove accumulated leaves if needed.

NON-ROUTINE MAINTENANCE:

- Replace Vegetation: When coverage falls below 90%, consult with horticulturist if vegetation suffers for no apparent reason and/or test soil as needed.
- Repair Check Dams: If structural damage is apparent at inlet/outlet structure or check-dams.

Filter Strips

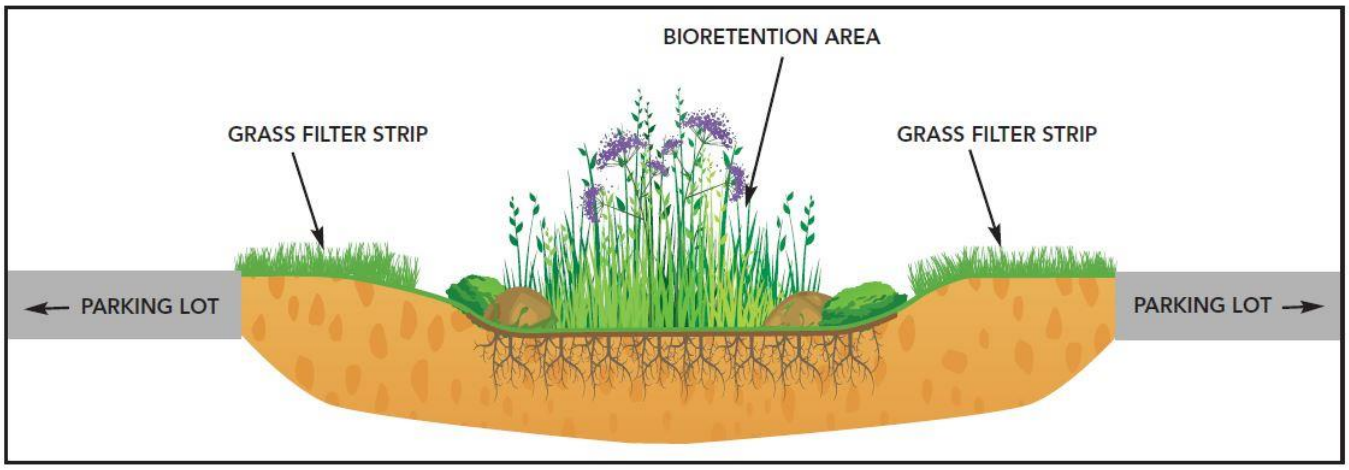


Figure 8-22 Grass Filter Strip Used for Pretreatment

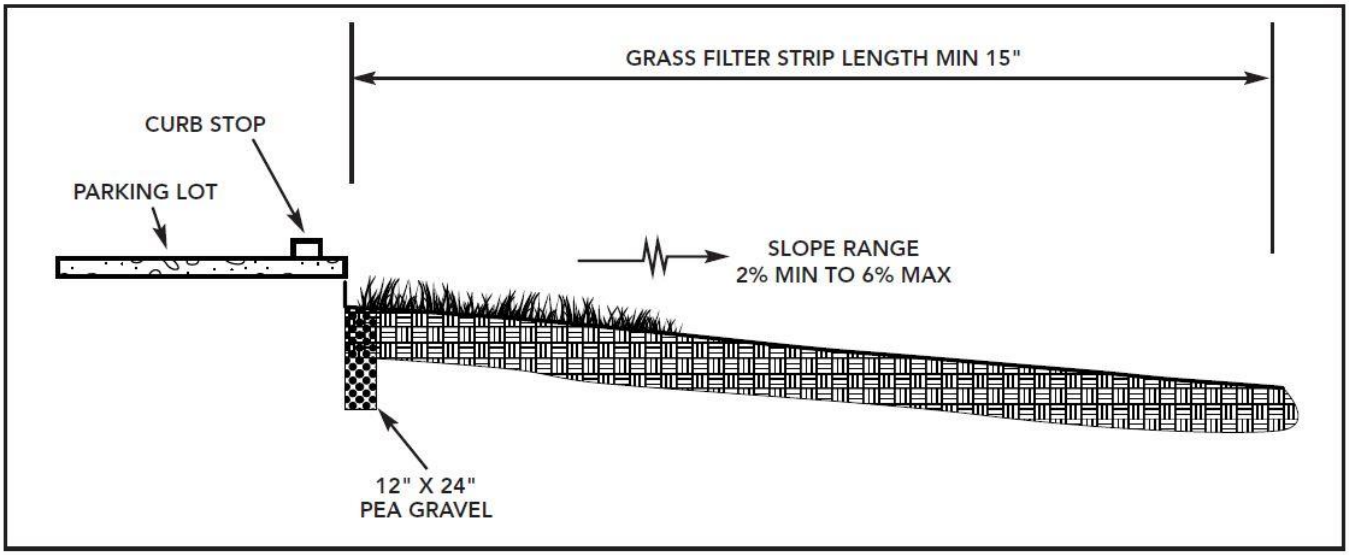


Figure 8-23 Grass Filter Strip Profile (Source Claytor and Schueler, 1996)

*Images from Omaha Stormwater Drainage Manual Stormwater Best Management Practices Chapter 8

**This drawing is only a template that needs to be adjusted and revised for each project.

MAINTENANCE REQUIRED WHEN:

- Standing water is visible 24 hours after a rain event.
- Erosion is visible within the filter strip, on the slopes and inlets leading into the filter strip, or on the berm if present.
- Vegetation, sediment or debris blocking inlets or is excessively present in filter strip.
- Vegetation is overgrown, wilting, discolored, or dying.
- Foul odors present.
- Mulch cover is inadequate.

ROUTINE MAINTENANCE:

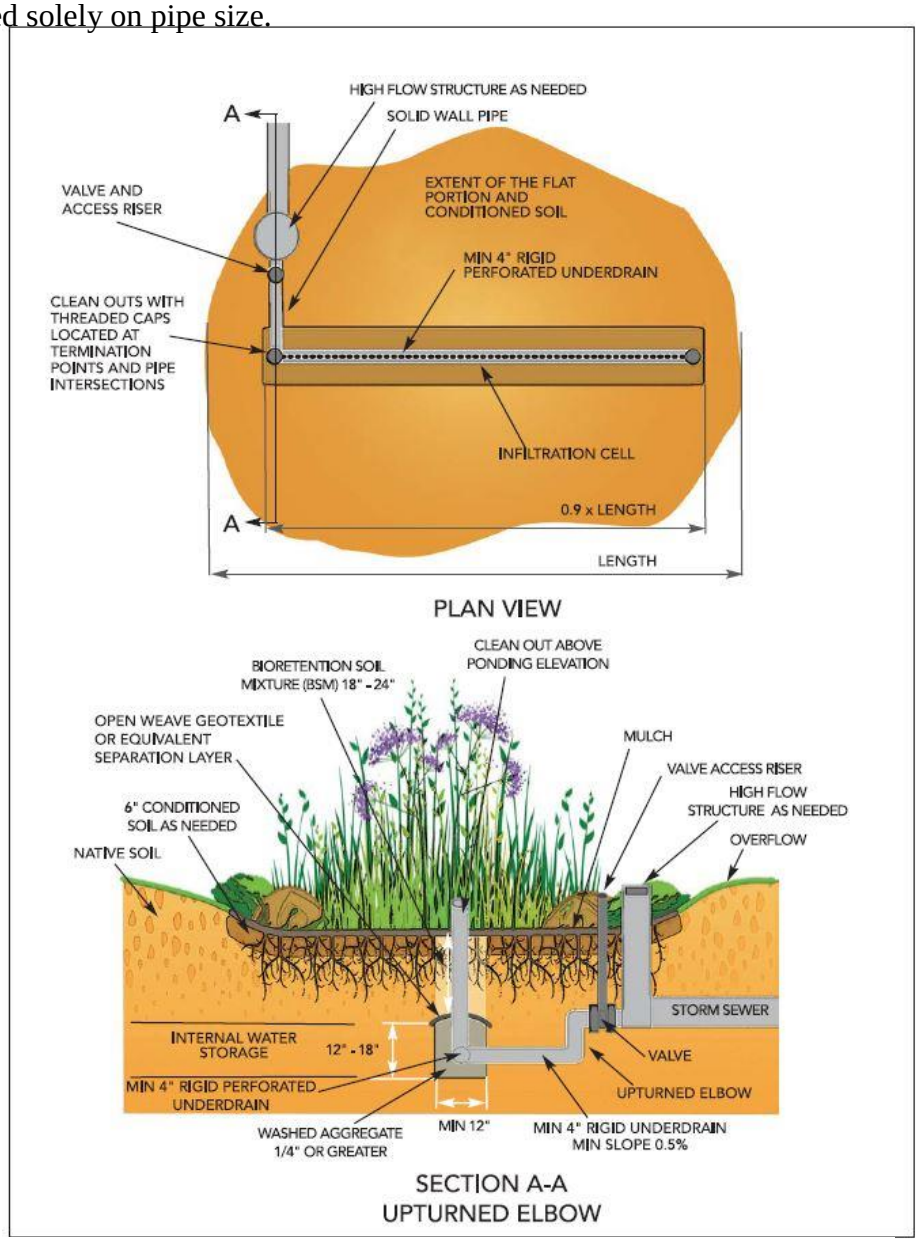
- Sediment and Debris: Remove accumulated sediment and debris from the mulch or grass surface area of the vegetated infiltration swale.
- Erosion and Scour: Repair soil erosion or scouring within the swale area or side slopes leading into the vegetated infiltration swale.
- Curb Cuts: Keep curb cuts to the infiltration trench free from blockage by sediment, debris and trash.
- Weeds: Remove weeds and invasive plants from the infiltration trench.
- Snow Removal: Do not pile or store snow within the infiltration trench as this will compact the specialized soils and add sediments that may lead to clogging.

NON-ROUTINE MAINTENANCE:

- Plant Replacement: Replace diseased or dying plants.
- Ponding Water: If ponding water occurs beyond the precipitation event, contact your local community stormwater manager for further consultation.
- Specialized Soil Replacement: Clogging of the specialized soil by fine sediments may require complete replacement of the specialized soil, mulch and plant materials.
- Underdrain Flushing: Some infiltration trenches are constructed with perforated underdrain pipes that drain the trench's specialized soils. If the underdrains become clogged with fine sediments they may need to be flushed with special equipment or replaced.

Bio-Retention Area

Bio-retention areas have a gradual swale that leads to a landscaped flowline. This could consist of rock, mulch, vegetation, etc.…The material in the flowline is a 'Bio-retention Soil Mixture' that allows for easy infiltration. Underneath this mixture is a trenched flowline that has a perforated underdrain in. To control the water quality discharge rate (Q_{wq}) through this perforated underdrain, a valve should be installed prior to the emergency overflow. If a valve is not desired, then design of the pipe diameter should be considered for creating a maximum outflow based solely on pipe size.



*The images were created by the Omaha Stormwater Drainage Manual Best Management Practices Chapter 8

**This drawing is only a template that needs to be adjusted and revised for each project.

MAINTENANCE REQUIRED WHEN:

- Standing water is visible 24 hours after a rain event.
- Erosion is visible within the bioretention area, or on the slopes and inlets leading into the bioretention area.
- Vegetation, sediment or debris is blocking inlets or outlets.
- Vegetation is wilting, discolored, or dying.
- Foul odors present.
- Sediment has accumulated over the mulch or soil media.

ROUTINE MAINTENANCE:

- Sediment and Debris: Remove gross accumulated sediment and debris from the mulch or grass surface area of the bioretention area.
- Outlet Structure: Keep outlets of bioretention area free from blockage by sediment, debris, trash, mulch or plant material.
- Erosion and Scour: Repair soil erosion or scouring within the bioretention area, side slopes or inlets leading into the bioretention area.
- Mulch: Maintain a 2 to 3-inch depth of hardwood bark mulch layer within the planted area of the bioretention area. If an excessive depth of mulch exists, remove mulch until the mulch layer is 2 to 3 inches in depth.
- Curb Cuts: Keep curb cuts to bioretention area free from blockage by sediment, debris and trash
- Weeds: Remove weeds and invasive plants from bioretention area.
- Vegetation Management: Inspect plant health seasonally to ensure vigorous growth. Prune plants, particularly shrubs and trees, during the dormant season (fall to early spring).
- Snow Removal: Do not pile or store snow within the bioretention area as this will compact the specialized soils and add sediments that may lead to clogging.

NON-ROUTINE MAINTENANCE:

- Plant Replacement: Replace diseased or dying plants.
- Water Ponding Period: When ponding continues beyond a 48 hour period or the designed ponding duration, there may be construction, or design issues that need to be corrected.

Contact your local community stormwater manager, state technical assistance staff and the designer for further consultation.

- Specialized Soil Replacement: Clogging of the specialized soil by fine sediments may require complete replacement of the specialized soil, mulch and plant materials.

References

- City of Lincoln, Nebraska; “Drainage Criteria Manual”; City of Lincoln Public Works and Utilities Department; Chapter 8, Stormwater Best Management Practices. 2014 Revision. https://lincoln.ne.gov/city/ltu/watershed/dcm/

- Nebraska Department of Transportation; “Drainage and Erosion Control Manual”; Chapter 3, Stormwater Treatment. 2013 Version. https://dot.nebraska.gov/projects/environment/roadside/

- Omaha Regional Stormwater Design Manual; Chapter 8, Stormwater Best Management Practices. 2014 Revision. https://omahastormwater.org/orsdm/

- Urban Drainage and Flood Control District, “Urban Storm Drainage Criteria Manual Volume 3”; Chapter 4, Treatment BMP’s. 2010 Version. https://udfcd.org/volume-three

- Flogard +Plus, Downspout Filter; https://oldcastleinfrastructure.com/product/flogard-plus-downspout-filter/

- BioClean Downspout Filter; https://biocleanenvironmental.com/downspout-filter/