3. BMP DESCRIPTIONS

The following pages provide descriptions of nineteen BMPs that can be implemented in Lincoln for effective stormwater management. As has been described in this guidance manual, these descriptions provide basic information to provide ideas of how and what practices can be used. This guide presents several practical site design and drainage Best Management Practices for developments in the City of Lincoln. Most of the BMPs apply to residential, commercial and industrial developments. All of them are effective in reducing the quantity and improving the quality of stormwater runoff. The following information is presented for each of the recommended BMP approaches:

- A Description of the Best Management Practice
- Effectiveness
- Advantages and Disadvantages
- Implementation Considerations
- Cost Range (Low, Medium, High)
- Main Design Components
- Maintenance

The following BMP descriptions are provided:

- Bioretention
- Retention Pond
- Extended Detention Basins
- Vegetated Buffer
- Grassed Swale
- Green Roof
- Infiltration Basin
- Infiltration Planter
- Infiltration Trench
- Native Vegetation
- Permeable Pavement
- Rain Barrels and Cisterns

- Rain Garden
- Soil Conditioning
- Stormwater Treatment Train
- Underground BMPs
- Urban Forest
- Vegetated Bioswale
- Constructed Wetland
- Hydrodynamic Separator

3.1 Bioretention

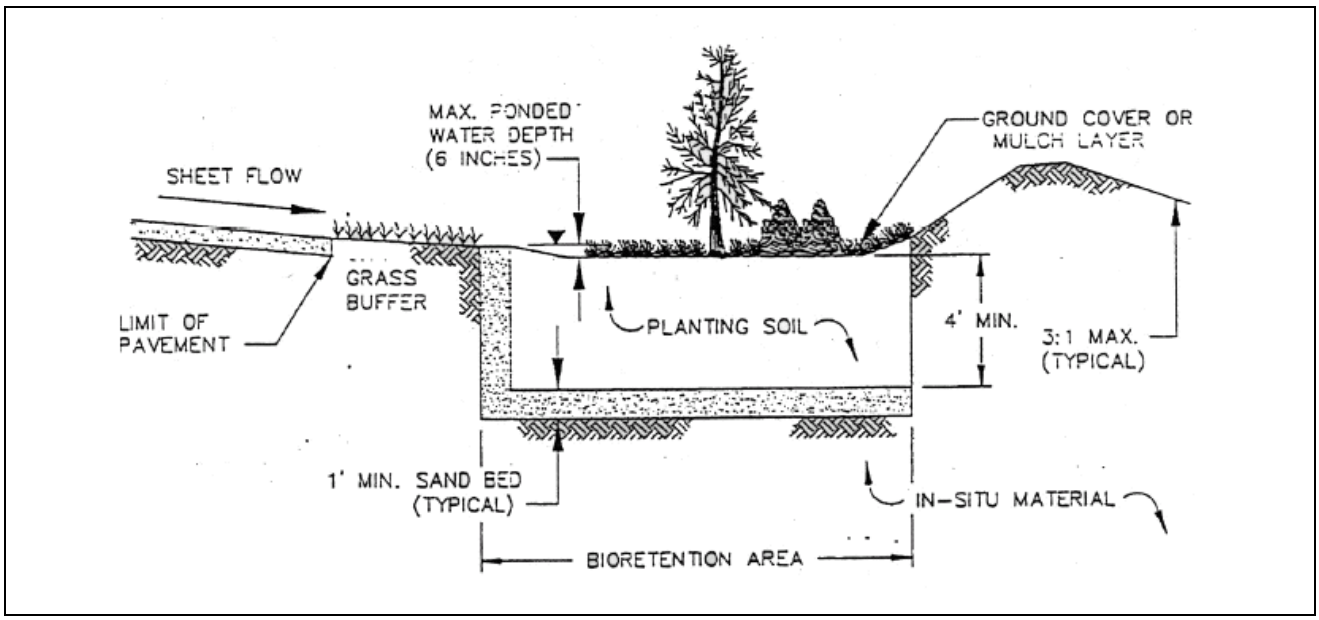
Bioretention garden utilizing native plants

Description	Bioretention areas are soil- and plant-based stormwater management practices that filter runoff from developed sites by mimicking natural vegetated systems; these naturally control hydrology through infiltration and evapotranspiration. A typical application for a bioretention area is to infiltrate and treat surface runoff from parking lots, in which the bioretention area may consist of a recessed, slotted-curb parking island. Bioretention areas are small vegetated depressions into which surface water is diverted. Stormwater flows into the bioretention area, ponds on the surface, and gradually infiltrates into the soil bed. Pollutants are removed by processes that include adsorption, filtration, volatilization, ion exchange, and decomposition. Treated water is allowed to infiltrate into the surrounding soil or is collected by an underdrain system and discharged to the stormwater system or directly to receiving waters.
Effectiveness	Improves water quality. According to estimates, bioretention areas have the potential to remove 90 percent of suspended solids, 65 percent of phosphorous, 50 percent of nitrogen, and 80 percent of metals from stormwater.
Advantages	• Provides effective stormwater flood control by slowing down runoff and increasing water infiltration into the soil. • Minimally consumes land. • Reduces site runoff. • Provides aesthetic enhancement. • Increases groundwater recharge.

Advantages (continued)	• Can be used as a stormwater retrofit.
Disadvantages	• Should not be installed until the entire contributing drainage area has been stabilized. • Requires proper plant selection and maintenance. • Susceptible to clogging by sediment, may require pretreatment. • Treats a relatively small drainage area.
Implementation Considerations	• Pine mulch and wood chips are not acceptable in the mulch layer because they are displaced during storm events. • Provide clean-out pipes on the underdrain to facilitate cleaning. • Incorporate a uniform mix of the planting soil during construction so that stormwater infiltrates evenly and does not create preferential pathways. • Minimize compaction of the base and planting soil as compaction results in design failure because it reduces infiltration. • Vegetation for the bioretention area should consist of native plant species with hydric tolerances. Do not place woody vegetation near the stormwater inflow location. Plant trees primarily along the perimeter of the bioretention area. • Water should remain on site for less than 48 hours to prevent mosquito breeding. • Not to be used for snow storage • Consider installing a benchmark that would indicate the level of sediment accumulation within the cell.
Cost Range	• Medium build cost • Low to medium cost to maintain (Refer to local contractors for area specific costs)
Main Design Components	• The surface area of the bioretention system should be between 5 to 10 percent of the impervious area it is draining. • Bioretention areas are best applied to areas with relatively shallow slopes (usually about 5 percent or less). • Bioretention areas can be applied in almost any soils as runoff percolates through a made soil bed and is returned to the stormwater system. It is also possible to design a bioretention system like an infiltration system.

Main Design Components (continued)	• Bioretention should be separated from the water table to ensure that the groundwater does not intersect with the bottom of the bioretention area. • The use of geotextiles is debated, but if used to separate the soil media from the drainage aggregate, ensure that it is arched upward and not flat in the profile of the cell. Geotextile has been observed to clog rapidly when laid flat over the drainage aggregate. Also use a light and open weave material and avoid thick, tight ones. Chocking layers of different-sized aggregates is an alternative to using geotextiles. A typical bioretention system involves the following components: • Pretreatment: Because bioretention areas are susceptible to clogging from sediments, pretreatment to remove suspended sediments is recommended. • Ponding area: A ponding area provides surface storage of stormwater before it filters through the soil bed. • Organic mulch layer: This layer protects the soil layer from erosion, retains moisture to sustain plants, and provides a medium for biological activity to decompose organic pollutants and adsorb inorganic pollutants. • Planting soil bed: Provides water and nutrients to support plant life in the bioretention system. Stormwater filters through the planting soil bed where pollutants are removed by sorption and biodegradation. • Under-drain: An under-drain is a perforated pipe in a gravel bed installed along the bottom of a sand bed to collect and filter stormwater directing it to an outflow or stormwater systems. • Provide redundant overflow structures to convey flow from large storms to the storm drain system. • Plants are an important component of a bioretention system. They remove water through transpiration, remove pollutants, enhance soil biological activity, and promote water infiltration. The plant species selected should be kept to a minimum, replicate a native forest or grassland system, and be able to survive flooded conditions.

Maintenance	• Inspect the infiltrating surface at least annually and following major precipitation events to determine if the bioretention area is providing acceptable infiltration. • Remove debris and litter from the infiltrating surface to minimize clogging of the media. Remove debris and litter from the overflow structure. • Weeds should be removed before they flower. The frequency of weeding will depend on the planting scheme and cover • Inspect bioretention side slopes and grass filter strips for evidence of any rill or gully erosion and repair it. • Inspect inlet/outlet (underdrain) structures for blockages and damage. • If applicable, check for broken sprinkler heads and repair them as needed. Completely drain the irrigation system before the first winter freeze each year. • Check for sediment buildup at curb cuts, gravel diaphragms or pavement edges that prevents flow from getting into the bed, and check for other signs of bypassing. • Sediment Removal and Growing Media Replacement: If ponded water is observed in a bioretention cell more than 48 hours after the end of a runoff event, check underdrain outfall locations and clean-outs for blockages. If clogging is primarily related to sediment accumulation on the filter surface, infiltration may be improved by removing excess accumulated sediment and scarifying the surface of the filter with a rake. If the clogging is due to migration of sediments deeper into the pore spaces of the media, removal and replacement of all or a portion of the media may be required. • If basin is used to remove specific pollutants (metals, etc.), soil media and vegetation may need to be replaced as needed. • If applicable, replace wood mulch only when needed to maintain a mulch depth of up to approximately 3 inches. Excess mulch will reduce the volume available for storage of stormwater. • For grasses started from seed, allow time for germination and establishment of grass prior to mowing. If mowing is required during this period for weed control, it should be accomplished with hand-held string trimmers to minimize disturbance to the seedbed. After vegetation is established, mow as desired or as needed for weed control. Remove cut vegetation from the BMP and dispose of properly. Following this period, mowing of native/drought tolerant grasses may stop or be reduced to maintain a length of no less than 6 inches.



Example of the Basic Lay-Out of a Bioretention System

Bioretention Maintenance Form

Site Name:

Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Control weeds (remove manually by hand or mowing)			
Remove debris/trash as needed			
Check any inlet/outlet pipes for clogging			
Ensure any cleanout pipes remain watertight			
Cut back plants as appropriate and replace plants as needed			
Check for standing water issues (< 48 hrs. after rainfall event)			
Check area for signs of erosion			
Check for accumulated sediment, remove as needed			
If irrigated, check for any necessary repairs (drain irrigation line in Fall)			
Other (miscellaneous)			

3.2 Retention Pond

Kennedy and Rockford Drive Pond, Lincoln, NE

Description	Retention Ponds are typically a construction pond or lake, or it may be a pond or lake incorporated into a stormwater treatment system. They are generally considered “end-of-the-pipe” BMPs. Lakes and ponds are standing bodies of water defined in terms of capacity, effective height, and effective storage. Lakes are larger than ponds, generally with total storage greater than 50 acre-feet, and the product of the effective height (in feet) and effective storage (in acre-feet) greater than 1,250. All developments involving lake and pond construction must conform to local, state, and federal regulations. Preserve undisturbed ponds and lakes during development according to federal and state laws and regulations. Preserving the natural drainage system, instead of replacing it with stormwater systems or concrete channels, reduces the potential for downstream degradation because of increased runoff. Ponds can be modified to increase their storage capacity and enhanced with vegetation to increase their water-quality treatment effectiveness. The primary pollutant removal mechanism in wet detention is sedimentation, with a moderate to high potential for removing metals, nutrients, and organics. Since wet ponds have the capability of removing soluble pollutants, they are suitable for sites where nutrient or pollutant loads are expected to be high.
Effectiveness	Efficient pollutant removal. Studies indicate that wet detention ponds can remove up to 50 to 90 percent of suspended solids, 30 to 90 percent of

Effectiveness (continued)	total phosphorous, 40 to 80 percent of soluble nutrients, 40 to 80 percent of metals, and 20 to 40 percent of biochemical compounds.
Advantages	• Improve runoff control, including reductions of overall runoff from adjacent sites with proper design. • Create wildlife habitat. • Encourage community recreation facilities. • Aesthetically pleasing. • May increase property values. Requires significantly less expense for maintenance if natural vegetation is used along the banks.
Disadvantages	• Reduces the amount of developable land. • May require approval from dam safety authorities. • May require maintenance at regular intervals to remove sediments deposited in the base of the pool. • If not designed or maintained correctly, could become a mosquito vector. • May have wildlife issues • Possible safety hazard
Implementation Considerations	• Vegetation on dams may need to be monitored and invasive species removed. • May require cleaning and removal of debris after major storm events. • May require removal of accumulated sediment. • May require monitoring and maintenance of erosion in the emergency spillway during establishment of vegetation. • May require vegetation buffer to reduce waterfowl issues
Cost Range	Low to medium build cost Low to medium cost to maintain (Refer to local contractors for area specific costs)
Main Design Components	• Storage volume: The City of Lincoln has established requirements in the Drainage Criteria Manual. • Sediment control: A sediment forebay is highly recommended. • An emergency spillway should be included in the basin design. • The basin should include a low-flow drain to assist in maintenance of the detention area.

Main Design Components (continued)	• Sediment storage life span. Typically, in most areas, the 25-year sediment volume is calculated for the pond. • Pond or lake depth: An average pool depth of 3 to 6 feet is recommended. Depths greater than 10 feet may have thermal stratification and anoxic conditions. Depths less than 3 feet increase sediment resuspension, water temperature, and algal blooms. • Flow path: Maximize the flow path length between the inlet and outlet. The length to width ratio should be at least 3:1. • Slopes: Side slopes of a permanent pool should not be greater than 3:1. Flatter slopes minimize bank erosion. Slopes leading to the pool should be less than 3:1. • Inlet points should be designed with energy dissipaters to reduce inflow velocity.
Maintenance	• Inspect the pond at least annually. Note the amount of sediment in any forebays and look for debris at the outlet structure • Remove debris and litter from the pond as needed. This includes floating debris that could clog the outlet or overflow structure. • Mosquito control may be necessary if mosquitoes are found to be breeding in the BMP. The most effective mosquito control programs include weekly inspection for signs of mosquito breeding with treatment provided when breeding is found. • Remove sediment from the forebay before it becomes a significant source of pollutants for the remainder of the pond. For dry forebays, sediment removal should occur once a year. Sediment removal in wet forebays should occur approximately once every four years or when buildup of sediment results in excessive algae growth or mosquito production. • Removal of sediment from the bottom of the pond may be required every 5 to 10 years to maintain volume and deter algae growth. This typically requires heavy equipment, designated corridors, and considerable expense. Harvesting of vegetation may also be desirable for nutrient removal. • Inspect the condition of stormwater inlets/outlet structures to the pond for material damage, erosion or undercutting. • Inspect internal and external side slopes of the pond for evidence of sparse vegetative cover, erosion, or slumping, and make needed repairs immediately.

Kennedy and *Rockford* Drive Pond, Lincoln, NE

Retention Pond Maintenance Form

Site Name:

Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Control weeds (remove manually by hand or mowing)			
Remove debris/trash, including floating debris			
Check inlet/outlet structures for clogging/damage			
Check sediment accumulation in pond			
Replace vegetation as needed (reseeding, planting)			
Check for signs of mosquito breeding			
Check for signs of erosion			
Other (miscellaneous)			

3.3 Extended Detention Basin

Detention basin located at NW 12th Street & Keating Drive, Lincoln, NE

Description	Extended detention basins, also called dry ponds or detention cells, are stormwater basins that are designed to intercept a volume of stormwater runoff and temporarily impound the water for gradual release to the receiving stream or stormwater system. Detention basins are typically on-line, end-of-pipe BMPs. Detention basins are designed to completely empty out between runoff events, typically within 48 hours, and therefore provide mainly runoff control as opposed to water quality control. They can provide limited settling of particulate matter, but a large portion of this material can be resuspended by subsequent runoff events. Detention basins can limit downstream scour and loss of aquatic habitat by reducing the peak flow rate and energy of stormwater discharges. As a general rule, dry detention basins should be designed for drainage of areas greater than 10 acres. In many areas, the detention basins, when dry, can be used for other recreational purposes.
Effectiveness	Detention basins may remove from 10 to 90 percent of suspended solids depending on the volume of stormwater held in the basin, and how long it resides there. Removal of pollutants is less efficient, and generally contingent on holding period of stormwater, which is typically substantially greater than the holding period required for reducing the peak period of storm periods.
Advantages	• Reduces peak flow rate and energy of stormwater discharges, therefore limiting downstream erosion and scouring. • Good potential for removal of sediments. • Can be used for recreation when dry.

Advantages (continued)	• Can serve as green space, supporting wet prairie functions and wildlife habitat. • Using native plants reduces mowing costs.
Disadvantages	• Generally, not prescribed for drainages less than 10 acres. • Potential for clogging of outlets. • Can be considered unattractive by residents if not designed or maintained correctly. • Limited ability to remove pollutants. • Depending on size and volume of stormwater capture, basin designs may require approval of dam safety authorities. • The fluctuating water levels within basin have potential to create conditions that lead to mosquito breeding. • Potential high mowing costs • Potential wildlife issues • If not regulated, may lead to community dump site and trespassing issues
Implementation Considerations	• The required volume of the detention basin, called the "flood storage volume," is dependent on the City's policies as provided in the City's Drainage Criteria Manual. Typically, storm volumes ranging from the 2- to the 100-year events are required. • A detention time of 48 hours or less should be targeted. Water should not remain more than 48 hours after a runoff event. • Smaller drainage areas can be considered if the dry detention is part of a stormwater treatment train. • Maximum depth of water, when full, should be 6 to 10 feet.
Cost Range	Low to medium build cost (depending on size) Low to medium cost to maintain (Refer to local contractors for area specific costs)
Main Design Components	• The outlet area should be a deeper micropool to provide final settling and prevent resuspension of sediments. The outlet pipe should be located in the pond embankment wherever possible for ease of maintenance. • In some cases, emergency spillways should be included in the basin design. • The basin should include a low-flow drain to assist in maintenance of the detention area.

Main Design Components (continued)	• Proper design and maintenance of the embankments will prolong the integrity of the basin structure. The embankments should have minimum side slopes of 3:1 and a top width of at least 4 feet, and should be well vegetated. • A low flow vegetated channel may need to be installed in the basin to ensure that the basin dries out completely between storm events. • Scour control is important to maintain the function of the dry detention basin and reduce erosion. • All federal, state, and local permit requirements must be established prior to construction of the dry detention basin.
Maintenance	• Detention basins are designed to be completely drained 48 hours after the end of a storm event – look for standing water after this time as it may indicate a drainage problem. • Remove debris and litter from the detention area as required to minimize clogging of inlet/outlet structure(s). • Control excess vegetation by mowing and removing dead vegetation on an annual basis. • Remove small volunteer trees from the basin as needed. Unwanted tree growth can damage the basin's structures and side slopes, as well as reduce the amount of stormwater storage capacity. • Remove sediment from the bottom of the basin when accumulated sediment occupies about 20% of the water quality design volume or when sediment accumulation results in poor drainage within the basin. • Repair basin inlets, outlets, trickle channels, and all other structural components required for the basin to operate as intended. Repair and vegetate eroded areas as needed following inspection. • Inspect internal and external side slopes of the pond for evidence of sparse vegetative cover, erosion, or slumping, and make needed repairs immediately.

Detention Basin utilizing orifice plate to control discharge

Extended Detention Basin Maintenance Form

Site Name:

Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Control weeds (remove manually by hand or mowing)			
Remove debris/trash/litter			
Check inlet/outlet structures for clogging/damage			
Check sediment accumulation in basin, remove when half full			
Check vegetation. Reseed any bare areas.			
Check for signs of mosquito breeding (scour holes, standing water)			
Check for signs of erosion			
Overgrown vegetation (mow annually)			
Other (miscellaneous)			

3.4 Vegetative Buffer

Designated buffer at Holmes Lake, Lincoln, NE

Description	Vegetative Buffers (also called filter strips) are densely-vegetated, often grassed practices that accept sheet flow runoff from adjacent surfaces. They slow runoff; filter out sediment and other pollutants; and enhance infiltration of surface water runoff. Use vegetative buffers to treat shallow sheet flows and evenly distribute storm flows over very short contributing distance areas. Vegetative Buffers are well suited to areas adjacent to parking lots and other impervious surfaces where runoff can be conveyed and filtered before it is discharged into swales, stormwater systems, or surface water bodies. Filter strips are also appropriate for construction sites and developing land to filter sediment from overland sheet flow. Well maintained buffers can be very effective in reducing runoff volumes, particularly when the impervious drainage area is not overly large. Vegetative Buffers are most effective in reducing surface runoff volumes – by up to 40 percent – for small storm events (storms up to the magnitude that may occur, on average, once every year or every other year).
Effectiveness	Depending on the type of vegetation and the size of the buffer, effectiveness of this BMP will vary. Buffers with dense, high vegetation can remove up to 80 percent of suspended solids. Filter strips utilizing grass only, particularly turf grass, are much less effective in slowing water and/or removing solids. If the Buffer is constructed with porous media in which water will readily infiltrate, the removal capability for sediments and pollutants will be as high as 98 percent (USEPA, 1999).

Advantages	• Provides effective stormwater flood control by slowing down runoff and storing water, including water infiltration into the soil. • Improves water quality by filtering pollutants from stormwater (oils, greases, metals, and sediments that can be picked up from paved surfaces). • Can be used as a system by itself, or in conjunction with other BMPs. • Easy to plan and build. • Reduces erosion. • May help maintain temperature of receiving waters. • Flexible to incorporate existing natural features and a variety of vegetation types. • Preserves natural/native vegetation and provides habitat for wildlife. • Protects adjacent properties. • Reduces waterfowl populations
Disadvantages	• Need to maintain vegetative cover for controlling erosion and reducing particulates in the runoff. • Not appropriate for hilly or highly impervious terrain. • Requires maintenance to remove trash.
Implementation Considerations	• The maximum drainage area into the filter strip should be 5 acres. • The buffer width (dimension perpendicular to the flow path) should be as close to the width of the impervious area flowing into the filter strip as practical. • The buffer length (dimension parallel to flow) depends on the filter strip width and drainage area. • The maximum slope of a buffer should be 6 percent, unless additional flow spreader devices are installed every 100 feet to maintain sheet flow. • To encourage reseeding, warm season vegetation should be mowed in early spring (end of March).
Cost Range	Low build cost Low cost to maintain (Consult local contractor for area specific cost)

Main Design Components	• Filter slopes should be no less than 1 or 2 percent slope, and no greater than 6 percent. Greater slopes will encourage concentrated flow and flatter slopes may result in ponding. • Top and toe of slope should be as flat as possible to encourage sheet flow. • Concentrated flow should not be discharged into buffers. If flow are concentrated, a level spreader should be included to spread the flow over the entire length of the filter strip. • To enhance the effectiveness of the buffer, install a pervious berm of sand and gravel at the toe of the slope. • Select plants that are able to withstand flowing water and both wet and dry periods. • Depending on adjacent land use and traffic, buffers may require fencing to control destructive access by vehicles, pedestrians, and animals. • Buffers are typically designed to handle flows from 1- to 2-year storm events and are usually not able to reduce flows from larger storms.
Maintenance	• Sediment and debris should be routinely removed when buildup exceeds 2 inches in depth in either the strip itself or the level spreader. If erosion is observed, measures should be taken to improve the level spreader or other dispersion method to address the source of erosion. • Perform periodic mowing to keep grasses at acceptable levels and to minimize the growth of successional vegetation. It is recommended that mowing be performed perpendicular to the slope to help minimize the development of rills. It is important to avoid the use of herbicides and fertilizers on grassed portions of the strip, since these applications can directly contribute undesirable pollutants to waterways. • Inspect buffers for evidence of sparse vegetative cover, erosion, or slumping, and make needed repairs immediately. • Inspect any inlet/outlet structures for blockages and damage. • Remove trash and litter on a continual basis. • If applicable, check for broken sprinkler heads and repair them as needed. Completely drain the irrigation system before the first winter freeze each year.

Tyrell Park in Lincoln, NE

Vegetative Buffer Maintenance Form

Site Name:

Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Sediment removal			
Erosion repair			
Weeds/Overgrown vegetation (mowing)			
Inspect irrigation components (if applicable)			
Fertilizing/Soil amendments			
Inspect for compacted/damage areas			
Remove trash/litter			
Inspect structures (signs, fences, etc.)			
Other (miscellaneous)			

3.5 Grassed Swale

Source: City of Eugene Stormwater Management Manual

Description	Grassed swales (also called grassed channels) are low-cost alternatives to conventional hard-engineered conveyance in residential and commercial neighborhoods. Like Vegetated Bioswales, they consist simply of a shallow channel, or swale, that conveys water down a slight gradient away from its source. As runoff travels down the swale, suspended solids and pollutants settle out, preventing them from entering stream systems.
Effectiveness	Grassed swales are most effective for dispersing the flow of stormwater across a greater area and distance. Grassed swales are not significantly effective for removal of suspended sediments or pollutants.
Advantages	• Less expensive than conventional, hard-engineering conveyance practices, in both the initial construction and maintenance phases. • Encourages infiltration.
Disadvantages	• Less effective than vegetated bioswales at filtering and reducing rates and volumes of runoff. • Swales can only treat a limited area.
Implementation Considerations	• Deep-rooted native grasses facilitate more effective infiltration and pollutant filtration, and a greater reduction in flow rates and volumes than conventional turfgrasses such as Kentucky bluegrass. • Mowing of grassed swales should be avoided or should be done as infrequently as possible depending on grass species. • Extent of drainage area.

Implementation Considerations (continued)	• Planning and engineering of effective treatment train appropriate for each area. • Determine the necessary space and length to achieve stormwater management goals and water quality.
Cost Range	Low build cost Low cost to maintain (Refer to local contractors for area specific costs)
Main Design Components	• Minimize slope (< 4:1) and depth of the swale to prevent erosion of side slopes. • Channel bottom should be relatively flat to prevent channelization that would lead to increased erosion. • Runoff should be distributed uniformly across the channel bottom at its entry point. • The bottom of the swale should be at least three feet above groundwater in order to prevent the swale bottom from remaining too wet. • The flat channel bottom should be between two and eight feet wide to ensure sufficient filtering surface for water quality treatment. • Unless existing soils are highly permeable, they should be replaced with a sand/soil mix that meets minimum permeability requirements. • An underdrain system may also be installed under the soil bed. Typically, the underdrain system is created by a gravel layer which encases a perforated pipe
Maintenance	• Add reinforcement planting to maintain 90% turf cover. Reseed any vegetation. • Remove any accumulated sand or sediment deposits behind check dams and inflow points. • Inspect upstream and downstream of check dams for evidence of undercutting or erosion and remove and trash or blockages at weep holes. • Examine channel bottom for evidence of erosion, braiding, excessive ponding or dead grass. • Inspect side slopes for evidence of rill or gully erosion and repair. • Remove weeds and mow overgrown vegetation as needed

Well maintained grassed swale

Grassed Swale Maintenance Form

Site Name:

Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Sediment removal			
Erosion repair			
Weeds/Overgrown vegetation (mowing)			
Inspect irrigation components (if applicable)			
Fertilizing/Soil amendments			
Inspect for compacted/damaged areas			
Remove trash/litter			
Inspect structures (signs, fences, etc.)			
Other (miscellaneous)			

3.6 Green Roof

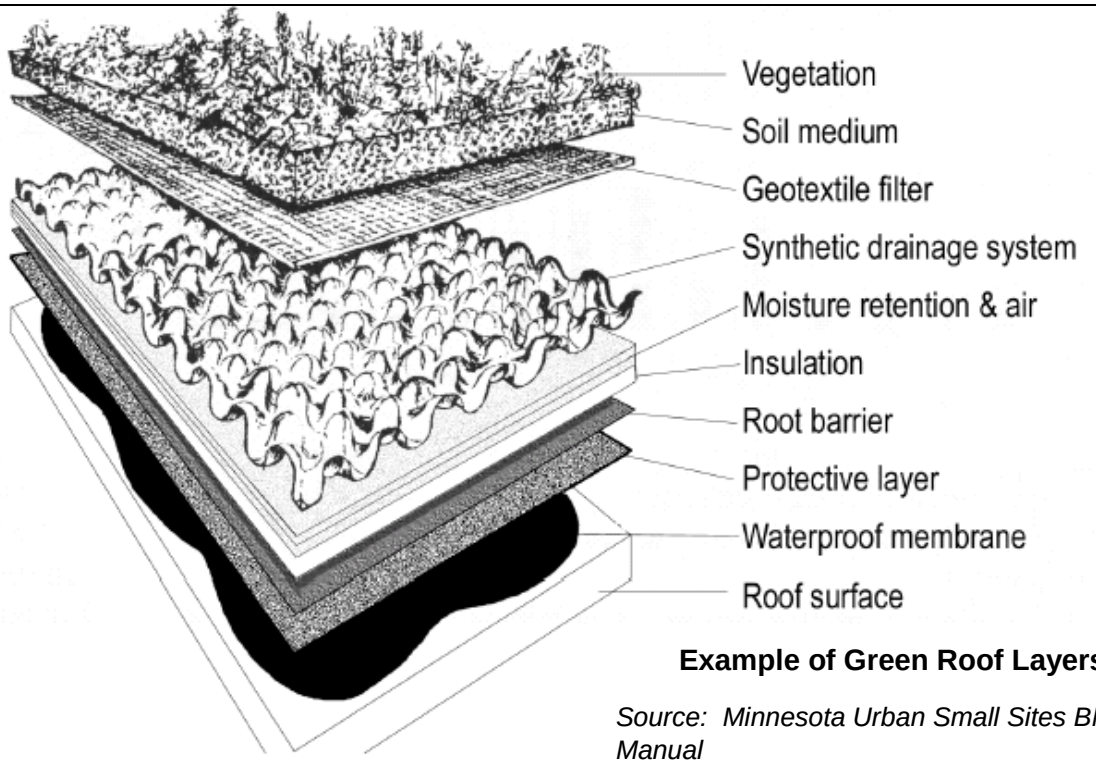
Chicago City Hall, Chicago, Illinois
source: greenroofs.com

Description	Green roofs have been used for hundreds, if not thousands of years, from sod roofs in Europe to sod houses in the Great Plains of the United States. What have changed are the materials, designs and new implementations of green roof technology. Further, a greater understanding on how green roofs function has led to using green roofs for stormwater management and building climate control. Essentially a green roof consists of placing layers of plants and rooting medium over a traditional roofing system. Green roofs are grouped into two categories: extensive and intensive. Extensive roofs are lightweight systems of manufactured root medium which typically have low plant diversity; they are more easily incorporated into conventional building construction and require little maintenance. Intensive roofs typically use a deep rooting medium such as topsoil and can incorporate a wide variety of plants but require special considerations due to higher roof loading and greater maintenance.
Effectiveness	Depending on the type of green roof used, effectiveness will vary. In most situations however, nearly all configurations will effectively reduce the volume of runoff from rooftops. If runoff is maintained through a constructed soil media, filtering capacity of sediments and pollutants may be higher than 80 percent.

Advantages	**Extensive** • Can reduce summer cooling costs. • Low maintenance. • Placement on up to 25-30° roof pitch. • Lightweight. • Suitable for retrofit. • Easier to install. • Slow stormwater runoff. • Aesthetically pleasing. • Provides insulation for roof. • Extends life of roof. • Reduction in impervious area for the property. **Intensive** • Greater plant diversity, better aesthetics. • Good insulation properties. • Potential access for recreation. • Slower stormwater runoff, larger detention capacity. • More amenable to wildlife. • Reduction in impervious area for the property.
Disadvantages	**Extensive** • Unattractive to some, especially in winter. • Limited plants, native species may not be possible. • No access for recreation. **Intensive** • Greater roof loads, heavier weight. • Expensive design and construction. • Irrigation and drainage systems necessary. • Higher maintenance than extensive roof. • Potential fire hazard during dormant season, especially with native plants.

Implementation Considerations	• Public outreach and acceptance for existing developments or communities. • Load-bearing capacity of roof structure and building. • Mechanisms to address fire hazard. • Life of the structure.
Cost Range	High build cost (may increase overall building costs to support heavier roof) Low to medium cost to maintain (Refer to local contractors for area specific costs)
Main Design Components	• The load-bearing capacity of the underlying roof structure is critical in the design of a vegetated rooftop. Generally, green roofs weighing more than 17 pounds per square foot saturated require consultation with a structural engineer. • Flat roofs are easiest to design and install. The maximum slope for a green roof is about 25 percent. • Follow federal and state standards for wind resistance. Since uplift pressures tend to be higher at roof corners, these areas may be considered for vegetation-free zones. • Monolithic membrane, applied as a hot liquid, provides superior waterproofing. • Protective layers are placed on top of waterproofing, including root barriers to prevent roots from damaging the waterproof layers. • A drainage system needs to be designed that will retain water for plant uptake and retain excess water for storage. • Soil for green roofs are lighter than typical soil mixtures, generally with about 75 percent mineral matter, and 25 percent organic matter. • A range of plants are suitable for green roofs. In Lincoln, native plants offer a variety of opportunities to create effective vegetative schemes. For extensive roofs (shallow soil systems), shallow-rooted plants that can withstand heat and drought are best. • It is essential to mark the position of roof drain outlets and irrigation pipe inlets before installing protective layers so they can be easily located. • Tray system is encouraged due to ease of install and maintenance

Maintenance	• Green roof inspection should be conducted at least three times per year. • Inspect joints, borders, waterproof membrane or other features that pass through the roof to remove roots and identify damage that could lead to leaks. For example, inspect abutting vertical walls, roof vent pipes, outlets, air conditioning units, and perimeter areas. Joints with facades must provide open access for inspection, maintenance, and upkeep. • A vegetation-free zone of approximately one foot should be maintained at the border of roof edges and at drain openings on the roof. Vegetation-free zones should be lined with pavers, stones, or gravel. Drains must remain free of vegetation and foreign objects. In order to allow for regular inspections and maintenance, drains on a green roof must remain permanently accessible. • Because of the severe consequences of drain backups, inspection of drainage flow paths is crucial. Remove the inlet cover and visually inspect drainage pipes for roots or other material that could impede the flow of water. • Plants are susceptible to poor drainage in the soil. If too much water is present and unable to drain, the plants will drown or rot. Routine inspections of drains should take place approximately three times per year as well as after precipitation events of 0.6 inches or more. • Inspect the irrigation system for leaks or malfunctions. Uneven vegetative growth or dying plants should serve as indicators of potential irrigation system problems. • Mow or trim plantings in early Spring of each year as needed. • Remove weeds on a continual basis.



Example of Green Roof Layers.

Source: Minnesota Urban Small Sites BMP Manual

Green Roof Maintenance Form

Site Name:

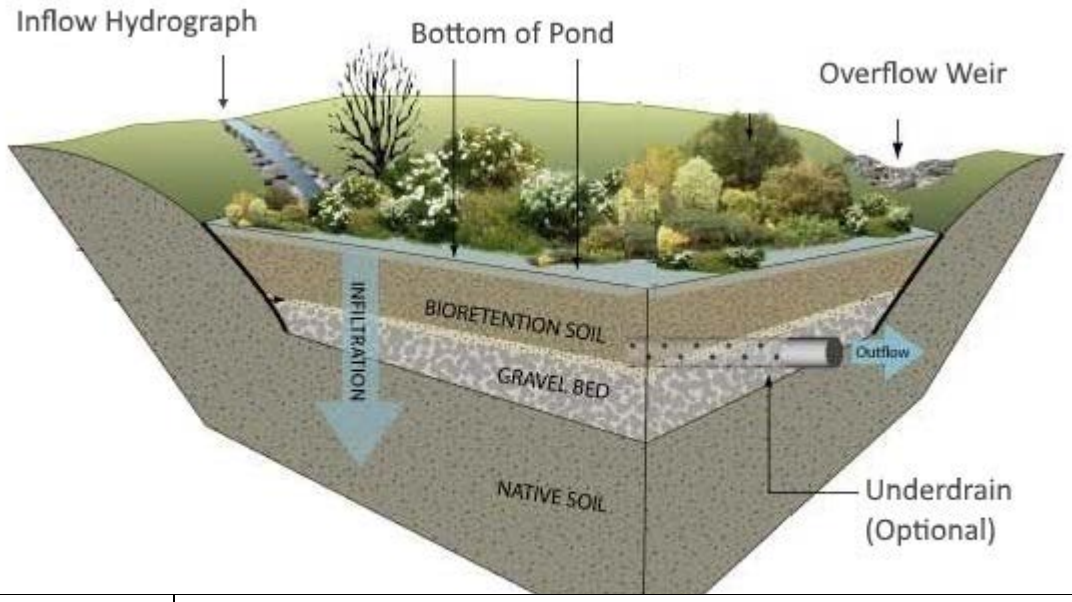
Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Control weeds (hand pulling, limit spraying if possible)			
Remove debris			
Inspect joints, borders, outlets, and other features for damage			
Inspect irrigation components (if applicable)			
Replace vegetation			
Thin, prune, and fertilize as needed			
Inspect growing media			
Inspect all drainage paths			
Other (miscellaneous)			

3.7 Infiltration Basin



Description	An infiltration basin (also known as a recharge basin or in some areas, a sump or percolation pond) is a type of device that is used to manage stormwater runoff, prevent flooding and downstream erosion, and improve water quality in an adjacent river, stream, lake or bay. It is essentially a shallow artificial pond that is designed to infiltrate stormwater through permeable soils into the groundwater aquifer. Infiltration basins generally do not release water except by infiltration, evaporation or emergency overflow during flood conditions (engineered outlet structure or spillway). It is distinguished from a detention basin, sometimes called a dry pond, which is designed to discharge to a downstream water body (although it may incidentally infiltrate some of its volume to groundwater); and from a retention basin, which is designed to include a permanent pool of water. Infiltration basins are typically off-line, end-of-pipe BMPs that vary in size and shape. The infiltration basins described in this section typically treat water from larger areas, from multiple lots to large parking lots, to broad areas such as neighborhoods. Infiltration basins use existing soil and vegetation to facilitate percolation of water into the ground and evapotranspiration of water through vegetation into the atmosphere. Vegetation is key to success of the infiltration basin. Deep-rooting vegetation will enhance infiltration of water while also staying well-anchored against disturbance from water or other factors. Another key element of the infiltration basin is having enough area to maintain a shallow pool that will infiltrate within 48 hours or less.
Effectiveness	Infiltration basins may remove from 10 to 90 percent of suspended solids depending on the volume of stormwater held in the basin, and how long it resides there. Removal of pollutants is dependent on the soil media and the ability to adsorb or decompose pollutant compounds. Removal of

Effectiveness (continued)	pollutants is contingent on the holding period of stormwater, which typically is substantially greater than the holding period required for reducing the peak period of storm periods.
Advantages	• Reduces peak flow rate and energy of stormwater discharges, therefore limiting downstream erosion and scouring. • Can be used for recreation when dry. • Can help to maintain baseflow of nearby streams. • Can serve as greenspace, supporting wet prairie functions and wildlife habitat. • Reduces local flooding.
Disadvantages	• Generally, not prescribed for drainages greater than 10 acres. • Potential for fouling infiltration capacity of the soil if runoff is sediment-laden. • Can be considered unattractive by residents if not designed or maintained correctly.
Implementation Considerations	• Re-Vegetation: For existing unvegetated areas or for infiltration basins that require excavation, vegetation may be added. Planting in the infiltration area will improve water quality, encourage infiltration, and promote evapotranspiration. This vegetation may range from a meadow mix to more substantial woodland species. The planting plan should be sensitive to hydrologic variability anticipated in the basin, as well as to larger issues of native plants and habitat, aesthetics, and other planting objectives. The use of turf grass, which requires frequent mowing is discouraged due to soil compaction. • A grassed Infiltration Basin can be used for recreation in dry periods. Heavy machinery and vehicular traffic of any type should be avoided so as not to compact the infiltration area. • Soil infiltration tests should be conducted. For soils with poor infiltration rates, a layer of sand (6”) or gravel can be placed on the bottom of the Infiltration Basin, or the soil can be amended to increase the permeability of the basin. • This BMP is not practicable in areas with high water tables. Guidelines for infiltration should be considered, including depth of water table, permeability of soils, and vegetation types.
Cost Range	Medium build cost (depending on existing site soils) Low cost to maintain

Main Design Components	• Uncompacted sub-grade. • Soil Infiltration Guidelines and Soil Testing Protocols apply. • Preserve existing vegetation, if possible. • Design to hold/infiltrate volume difference in 2-yr storm. • Provide emergency stormwater overflow through engineered outlet structure or spillway. • Allow 3 ft buffer between bed bottom and seasonal high groundwater table and 2 ft buffer for rock. • When possible, place on upland soils. • The slope of the infiltration basin should be flat or less than 1 percent. • There should be at least 2 feet of freeboard between the invert out and the top of the berms. • Inlets should have erosion protection.
Maintenance	• Inspect the infiltrating surface at least annually and following major precipitation events to determine if the area is providing acceptable infiltration. • Remove debris and litter from the infiltrating surface to minimize clogging of the media. Remove debris and litter from the overflow structure. Ensure that the contributing drainage area, inlets, and facility surface are clear of debris. • Weeds should be removed before they flower. The frequency of weeding will depend on the planting scheme and cover. When the growing media is covered with mulch or densely vegetated, less frequent weeding will be required. Remove volunteer trees that start to grow in the vicinity of the basin. • Adjust irrigation throughout the growing season to provide the proper irrigation application rate to maintain healthy vegetation. Check for broken sprinkler heads and repair them, as needed. Completely drain the irrigation system before the first winter freeze each year. • Replace top layers (stone/topsoil/mulch/etc.) and filter fabric as needed if clogged. If ponded water is observed in the basin more than 48 hours after the end of a runoff event, check underdrain outfall locations and clean-outs for blockages. • Maintenance activities to restore infiltration capacity of basin will vary with the degree and nature of the clogging. If clogging is primarily related to sediment accumulation on the filter surface, infiltration may be improved by removing excess accumulated sediment and scarifying the surface of the filter with a rake. If the clogging is due to migration of sediments deeper into the pore spaces of the media, removal and replacement of all or a portion of the media may be required. The

Maintenance (continued)	frequency of media replacement will depend on site-specific pollutant loading characteristics. • Repair undercut and eroded areas around and within basin area.

Infiltration Basin utilizing native plants and decorative boulders

Infiltration Basin Maintenance Form

Site Name:

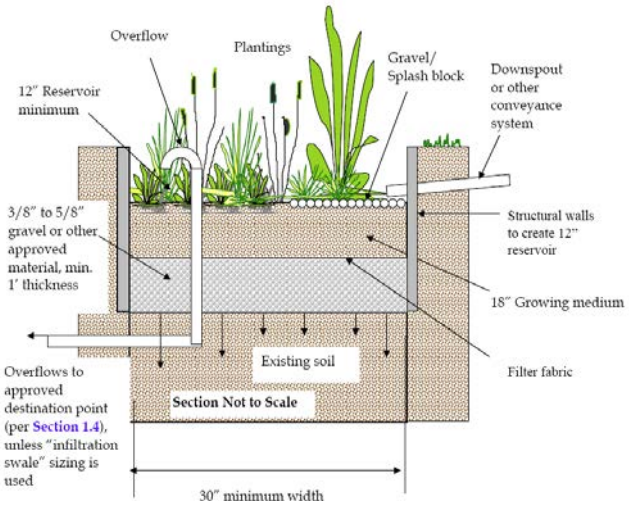
Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Control weeds (remove manually by hand or mowing)			
Remove debris/trash as needed			
Check any inlet/outlet pipes for clogging			
Ensure any cleanout pipes remain watertight			
Cut back plants as appropriate and replace plants as needed			
Check for standing water issues (< 48 hrs. after rainfall event)			
Check area for signs of erosion			
Check for accumulated sediment, remove as needed			
If irrigated, check for any necessary repairs (drain irrigation line in Fall)			
Other (miscellaneous)			

3.8 Infiltration Planter

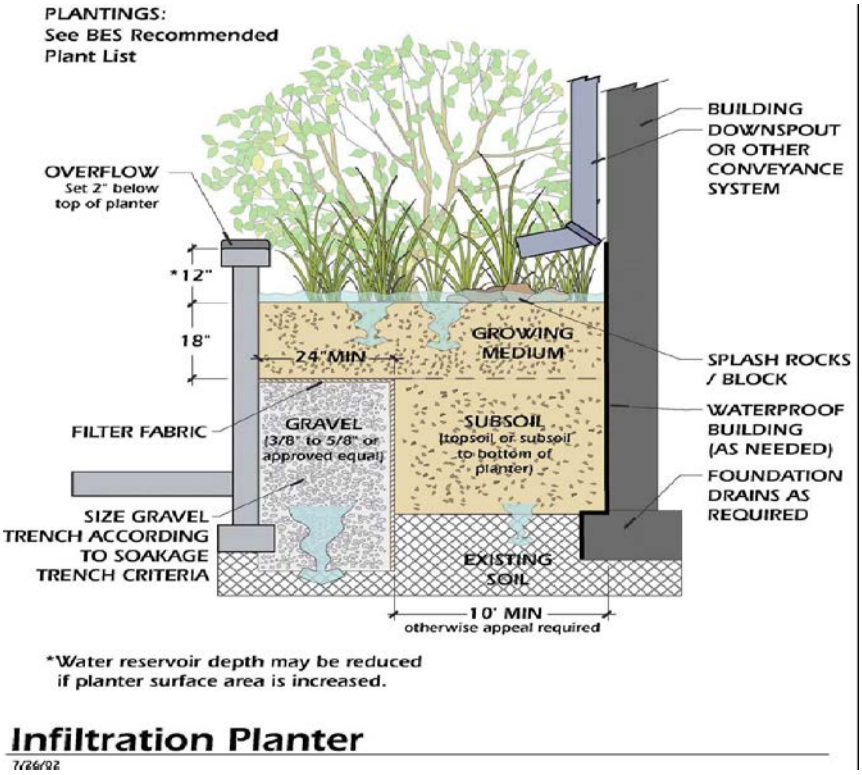


Source: City of Eugene Stormwater Management Manual

Description	Infiltration planters are raised structural planting beds that filter and infiltrate runoff from surrounding rooftops, parking lots, or sidewalks. They can be installed in a variety of sizes and styles, integrating an endless variety of plants, to suit any architectural style. Infiltration planters work well at the scale of individual residential, commercial, residential, or governmental parcel levels.
Effectiveness	Infiltration planters have limited capability to reduce significant amounts of runoff, with limitations based on the receiving area of runoff flowing to the planter, and the size of the planter itself. For runoff that enters the planter, removal of sediments and pollutants is high, often exceeding 80 percent.
Advantages	• Provides filtration of pollutants, as well as infiltration of runoff. • Reduces flow rates and volumes. • Suitable in areas with limited space. • May be used as part of a traditional landscaping plan. • Should reduce the amount of watering necessary to maintain landscaping.
Disadvantages	• Though infiltration planters will require less watering than traditional landscaping, they may require maintenance to prevent clogging of permeable medium.

Implementation Considerations	• Requires soils that allow at least two inches of infiltration per hour. • The walls of the planter should allow up to a foot of standing water to accumulate for less than twelve hours at a time. • A minimum of three feet of permeable medium (washed gravel or other aggregate) should exist between the bottom of the growing medium (topsoil) and above impermeable layers or seasonally high water table.
Cost Range	Low to medium build costs Low cost to maintain (Refer to local contractors for area specific costs)
Main Design Components	• Planter walls should be constructed of durable, impervious materials, but should not employ chemically treated wood that may leach chemicals into groundwater. • Planters should incorporate trees and shrubs where feasible • An overflow should be installed to divert excess water during high-flow runoff events
Maintenance	• Debris and Litter shall be removed to prevent channelization, clogging, and interference with plant growth. Fallen leaves and debris from deciduous plant foliage shall be raked and removed. • Erosion Damage shall be identified and controlled when native soil is exposed, or erosion channels are forming. • Filter Media consisting of sand and/or topsoil shall be tested to ensure stormwater percolates through the planter. Remove and replace sand and/or topsoil to correct percolation deficiencies. • Infiltrating Stormwater Planters shall be excavated and cleaned, and gravel or soil shall be replaced to correct low infiltration rates. Water should drain through the planter within 3-4 hours after a storm event. • Inlets/outlets shall be cleared when conveyance capacity is plugged to ensure unrestricted stormwater flow to the rain garden. • Mulch shall be replenished as needed to ensure healthy plant growth. • Nuisance and Prohibited Vegetation shall be removed when discovered. • Piping shall be cleared of sediment and debris to maintain conveyance capacity. • Planter Walls shall be examined for deficiencies, such as rot, cracks, and failure, and repaired as needed. Holes that are not consistent with the design and allow water to flow directly through the planter to the ground shall be plugged.

Maintenance (continued)	• Sedimentation build-up near or exceeding 2” in depth shall be hand-removed with minimum damage to vegetation using proper erosion control measures. Sediment shall be removed if it is more than 4 inches thick or so thick as to damage or kill vegetation. • Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion. Dead vegetation shall be removed to maintain less than 10% of area coverage or when vegetative filter function is impaired. Vegetation shall be replaced immediately to control erosion where soils are exposed and within 3 months to maintain cover density.



Source: City of Eugene Stormwater Management Manual

Infiltration Planter Maintenance Form

Site Name:

Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Control weeds (remove manually by hand or mowing)			
Remove debris/trash as needed			
Check any inlet/outlet pipes for clogging			
Ensure any cleanout pipes remain watertight			
Cut back plants as appropriate and replace plants as needed			
Check for standing water issues (< 48 hrs. after rainfall event)			
Check area for signs of erosion			
Check for accumulated sediment, remove as needed			
If irrigated, check for any necessary repairs (drain irrigation line in Fall)			
Other (miscellaneous)			

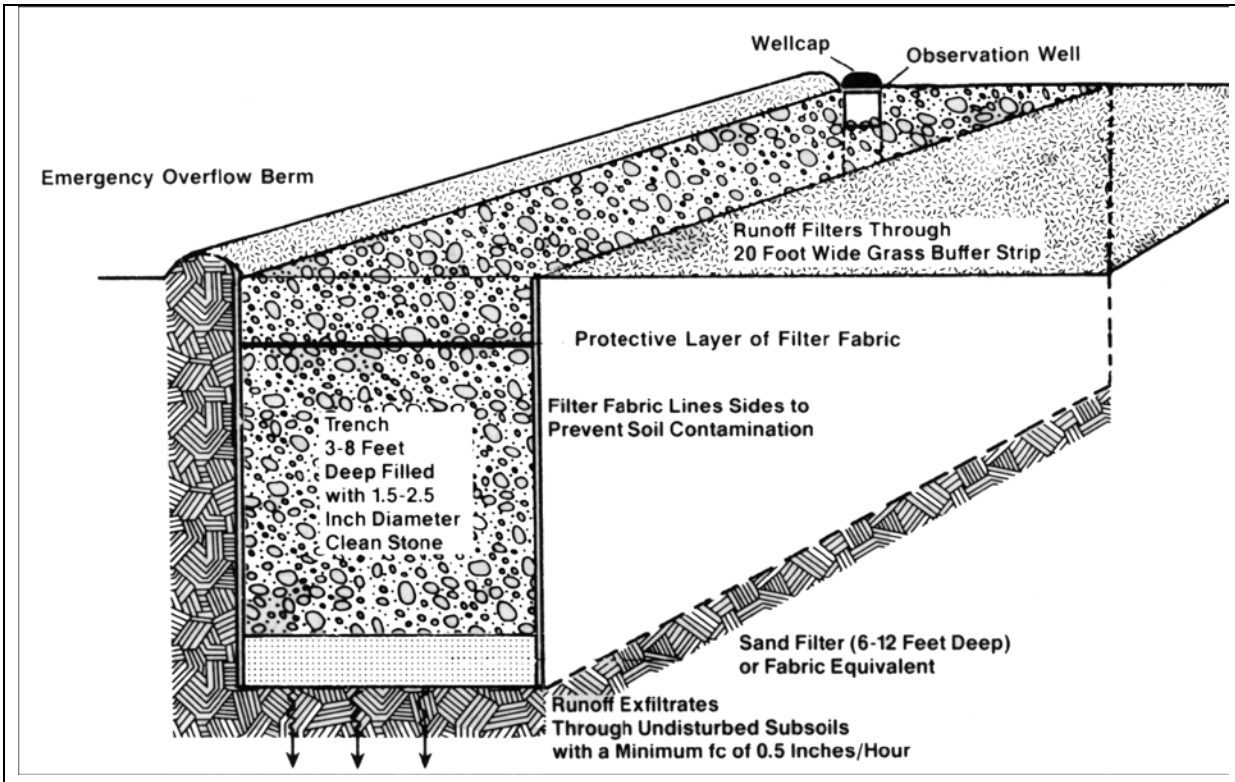
3.9 Infiltration Trench

South 48th Street & Prescott Avenue, Lincoln, NE

Description	Infiltration trenches are excavations that are lined with filter fabric and backfilled with aggregate. They are similar to bioswales but often differ in shape and size. During runoff events water enters the trench where it is initially stored and then infiltrated into surrounding soil. Pollutants are filtered out as water passes through the aggregate and filter fabric, and into the soil. Infiltration trenches can treat and detain runoff for areas at the scale of residential blocks or individual commercial and governmental parcels. Their ability to remove a variety of pollutants, as well as their relatively small footprints, makes them ideally suited for applications such as parking lot islands. Infiltration trenches are most effective when applied in conjunction with other BMP types. For example, placing a vegetated filter strip around the trench decreases the amount of sediment flowing into the trench, reducing maintenance requirements and increasing the filtration efficiency.
Effectiveness	Infiltration trenches can be very effective for reducing runoff volume and for filtering sediments. Removal efficiency for pollutants can vary but is expected to be relatively low. Infiltration trenches must be maintained as they are susceptible to clogging from fine particles.
Advantages	• Effectively removes or reduces many pollutants, including suspended solids, bacteria, and trace metals. • Reduces runoff volumes during storm events.

Advantages (continued)	• Increases baseflow in nearby streams.
Disadvantages	• Infiltration trenches may require periodic maintenance to prevent clogging.
Implementation Considerations	• Soils adjacent to planned trench site should be adequately permeable so as to allow infiltration • Slopes adjacent to the trench should be less than 12-15%. • Bottom of trench must be far enough from seasonally high water table to allow filtration by intermediate soil. • Trenches should not be employed where the potential is high for spills that might contaminate groundwater via the trench. • Pre-treatment practices, such as a vegetated filter strip, vegetated swale, or oil-grit separator are required where sediment loads from the contributing area would otherwise clog the trench, such as in parking lots and along roadsides. • Infiltration trenches in Lincoln should be constructed so a portion of the trench is below the frost line and so that ice and snow can be removed from the surface, ensuring proper functioning during cold weather. • During construction, care should be taken to avoid compacting soil surrounding the trench site, by using light equipment. • The contributing area must be stabilized before construction. Unstable areas will contribute excessive sediment to the trench, quickly clogging.
Cost Range	Medium build costs Low cost to maintain (Refer to local contractors for area specific costs)
Main Design Components	• Trenches should be excavated to a depth of approximately 3-8’ and filled with washed aggregate of a diameter between approximately 1.5 to 3 inches. • The surface of the trench may be covered by aggregate, pea gravel, or vegetation. Pea gravel and vegetation both increase sediment filtering and prolong the life of the trench. If a vegetated surface is desired, it should be installed in approximately one foot of soil. • A vegetated filter strip at least 20 feet wide should be constructed upslope from the trench, to increase sediment capture and prolong the life of the trench.

Main Design Components (continued)	• Simple observation wells, constructed of PVC pipe, allow monitoring of water levels and evaluation of performance. • Flow into the trench should be evenly distributed.
Maintenance	• Inspect the infiltrating surface at least annually and following major precipitation events to determine if the area is providing acceptable infiltration. • Remove debris and litter from the infiltrating surface to minimize clogging of the media. Remove debris and litter from the overflow structure. Ensure that the contributing drainage area, inlets, and facility surface are clear of debris. • Weeds should be removed before they flower. The frequency of weeding will depend on the planting scheme and cover. When the growing media is covered with mulch or densely vegetated, less frequent weeding will be required. Remove volunteer trees that start to grow in the vicinity of the basin. • Adjust irrigation throughout the growing season to provide the proper irrigation application rate to maintain healthy vegetation. Check for broken sprinkler heads and repair them, as needed. Completely drain the irrigation system before the first winter freeze each year. • Replace top layers (stone/topsoil/mulch/etc.) and filter fabric as needed if clogged. If ponded water is observed in the basin more than 48 hours after the end of a runoff event, check underdrain outfall locations and clean-outs for blockages. • Maintenance activities to restore infiltration capacity of trench will vary with the degree and nature of the clogging. If clogging is primarily related to sediment accumulation on the filter surface, infiltration may be improved by removing excess accumulated sediment and scarifying the surface of the filter with a rake. If the clogging is due to migration of sediments deeper into the pore spaces of the media, removal and replacement of all or a portion of the media may be required. The frequency of media replacement will depend on site-specific pollutant loading characteristics. • Repair undercut and eroded areas within the trench including the trench slopes and base.



Typical infiltration trench cross section

Infiltration Trench Maintenance Form

Site Name:

Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Control weeds (remove manually by hand or mowing)			
Remove debris/trash as needed			
Check any inlet/outlet pipes for clogging/damage			
Ensure any cleanout pipes remain watertight			
Cut back plants as appropriate and replace plants as needed			
Check for standing water issues (< 48 hrs. after rainfall event)			
Check area for signs of erosion. Reseed/re-plant as needed			
Check for accumulated sediment, remove as needed			
If irrigated, check for any necessary repairs (drain irrigation line in Fall)			
Other (miscellaneous)			

3.10 Native Vegetation

Roberts Park in Lincoln, NE

Description	Undisturbed or native landscaping can serve many BMP functions. They can help reduce erosion by protecting the underlying soil from splash erosion and slowing velocity of runoff. They can reduce off-site runoff by providing infiltration. They can filter sediment and other pollutants from stormwater runoff. They can also provide wildlife habitat and aesthetic values for the public. Native prairie planting, after the first two years, requires less maintenance than "tame" or domestic turf grass planting, reducing operations and maintenance costs. Native vegetation is also better suited than turf grasses for poor soils. Native grasses have deeper roots and can access more nutrients and water. Mowing and fertilizer application are not required to maintain a healthy stand of native vegetation. If controlled burning is not an option, mowing can control woody growth that may encroach on prairie plantings.
Effectiveness	Native vegetation is the core of using alternative strategies for reducing runoff volumes and pollutant transport. Native vegetation including grasses, forbs, and woody vegetation/trees, effectively slows runoff where if falls, maximizing infiltration and reducing the volume of pollutants that would otherwise be transported downstream.
Advantages	• Preserves predevelopment hydrology effectively. • Slows surface flows, promotes infiltration, and reduces erosion. • Traps sediment and sediment-bound pollutants.

Advantages (continued)	• Improves soil structure. • Transforms nutrients into usable forms and breaks down many pollutants. • Typically requires less maintenance than non-native landscaping. • Preserves wildlife habitat and provides aesthetic and recreational benefits. • Requires significantly less expense. • May increase property values.
Disadvantages	• Requires planning to maximize land available for development. • May require close maintenance until established. • May require a cover crop. • Cannot be established during winter.
Implementation Considerations	• To establish native vegetation, choose plant species suited to the location. Consider moisture regimes, soils, light levels, runoff properties (pollutants, concentrated flow, and sheet flow), intended land use, and level of maintenance. Determine seeding rates considering the intended purpose of the site. Typically, an installation and management plan is appropriate. • Seedbed preparation is critical to success of plantings — do not over compact the soil. • Preserving existing native vegetation ultimately demands less maintenance than turf grass plantings or other landscaping, reducing operations and maintenance costs. • Minimal mowing and herbicide application is needed to maintain a healthy stand of native vegetation. • Some mechanical means may be necessary to control invasive species and preserve the health of the system. • Minimal fertilization is required. • Establishing native uplands necessitates that seeded areas be kept moist during the first weeks of establishment; mulch also may be needed. Reseeding may be necessary if the first seeding does not produce a vigorous stand.
Cost Range	Low build cost Low cost to maintain
Main Design Components	• Seed should be applied uniformly (cyclone, drill, or hydroseeder). If feasible, broadcast seed should be covered by light raking followed by a roller.

Main Design Components (continued)	• Sod has the advantage of immediate erosion control; however native grass sod is rarely available. Native grasses can be installed as "plugs," (i.e. young, individual grass plants).
Maintenance	• Inspect area for signs of over mowing. Clearly mark areas with stakes and signs that show boundaries of areas that are not to be mowed. If mowing is needed, make sure the vegetation is mowed to the correct height. • Perform periodic weeding as needed to reduce weed competition. Check for noxious weeds and remove as needed. • Reseed bare and thin areas as needed during spring and fall. Check seed mixtures for correct formula. • Inspect areas for signs of erosion (gulley, rills, etc.). repair/regrade/reseed as needed. • Controlled burning is not allowed within City of Lincoln limits. Check local regulations before performing any type of burnings. • Avoid using fertilizers whenever possible.

Tierra Park in Lincoln, NE

Union Plaza in Lincoln, NE

Native Vegetation Maintenance Form

Site Name:

Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Sediment removal			
Erosion repair			
Weeds/Overgrown vegetation (mowing)			
Inspect Irrigation components (if applicable)			
Fertilizing/Soil Amendments			
Reseed bare/thin areas of vegetation			
Remove trash/litter			
Check structures (If applicable, signs, fencing, etc.)			
Other (miscellaneous)			

3.11 Permeable Pavement

Decorative permeable paving system installed in public square

Description	Permeable pavement, also known as pervious pavement, allows precipitation to infiltrate by way of vertical pore spaces in the paving material. A wide variety of materials are used in the creation of pervious pavement, including brick, concrete, asphalt, plastic, rock, and gravel. A pervious pavement system may make use of porous concrete or asphalt, or it may make use of cobbles, bricks, or other evenly spaced paving units. Paving systems may even integrate vegetation within spaces in the paving units, augmenting the infiltration and filtration capacity. Studies of existing permeable pavement indicate removal rates of over 80 percent for sediment and for a number of other pollutants. Infiltration of precipitation falls where it intercepts parking lots, roads, and sidewalks reducing the volume of runoff that must be handled by stormwater management systems. Permeable pavement is suitable at a variety of scales, including individual driveways, trails, overflow parking lots, and light traffic roadways.
Effectiveness	Permeable pavement, when properly maintained, has been shown to remove from 65 to 95 percent of pollutants and sediments (USEPA, 1999). Some monolithic porous pavement materials, however, have been shown to clog within one- to two years. Clogging can be remediated to restore the function of the pavement material.
Advantages	• Reduces runoff volumes. • Reduces impervious surface area. • Depending on pavement system, may provide pollutant filtering.

Disadvantages	• Certain pervious pavement types have a high potential for failure unless properly designed, constructed, and maintained. Restricting pervious pavement to areas with relatively low traffic volumes and relatively light vehicles will also increase the success rate. • May require costly maintenance if pavement becomes clogged with sediment and no longer allows infiltration.
Implementation Considerations	• Excessive runoff from adjacent impervious surfaces may lead to clogging of paving systems. • Permeable pavement should not be used in sites where excessive oil, grease, or other chemical deposition may lead to groundwater contamination, such as automotive repair shops. • Given the potential for contamination by chemicals associated with automobile traffic, pervious pavement should not be employed near groundwater drinking supplies. • The type of traffic a surface receives (i.e. pedestrian, light vehicular, heavy vehicular) will determine the most suitable pavement type. • Snowplowing must be done carefully to avoid damaging the surface and paving units, and sanding and de-icing should be avoided as they will increase clogging. • Required maintenance, especially for porous concrete and asphalt paving includes vacuum sweeping to remove deposited sediment as well as washing with a high-pressure hose to remove clogs in the surface of the pavement.
Cost Range	Medium to high build cost Medium cost to maintain (Refer to local contractors for area specific costs)
Main Design Components	• Pavement surface must allow water to infiltrate to a permeable infiltration medium below. • An underdrain system may be required where soils beneath paving system do not allow adequate infiltration (more than two inches per hour). • Slopes should be less than 5-10% to allow infiltration rather than runoff. • Integration with other BMPs improves the effectiveness of pervious pavement. For example, placing a vegetated filter strip around the pervious pavement will reduce sediment transport to the project area, reducing the amount of maintenance required.

Maintenance	• Always read the manufactures specifications first and follow as directed. • Inspect pavement condition and observe infiltration at least annually, either during a rain event or with a garden hose to ensure that water infiltrates into the surface. Video, photographs, or notes can be helpful in measuring loss of infiltration over time. • Debris should be removed, routinely, as a source control measure. Typically, sites that require frequent sweeping already plan for this activity as part of their ongoing maintenance program. For example, a grocery store may sweep weekly or monthly. Although this type of sweeper can be effective at removing solids and debris from the surface, it will not remove solids from the void space of a permeable pavement. Use a vacuum or regenerative air sweeper to help maintain or restore infiltration. • Permeable Interlocking Concrete Pavers, Concrete Grid Pavements (with aggregate infill), Pervious Concrete, and Porous Asphalt: Use a regenerative air or vacuum sweeper after any significant site work (e.g., landscaping) and approximately twice per year to maintain infiltration rates. • In general, permeable pavements do not form ice to the same extent as conventional pavements. Additionally, conventional liquid treatments (deicers) will not stay at the surface of a permeable pavement as needed for the treatment to be effective. Sand should not be applied to a permeable pavement as it can reduce infiltration. Plowing is the recommended snow removal process. Conventional plowing operations should not cause damage to the pavements.

Permeable pavers installed at Lincoln Children's Zoo

Permeable Paving Maintenance Form

Site Name:

Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Sediment/debris removal (sweep and vacuum)			
Control weeds			
Check permeability (rain event, hose, bucket, perk test)			
Check for paver damage (replace as needed)			
Remove snow and ice (if applicable)			
Remove trash/litter			
Check clean out structures (If applicable)			
Other (miscellaneous)			

3.12 Rain Barrels and Cisterns

Rain barrels installed on residential properties

Description	A rain barrel is any above-ground container modified to receive, store, and distribute rooftop runoff for non-potable uses. Rain cisterns are similar systems designed for below-ground use, but typically provide much greater storage and more complex construction techniques. Rain barrels are ideal BMP applications for residential or small commercial sites. Both practices supply water for gardens, lawns, and flowerbeds. Homeowners with large gardens, or small businesses may want to consider installing a cistern, instead of a rain barrel, since they offer much greater storage capacity.
Effectiveness	Rain barrels and Cisterns are effective in storing limited volumes of water from rooftops. Larger cisterns can provide effective volume reduction of runoff during storms. For example, a 0.1" rainfall event falling on a 1000 square foot roof produces about 60 gallons of runoff – more than enough to fill an average-sized 55-gallon rain barrel. These systems are not effective for removal of pollutants, and sediments may collect in the vessels that will have to be removed.
Advantages	• Reduces flow volumes, thereby reducing demands on stormwater management systems. • Provides free supply of water for non-potable uses, easing demands on potable drinking water sources. • Provides homeowners and small businesses with water for irrigation.

Disadvantages	• Rain barrels may not provide sufficient water in drier climates. • Rain cisterns are more expensive and require somewhat more complex design and construction.
Implementation Considerations	• Rain barrel should be sized to adequately capture runoff based on precipitation patterns in this area. • Occasional cleaning may be necessary to remove debris, such as leaves, coming off the rooftop. The barrel must also be sealed during warm months to avoid mosquito breeding and should be drained prior to winter to prevent damage caused by freezing. • Water should be drained between rainfall events (for irrigation) to maximize effectiveness. • Rain barrels are most effective when they are designed to help meet demands for non-potable water, such as irrigation.
Cost Range	Low build cost Low cost to maintain (Refer to local contractors for area specific costs)
Main Design Components	• Complete rain barrels can be purchased from a number of retailers, or they can be constructed relatively easily and economically. • Instructions for creating your own rain barrel can be found at Maryland Environmental Design Program Website. (http://www.dnr.state.md.us/ed/rainbarrel.html) • The main components of a rain barrel include tubing to connect the barrel to a downspout, a cover to prevent mosquitoes from entering, a faucet to allow regulated use of the captured water, and an overflow pipe to divert excess water once the barrel is filled. • The basic components of a rain cistern are much the same as with rain barrels, but with a much larger storage tank that is buried underground. This means a pump must also be installed to bring water out of the cistern.

Maintenance	• **Cleaning Rain Barrels**
	  • Drain, then disconnect the rain barrel from the down spout that is feeding the barrel. Place barrel to the side.
	  • Start at the gutter canal that feeds the rain barrel to make sure that the gutter is clean and clear from debris.
	  • View the interior of the downspout to be sure that there is no material blocking the downspout that could end up in the rain barrel.
	  • Remove and clean or replace the mesh screen on the rain barrel. Be sure the mesh is in good condition to handle the new season. This screen is to filter out smaller debris from entering into your rain barrel, thereby reducing overall maintenance. This screen also keeps insects or critters from entering your rain barrel.
	  • Inspect the inside of the rain barrel for general condition, looking for cracks in the barrel, debris on the bottom, or algae growth on the interior.
	  • If you need to scrub the interior of the barrel a long handled brush will work well. Using a mixture of vinegar and water, or a light bleach and water solution; scrub the interior of the barrel's walls and bottom with the brush. Then rinse the barrel again and let dry.
	  • Inspect the spigot of the barrel to make sure it is functioning well. Clean if necessary.
	  • Considering moving barrel indoors during winter months to avoid freeze damage.
	• **Cleaning Cisterns**
	  • Clean the catchment area (for example, rooftop and gutters) and remove all debris and water.
	  • Scrub the inside with a stiff brush and a solution of 1 cup (about 0.25 liter) of unscented liquid household bleach (5%-8.25%) mixed with 10 gallons (about 38 liters) of water.
	  • Rinse cistern with clean, safe water, then drain, refill the cistern with clean, safe water.
	  • Consider installing a treatment system to improve the quality and safety of cistern water. Measure the chlorine residual regularly; chlorine test kits can be found at most swimming pool supply stores. Maintain a free chlorine residual between 0.2 ppm to 2.0 ppm to prevent microbial growth.

Larger rain barrel installed on commercial property
Source: Higher Ground Rainwater Systems

Rain Barrel/Cistern Maintenance Form

Site Name:

Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Sediment/debris removal (vacuum or drain structure)			
Clean out filters/inlets/hoses			
Clean out gutters/drainage paths leading to structure			
Check for exterior damage and leaks			
Prep structure for Winter (if applicable)			
Other (miscellaneous)			

3.13 Rain Garden

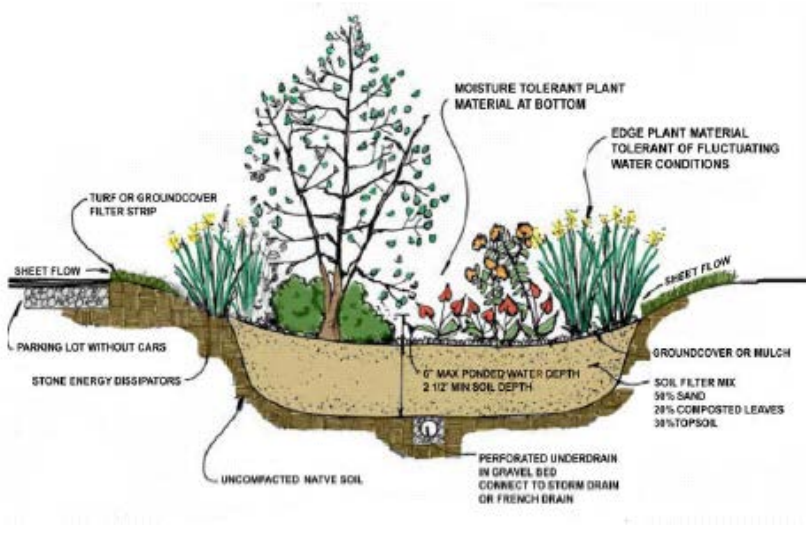
26th Street & N Street, Lincoln, NE

Description	A rain garden is a small residential depression planted with native wetland and prairie vegetation (rather than a turfgrass lawn) where sheet flow runoff collects and infiltrates. Rain gardens function similar to larger-scale bioretention areas. Typical sites for rain gardens include residential yards and community common areas.
Effectiveness	Raingardens are effective in removing from 30 to 90 percent of nutrients (such and nitrogen and phosphorus) and 80 percent of sediments as well as reducing runoff volumes.
Advantages	• Provides localized stormwater control by collecting and storing water, allowing water infiltration into the soil. • Improves water quality by filtering pollutants from stormwater. • Easy to plan and build. • Aesthetically pleasing. • Flexible to incorporate existing natural features. • Preserves natural/native vegetation. • Protects adjacent properties.
Disadvantages	• May need to irrigate to maintain vegetation during dry periods. • Requires annual maintenance to maintain vegetation and aesthetic qualities.
Implementation Considerations	• The maximum drainage area into rain gardens should be less than one acre.

Implementation Considerations (continued)	• The ponding depth of a rain garden is typically 4 to 6 inches. • Limit ponding in the depressional area to 3 days or less to avoid nuisance insects. • Line the depressional area with a mulch and organic layer in which vegetation is planted. • The mulch holds moisture and aids removal of metals. • Underneath the mulch and organic layer is the planting soil. • Place rain gardens a minimum of 10 feet away from building foundations. • Placement of the rain garden and overflow path should not interfere with adjoining property drainage patterns. • Rain gardens should not be located in areas where ponded water may create problems for surrounding vegetation or land use.
Cost Range	Low to medium cost (depending on size) Low to medium cost to maintain (Refer to local contractors for area specific costs)
Main Design Components	• Ponding depths restricted to 6 inches or less. • Deep rooted perennials and trees are encouraged. • The planting soil should be a mixture of sand, loam, and clay to provide water and nutrients to the plants. • Native species that are tolerant of both wet and dry cycles are highly recommended. • Modify soil with compost to increase permeability. • Provide a drain tile system if soil permeability is a problem. • Maintenance, including mowing and weeding, is typically required two times a year.
Maintenance	• Inspect the infiltrating surface at least annually and following major precipitation events to determine if the rain garden is providing acceptable infiltration. • Remove debris and litter from the infiltrating surface to minimize clogging of the media. Remove debris and litter from the overflow structure.

Maintenance (continued)	• Weeds should be removed before they flower. The frequency of weeding will depend on the planting scheme and cover • Inspect rain garden side slopes and grass filter strips for evidence of any rill or gully erosion and repair it. • If applicable, check for broken sprinkler heads and repair them as needed. Completely drain the irrigation system before the first winter freeze each year. • Check for sediment buildup at curb cuts, gravel diaphragms or pavement edges that prevents flow from getting into the bed, and check for other signs of bypassing. • Sediment Removal and Growing Media Replacement: If ponded water is observed in a bioretention cell more than 48 hours after the end of a runoff event, check underdrain outfall locations and clean-outs for blockages. If clogging is primarily related to sediment accumulation on the filter surface, infiltration may be improved by removing excess accumulated sediment and scarifying the surface of the filter with a rake. If the clogging is due to migration of sediments deeper into the pore spaces of the media, removal and replacement of all or a portion of the media may be required.

Typical Rain Garden Cross Section (Source: Pennsyvania Stormwater BMP Manual, 2005)



Rain Garden Maintenance Form

Site Name:

Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Control weeds (remove manually by hand or mowing)			
Remove debris/trash as needed			
Check any inlet/outlet pipes for clogging/damage			
Ensure any cleanout pipes remain watertight			
Cut back plants as appropriate and replace plants as needed			
Check for standing water issues (< 48 hrs. after rainfall event)			
Check area for signs of erosion			
Check for accumulated sediment			
If irrigated, check for any necessary repairs (drain irrigation line in Fall)			

3.14 Soil Conditioning

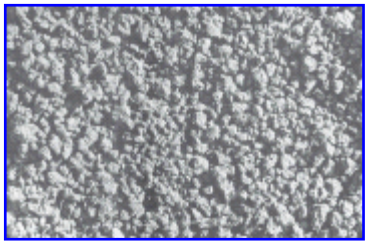
Amended soils with healthy vegetation

Description	Soils are the primary medium of stormwater infiltration and storage. Soil management, whether by managing existing soils, or amending soil with supplemental materials to facilitate stormwater infiltration and treatment, is essential for the success of nearly all best management practices. Essentially, retaining the natural soil structure where possible is the preferred approach for soil management. Even with clay soils that may typically have low permeability, proper soil management will enhance stormwater infiltration. Soil texture is the term applied to describe the sand, silt, and clay content of the soil. Sandier soils are more permeable and allow water to move into and through them more rapidly. Clay soils have smaller, tighter pores, and water moves into and through clayey soils more slowly. Soil structure is the term applied to the arrangement of soil components – the sand, silt, and clay, as well as organic matter, into secondary units, or aggregates. Soil structure may be more important than soil texture, as soil structure more effectively describes the soil's capability to infiltrate and move water through the profile. "Good" soil structure usually describes soil that is friable, or easily broken into smaller pieces, and that has a combination of large and small pores. This soil will typically be high in organic matter and allow plant roots to grow freely and water to move rapidly into the soil. Even clay soils can have good soil structure and provide an optimal medium for stormwater management BMPs. **Soil Amendments** The clayey soils in Southeast Nebraska can limit stormwater infiltration, especially soils in developed areas. Where soils have little topsoil and are predominantly clay or fine silt, soil amendments may be necessary to "open up" the soil with greater macro porosity and better soil structure. Soil amendments typically include manure or compost, plant materials, or

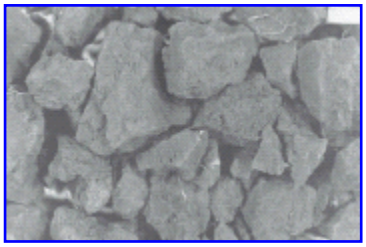
Description (continued)	chemicals that will help aggregate soil particles. When soil amendments are added to existing soils, they need to be thoroughly mixed and integrated into the soil. Soil amendments can also be added to sandy soils to increase water holding capacity and its ability to support plants.
Effectiveness	Proper soil management is essential for nearly all stormwater BMPs. Soil that provides adequate infiltration will filter more than 90 percent of pollutants, 100 percent of sediments, and substantially reduce surface runoff. Soil management is most effective with native vegetation cover to stabilize soils and reduce erosion.
Advantages	• Retaining native or natural soils on a site allows for more rapid and successful plant establishment. Plants in soils with good structure and high organic matter will survive climate extremes better than plants in "poor" soils. • Retaining topsoil maximizes rainwater infiltration and storage capacity. One foot of topsoil can store more than one-inch of precipitation. • Soils high in organic matter filter pollutants and break down organic compounds. • Organic matter in soils hold more water, acting like a sponge. The water is released as needed for plant use. • Organic matter in soils hold and provide nutrients for plant growth. • Soils with good structure and high organic matter are more stable.
Disadvantages	• Re-building soils with good porosity and structure can be expensive. • If improperly managed, soils high in clay may not support stormwater infiltration or good plant growth. • Development may require removing topsoil, grading, and then replacing the topsoil. • Too much heavy equipment on soils may compact them, resulting in poor BMP performance. • Soil amended with other materials must be carefully mixed to assure uniformity.
Implementation Considerations	• Local soils and soil conditions should be examined before site construction begins. • Soil tests should be completed to determine if the physical and chemical properties are adequate for absorbing rainwater or supporting vegetation. • BMP goals (infiltration, detention, biotreatment) should be established prior to determining what appropriate soil characteristics are desired.

Implementation Considerations (continued)	• Avoid stripping topsoil from construction sites if possible. Avoid storing heavy equipment/materials over soil to reduce compaction.
Cost Range	Low build cost if existing soil can be re-used, medium to high build cost if soil is re-engineered. Low to medium cost to maintain (Refer to local contractors for area specific costs)
Main Design Components	• Depth of soil. • Clay content. • Soil permeability, organic content, infiltration rate. • Subsoil consistency, depending on performance criteria of BMP. • Effective homogenization of soils to assure effective porosity, texture, and particle distribution.
Maintenance	• Inspect the condition of the soil at least annually. If poor vegetation growth and/or drainage is observed, soil testing is recommended. Decide how many soil samples are necessary for your landscape. One sample is usually sufficient for most landscapes unless there are obvious soil differences, then each unique area should be sampled separately. Choose a test that will give results for residual nitrogen, phosphorus, potassium, organic matter, cation exchange capacity (CEC) and soil pH. Add amendments as needed. • Depending on the application, aerating may be needed on heavily compacted soils. • If soils begin to lack nutrients and erode, adding mulch is an easy way to retain water, inhibit weed growth, and prevent erosion. Mulch is any material, such as wood chips, grass clippings, leaves or compost, even rock, newspaper or shredded tires, that is spread over the surface of soil to retain water, inhibit weed growth and keep temperature moderate. Organic mulches are preferred as they break down overtime and encourage earthworms and beneficial insects to live in your garden. • Before reseeding/re-planting, it's important to thoroughly work the soil. Amend poor soils, such as heavy clay, by adding organic matter. Sources include compost, rotted manure, peat, and quality topsoil Incorporate these materials into the existing soil, rather than layering them on the surface. A goal is to have six inches or more of well-prepared soil, and beyond that is impractical around large trees where many roots are found within the dripline.

Examples of Typical Soil Structure



Granular Structure



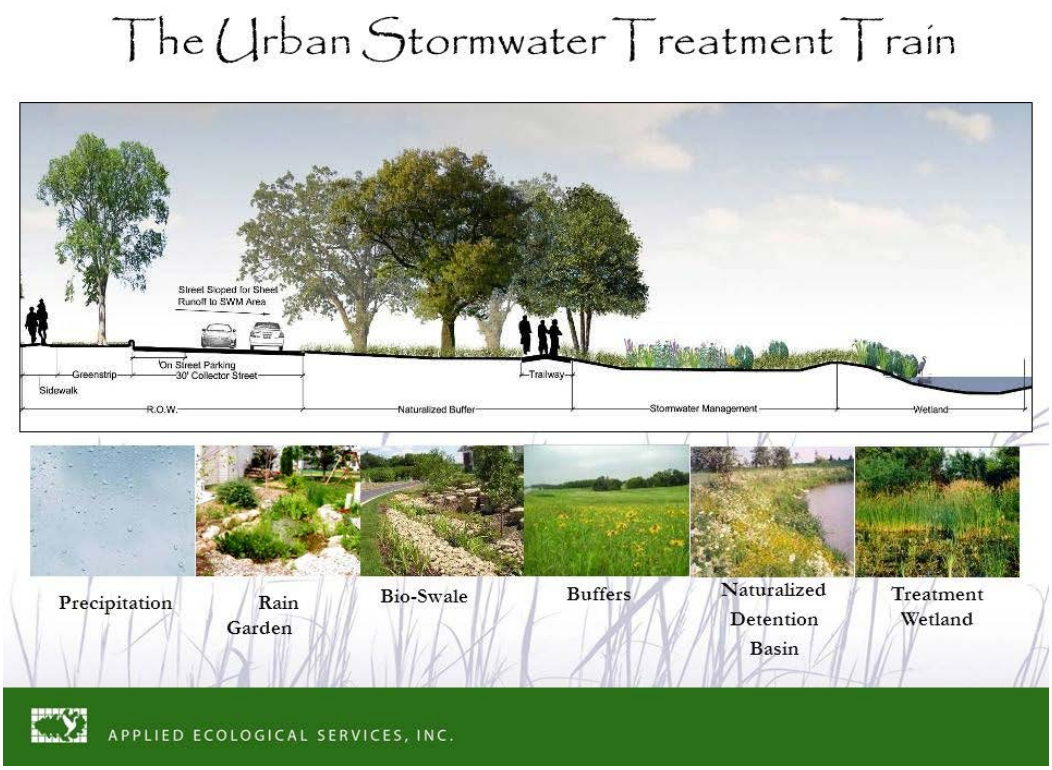
Blocky Structure

Platy Structure

Massive Structure

Prismatic Structure

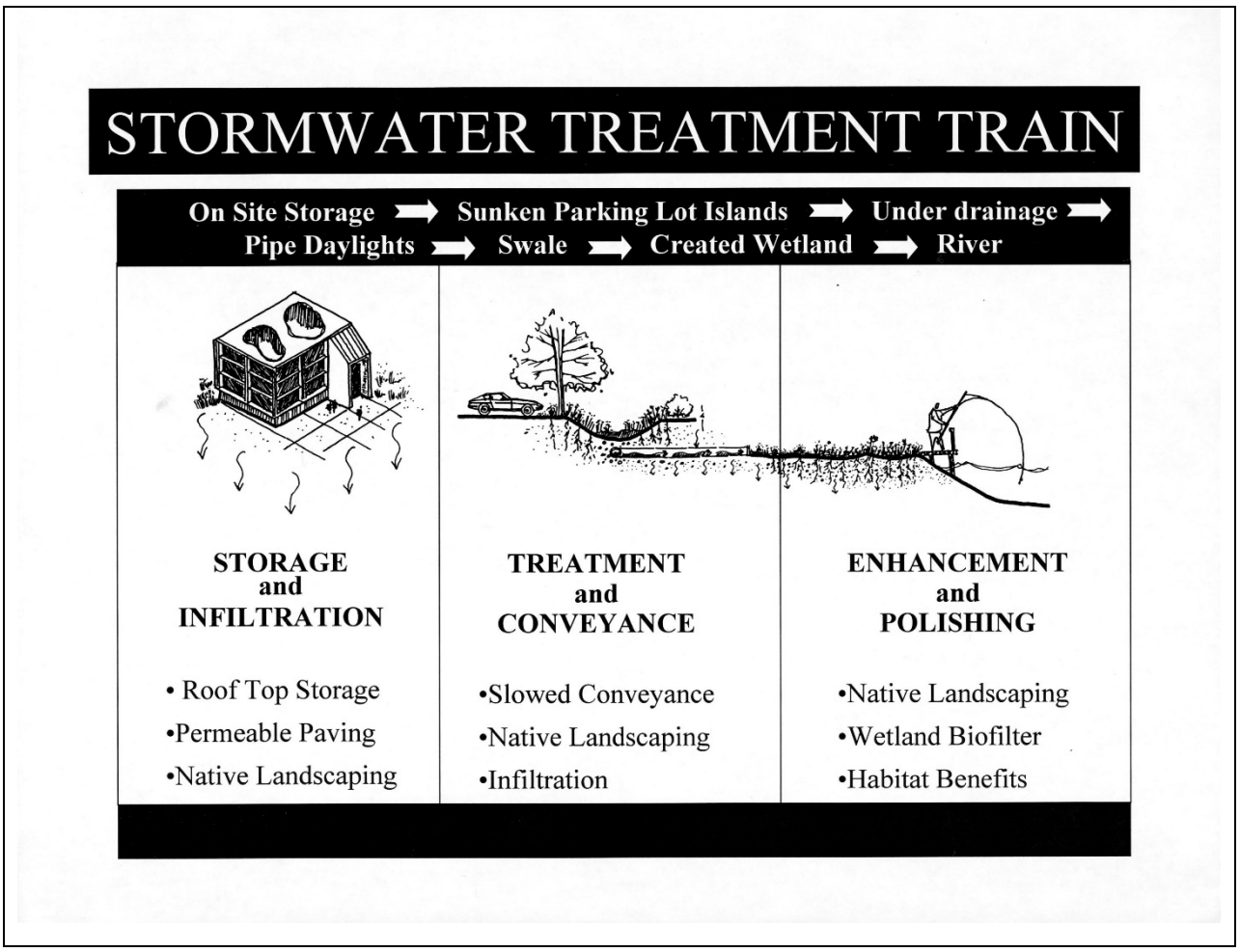
3.15 Stormwater Treatment Train



Source: Applied Ecological Services, Inc.

Description	The Stormwater Treatment Train (STT) represents an ecological approach to stormwater management and has proven effective and versatile in its various applications. The STT was designed with sequential components that contribute to the treatment of stormwater before it leaves the site. The components of the Stormwater Treatment Train system were designed to treat stormwater runoff for water quality benefits and to reduce stormwater runoff peaks and volumes. Based on hydrologic modeling and published information on BMP effectiveness, the STT approach can be expected to reduce surface runoff volumes by 65 percent and reduce solids, nutrients, and heavy metals loads by 85 percent to 100 percent. Source controls (upstream from the initial swale component) minimize the impacts of the development even further. This alternative approach to stormwater management not only has the potential to reduce infrastructure costs, but it also reduces maintenance costs. As described above, native plants are adapted to the environment, and do not need extensive watering, chemical treatment, mowing, and replanting that non-native species demand. In addition, there is also a substantial benefit to downstream neighbors. By treating stormwater where it falls on the land, responsible landowners are reducing their contribution to downstream flooding and sedimentation.

Effectiveness	The STT incorporates a number of BMPs with varying effectiveness for removing particulates and pollutants while also reducing runoff volume.
Advantages	• Provides effective stormwater flood control by slowing down runoff and storing water, including water infiltration into the soil. • Improves water quality by filtering pollutants from stormwater (oils, greases, metals, and sediments that can be picked up from paved surfaces). • Reduces erosion. • Flexible to incorporate existing natural features and/or introduced stormwater control features. • Provides open space that can be used for recreation and aesthetic value. • Preserves natural/native vegetation and provides habitat for wildlife. • Protects adjacent properties. • Improves property values.
Disadvantages	• May require more space than is available. • Requires planning and stakeholder acceptance.
Implementation Considerations	• Public outreach and acceptance for existing developments or communities. • Effect on long-term stormwater management infrastructure. • Demonstration of improved property values and cost of development with implementation of the Stormwater Treatment Train. • Planning and engineering of effective treatment train appropriate for each area. • Determine the necessary space and length to achieve stormwater management goals and water quality.
Cost Range	Medium to high build cost (depending on extent of system) Low to medium cost to maintain (Refer to local contractors for area specific costs)
Main Design Components	Not applicable.
Maintenance	• Not applicable (see specific BMP sections for more information)


STORMWATER TREATMENT TRAIN
On Site Storage
Sunken Parking Lot Islands
Under drainage
Pipe Daylights
Swale
Created Wetland
River
STORAGE and INFILTRATION
• Roof Top Storage
•Permeable Paving
•Native Landscaping
TREATMENT and CONVEYANCE
•Slowed Conveyance
•Native Landscaping
•Infiltration
ENHANCEMENT and POLISHING
•Native Landscaping
•Wetland Biofilter
•Habitat Benefits

3.16 Underground BMP

Source: Colorado Stormwater Center

Description	In relatively dense urban areas where a large percentage of the landscape may already be developed, subsurface facilities may be the most practical way to achieve substantial flow volume and rate reductions. Although costs for constructing subsurface storage practices may be high, it may be the most economical way to detain stormwater in urban settings where land values are high. There are a number of types of subsurface storage available. In the simplest system, oversized pipes replace standard pipes in a storm drain, providing temporary storage of water. More storage can be achieved by using a series of interconnected pipes or a single large storage vault. Since these systems offer little or no water quality enhancement when used on their own, they should be coupled with other BMPs in a Stormwater Treatment Train™ to achieve water pollution control objectives. Certain measures, such as sand filters or sediment traps will reduce the amount of maintenance required to keep subsurface storage systems functioning properly.
Effectiveness	Underground BMPs are effective for reducing stormwater runoff, however little reduction of sediments or pollutants occurs without supplemental means to filter stormwater.
Advantages	• Provides substantial storage in areas with limited or no land left undeveloped.

Advantages (continued)	• Can be constructed under parking lots or other surfaces, allowing multiple uses for land. • Underground BMP facilities can be constructed relatively quickly and are quite durable once constructed. • Safer than above-ground storage such as ponds, since residents will not have access to them. • Water captured in subsurface storage can be used for non-potable uses on-site, such as toilet flushing, irrigation, or evaporative air-conditioning.
Disadvantages	• Does not provide water quality benefits, unless other measures, such as oil/grit separators, sand filters, or water quality inlets, are integrated into the design. • May be relatively expensive to implement. • Requires removal of existing surface. • May require more excavation than aboveground storage facilities. • Maintenance may be more difficult than for above ground storage.
Implementation Considerations	• The size and shape of the available site will determine the correct system. Large continuous areas are more suited to large vault-type systems, while more linear, angular sites are better suited for pipe-based system. • Plastic pipes used in storage may float upward if water table is too high. • Construction materials are influenced by the usable depth and size of the site. Sites requiring more shallow construction should use concrete, since corrugated steel and plastic must be surrounded by more fill.
Cost Range	High build cost Low to medium cost to maintain (Refer to local contractors for detailed cost on Vac trucks)
Main Design Components	• May consist of a simple storage pipe or chambers, or a more complex network of inlets, pipes, chambers, joints, outlets, and access points. • All underground storage must have, at a minimum, an inlet structure, an outlet structure, and an access point, such as a manhole, to the chamber.

Main Design Components (continued)	• HDPE or corrugated metal pipes are more economical, and easier to install, but require greater fill for stabilization and support.
Maintenance	• Always follow the manufacturer's recommended maintenance requirements and inspection frequency schedule. • A good rule to follow is to inspect underground BMPs at least quarterly for the first two years of operation and then two to three times a year for the life of the BMP. • Check for debris that could cause the structure to bypass water quality flows. Strong odors may also indicate that the facility is not draining properly. • Inspect inlet areas frequently; at a minimum, inspect after every storm event exceeding 0.6 inches. Removal of flow blocking debris is critical for flood control. • Remove sediment/debris as needed depending on manufactures recommendations. Vac trucks may be needed depending on application.

Parking lot subsurface storage detail

Underground BMP Maintenance Form

Site Name:

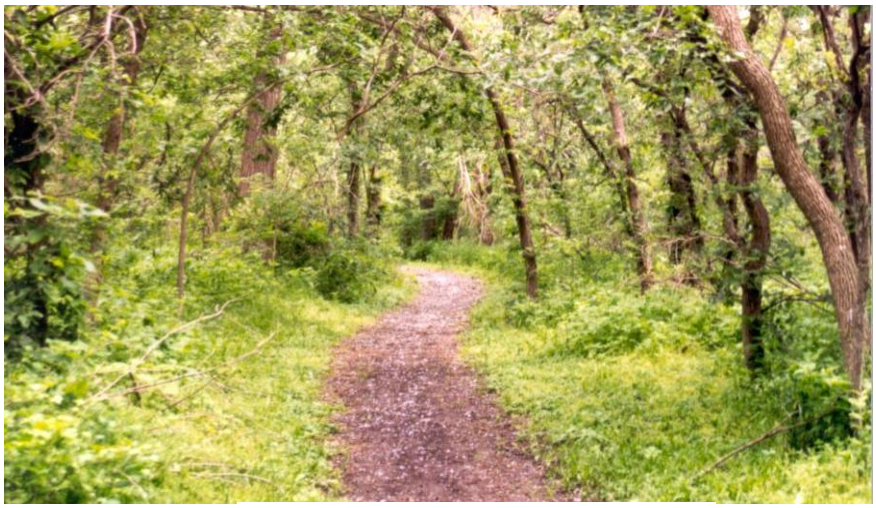
Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Follow manufacturer's instructions for maintenance			
Remove debris			
Vacuum out debris as needed			
Replace filter material as needed			

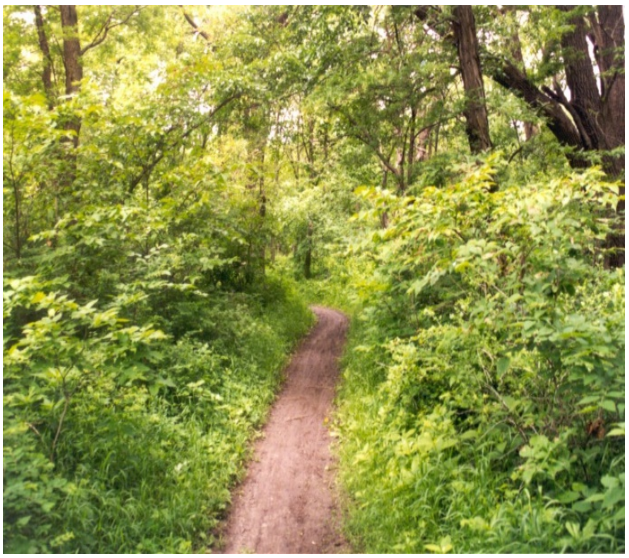
3.17 Urban Forests



Wilderness Park, Lincoln, NE

Description	Trees clean the air and water, provide protection from the wind, improve the view from our homes, and create green space that provides recreational and educational opportunities. Trees along streams cool the water, provide food for stream organisms, add structure to the stream channel, and stabilize streambanks. While sod and other ground cover hold topsoil in place, tree roots penetrate deep and spread out anchoring large blocks of soil. Densely-planted trees and shrubs can do additional duty by keeping bikes, foot traffic, and motor vehicles off slopes and fragile soils that are prone to wind and water erosion.
Effectiveness	Trees intercept rainfall, reducing its velocity and impact by holding a substantial portion of the rain in the canopy. In one study, a 32-foot tall tree intercepting rainfall reduced stormwater runoff by 327 gallons. Trees and shrubs planted in bioswales, wetlands, and riparian forest buffers can filter out contaminants as they slow and capture stormwater runoff.
Advantages	• Trees improve soil erosion and sediment control. • Trees provide excellent streambank stabilization. • Create green space for riparian zones, and utilization for recreation. • Require minimal or no maintenance. • Trees provide food, shelter, nesting, and travel corridors for wildlife. • Trees provide many additional environmental values including noise reduction, temperature modification, and aesthetic benefits. • Trees resist environmental extremes. • Improve value of property.

Disadvantages	• Slow growth, therefore, benefits are not immediately realized. • May require substantial space if many trees are desired.
Implementation Considerations	• Green spaces should be designed with a variety of plant species to guard against major losses from insects and disease and help diversify the urban landscape. • Species should be chosen that are indigenous to the area and will tolerate climatic extremes. • Surrounding environment, including soils, hydrology, and land-use, should be considered in picking the types of trees used and where they will be planted. • Surrounding vegetation should not out-compete young trees.
Cost Range	Low build costs (depending on existing site conditions) Low cost to maintain (Refer to local contractors for area specific costs)
Main Design Components	• If buildings will be nearby future tree canopy height and extension must be considered. • Depth of soil. • Surface and subsurface hydrology. (How much water will support the tree?) • When possible, design developments around stands of existing trees; avoid complete clearing, and replant trees.
Maintenance	• Inspect vegetation for signs of overgrowth and/or noxious weeds, which may outcompete young seedlings. • Remove trash/litter from the area on a continuous basis. If the area is in public place with frequent foot traffic, trash containment containers might be warranted if littering is evident. • After initial planting, periodically check tree growth for any signs that may be preventing the trees from reaching maturity (soil condition, watering amounts, fertilizing etc.) • Inspect trees for signs of disease and insect damage. Consult a local arborist for more information on treatment/prevention.



Wilderness Park, Lincoln, NE

Urban Forest Maintenance Form

Site Name:

Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Weeds/Vegetation overgrowth (mow as needed)			
Remove debris/trash as needed			
Plantings/ Tree growth (adjust watering, fertilizer as needed)			
Inspect vegetation for signs of disease			
Inspect vegetation for signs of insect damage			
Check structures for damage (if applicable, signs, fencing, etc.)			
Other (miscellaneous)			

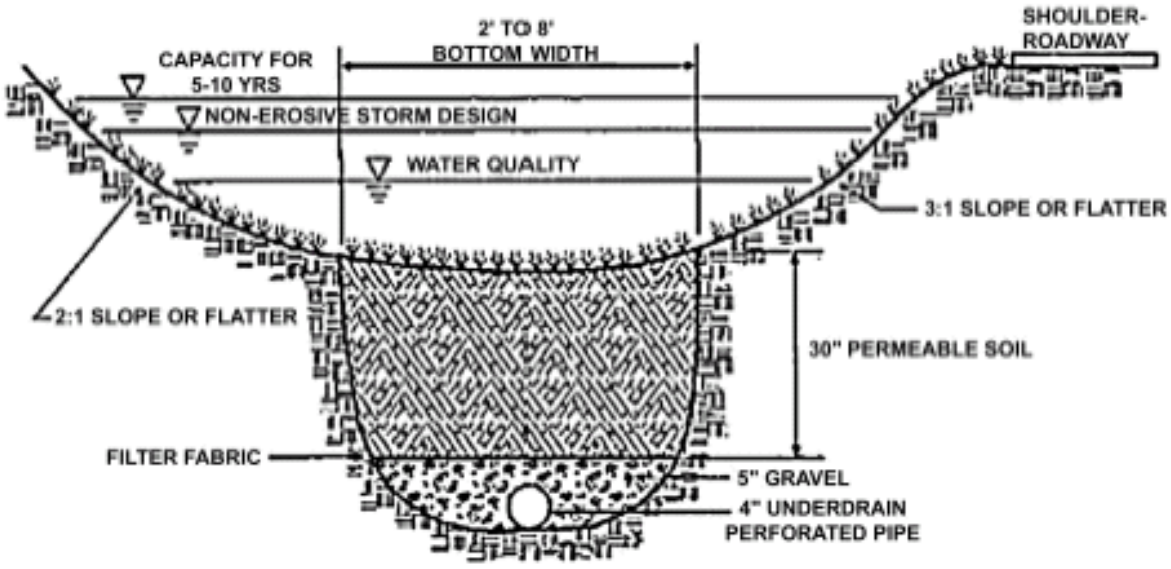
3.18 Vegetated Bioswale

Bioswale using native plantings in a residential applicable

Description	Vegetated swales are basically a filter strip located along a gentle ditch known as a “swale”. Drainage swales that are planted with native vegetation are commonly called bioswales. Swales have gently sloping sides and are used to convey the overland flow of stormwater down a subtle gradient. Swales accomplish many of the same functions provided by filter strips (slowing and cleaning water, encouraging infiltration, etc.), while also providing directed conveyance. This conveyance function is particularly important when managing concentrated flows and during severe storm events when stormwater needs to be directed to a destination, such as a wetland. Swales should be designed with native species for the reasons described above and can be augmented with check dams and other techniques to maximize their effectiveness at managing stormwater.
Effectiveness	Vegetated bioswales are effective in slowing stormwater and reducing significant amounts of runoff. Removal of sediments and pollutants is high, ranging from 20 to 40 percent, but removal rates have been reported to exceed 80 percent (USEPA, 1999).
Advantages	• Provides effective stormwater flood control by slowing down runoff and storing water, including water infiltration into the soil. • Improves water quality by filtering pollutants from stormwater (oils, greases, metals, and sediments that can be picked up from paved surfaces). • Can be used as a system by itself, or, in conjunction with other Best Management practices.

Advantages (continued)	• Easy to plan and build. • Reduces erosion. • Flexible to incorporate existing natural features. • Preserves natural/native vegetation and provides habitat for wildlife. • Protects adjacent properties. • Although periodic cleaning may be required, swales should never need to be replaced, in contrast to conventional stormwater systems.
Disadvantages	• May require planning and stakeholder acceptance depending on location. • Requires proper sloping. • Not the fastest conveyance method—carefully design and place swales to minimize risk of flooding. • Swales can only treat a limited area.
Implementation Considerations	• Public outreach and acceptance for existing developments or communities. • Extent of drainage area. • Demonstration of improved property values and cost of development with implementation of the Stormwater Treatment Train. • Planning and engineering of effective treatment train appropriate for each area. • Determine the necessary space and length to achieve stormwater management goals and water quality.
Cost Range	Low build costs Low cost to maintain (Refer to local contractors for area specific costs)
Main Design Components	• Individual swales should be designed to treat relatively small, flat drainage areas. If swales use slopes steeper than four percent, or if they treat areas larger than 5 acres, the flow velocity may be too great for effective treatment and erosion could occur. • Unless existing soils are highly permeable, they are replaced with a sand/soil mix that meets minimum permeability requirements. An underdrain system may also be installed under the soil bed. Typically, the underdrain system is created by a gravel layer which encases a perforated pipe.

Main Design Components (continued)	• The bottom of the swale should be at least three feet above groundwater in order to prevent the swale bottom from remaining too wet. • The swale should have trapezoidal or parabolic cross section with relatively flat side slopes (less than 3:1). • The flat channel bottom should be between two and eight feet wide to ensure sufficient filtering surface for water quality treatment.
Maintenance	• Inspect the infiltrating surface at least annually and following major precipitation events to determine if the area is providing acceptable infiltration. • Remove debris and litter from the infiltrating surface to minimize clogging of the media. Remove debris and litter from the overflow structure. Ensure that the contributing drainage area, inlets, and facility surface are clear of debris. • Weeds should be removed before they flower. The frequency of weeding will depend on the planting scheme and cover. When the growing media is covered with mulch or densely vegetated, less frequent weeding will be required. Remove volunteer trees that start to grow in the vicinity of the basin. • Adjust irrigation (if applicable) throughout the growing season to provide the proper irrigation application rate to maintain healthy vegetation. Check for broken sprinkler heads and repair them, as needed. Completely drain the irrigation system before the first winter freeze each year. • Replace top layers (stone/topsoil/mulch/etc.) and filter fabric as needed if clogged. If ponded water is observed in the basin more than 48 hours after the end of a runoff event. • Maintenance activities to restore infiltration capacity of swale will vary with the degree and nature of the clogging. If clogging is primarily related to sediment accumulation on the filter surface, infiltration may be improved by removing excess accumulated sediment and scarifying the surface of the filter with a rake. If the clogging is due to migration of sediments deeper into the pore spaces of the media, removal and replacement of all or a portion of the media may be required. The frequency of media replacement will depend on site-specific pollutant loading characteristics. • Repair undercut and eroded areas within the swale including the swale slopes and base.



Typical cross section of a parabolic vegetated swale

Vegetated Bioswale Maintenance Form

Site Name:

Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Control weeds (remove manually by hand or mowing)			
Remove debris/trash as needed			
Check any inlet/outlet pipes for clogging			
Ensure any cleanout pipes remain watertight			
Cut back plants as appropriate and replace plants as needed			
Check for standing water issues (< 48 hrs. after rainfall event)			
Check area for signs of erosion			
Check for accumulated sediment, remove as needed			
If irrigated, check for any necessary repairs (drain irrigation line in Fall)			
Other (miscellaneous)			

3.19 Constructed Wetlands

63rd Street and Platte Urban Wetland, Lincoln, NE

Description	Stormwater wetlands are shallow marsh systems planted with emergent vegetation that are designed to treat stormwater runoff. While they are one of the best BMPs for pollutant removal, stormwater wetlands can also mitigate peak rates and even reduce runoff volume to a certain degree. They also can provide considerable aesthetic and wildlife benefits. Wetlands use a relatively large amount of space and require an adequate source of inflow to maintain the permanent water surface. Like detention basins and wet ponds, stormwater wetlands may be used in connection with other BMP components, such as forebays and micropools.
Effectiveness	Properly designed wetlands can remove significant amounts of nitrogen and phosphorus, suspended solids, and other pollutants from urban environments. The relative amounts of pollutant and suspended solid removal is similar to other BMPs, however, with removal rates ranging from 40 to 80 percent. Wetlands are very effective for reducing runoff volume and velocity.
Advantages	• Improvements in downstream water quality. • Settlement of particulates. • Removal of pollutants. • Flood attenuation and reduction of peak discharge. • Enhancement of biological diversity and wildlife habitat in urban areas. • Aesthetic enhancement and valuable addition to community green space. • Relatively low maintenance costs.

Disadvantages	• May be difficult to maintain vegetation under a variety of flow conditions. • May require larger land requirements than other BMPs. • Pollutant removal efficiencies may be low until vegetation is established. • Relatively high construction costs. • If not designed properly, wetlands may not receive favorable community attention.
Implementation Considerations	• Site must have adequate water flow and appropriate underlying soils. • Baseflow must be sufficient to maintain a shallow pool in the wetland. • Underlying soils should allow only allow small infiltration losses.
Cost Range	Medium to high build costs (will vary based on plant selection and size of area) Low cost to maintain (Refer to local contractors for area specific costs)
Main Design Components	• Sediment forebays are recommended to decrease the velocity and sediment loading to the wetland. • The wetland design should include a buffer to separate the wetland from surrounding land. • Above-ground berms or marsh wedges should be placed at approximately 50 foot intervals to increase the dry weather flow path within the wetland. • Before the outlet, a four- to six-foot micropool should be included in the design to prevent the outlet from clogging. The micropool should hold at least 10 percent of the total treatment volume. • The outlet from the micropool should be at least one foot below the normal pool surface. • Install a bottom drainpipe with inverted elbow to prevent sediment clogging in order to drain the wetland in case of emergencies or for routine maintenance. • As the wetland-to-watershed ratio increases, the average runoff residence time increases and the effectiveness of the wetland for pollutant removal also increases. • The stormwater wetland's effectiveness for removing pollutants depends on the residence time of water in the wetland.

Main Design Components (continued)	• Vegetation can be established by allowing volunteer vegetation to become established, or, from planting nursery stock. • Give priority to species that have already been used successfully in constructed wetlands. • Lincoln has unique saline wetlands that are home to the threatened and endangered Salt Creek Tiger Beetle at some locations. Special care must be taken when designing wetlands near or around these sensitive environments.
Maintenance	• Inspect the wetland area at least annually. Note the amount of sediment accumulation and look for debris at the outlet areas. • Remove debris and litter from the wetland area as needed. This includes floating debris that could clog the inlet/outlet areas or overflow structure. • If a reduction in cattails is desired, harvest them annually, especially in areas of new growth. Cut them at the base of the plant just below the waterline, or slowly pull the shoot out from the base. Cattail removal should be done during late summer to deprive the roots of food and reduce their ability to survive winter. • Mosquito control may be necessary if mosquitoes are found to be breeding in the BMP. The most effective mosquito control programs include weekly inspection for signs of mosquito breeding with treatment provided when breeding is found. These inspections and treatment can be performed by a mosquito control service and typically start in mid-May and extend to mid-September. The use of larvicidal briquettes or "dunks" is not recommended for ponds due to their relatively large size and configuration. • For constructed wetland ponds, reestablish growth zone depths and replant if necessary.

Peterson Park wetland area, Lincoln, NE

Constructed Wetland Maintenance Form

Site Name:

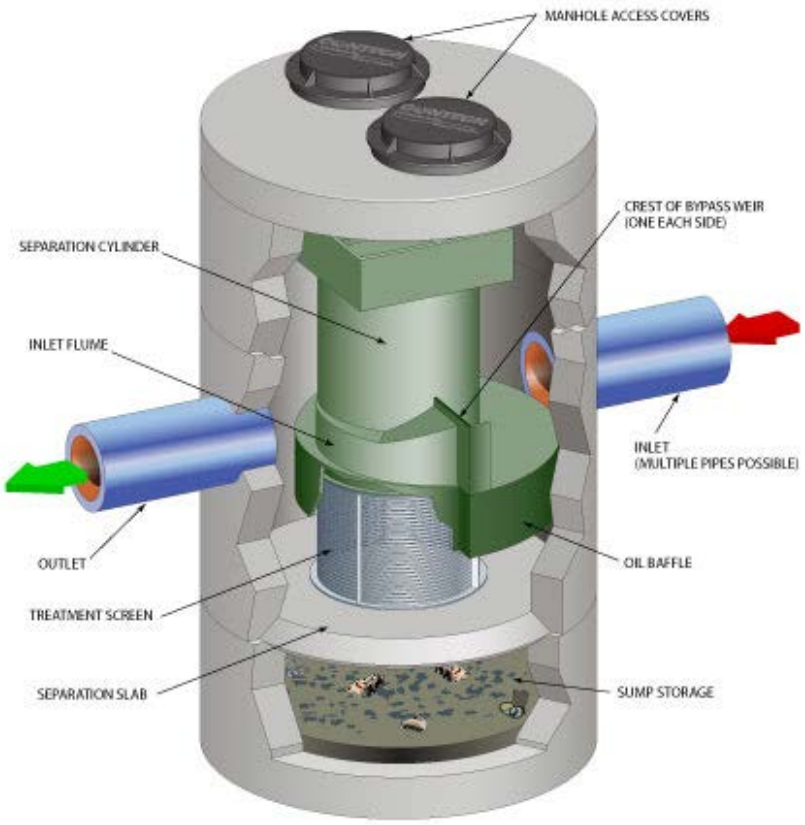
Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Control weeds (remove manually by hand or mowing)			
Remove debris/trash as needed			
Check inlet/outlet pipes for clogging			
Check for signs mosquito breeding			
Cut back plants as appropriate and replace plants as needed			
Check area for signs of erosion			
Check for accumulated sediment, remove as needed			
Other (miscellaneous)			

3.20 Hydro-Dynamic Separator



Hydrodynamic Separator detail

Description	Hydrodynamic separators are stormwater management devices that use cyclonic separation to control water pollution. They are designed as flow-through structures with a settling or separation unit to remove sediment and other pollutants and are used to treat and pre-treat stormwater runoff.
Effectiveness	Effectiveness is dependent on application. Hydrodynamic separators are most effective where the separation of heavy particulate or floatable from wet weather runoff is required. There are limitations to treatment effectiveness. Solids and floatables capture is sensitive to the flow rate and detention time within the device, as longer detention time results in better removal of pollutants. Generally, they provide relatively low and variable capture of fine particulates (< 50 microns) and particulate-bound pollutants (metals, nutrients, hydrocarbons, bacteria) that are concentrated on the fine particle fractions, except at low surface loading rates during low intensity storms and during inter-event settling periods.

Advantages	• Good capture of sand and grit at relatively high surface loading rates, capture of floatable pollutants, capture of oil and fuel spills, and relatively simple and low cost maintenance. • Since devices are typically installed underground, treatment can be provided without consuming valuable developable land. • Devices are very effective pretreatment for other BMPs such as stormwater ponds, bioretention, filter devices, detention structures, and infiltration, and can significantly extend the maintenance interval for these downstream measures.
Disadvantages	• Provides relatively low and variable capture of fine particulates (< 50 microns) and particulate-bound pollutants (metals, nutrients, hydrocarbons, bacteria) that are concentrated on the fine particle fractions, except at low surface loading rates during low intensity storms and during inter-event settling periods. • Installation and maintenance costs may be significant.
Implementation Considerations	• Engineers should identify the maximum flow rate (peak flow rate) that could enter the device. • Engineers must identify the footprint and depth constraints where the device is to be located. If utilities, bedrock or groundwater are in the way, a shallower vault system with a larger footprint may be more appropriate.
Cost Range	High build cost Low to medium cost to maintain (Refer to local contractors for area specific costs)
Main Design Components	• Size of device • Runoff area • Structural Loading • Inlet and Outlet Pipe Diameter • Pipe Orientation
Maintenance	• Before commencing maintenance activities, refer to the manufacturer of the device for any specific maintenance instructions. • Typically, the maintenance of most hydrodynamic separators requires the use of a vacuum truck equipped with a water supply and a high pressure water spray. With that type of equipment, the accumulated

	solids may be removed through the manufacturer supplies access to the sump of the device. During and after the vacuum operation a high pressure water spray should be used to wash sediment and debris from all surfaces of the device into the sump where it may be vacuumed out. • Inspect device frequently to check for obstructions and the amount of its sediment or floatable pollutant storage capacity. If sediment and debris are observed to be over capacity, the device will need to be cleaned out.

N 62nd and Cotner Blvd., Lincoln, NE

Hydrodynamic Separator Maintenance Form

Site Name:

Location: Owner:

Contact Information:
(Name, Address, Phone #, Email)

Inspection Date: Inspection By:

Inspection Activity	Maintenance Needed	Description of Required Maintenance Activity	Date Maintenance Completed
Follow manufacturer's instructions for maintenance			
Check inlet(s) for debris accumulation			
Vacuum out sediment/debris (follow manufacture's recommendation)			
Remove trash/debris from drainage paths leading to device			
Other (miscellaneous)			