8.2.1 Forebays

Description

Forebays are man-made surface waters used as pretreatment systems. Forebays are designed to temporarily store the first flush of runoff from a storm event and provide for pollutant removal through settling. A forebay or other pretreatment system is required at each inlet to a detention system or retention basin.

Design Standards

Forebays must capture the first flush and release it gradually to the detention system and/or retention basin over a period of twenty-four (24) hours. Section 6.3.1 provides detailed information regarding how to calculate the storage volume required to capture the first flush for the area tributary to each forebay, and how to calculate the average allowable release rate form the forebay.

Design standards specific to forebays include the following:

- The volume of the forebay above any permanent pool may be used to satisfy a portion of the flood control storage volume (described in Section 6.2.1) and the bank full flood storage volume (described in Section 6.3.2). If a permanent pool is provided, the volume of the permanent pool may not be used to satisfy these other storage volume requirements.
- All closed conduits entering or exiting a forebay should have an end treatment and adequate soil erosion protection, as described in Section 8.3.1. Some enclosures should also be covered with a grate to prevent children and animals from entering the enclosure.
- A buffer strip must be provided around all surface waters such as forebays. Except as noted below, the buffer strip must be at least 25 feet wide measured from the minimum freeboard elevation of the surface water or forebay. Of the minimum 25 ft width, a minimum of 15 feet of the buffer strip should be exterior to the forebay perimeter defined by the top of bank. The slope of the buffer strip should be 1:6 or flatter. These provisions ensure that there is sufficient room to provide access to the forebay for maintenance.

  The buffer strip requirements illustrated in the figure "Required Buffer Strip for Forebays, Open Detention Basins, and Retention Basins" in Attachment C of Section 8.1.1 for open detention basins are applicable to forebays.
- In the following situations, the minimum width of the buffer strip around a forebay is 15 feet measured from the minimum freeboard elevation of the forebay:
  - When the forebay has a drainage area 5 acres or less; or
  - When the forebay has a drainage area greater than 5 acres and no storm water from areas outside or within the buffer strip enters the forebay via direct sheet flow.
- Plant vegetation, such as along the side slopes of retention basins, is necessary to control erosion and enhance sediment entrapment. A landscaping plan is required for retention basins, due to the importance of the vegetation to the function of the entire system. Use of a professional landscape architect with experience in storm water management system design and native landscaping is encouraged.
- Forebays may not be located within pre-existing surface waters.
- Design standards for outlet structures associated with forebays are described in Section 8.1.4.

Wayne County generally requires forebays to have side slopes no steeper than 1:6. However, earthen berms used as a weir between the forebay and an open detention basin have no minimum side slope requirement.

Vegetation Specifications

The type of vegetation used is dependant on site-specific conditions, such as soil types, amount of sunlight, and other factors. Vegetation specifications for forebays are the same as those for open detention basins (see Section 8.1.1).

Maintenance

Maintenance activities for forebays are the same as those for open detention basins (see Section 8.1.1). These activities must be identified in the submitted maintenance plan.

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8.2.2 Bioretention Areas

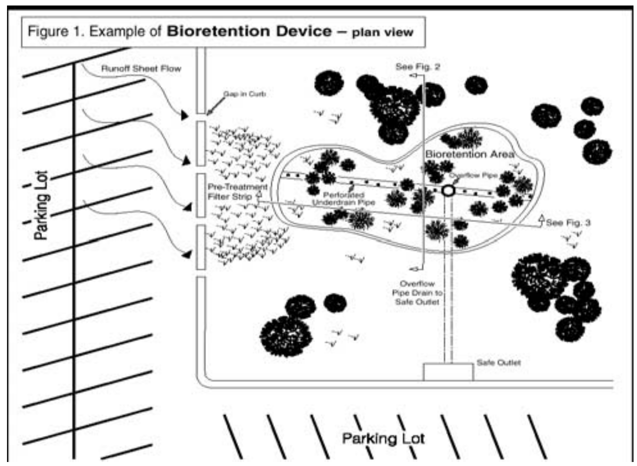
Use of Bioretention within a Parking Lot: Wayne City Hall
(Photo courtesy Alicia Askwith, Ayres Lewis Norris & May)

Bioretention areas are designed to use soil and plant material to mimic natural processes and store, filter and infiltrate storm water into the ground. Bioretention areas may be used anywhere to achieve a degree of stormwater treatment; the location depends in part on the type of facility employed. Common applications include:

- Pretreatment system for detention systems and retention basins.
- Within parking lots: bioretention areas are recessed and the pavement is graded to these areas, where storm water is captured and treated (see figure above). Traditional parking lots typically have curbed, elevated islands of vegetation.

Use of Bioretention within a Residential Development

- On new residential subdivision lots or commercial lots, near the source of the runoff generated from impervious surfaces.
- Areas upland from inlets or outfalls that receive sheet flow from graded areas.
- Areas of the site that are planned to be excavated or cut.
- In stormwater management retrofit and redevelopment situations, the addition of bioretention facilities will provide some improvement in the amount of runoff and in water quality.



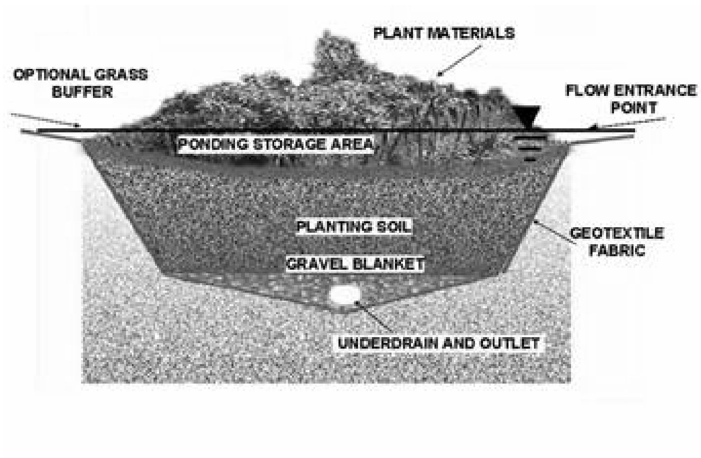
Schematic showing example Bioretention Area *(Photo bottom left and Figure above from Wisconsin Department of Natural Resources, Post Construction Stormwater Management presentations)*

Benefits of Use

Potential benefits for the incorporation of bioretention facilities as part of storm water management systems include:

- Assist with compliance with Wayne County Storm Water Standards
- Reduces impervious surfaces and increases the amount of disconnected impervious areas, which reduces the amount of storm water runoff that must be managed.
- Potential reductions in the need for and size of traditional storm sewers and storm water management systems.
- The above ground pooled water and some of the below ground storage volume can be counted toward meeting the water resources protection requirements described in Chapters 5 and 6.

- Greater lot yields.
- May count as both part of the required stormwater management system and toward local landscape and/or green space requirements.
- Increases natural habitats within a development.
- Construction and maintenance of bioretention facilities can be less costly than detention ponds.



Components of a Typical Bioretention Area *(Figure from Bioretention Manual. Prince George's County, Maryland)*

Features of Bioretention Areas

Bioretention areas typically have the following features:

- Grass buffer strips reduce runoff velocity and filter particulate matter.
- Sand bed provides aeration and drainage of the planting soil and assists in the flushing of pollutants from soil materials
- Ponding area provides storage of excess runoff and facilitates the settling of particulates and evaporation of excess water.
- Organic layer performs the function of decomposition of organic material by providing a medium for biological growth (such as microorganisms) to degrade petroleum-based pollutants. It also filters pollutants and prevents soil erosion.
- Planting soil provides the area for storm water storage and nutrient uptake by plants. The planting soils contain clays, which adsorb pollutants such as hydrocarbons, heavy metals and nutrients.
- Vegetation functions in the removal of water through evapotranspiration and pollutant removal through nutrient cycling.

Design Standards

Bioretention areas must be designed as follows:

- The drainage area to each bioretention area should be smaller than 5 acres and preferably less than 1 acre. Note that there can be multiple bioretention areas within a given development site.
- Sheet flow to bioretention areas should travel a maximum distance of 150 feet.
- A vegetated buffer strip with a minimum width of 2 feet must be provided around each bioretention area. The width of the buffer strip around bioretention areas is measured from the maximum water surface elevation of the ponding area associated with the bioretention area.
- The depth of the ponding area in a bioretention area cannot exceed 6 inches (see Typical Bioretention Cross-Section at end of this section). A maximum of 3 inches to 4 inches is preferred for areas that receive high hydraulic loading or have soils with low infiltration rates. This should be done in combination with a smaller drainage area.
- Soil borings and field infiltration/laboratory tests must be performed to determine characteristics of the in-situ soils at the proposed bioretention areas.
- Bioretention areas must include an underdrain and overflow structure (see Typical Bioretention Overflow Structure detail at end of this section), unless the applicant demonstrates that the infiltration rate of soil within the bioretention area is sufficient to prevent excess ponding. Underdrains must satisfy the following requirements:
    - Underdrains must have a hydraulic capacity greater than the infiltration rate of the soil in the bioretention area.
    - The underdrain must be perforated along its entire length. The location of the perforations (invert of pipe or elsewhere) depends upon the design of the facility. Typically, the perforations are placed closest to the invert of the pipe to achieve maximum potential for draining the facility. The perforations can be placed near the top of the pipe if an anaerobic zone is intended. Water below the perforated portion of the underdrain will have a tendency to

accumulate during periods of saturation. Otherwise, water will have a tendency to infiltrate into the surrounding in-situ soils.
  - Underdrains cannot be perforated within 5 feet of where the underdrain system connects to a storm sewer structure.
  - Underdrains must include an adequate outlet into a detention system, retention basin, storm sewer or watercourse to achieve positive flow.
  - A 6-inch gravel bed is required to protect underdrain pipes and to reduce clogging. A gravel blanket around the underdrain helps keep it free of possible soil transport.
  - The underdrain system must include a cleanout well to provide access for cleaning the system.
- The bottom of bioretention areas should be 3 feet or more above the seasonal high ground water table.
- A maximum of 20% void spaces in the planting soils and underdrain gravel blankets can be considered storage volume within the bioretention area.
- Bioretention areas may not be located within pre-existing surface waters.

Grading and Landscape Plans

Applicants that propose to include one or more bioretention areas as components of a storm water management system must submit a grading plan for the development project. The grading plan must clearly identify bioretention areas in relation to the topography and physical location. In addition, the grading plan must clearly identify routes for construction traffic that direct traffic around the bioretention areas. Allowing construction traffic to traverse a bioretention area may compact the soils or other subsurface media.

Applicants that propose to include one or more bioretention areas as components of a storm water management system also must submit a landscape plan for the development project. At a minimum, the landscape plan must specify soils and plant materials that the applicant proposes to include in a landscape, and describe the methods and planting techniques that the applicant proposes to utilize. Landscaping is included as regulated construction activity for which financial assurance must be provided.

Preferred Design Elements

- Distributed placement of bioretention areas across a development site results in smaller, more manageable subwatersheds within the development site.
- On new residential subdivision lots or commercial lots, bioretention areas should be located near the source of the runoff generated from impervious surfaces. Facilities should be located near the perimeters and edges to maintain typical use of the property.
- Bioretention areas should not be located within 10 feet of building foundations unless the building design incorporates adequate waterproofing measures. Bioretention areas should not be located near wellheads or septic systems.
- Bioretention areas should not be located within 10 feet of public road rights of way.
- To minimize excess ponding, excess runoff should be diverted away from the bioretention by grading the elevation of maximum surface ponding equivalent to the elevation at which runoff is discharging into the bioretention area.
- A safe overland flow path for the excess runoff is recommended.
- Bioretention areas should be designed as off-line systems whenever possible. This is to prevent erosive flow of water within the facility.
- Sloped areas exceeding 20% should not be used for bioretention unless “weep-garden” designs are employed.
- Bioretention areas should not be built where wooded areas would need to be cleared, to make room for the facility.
- Bioretention areas should be located away from traveled areas such as public pathways to avoid compaction.
- In parking lot applications, bumper blocks or gapped curbing should be used to prevent entry of vehicles into the bioretention area.
- A raised underdrain has the effect of providing a storage area below the invert of the underdrain discharge pipe. The storage area is equal to the void space of the material used.

Filters

Filter material should be used between the gravel blanket around the underdrain and the planting soil above.

- A pea gravel diaphragm to filter water and soil before passing through to the underdrain gravel blanket is recommended.
  It should have a minimum thickness of 3-4 inches and a maximum thickness of 8 inches. Where situations permit, a greater depth may be appropriate, although the depth generally should not exceed 12 inches.
- A permeable filter fabric should be placed between the underdrain gravel blanket and the pea gravel diaphragm where the underdrain is located. The filter fabric should extend 2 ft to either side.
- Filter fabric may be placed along the "walls" of the bioretention area to help direct the water flow downward and to reduce lateral flows. For example, to prevent lateral flow under roads and parking lot pavement, filter fabric can be placed along the sidewalls of a bioretention area that is installed in the median strip or parking lot landscape island. The fabric should extend from the subgrade over the stone.

Rain Garden at Lathrup Village Offices *(Photo courtesy of Lillian Dean, Southeastern Oakland County Water Authority)*

Planting Soil

- The planting soil should have sufficient depth to provide adequate moisture capacity and to create space for root systems. There is a preferred mixture for planting soil used in bioretention facilities (see "Material Specifications" below).
- Planting soil should be 4 inches deeper than the bottom of the largest root ball.

Plants

- Select plant materials that can tolerate extreme hydrologic changes, pollutant loading, and highly variable soil mixture conditions. Use of native plants is highly recommended. The material specification section below presents plant species recommended for bioretention areas.
- The minimum recommended caliper size for trees planted within a bioretention facility is 1 inch.
- Plant material and planting applications should meet guidelines set by the American Standard of Nursery Stock). Plant stock should be grown by suppliers or nurseries certified by the Michigan Native Plant Producers Association (see "References" for this section).

Material Specifications

- Planting Soil: Planting soil should have a sandy loam, loamy sand, or loam texture per USDA textural triangle. Maximum clay content is <5%. The soil mixture should have pH between 5.5 and 6.5 with an organic content of 1.5 – 3.0 %. The soil mixture should have an infiltration rate greater than 0.5 in/hour. The soil should be a uniform mix, free of stones, stumps, roots, or other similar objects larger than two inches. No other materials or substances should be mixed or dumped within the bioretention area that may be harmful to plant growth, or prove a hindrance to the planting or maintenance operations. The planting soil should be free of Bermuda Grass, Quack Grass, Johnson Grass, Mugwort, Nutsedge, Poison Ivy, Canadian Thistle, Tearthub, or other noxious weeds.
- Sand: Sand should be clean and free of deleterious materials. For planting soil, MDOT Class II clean sand is recommended.
- Mulch: Mulch should consist of raw hardwood, MDOT Quality Product List (QPL). Grass clippings are unsuitable for mulch, primarily due to the excessive quantities of nitrogen built up in the materials.

- Geotextile fabric: Geotextile fabric should maintain a flow rate of 125 GPM per square foot. MDOT specifications are recommended (Table 910-1).
- Underdrain gravel blanket: The gravel blanket should be double washed, 1-1/2 inches in size. MDOT 4AA, 6A, or 6AA porous material is recommended.
- Pea Gravel: Pea gravel should be washed, river-run, round diameter, ¼ - ½ inches in size.
- Underdrain piping: A variety of materials can be used for underdrain piping, including heavy-duty PVC pipe and corrugated metal pipe. Other pipe materials may be used.
- Vegetation: The following is a partial listing of plants native to southeast Michigan that may be suitable for bioretention areas. The plants listed here are excellent for moist organic gardens that are "dry" within 48 hours of a rain. Check sun/shade conditions before planning and planting.

  Wildflowers, sedges, and grasses
  Beardtongue (*Penstemon digitalis)*
  Bergamot (Bee-Balm) (*Monarda fistulosa)*
  Black-Eyed Susan (*Rudbeckia hirta)*
  Blue Flag Iris (*Iris Viginica)*
  Blue Vervain (*Verbena hostata)*
  Boneset (*Eupatorium perfoliatum)*
  Canada Anemone (*Anemone canadensis)*
  Columbine (*Aquilegia canadensis)*
  Culver's Root (*Veronicastrum virginicum)*
  Indian Grass (*Sorgastrum nutans)*
  Joe-Pye Weed (*Eupatorium Maculatum)*
  Marsh Blazing Star (*Liatris spicata)*
  Missouri Ironweed (*Vernonia missurica)*
  New England Aster (*Aster novae-angliae)*
  Old-Field Cinquefoil (*Potentilla simplex)*
  Porcupine Sedge (*Carex hystericina)*
  Sneezeweed (*Helenium autumnale)*
  Spiderwort (*Tradescantia Ohiensis)*
  Swamp Goldenrod (*Solidago patula)*
  Swamp Milkweed (*Asclepias incarnata)*
  Tall or Green-Headed Coneflower (*Rudbeckia trilobum)*
  Tall Tickseed (*Coreopsis verticillata)*
  White Turtlehead (*Chelone glabra)*
  White Vervain (*Verbena urticiforia)*
  Wild Strawberry (*Fragaria virginiana)*

  Shrubs
  American Cranberrybush Viburnum (*Viburnum trilobum)*
  Black Chokeberry (*Aronia prunifolia)*
  Common Buttonbush (*Cephalanthus occidentalis)*
  Meadowsweet (*Spiraea alba)*
  Ninebark (*Physocarpus opulifolius)*
  Redosier Dogwood (*Cornus stolonifera)*
  Shrubby Cinquefoil (*Potentilla fruticosa)*
  Shrubby St. John's-Wort (*Hypericum prolificum)*
  Spicebush (*Lindera benzoin)*
  Steeplebush (*Spiraea tomentosa)*

Construction

Proper construction techniques (including proper grading), adequate landscaping, suitable soil mixtures, and approved materials are critical to the success of bioretention areas.

- The grading plan for the entire development project must clearly identify the bioretention areas. Grading of or construction traffic over those areas should be avoided.
- The area surrounding the bioretention areas should be stabilized prior to construction of the bioretention areas to minimize compaction and contamination of the bioretention site.
- Placement of the gravel over the underdrain must be done with care. Avoid dropping the gravel high levels from a backhoe or front-end loader bucket. Spill directly over underdrain and spread manually.
- Placement of the planting soil in the bioretention area should be in lifts of 12 to 18 inches and lightly compacted. Minimal compaction effort can be applied to the soil by tamping with a bucket from a dozer or backhoe. Do not use heavy equipment within the bioretention facility. Heavy equipment can be used around the perimeter of the basin to supply soils and sand. Grade bioretention materials with light equipment such as a compact loader or a dozer/loader with marsh tracks.
- Compaction will significantly contribute to design failure. Compaction can be alleviated at the base of the bioretention facility by using a primary tilling operation such as a chisel plow, ripper, or subsoiler. These tilling operations are

to re-fracture the soil profile through the 12-inch compaction zone. Rototillers typically do not till deep enough to reduce the effects of compaction from heavy equipment.

- Rototill 2 to 3 inches of sand into the base of the bioretention facility before back filling the facility and placement of underdrain. Pump any ponded water before preparing (rototilling) base.
- In order to speed up the *natural* compaction process, presoaking the placed soil may be performed. Significant settlement can occur after the first presoak, and additional settlement may occur subsequent to the initial wetting. If time and construction scheduling permits, it is preferable to allow natural settlement to occur with the help of rain events to presoak the soil medium.

Construction of Rain Garden at Lathrup Village Offices *(Photo courtesy of Lillian Dean, Southeastern Oakland County Water Authority)*

Maintenance

Proper maintenance will not only increase the expected life span of the facility, but will also improve aesthetics. Annual maintenance of plant material, soil layer and the mulch layer is required for the overall success of bioretention systems.

- Mulch should be re-applied once every six months, to maximize nitrogen uptake by the facility and to help control growth of unwanted plants. The mulch layer should be removed and replaced every 2 years.
- Mulch should be uniformly applied approximately 2 to 3 inches in depth. Piling mulch around the base of the tree is not recommended as the tree may become infested with pests and diseases. Mulch applied any deeper than three inches reduces proper oxygen and carbon dioxide cycling between the soil and the atmosphere, and keeps roots from making good contact with the soil.
- Soils begin filtering pollutants immediately but can lose their ability to function in this capacity over time. Evaluation of soil fertility is important in maintaining an effective bioretention system. It is recommended that soils be tested annually and replaced when soil fertility is lost. Depending on environmental factors, this usually occurs within 5-10 years of construction.
- As with any garden, bioretention requires weeding to control growth of unwanted plants that can be invasive, consuming the intended planting, and destroying the aesthetic appeal. Weeding should be accomplished routinely and at least monthly.
- Water in the facility should infiltrate the system within 4-6 hours or less. Clogging or blockage of either the surface layer or fines obstructing the filter fabric used between the gravel bed/underdrain and the surrounding planting soil usually causes pooling water. Including a clean out pipe in the underdrain system will provide access for cleaning the system. Removing the mulch layer and raking the surface may correct the surface blockage problem. For blocked filter fabric, use lengths of small reinforcing bar (e.g., 2-3 ft of #4 rebar) to puncture the fabric with holes every 1-foot on center. If the soils themselves are causing the problem, punch holes in the soil or optionally, install a “sand window” at least 1 foot wide running vertically to the underdrain system elevation.
- If plants wilt during the heat of the day, but recover in the evening, watering is not necessary. The plants are simply conserving moisture. If they do not recover, watering is indicated. Another good rule of thumb is to stick a pencil or screwdriver about four inches into the soil. If the soil is moist at that depth, watering is not needed. If the soil is dry, and the shrubs or trees were planted within the last three years, watering is necessary.
- If any of the plants do not perform well, become diseased or die, they should be replaced.
- For trimming and harvesting, the current practice is to leave ornamental grasses and

perennial seed heads standing to provide winter interest, wildlife forage, and homes for beneficial insects. Plants should not be cut back until spring when new growth commences, and even then it is only done for neatness; it does not impact growth. Plants may be pinched, pruned, sheared or deadheaded during the growing season to encourage more flowering, a bushier plant, or a fresh set of leaves. Diseased or damaged plant parts should be pruned as they occur. If a plant is pest-infested, perform cleanup in fall to deny the pest a home. Trees and shrubs may be pruned for shape or to maximize fruit production.

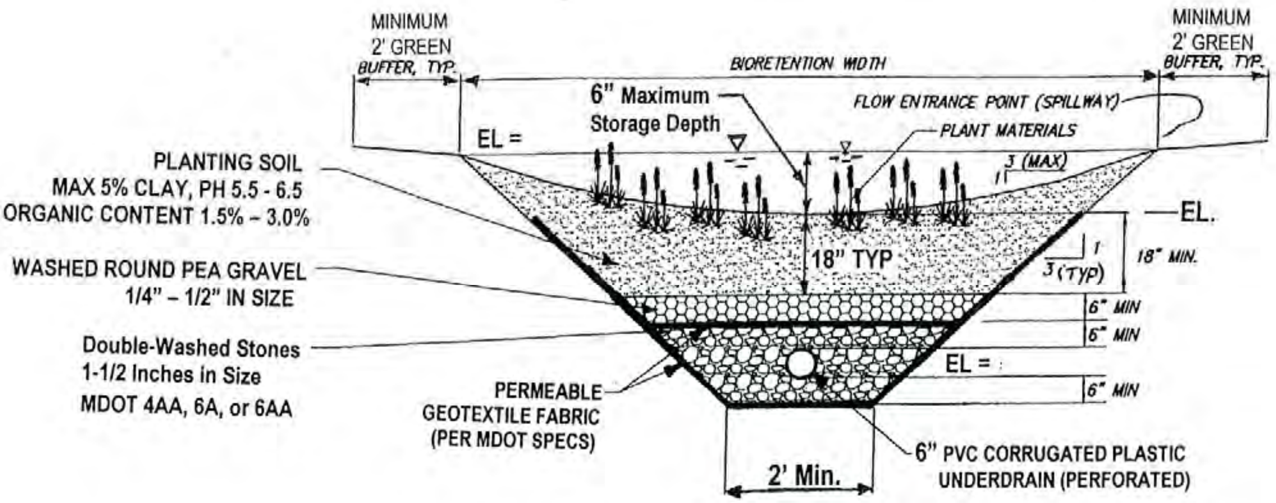
- The properly designed bioretention area should thrive and allow planting materials to expand and propagate, eventually becoming overcrowded. If this occurs, perennial plants should be divided in spring or fall.
- By design, bioretention facilities are located in areas where nutrients (especially nitrogen) are significantly elevated above natural levels. Fertilization in such areas usually is unnecessary, because it is unlikely that soil fertility will be the limiting factor in plant growth. If soil fertility is in doubt, a simple soil test can resolve the question. If fertilization should become necessary, an organic fertilizer will provide nutrients as needed without disrupting soil life.
- Runoff flowing into bioretention facilities may carry trash and debris with it, particularly in commercial settings. Trash and debris should be removed regularly both to ensure that inlets do not become blocked and to keep the area from becoming unsightly.

References and Additional Resources

- American Hort. www.americanhort.org
- City of Wayne (MI), "City Hall Storm Water Quality Improvements Project Fact Sheet" and project summary, Clean Michigan Initiative Nonpoint Source Grant "City Hall Storm Water Quality Improvements". Contact: Ramzi El-Gharib, City Engineer. Additional project information provided by Michelle West; Ayres, Lewis, Norris & May, Inc.
- Office of the Washtenaw County Water Resources Commissioner. Resources and Techniques for Street Runoff Infiltration: http://www.ewashtenaw.org/government/drain_commissioner/dc_webWaterQuality/street-runoff-infiltration/resources-and-techniques-for-street-runoff-infiltration
- Prince George's County, Maryland. Stormwater Management Design Manual (September 2014) and its predecessor Bioretention Manual (November 2001). http://www.princegeorgescountymd.gov/sites/DPIE/Resources/Publications/design/Pages/default.aspx
- Southeastern Oakland County Water Authority. Rain Gardens for the Rouge River: A Citizen's Guide to Planning, Design, & Maintenance for Small Site Rain Gardens and other related publications. http://www.socwa.org/lawns_gardens.shtml
- United States Environmental Protection Agency, Office of Water. Publications on green infrastructure (http://water.epa.gov/infrastructure/greeninfrastructure/index.cfm) and storm water management (http://water.epa.gov/polwaste/npdes/swbmp/PostConstruction-Stormwater-Management-in-New-Development-and-Redevelopment.cfm)
- Wisconsin Department of Natural Resources (WDNR). Storm Water Post-construction Technical Standards http://dnr.wi.gov/topic/stormwater/standards/postconst_standards.html
- "Local Storm Water and Watershed Management Practices Constructed/Implemented in Southeast Michigan", available at http://www.waynecounty.com/doe/1190.htm Project summaries, photos, location and contact information, web links, and other information for a variety of storm water and watershed management practices in six categories including Bioretention / Low Impact Development / Native Landscaping
- Low Impact Development Center www.lowimpactdevelopment.org
- Center for Watershed Protection www.cwp.org and http://xn--www-rp0a.stormwatercenter.net/

Resources For Native Plant Material

- Michigan Native Plant Producers Association.
  http://www.MNPPA.org
- Michigan Association of Conservation Districts.
  http://www.macd.org/
- Wild Ones Organization.
  http://www.wildones.org/



Typical Bioretention Cross-Section

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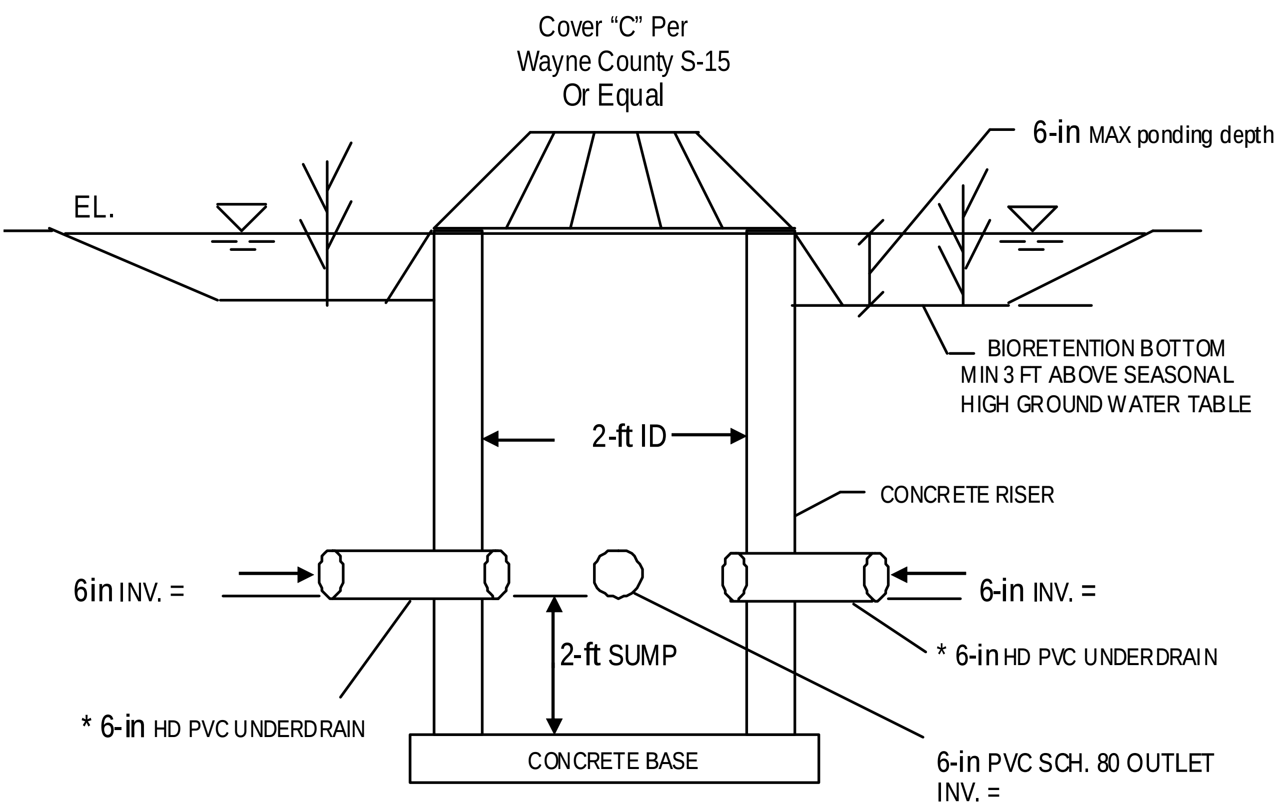

TYPICAL BIORETENTION OVERFLOW STRUCTURE

NOT TO SCALE

*UNDERDRAIN PIPE SHOULD NOT BE PERFORATED WITHIN 5 FT OF THE OVERFLOW STRUCTURE

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8.2.3 Manufactured Treatment Systems

Description

Manufactured treatment systems are manmade devices or structures that are used to remove sediment and other particulate matter from storm water runoff. Manufactured treatment systems may be used at the inlets to underground detention systems, open detention basins, or retention basins. By removing settleable materials, pretreatment systems reduce the amount of material that accumulates in detention/retention systems, and the frequency at which accumulated materials must be removed. Manufactured treatment systems are particularly applicable in small development sites for meeting the water resources protection performance standard of the Wayne County Storm Water Management Standards.

Wayne County periodically evaluates various types of manufactured treatment systems for conformance with the design standards, preferred design elements, and materials specifications presented in this section. Please refer to the "Guideline for Wayne County Review of Manufactured Treatment Systems" document available from the Wayne County website for more information about the review process (see the "Supplemental Information" webpage at http://waynecounty.wc/mygovt/doe/depts/wqd/supplement_info.aspx). Please contact the Wayne County Permit Office (734-595-6504) for more information about which types of manufactured treatment systems have been reviewed by Wayne County under this procedure.

Design Standards

- Manufactured treatment systems must include a chamber or other device to accumulate and store settleable solids in a manner and a location that will prevent re-suspension of previously captured particulates.
- The system should be capable of removing 80% of the net annual Total Suspended Solids (TSS) load based on a 75-micron (and smaller) particle size for a gradation mix of "50-125" microns.
    - o Annual TSS removal efficiency estimates or models must be based on documented removal efficiency performance from certified full-scale independent studies (for example, laboratory tests) over a range of storm sizes.
    - o The tested full-scale model should be tested for efficiency under various flow rates at equal increments. The flow rate increments should start at a minimum of 10% of presumed capacity up to at least 25% above the presumed capacity. There should be a minimum of 3 tests at each incremental flow rate. The influent concentration should be a maximum of 300 mg/L.
    - o Supporting engineering calculations and other relevant documentation for upscaling and downscaling the full-scale tests of select size units to other size units should be provided.
    - o Generally, annual TSS removal efficiency models should be corroborated by field tests performed by an independent third party using influent and effluent composite samples from a minimum of ten storms at one location.
    - o Procedures for submitting a manufactured treatment system to Wayne County for review for compliance with these criteria are documented in "Guideline for Wayne County Review of Manufactured Treatment Systems"; check the website for the most current version of this document (http://waynecounty.wc/mygovt/doe/depts/wqd/supplement_info.aspx).
    - o A water-lock feature must be incorporated into the design of the storm water treatment system to prevent the introduction of trapped oil and floatable contaminants to the downstream piping during routine maintenance and to ensure that no oil escapes the system during subsequent storm events.
    - o Peak flow rates for various models of manufactured treatment systems that have been approved by the County under this section are shown in Table 8.2.3-1.
- The installed manufactured treatment system (manufactured unit and surrounding soil structure) must sustain an HS20 loading as determined by a Professional Engineer licensed in the State of Michigan.
- The minimum cover of backfill material should be recommended by the manufacturer and approved by the Permit Engineer.

Preferred Design Elements and Materials

Due to the potential for manufactured treatment systems to malfunction and/or create maintenance problems, Wayne County recommends that manufactured treatment systems incorporate the following design elements:

- Manufactured treatment systems should be designed to treat up to the peak flow rate for the design storm event (i.e., 10-year storm).

- Manufactured treatment systems should be designed so that they do not re-suspend trapped sediments or re-entrain floating contaminants at flow rates up to or exceeding those for the design storm event.
- The system pump-out volume should be less than ½ of the total system volume.
- The system should not create backwater in the upstream piping network for flows up to and including the design storm event.
- Direct access should be provided to the sediment and floatable contaminant storage chambers to facilitate maintenance. The storage chambers should have no appurtenances or restrictions within them which would prohibit removal of accumulated sediment and debris during maintenance.

<u>Materials Specifications</u>

Manufactured treatment systems may be constructed from pre-cast or cast-in-place concrete or other materials approved by Wayne County and should meet the following specifications:

- For treatment systems made of cast-in-place or pre-cast concrete:
  - Concrete for pre-cast manufactured treatment systems should conform to ASTM C 857 and C 858.
  - Cement should be Type II Portland cement conforming to ASTM C 150.
  - Treatment systems constructed from pre-cast concrete should be manufactured in accordance with ASTM C 478.
    - Sections should be cured by an approved method and should not be shipped until (1) at least 5 days have passed since fabrication and/or repair, and (2) the concrete has attained a compressive strength of 4,000 psi.
  - Manufactured treatment systems constructed from cast-in-place concrete or reinforced concrete should conform to current Wayne County specifications for structural concrete.
  - Sections should have tongue and groove or ship-lap joints with a butyl mastic sealant conforming to ASTM C 990.
  - Wall thicknesses should not be less than 6 inches or as otherwise shown on the dimensional drawings
  - Openings should be sized to accept pipes of the specified size(s) and material(s), and should be sealed with hydraulic cement conforming to ASTM C 595M.
  - Internal aluminum plate components should be aluminum alloy 5052-H32 in accordance with ASTM B 209.
  - A bitumen sealant in conformance with ASTM C 990 should be utilized in affixing the aluminum swirl chamber to the concrete vault.
- For manufactured treatment systems (including smooth bubble and weir plates) fabricated from high density polyethylene (HDPE):
  - Virgin HDPE material should be used, conforming with the minimum requirements of cell classification 424420C (4-in – 10-in diameter) and 435440C (12- in – 60-in diameter) per ASTM C 3350.
  - The virgin HDPE material should be evaluated using the notched constant ligament-stress (NCLS) test as specified in Section 9.5 and 5.1 of AASHTO M294 and ASTM F2306.
  - Weir and battle plates shall be welded at all interfaces between the plate and water quality unit.
- For manufactured treatment systems fabricated from corrugated polyethylene pipe (CPE):
  - The system and all required fittings should conform to AASHTO M294 Type S.
  - Fittings and couplings must be noncorrugated, solid sleeve fabricated from polyethylene with a gasket on both sides of the joint.
  - Split collar couplers are not allowed.
  - Weir and battle plates shall be welded at all interfaces between the plate and water quality unit.

<u>Testing</u>

<u>The manufacturer of these systems must contact the Wayne County Testing Office (734-595-6504 x 2015) at least 72 hours prior to fabrication to schedule inspection during fabrication</u>. Wayne County inspects the material fabrication process to ensure that the manufacturer's testing of the product occurs at the applicable AASHTO or ASTM standards.

Installation

Manufactured treatment systems must be constructed to serve the capacity shown on the drawings and as specified in the approved permit plans. The system must be installed at elevations and locations shown on the approved plans, or as otherwise directed by the County.

<u>A Wayne County Permit Engineer must observe the installation of all manufactured treatment systems.</u> Contact the Wayne County Permit Office (734-595-6504 x 2009) at least 72 hours days prior to installation to schedule inspection during

installation. Wayne County will not accept any manufactured treatment systems installed when a County Permit Engineer is not present; permits and financial assurances will not be released at the conclusion of construction for such systems.

The following procedures should be followed for installation of manufactured treatment systems:

- For concrete manufactured treatment systems, installation should conform to ASTM specification C 891 "Standard Practice for Installation of Underground Precast Utility Structures." Cast-in-place installation should follow Wayne County specifications for structural concrete. Installation procedures recommended by the manufacturer, if any, should also be consulted.
- For manufactured treatment systems made of materials other than concrete, installation procedures recommended by the manufacturer should be followed. These procedures should be included in the application package submitted to Wayne County for approval of the entire storm water management system for the development project.
- The base unit of the manufactured treatment system should be placed on a subbase consisting of MDOT Class II granular material of a minimum thickness of six inches, or greater after compaction by the "Controlled Density Method" to 95% of the Maximum Unit Weight. The granular subbase should be checked for level prior to setting and the pre-cast base section of the trap should be checked for level at all four corners after it is set. If the slope from any corner to any other corner exceeds 0.5%, the base section should be removed and the granular subbase material re-leveled.
- For pre-cast concrete systems, prior to setting subsequent sections, a bitumen sealant that conforms to ASTM C 990 should be placed along the construction joint in the section that is already in place. Pre-cast sections should be set in a manner that will result in a watertight joint.
- For manufactured treatment systems made of materials other than concrete, prior to setting subsequent sections, a sealant that conforms to the specification recommended by the manufacturer should be placed along the construction joint in the section that is already in place. Sections should be set in a manner that will result in a watertight joint.
- For pre-cast concrete systems, holes made in the concrete sections for handling or other purposes should be plugged with a nonshrink grout or by using grout in combination with concrete plugs.
- For manufactured treatment systems made of materials other than concrete, holes made in the unit for handling or other purposes should be plugged with materials meeting the specification recommended by the manufacturer for such materials.
- For pre-cast concrete systems, where holes must be cut in the pre-cast sections to accommodate pipes, cutting should be completed before the sections are set in place, to prevent any subsequent jarring which may loosen the mortar joints. For manufactured treatment systems made of materials other than concrete, field cutting of the system to accommodate pipes is not allowed.
- Backfill around the manufactured treatment system should consist of:
    - MDOT Class II granular material for systems made of cast-in-place and pre-cast concrete
    - MDOT 6A, 2G, or 34G material for systems made of HDPE or CPE
- All backfill materials should be placed in a balanced manner and such that there is no more than a 2 lift differential from one side to the other. Balanced lifts should be advanced across the width of the system, evenly along the length of the system throughout the backfilling process.
- All backfill materials should be placed in lifts of maximum 10-inches in depth.
- For each backfill lift, all materials should be compacted to a minimum of 95% (90% minimum required for backfill consisting of MDOT 6A material) of the backfill material's maximum unit weight at a moisture content not greater than the optimum. The maximum unit weight of the backfill material should be determined by the AASHTO T 180 or Michigan Cone Method. The frequency of the compaction testing should be one or more tests per lift of backfill around the trench of the structure.

<u>Documentation of the following items relative to the installation of manufactured treatment systems is required to be submitted to the Wayne County Permit Engineer</u> before permits and financial assurances before are released:

- All backfill materials are from Wayne County tested stock.
- All backfill materials were placed in lifts of maximum 10-inches.
- For each backfill lift, all materials were compacted to a minimum of 95% of the backfill material's maximum unit weight at moisture content not greater than optimum. If MDOT 6A backfill material was used, materials were compacted to 90% of the backfill material's maximum unit weight at moisture content not greater than optimum.

- The maximum unit weight of the backfill material was determined by the AASHTO T 180 or Michigan Cone Method.
- The compaction was tested a minimum of one test per lift of backfill around the trench of the structure.

Maintenance

Manufactured treatment systems should be maintained in accordance with the manufacturer's recommended schedule.

Table 8.2.3-1

PEAK FLOW RATES OF VARIOUS MODELS OF MANUFACTURED TREATMENT SYSTEMS APPROVED BY WAYNE COUNTY UNDER THIS SECTION

Kennedy Solutions, Inc (KSI) Storm Water Treatment Systems

KSI Model	Chamber Size/Diameter (inches)	Peak Flow (cfs)
Series 350	36	1.8
Series 500	48	2.3
Series 750	48	3.3
Series 1000	48	4.1
Series 1250	48	5.0
Series 1500	60	6.2
Series 1750	60	7.4
Series 2000	60	8.3
Series 2500	60	9.8
Series 3000	60	11.3
Series 3500	60	13.8

Stormceptor STC™

Stormceptor STC™ Model	Peak Flow (cfs)
450	0.48
900	0.99
1200	1.27
1800	2.22
2400	3.48
3600	5.35
4800	8.75
6000	10.96
7200	13.98
11000	22.50

Vortechs™

Vortechs™ Model	Peak Flow (cfs)
1000	1.2
2000	2.1
3000	3.4
4000	4.5
5000	6.4
7000	8.3
9000	10.5
11000	13.1
16000	18.8

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