FORT BELVOIR DIRECTORATE OF PUBLIC WORKS

GENERAL PLAN FOR STORMWATER MANAGEMENT FACILITY INSPECTION AND MAINTENANCE

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General Plan for Stormwater Management Facility Inspection and Maintenance

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1.0 FORT BELVOIR STORMWATER MANAGEMENT

Stormwater runoff is the excess water from precipitation that flows overland or through drainage conveyance systems to receiving streams. Undeveloped lands allow the stormwater to soak into the ground. In areas with buildings, roads, parking lots, and other impervious surfaces, the water flows overland into stormwater infrastructure, carrying a variety of pollutants along the way. Runoff eventually reaches receiving lakes, streams, and rivers. On Fort Belvoir, the immediate bodies of water affected by stormwater include: Pohick Bay, Accotink Bay, Gunston Cove, Dogue Creek, and the Potomac River, all of which drain into the Chesapeake Bay. Stormwater management facilities control polluted runoff by changing its characteristics such as: water quality, peak discharge, runoff volume, time of concentration, and/or velocity. These management measures are designed to cumulatively reduce the impacts of development on runoff and minimize the pollution that reaches the Chesapeake Bay.

1.1 PURPOSE

This manual includes procedures and standard forms that Fort Belvoir will use to execute and record stormwater management facility inspection and maintenance activities to comply with the Small Municipal Separate Storm Sewer system (MS4) general permit (4VAC50-60-1240). This permit was developed and is administered by the Commonwealth of Virginia in accordance with the Federal Clean Water Act. Specific to the Inspection and Maintenance Plan is Section IIB of the MS4 General Permit, which requires pollution prevention and good housekeeping practices for municipal (i.e. Garrison) operations.

1.2 WHY MAINTAIN STORMWATER MANAGEMENT FACILITIES?

Thorough maintenance and inspection procedures for stormwater management facilities will reduce flooding and mitigate surface and groundwater pollution. Stormwater treatment methods called Best Management Practices (BMPs) are designed to minimize the degradation of downstream waters by treating stormwater before it enters the stormwater drainage system. Existing BMPs found on Fort Belvoir include detention and retention ponds, bioretention, filtration, infiltration, and manufactured treatment devices. Each facility has specific and time-sensitive maintenance requirements to ensure they operate in accordance with their design.

1.3 REGULATORY BACKGROUND

The following sections provide some background on the regulatory framework that Fort Belvoir has to operate under. While not all of these requirements relate directly to the requirements

of the MS4 Permit, there are a broad range of regulations and policies that Federal facilities in the Chesapeake Bay region are subject to that pertain to the management of stormwater associated with development activities.

1.3.1 Clean Water Act

The *Clean Water Act* (CWA) sets a goal that all waters in the United States be "fishable" and "swimmable," and requires all states and the District of Columbia to establish minimum water quality standards for wastewater treatment plants, agricultural operations, and municipal stormwater systems to ensure the health of their water bodies. Section 305b of the Clean Water Act requires vigorous monitoring and assessment programs to ensure compliance and progress.

The National Pollution Discharge Elimination System (NPDES) is a national program for issuing, modifying, monitoring, terminating, and enforcing state permits required for a municipality that discharges directly to surface water. The NPDES regulates point source pollution which is wastewater that comes from discrete point sources such as industrial discharges. The MS4 General Permit is developed under the NPDES program to regulate municipalities, military installations, and campuses at their points of discharge, as though they are point source dischargers.

For more information, see:
http://cfpub.epa.gov/npdes/cwa.cfm?program_id=45

1.3.2 Executive Order 13508

In 2010, President Obama signed Executive Order 13508 declaring the Chesapeake Bay to be a "national treasure" and ordering Federal facilities to "protect and restore the health, heritage, natural resources, and social and economic value of the nation's largest estuarine ecosystem." Environmental initiatives of this act include increased regulatory pressure on municipalities to reduce or eliminate pollution entering the Chesapeake Bay. The Order provides requirements intended for federal agencies to demonstrate leadership in stormwater management practices. These recommendations included employing site selection, layouts, and development strategies to minimize impacts from development and redevelopment.

For more information, see:
https://www.federalregister.gov/executive-order/13508.pdf

1.3.3 Chesapeake Bay TMDL

In 2010, the US EPA established the Chesapeake Bay Total Maximum Daily Load (TMDL) which serves as a regulatory tool to enforce compliance with the Clean Water Act by monitoring and tracking control measures to restore the bay and its tidal rivers. The TMDL sets allowable limits for Total Phosphorous (TP), Total Nitrogen (TN), and Total Suspended Solids (TSS) that can be discharged to the Chesapeake Bay, while allowing the bay to still make sufficient progress toward water quality standards for dissolved oxygen, water clarity, underwater Bay grasses, and chlorophyll a, an indicator of algal presence. The TMDL subdivides the Chesapeake Bay Watershed into major river basins, thereby determining wasteload allocations at direct discharge points to the Bay.

Compliance with the Chesapeake Bay TMDL is explicitly written into the MS4 General Permit, and as such, Fort Belvoir will have to demonstrate its compliance through annual reporting and periodic audits by Commonwealth and Federal regulatory enforcement officials.

For more information, see:
http://www.epa.gov/chesapeakebaytmdl/

1.3.4 Energy Independence and Security Act of 2007

Section 438 of the Energy Independence and Security Act (EISA) instructs federal agencies to use design, construction, and maintenance strategies to maintain or restore the predevelopment hydrology for any project that exceeds 5,000 square feet. While the majority of the Act addresses energy efficiency and other topics, one paragraph addresses stormwater and sets strict requirements. It is as follows:

> *"Storm water runoff requirements for federal development projects. The sponsor of any development or redevelopment project involving a Federal facility with a footprint that exceeds 5,000 square feet shall use site planning, design, construction, and maintenance strategies for the property to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow."*

The US EPA, in coordination with other federal agencies, published the "Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the

Energy Independence and Security Act" (Dec 2009) to assist federal agencies in complying with the Act.

For more information, see:
http://www2.epa.gov/laws-regulations/summary-energy-independence-and-security-act
http://www.epa.gov/oaintrnt/documents/epa_swm_guidance.pdf

1.3.5 Virginia Stormwater Management Program (VSMP) Permit Regulations

The Virginia Stormwater Management Program (VSMP) includes the legal requirements for addressing stormwater in the Commonwealth of Virginia. This includes the permit program under the National Pollutant Discharge Elimination System (NPDES) that covers municipal separate storm sewer systems (MS4), as well as construction related stormwater discharges. The program and permits issued under the program require the use of stormwater management practices, control techniques, design and engineering methods, and other provisions to protect water quality from discharge of pollutants associated with stormwater discharges.

The state's General MS4 Permit requires Fort Belvoir to, among other things, operate under a plan to inspect and maintain existing stormwater management facilities in a functioning state (*Virginia Stormwater Management Program Regulations* or Regulations at 4VAC50-60-1240). Inspection, operation, and maintenance of stormwater management facilities are the responsibility of the MS4 operator and permittee. As such, Fort Belvoir must establish in writing an inspection program that ensures stormwater management facilities are functioning as intended. According to the Regulations (VAC50-60-1240 Section II.B.5) the inspection program is to be based on a system of priorities that considers the purpose of the facility, the contributing drainage area, and the downstream conditions, and is to be documented by inspection records. The intent of the inspection program is to provide for adequate long-term operation and maintenance of stormwater management facilities.

For more information, see:
http://www.deq.virginia.gov/Programs/Water/StormwaterManagement/VSMPPermits.aspx
https://www.belvoir.army.mil/environdocssection.asp

1.3.6 Fairfax County

Fairfax County surrounds Fort Belvoir, and is broken into 30 different watersheds. The Fairfax County Department of Public Works and Environmental Services began developing

watershed management plans to cover all 30 watersheds in 2000 when Virginia signed the Chesapeake Bay 2000 Agreement that required these plans to cover 2/3 of the Chesapeake Bay Watershed. The plans included protection, conservation and restoration of streams and wetlands as well as flood protection.

In 2004, the Stream Quality Assessment reported 80% of the streams in Fairfax were categorized between "fair" and "very poor." Proper stormwater runoff and pollutant control measures employed within the Fairfax County Watersheds will help reverse this trend, leading to cleaner watersheds draining to the Chesapeake Bay.

Fort Belvoir coordinates stormwater management with Fairfax County where the MS4 systems interact, to the extent practical, as required by the permit. Fort Belvoir also uses the *Fairfax County Public Facilities Manual* when practical and feasible, but it is used voluntarily, not mandated by statute, regulation, or permit.

For more information, see:
http://www.fairfaxcounty.gov/dpwes/watersheds/

1.3.7 Stormwater BMP Clearinghouse Committee

The Virginia Stormwater Management BMP Clearinghouse is a helpful tool for identifying standards and specifications for all BMPs. Categories include, but are not limited to, Low Impact Development (LID), Environmental Site Design (ESD), or Manufactured Treatment Devices (MTD's). The BMP Clearinghouse Committee is comprised of experts from the Virginia Department of Conservation and Recreation (DCR) and the Virginia Water Resource Research Center (VWRRC). The BMP Clearinghouse website provides technical and regulatory guidance on all BMP design, applications, and maintenance, and is explicitly referenced in the *Virginia Stormwater Management Program Regulations*.

For more information, see:
http://vwrrc.vt.edu/swc/

2.0 FORT BELVOIR AREAS OF RESPONSIBILITY

In order to identify and quantify the stormwater and stream systems on Fort Belvoir, the property has been divided up first into seven (7) watersheds, then 52 sub-watersheds. These divisions can be seen in the map below. Not pictured are sub-watersheds 53 (BNA area), 54 (Rivanna area), and 0 (select areas not included in any other sub-watersheds, such as the Tyson's and Suitland towers).

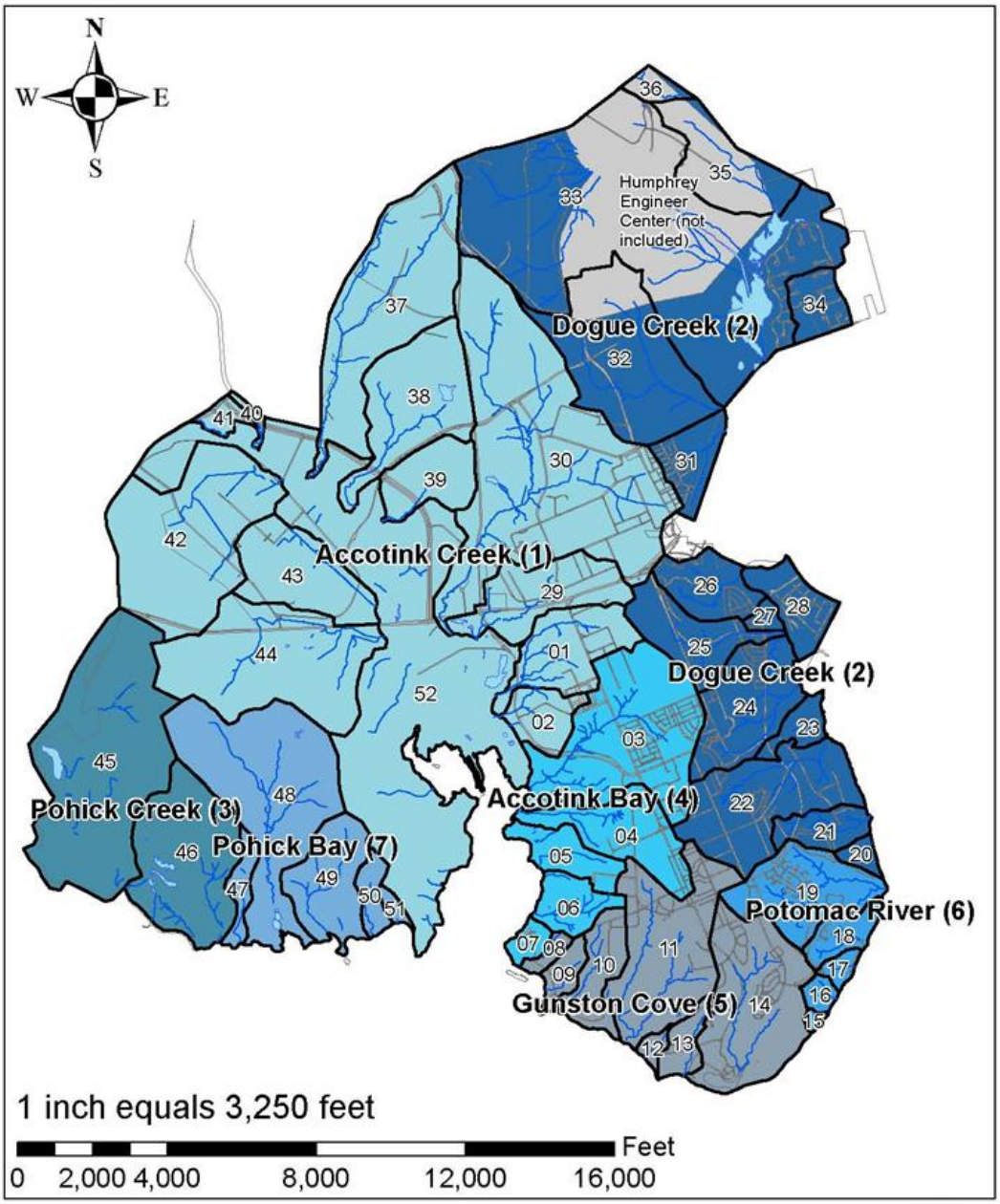


Figure 2-1 Fort Belvoir Watershed Subdivision
(Source: Fort Belvoir BMP Inventory Report)
Note: Humphrey Engineer Center is not owned or operated by Fort Belvoir

2.1 FORT BELVOIR MAIN POST (FBMP)

Fort Belvoir Main Post refers to the portion of Fort Belvoir that lies on approximately 7,800 acres of land near the Mount Vernon area of Fairfax County, along the Potomac River. Responsibility for the Inspection and Maintenance of stormwater management facilities within this portion of Fort Belvoir is currently broken into two Areas of Responsibility, based on who will be conducting inspections and will be responsible for maintenance activities. Additional Areas of Responsibility may be assigned in the future and will be added to this Plan, as deemed appropriate.

2.1.1 FBMP - Leased Areas

A significant portion of developed area at FBMP is leased to managers of residential properties for On-Post housing. These leased areas are depicted in Figure 2-2, along with the current BMPs known to be in these areas. The leased properties will conduct their own inspections and maintenance in accordance with this Plan and provide documentation of these activities to the Directorate of Public Works (DPW) each year for inclusion in the MS4 Annual Report.

2.1.2 FBMP - DPW

For all areas at FBMP, outside of those previously listed (see Figure 2-3), staff from the Directorate of Public Works will retain responsibility for conducting Inspection and Maintenance Activities in accordance with this Plan.

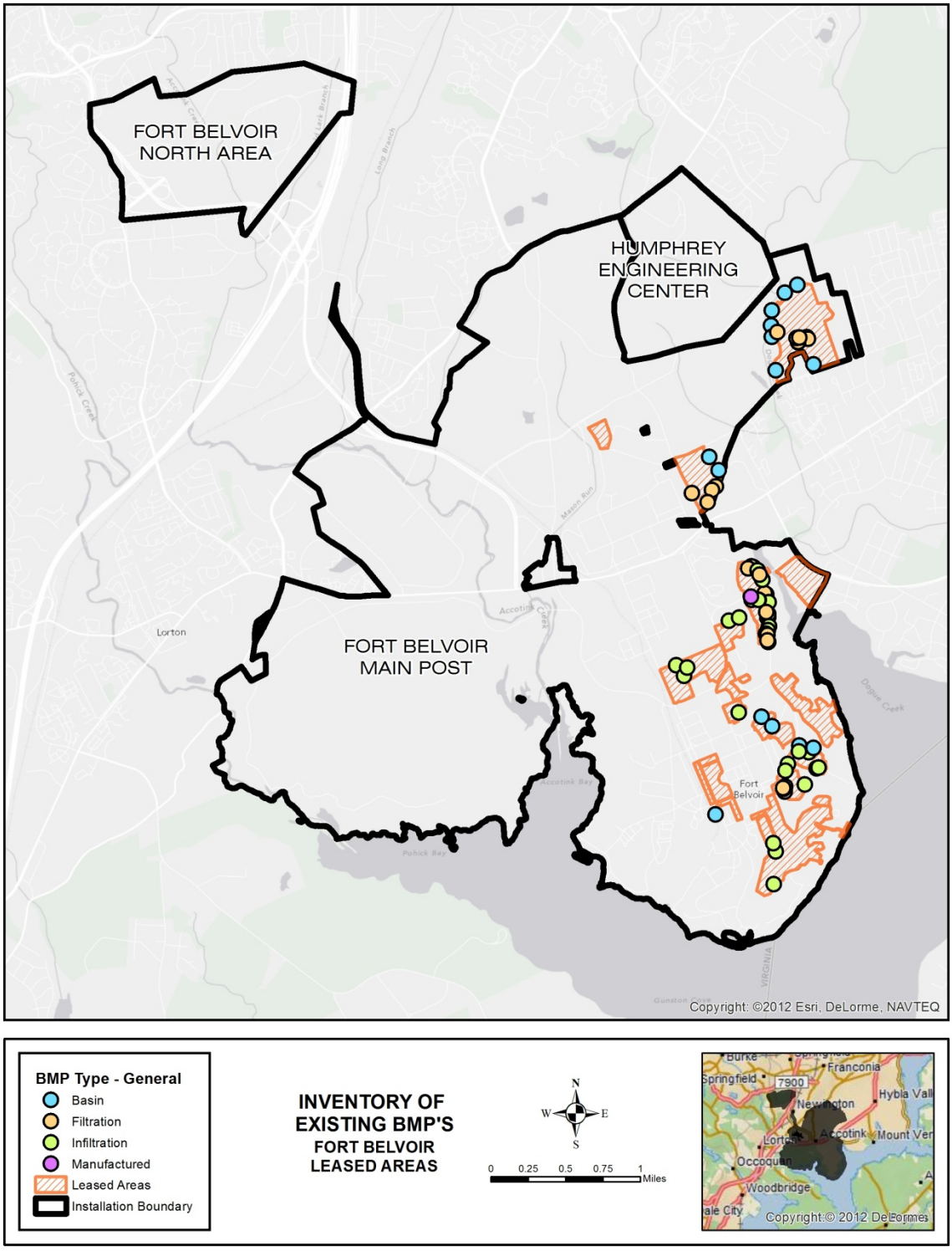


Figure 2-2 Fort Belvoir Main Post – Leased Areas
(Source: Fort Belvoir GIS)
Note: Humphrey Engineer Center is not owned or operated by Fort Belvoir

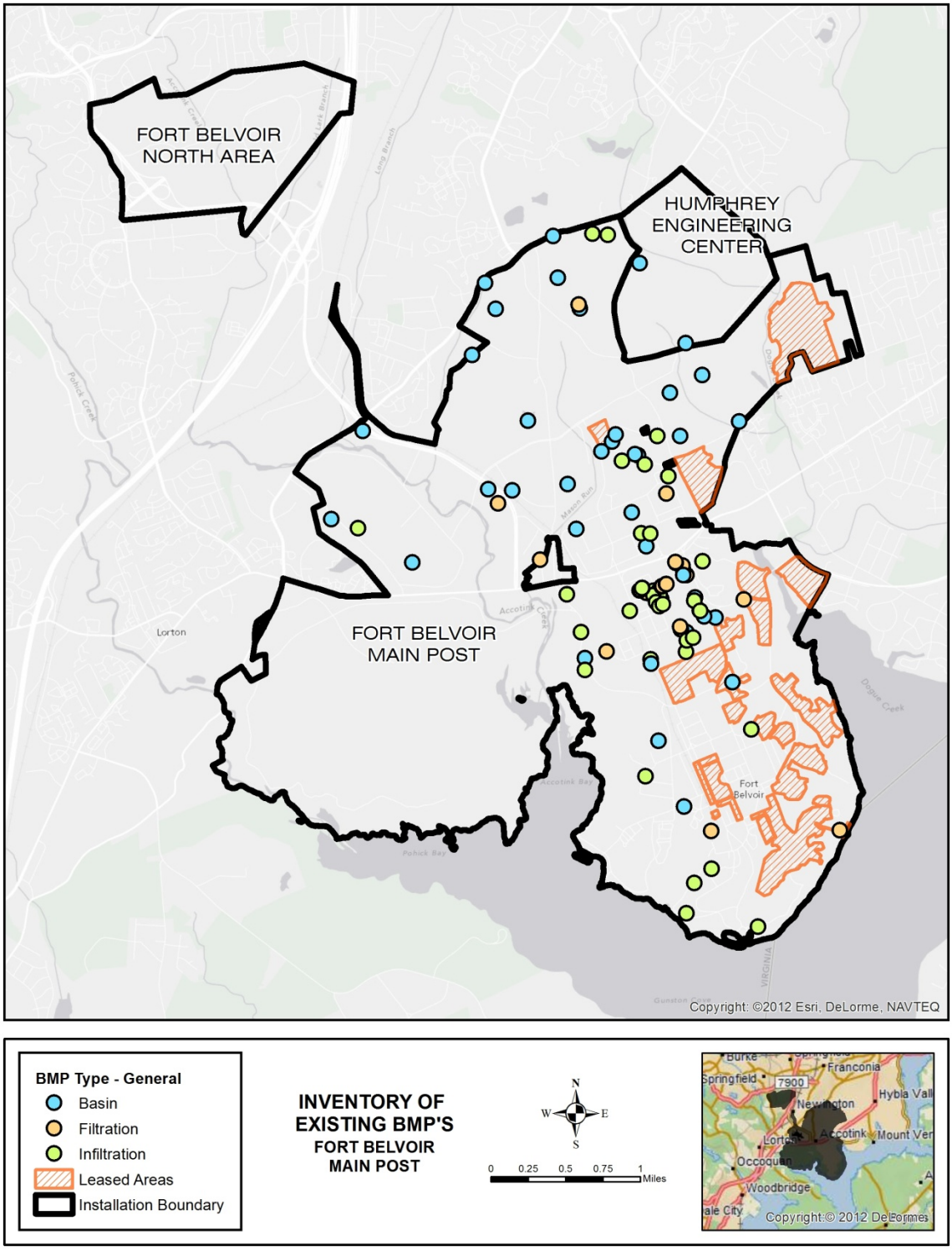


Figure 2-3 Fort Belvoir Main Post – DPW
(Source: Fort Belvoir GIS)
Note: Humphrey Engineer Center is not owned or operated by Fort Belvoir

2.2 FORT BELVOIR NORTH AREA (FBNA)

Fort Belvoir North Area refers to the portion of Fort Belvoir that lies on approximately 804 acres of land near the Springfield area of Fairfax County, approximately three miles north of FBMP. Responsibility for the Inspection and Maintenance of stormwater management facilities within this portion of Fort Belvoir is currently broken into two Areas of Responsibility, based on who will be conducting inspections and will be responsible for maintenance activities. Additional Areas of Responsibility may be assigned in the future and will be added to this Plan, as deemed appropriate.

2.2.1 FBNA - New Campus East Area (NCEA)

An area in the central portion of the Fort Belvoir North Area (see Figure 2-4) has restricted access and that is not conducive to conducting periodic stormwater facility inspections or maintenance activities. In this area, referred to as the New Campus East Area (NCEA), the Fort Belvoir Directorate of Public Works will be responsible for inspections, while the tenants will retain responsibility for maintenance in accordance with this Plan. The tenants will provide documentation of maintenance activities to the Directorate of Public Works each year for inclusion in the MS4 Annual Report.

2.2.2 FBNA - DPW

For all areas at FBNA, outside of those previously listed, staff from the Directorate of Public Works will retain responsibility for conducting inspection and maintenance activities in accordance with this Plan.

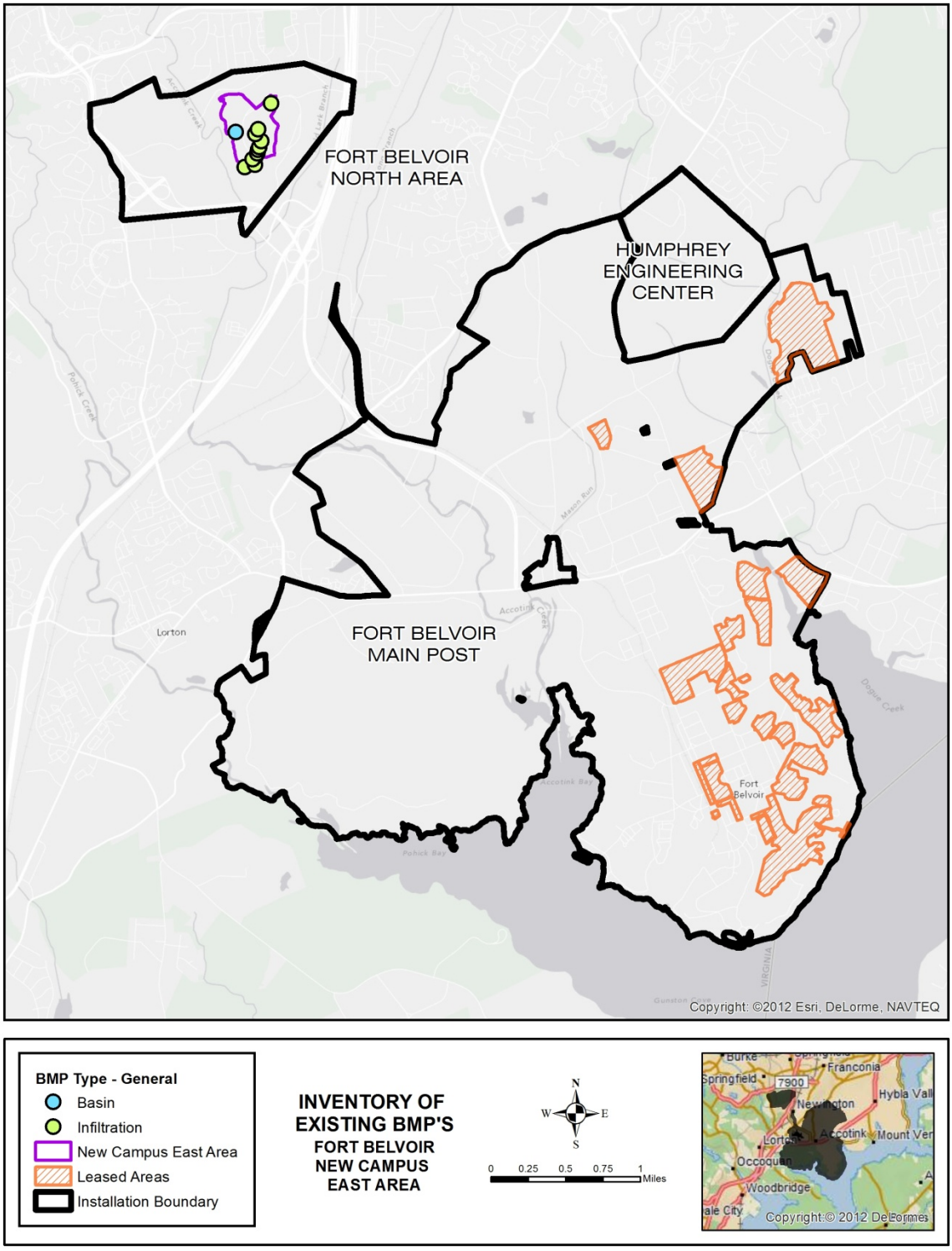


Figure 2-4 Fort Belvoir North Area – NCEA
(Source: Fort Belvoir GIS)
Note: Humphrey Engineer Center is not owned or operated by Fort Belvoir

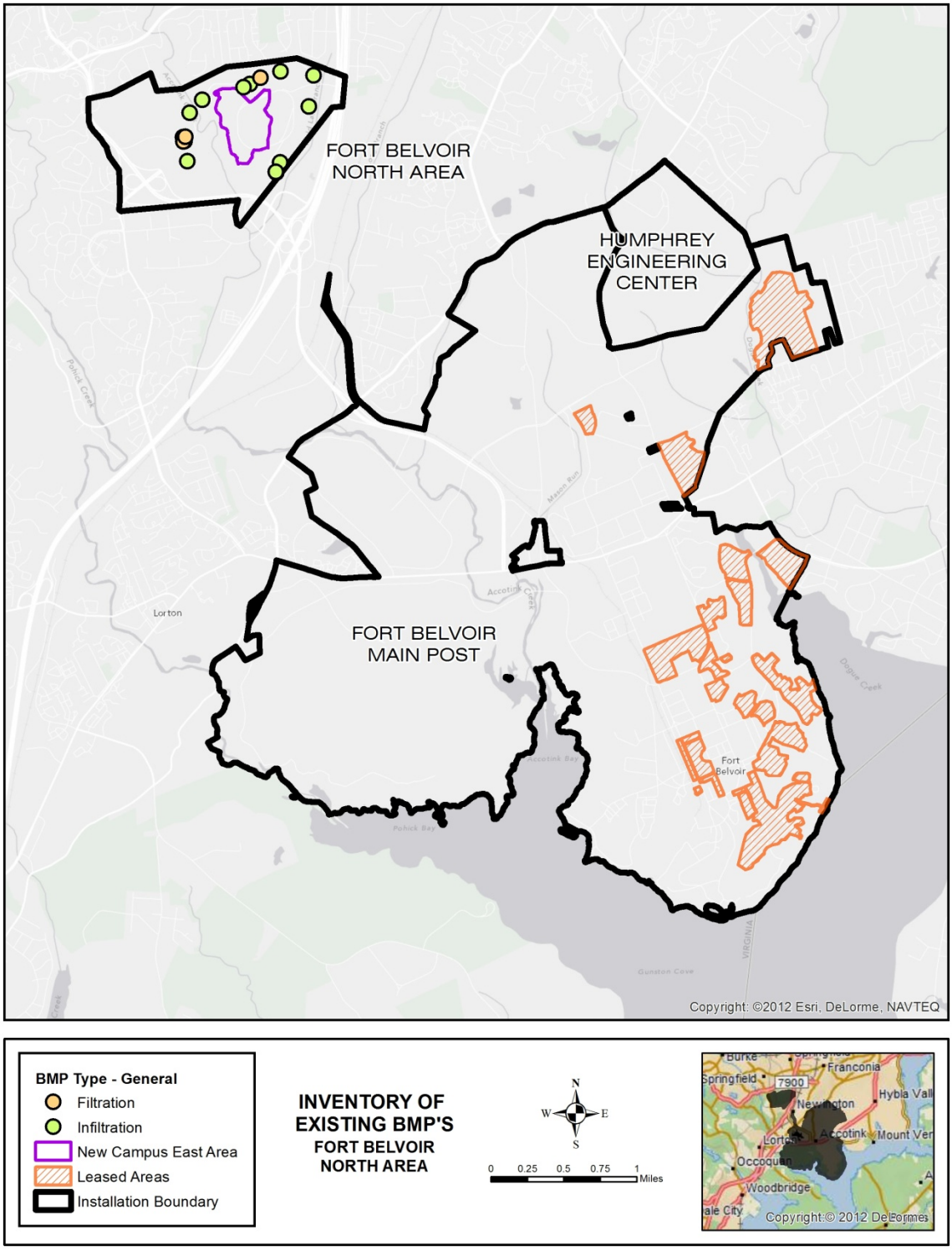


Figure 2-5 Fort Belvoir North Area
(Source: Fort Belvoir GIS)
Note: Humphrey Engineer Center is not owned or operated by Fort Belvoir

3.0 FUNCTIONAL COMPONENTS

The subsequent sections discuss common primary functional components of stormwater BMPs. The components listed may not be present on every type of stormwater BMP present on Fort Belvoir, but rather represent general features that are common components of stormwater BMPs. A sufficient understanding of the terminology and functionality of each component will create uniformity among personnel and maintenance operations. More detailed information is available in the *Virginia Stormwater Management Handbook* and the Virginia BMP Clearinghouse.

3.1 EARTHEN EMBANKMENT

The embankment is the feature of a pond facility that is used to impound water. The most common embankment used in ponds is made from compacted soil and will typically be at least 3' and 25'. The height of an embankment is measured from the lowest part of the fill (toe) on the downstream side of the pond to the crest of the embankment.

An embankment is designed to remain stable against forces that may develop during the life of the structure. However, there are three critical conditions as defined by the VSWMH that are most likely to cause embankment failure. Catching these conditions during routine inspections can increase the life of an embankment and stormwater pond, as well as protect the health, safety, and welfare of people and property downstream.

1. Differential Settlement can be caused by variation in materials, embankment height, or compression of the foundation strata. This may cause cracks in the embankment than can concentrate seepage and lead to failure by internal erosion.
2. Seepage can lead to piping within the embankment or foundation, which in turn can result in failure by internal erosion.
3. When Shearing Stresses acting on the embankment are too great, the embankment can begin to slide, resulting in the displacement of large portions of the embankment.

Adequate erosion protection such as vegetative groundcover, riprap, or concrete is essential to maintaining an embankment. Trees, shrubs, or other woody plants should not be found on or near the embankments because the roots can loosen the compacted soil and lead to failure. Additionally, the woody vegetation can lead to mass wasting while dead and rotting roots can create piping channels. Table 3-1 below provides a routine maintenance schedule for earthen embankments.

Figure 3-1 Earthen Embankment
(Source: Fort Belvoir DPW)

Table 3-1 Earthen Embankment Maintenance Guidelines

Maintenance	Frequency
Mow	Minimum of twice per year to manage groundcover, prevent growth of woody vegetation, and allow for observations and inspections
Repair Erosion	As needed and within 30 days of discovery to maintain adequate stabilization
Repair Rodent Burrows	As needed and within 30 days of discovery to maintain structural integrity
Overseed, lime, and fertilize	As needed and within 30 days of discovery to maintain adequate permanent vegetation for stabilization
Replace or repair riprap or concrete (when used instead of vegetation)	As needed to maintain permanent stabilization

3.2 PRINCIPAL SPILLWAY

A principal spillway is the primary outlet for stormwater to leave the basin and may be a component on any impoundment BMP. It is designed to regulate the allowable discharge for water quality, and typically the 1-, 2-, 10-year frequency storm events. Stormwater may be regulated by an orifice, weir system, or a riser structure, and may include an outlet conduit called a “barrel”. The

barrel runs through the embankment, and can be a trouble spot for long-term maintenance due to piping and seepage around the barrel. For aesthetics, a riser structure may only have the top showing, typically with a trash rack for safety and to collect trash and debris so it does not clog the riser and barrel.

Figure 3-2 Principal Spillway
(Source: Fort Belvoir DPW)

Table 3-2 Principal Spillway Maintenance Guidelines

Maintenance	Frequency
Clear trash rack(s), orifices, weirs, risers, and other features of trash, debris, and sediment	As needed to maintain proper flow
Supplement corrosion resistant coatings on metal structures or assemblies	As needed to halt or delay corrosion
Repair cracking or spalling of concrete structures	As needed based on observations and inspections

3.3 EMERGENCY SPILLWAY

The emergency spillway (also known as an auxiliary spillway) is designed to convey flows that exceed the principal spillway design to an adequate channel. It is typically an open channel

constructed beside an embankment with an inlet channel, a control section, and an exit channel. Non-erodible vegetation is typically used; however for armoring, riprap, concrete or other permanent and non-erodible surfaces may be used.

Although the performance of the emergency spillway doesn't affect stormwater basins during small storms, larger storms require access to the emergency spillway to convey large amounts of water once the original design of the principal spillway is exceeded. Regular maintenance on the emergency spillway will ensure functionality of the BMP during large storm events.

An auxiliary spillway, or emergency spillway, may not exist on all impoundment structures or it may be a combined principal/emergency spillway. An overland emergency spillway may not always be possible because of site limitations. A combined spillway simply means the principal spillway structure is designed to convey both high and low flows.

Figure 3-3 Emergency Spillway
(Source: VSWMH)

Table 3-3 Emergency Spillway Maintenance Guidelines

Maintenance	Frequency
Mow. Do not cut less than 6 to 8 inches in height.	Minimum of twice per year to manage groundcover, prevent growth of woody vegetation, and allow for observations and inspections
Clear approach and discharge channels of trash, debris, and sediment	As needed to maintain proper flow
Repair Erosion	As needed and within 30 days of discovery to maintain adequate stabilization
Repair Rodent Burrows	As needed and within 30 days of discovery to maintain adequate stabilization
Overseed, lime, and fertilize	As needed to maintain adequate permanent vegetation for stabilization

3.4 TRASH RACK

Control structures that are designed to regulate stormwater flow typically need to have a trash rack or other device to block out solids commonly found in stormwater that may damage the basin or spillway (grass clippings, trash, leaves, sediment, etc.). Trash and debris accumulation on the trash rack may clog the principal spillway, not allowing the basin to function as designed.

Figure 3-4 Trash Rack
(Source: Fort Belvoir DPW)

Table 3-4 Trash Rack Maintenance Guidelines

Maintenance	Frequency
Clear trash rack(s) of trash, debris, and sediment	As needed to maintain proper flow
Supplement corrosion resistant coatings on metal structures or assemblies	As needed to halt or delay corrosion
Check and maintain locks on trash racks	As needed to maintain proper function and limit access to structure via trash rack

3.5 ENERGY DISSIPATER

Flow from a pipe, channel, or BMP can become concentrated flow and cause erosion. To prevent this, energy dissipating devices are employed to reduce the velocity and energy of concentrated stormwater flow before entering the receiving stream. In order to decrease erosion and runoff velocity, energy dissipaters are designed to convert concentrated flow to sheet flow or less concentrated flow. There are multiple designs for energy dissipaters, including flared end sections, riprap lined aprons, level spreaders, stilling basins, and impact basins. The most common of these structures is an apron with a riprap lining, grouted riprap, or concrete. The riprap apron is typically lined with filter fabric to prevent soil movement through and into the riprap. It is constructed of non-erodible material and designed to spread the flow out to reduce depth and velocity.

Figure 3-5 Energy Dissipater with Riprap Lined Apron
(Source: Fort Belvoir DPW)

Table 3-5 Energy Dissipater Maintenance Guidelines

Maintenance	Frequency
Remove trash, debris, and accumulated sediment	As needed to maintain proper flow and function
Reset or replace displaced riprap	As needed to maintain proper function
Repair erosion and stabilize with appropriate materials	As needed to maintain proper function
Repair or replace cracked or spalling grouted and concrete structures	As needed to maintain proper function

3.6 VEGETATION/LANDSCAPING

Landscaping, such as groundcovers, aquatic or marsh plants, trees, or shrubs, plays a crucial role in stormwater management BMPs because it helps stabilize post-construction areas, provides enhanced pollution removal capabilities, and increases the overall aesthetics of a stormwater BMP. Vegetated areas can provide better filtration, infiltration, sediment trapping, evapotranspiration, and pollutant export through the biological uptake of water and nutrients. In Virginia, some BMPs are assigned target pollutant removal efficiencies based on the use of vegetative practices. Because of these attributes, landscape plans are often an essential part of the BMP construction, operation, and maintenance.

Each BMP that has a vegetative or landscaping component requires regular maintenance, especially during the growing season. Each BMP should ideally have native plants of a suitable variety and density, however different BMPs will have different species based on hydrology, exposure, or pollutant load, and construction plans should provide guidance on location specific maintenance needs. When there is a doubt about the proper maintenance for aquatic and marsh benches, a qualified professional should be consulted for guidance and direction.

Wet ponds, constructed wetlands, and enhanced extended detention facilities may be surrounded by aquatic or marsh benches. The aquatic or marsh bench may be located just within the perimeter of the pond and serves to promote vegetation in order to enhance pollutant removal and reduce shoreline erosion. Separate safety benches may be included as well, or they may be integrated into the aquatic or marsh bench. The safety bench is generally located outside the perimeter of the wet pond, wetland, and marsh to provide access for maintenance personnel and vehicles, as well as provide a barrier between the public and the deeper pond. When integrated with the aquatic and marsh features, the safety bench is intended to separate the public from deeper pond waters. Maintenance of landscape vegetation for aquatic and marsh benches will vary according to the design. Often, separate safety benches are merely stabilized with groundcover and are maintained accordingly.

Table 3-6 provides general schedule for landscape vegetation maintenance. Facilities with unique landscape features, such as aquatic benches and marshes, should have detailed maintenance directions provided in the design and construction documents. When the original construction plans and maintenance documents are missing or do not provide specific information for unique landscape features, or there is a doubt about the proper maintenance, a qualified professional should be consulted for guidance and direction.

Figure 3-6 Landscaping in a Bioretention Filter
(Source: Fort Belvoir DPW)

Table 3-6 Landscaping Maintenance Guidelines

Maintenance	Frequency
Mow groundcover (grasses legumes) unless designated as a meadow or no-mow zone	Minimum of twice per year if required to maintain healthy vegetation
Prune dead or dying limbs and branches on trees and shrubs	As needed to maintain healthy vegetation
Remove and replace dead or dying plants, trees, and shrubs	As needed to maintain healthy vegetation
Overseed, lime, and fertilize	As needed to maintain permanent stabilization
Manage non-native and invasive species	As needed to maintain a healthy and diverse plant community

3.7 ACCESS

Most BMPs are constructed with stable entrance and path to allow large or heavy equipment access for operations and maintenance. Maintaining these access paths and roads to the original design specifications will facilitate routine inspections and maintenance.

Figure 3-7 BMP Access
(Source: Fort Belvoir DPW)

Table 3-7 Access Road Maintenance Guidelines

Maintenance	Frequency
Check and maintain gates, bollards, and locks	As needed to maintain and limit access
Repair or replace path or road surface	As needed to maintain access

3.8 SEDIMENT FOREBAY

Some stormwater BMPs are designed with a sediment forebay that holds incoming stormwater runoff to allow larger sediment to settle and trash or debris to be captured as a pretreatment before flowing to the primary treatment area. A sediment forebay is a key element in retention, detention, extended-detention, constructed wetlands, and infiltration practices because it enhances pollutant removal capabilities and extends the functional life of the overall BMP by concentrating pollutants in an area that is easily accessible for maintenance. Sediment forebays are

designed to capture sediment in a confined area and require maintenance more frequently (every 3-5 years) than a stormwater pond without a sediment forebay (20-25 years). However, the maintenance on a sediment forebay is easier and less expensive and can delay more costly maintenance in the primary treatment area for beyond 20-25 years.

The forebay is typically separated from the rest of the BMP with a smaller volume and embankment, typically made of gabion, concrete, riprap, or even an earthen embankment. The forebay is intended to eliminate the resuspension of sediment and pollutants captured in the BMP. Sediment buildup may cause a decrease in available storage and periodic maintenance removal is required to maintain the treatment and storage volume.

Figure 3-8 Earthen Embankment Sediment Forebay
(Source: VSWMH)

Table 3-8 Sediment Forebay Maintenance Guidelines

Maintenance	Frequency
For earthen forebays stabilized with vegetation, see embankment section above	For earthen forebays, see embankment section
For forebays stabilized or constructed with riprap, gabions, or other concrete structures	Repair or replace displaced, cracked, or spalling structures as needed to maintain function
Remove trash and debris	As needed to maintain function
Remove accumulated sediment, trash, and debris	As needed to maintain storage volume (generally every 3-5 years, depending upon pollutant sources in the contributing watershed)

3.9 OBSERVATION WELLS, CLEAN OUTS, AND MANHOLE ACCESS FOR UNDERGROUND FACILITIES

Underground facilities or facilities that rely on infiltration or underdrain pipes located below ground, such as bioretention, sand filters, and infiltration systems, are commonly utilized in urban areas. An observation well should be located near the bottom of the facility or underdrain pipe to facilitate periodic inspections and monitoring of function. Clean out access is also common for BMPs with underdrains. Sometimes, manholes may provide maintenance personnel access to observe or enter an underground chamber for inspections and maintenance. It is important to maintain visibility and sufficient access to an underground facility to allow vacuum trucks or similar equipment to reach the sedimentation chamber, underdrains, and filter bed surface. Underground facilities are often classified as confined space, and special OSHA rules and training are required to protect the maintenance workers and inspectors who access them.

Both filtration and infiltration BMPs require a drainage or filter bed to serve as a surface or underground storage to exfiltrate stormwater into the ground or allow filtration through media to be collected by underdrains. Common materials for the drainage or filter bed include stone, sand, bioengineered media, or other mixed media. Pollutants are removed as the stormwater penetrates through the drainage bed into the underlying soils or as the stormwater is filtered through the media. The rate at which the stormwater moves vertically through the drainage or filter bed may indicate its need for maintenance. The most common maintenance issue for a drainage or filter bed occur when sediment o other pollutants accumulate, slowing the rate the stormwater exfiltrates or filters though the system.

Wells, clean outs, and other access features are critical for inspecting and maintaining drainage and filter beds an underdrains. Table 3-9 provides general maintenance activities for these underground features.

Figure 3-9 Manhole Access
(Source: Fort Belvoir DPW)

Table 3-9 Observation Well, Clean Outs, and Manhole Access Maintenance Guidelines

Maintenance	Frequency
Check and maintain hatches, doors, manholes, caps, locks, and other barriers	As needed to maintain access for inspections and maintenance and to limit access to the public
Keep wells, clean outs, and manhole access clear of obstructions, including trash, debris, sediment, and roots	As needed to maintain access for observation, monitoring, clean out, and maintenance.

4.0 STORMWATER BASINS

4.1 DETENTION BASINS

There are currently a number of detention basins operating at Ft. Belvoir Main Base and serving the Ft. Belvoir North Area. Detention basins, also known as detention ponds or dry ponds, are primarily designed to hold stormwater runoff temporarily until a receiving channel has space to accept it. This period of time is generally less than 12 hours, which allows limited pollutant removal or opportunity for infiltration and evaporation before the stormwater releases through a control structure outlet. Detention basins can either be excavated, utilize above ground embankments, or a combination of excavation and fill embankment. The facilities are not designed to hold a permanent pool of water like a retention basin or wet pond. The flow out of the control structure is regulated in order to prevent damage to property and waters downstream of the facility.

A detention pond can also provide flood control by including additional flood detention storage pools at the inlet and outlet of the pond. They can vary greatly in size and appearance in order to meet the requirements on the specific region being treated.

Figure 4-1 Detention Basin
(Source: Fort Belvoir DPW)

Table 4-1 Functional Components of a Detention Basin

Functional Components
Earthen Embankment
Principal Spillway
Emergency Spillway
Trash Rack
Energy Dissipater
Vegetation/Landscaping
Access
Sediment Forebay

4.2 EXTENDED DETENTION AND ENHANCED EXTENDED DETENTION BASIN

An extended detention basin or pond requires the temporary impoundment of stormwater for 24 to 48 hours or more to allow for greater opportunity for pollutant removal, infiltration, and evaporation. This is compared to the detention basin, which is designed to release stormwater more quickly (< 12 hours), hence the designation "extended". The temporary ponding allows more pollutants to settle out in addition to reducing the rate the stormwater is released downstream, providing water quality and quantity control. The extended detention basin is usually dry after storm events are released. An extended detention basin can be enhanced by creating areas with a shallow permanent wet pool planted with marsh or wetlands vegetation to promote further pollutant removal through biological and physiochemical processes.

Figure 4-2 Extended Detention Basin
(Source: Fort Belvoir DPW)

Table 4-2 Functional Components of Extended Enhanced Extended Detention Basins

Functional Components
Earthen Embankment
Principal Spillway
Emergency Spillway
Trash Rack
Energy Dissipater
Vegetation/Landscaping
Access
Sediment Forebay

4.3 RETENTION BASIN

A retention basin or pond (also known as a wet basin or pond) is an impoundment facility that is designed to permanently hold water. The standing water provides better pollutant removal through sediment settling, reduced resuspension of sediment, biological removal (algae and aquatic plants), and further opportunity for infiltration and evapotranspiration. By design, the water level should remain constant because "dirty" stormwater enters the pond and displaces "clean" stormwater from previous rain events.

Note that some retention basins include a low level drain that allows controlled temporary dewatering of the wet storage to allow for inspections or maintenance of the embankment or spillways. Occasionally, a retention basin may be lined with clay or a synthetic liner to retain water in the basin between storms, especially when constructed in highly permeable soils.

Figure 4-3 Retention Basin
(Source: Fort Belvoir DPW)

Table 4-3 Functional Components of Retention

Functional Components
Earthen Embankment
Principal Spillway
Emergency Spillway
Trash Rack
Energy Dissipater
Vegetation/Landscaping
Access
Sediment Forebay

4.4 CONSTRUCTED WETLAND

A constructed wetland functions similarly to a shallow retention basin or enhanced extended detention basin. They wet pool is typically less than 18 inches deep and may host a wide variety of vegetation suitable for wetlands. As stormwater flows through a constructed wetland, suspended solids settle to the bottom, pollutants are filtered through vegetation, nutrients are removed via biological processes, and an increased opportunity for infiltration and evapotranspiration may exist. The water level should remain constant between storm events to support the wetlands vegetation.

Figure 4-4 Constructed Wetlands
(Source: Fort Belvoir DPW)

Table 4-4 Functional Components of Constructed Wetlands

Functional Components
Earthen Embankment
Principal Spillway
Emergency Spillway
Trash Rack
Energy Dissipater
Vegetation/Landscaping
Access
Sediment Forebay

4.5 UNDERGROUND STORAGE

Underground stormwater storage primarily treats stormwater quantity, similar to a detention or extended detention basin; however some underground storage devices may be enhanced with stormwater quality features, such as filters and infiltration. The stormwater enters the system through a catch basin or inlet structure and flows to a series of chambers, vaults, or over-sized pipes for temporary storage. The low-flow outlet structure is sized to release the stormwater at a slower rate to protect against flooding and stream channel erosion downstream of the BMP. Materials may vary from concrete, steel, or plastic, and may include detention in the pore space of aggregates.

Figure 4-5 Underground Storage
(Source: Fort Belvoir DPW)

Table 4-5 Functional Components of Underground Storage

Functional Components
Principal Spillway
Trash Rack
Energy Dissipater
Sediment Forebay
Observation Well, Clean Out, or Manhole Access

5.0 FILTRATION AND INFILTRATION

5.1 BIORETENTION

A bioretention facility or bioretention filter is a depressed landscape area that consists of a shallow basin for surface ponding. The facility usually includes a planting medium of mulch and an engineered soil mix, with a gravel sump underneath providing for biological and physiochemical treatment of stormwater. The landscaping and vegetation is strategically selected for maximum pollutant removal and survival in varying hydrologic conditions.

In a bioretention facility, water exits the planting medium by infiltrating to the surrounding soil and groundwater table. In a bioretention filter, the surrounding soils are generally unsuitable for infiltration, so the filtered stormwater must be collected by an underdrain. The underdrain system generally consists of a perforated pipe protected by a pea gravel filter to collect and convey treated stormwater.

Bioretention facilities range in size, and may look like a small garden (also referred to as a rain garden). Facilities that rely on infiltration are not designed to impound water deeper than 6 inches, while facilities that filter may pond water up to 12 inches deep. Standing water in the ponding area and saturation of the engineered soil media should disappear in 24 to 48 hours, if the facility is functioning properly. Some filtration facilities may be designed to provide some retention of stormwater in the aggregate sump below the underdrain to create anaerobic conditions for enhanced removal of nitrogen, so it is important to consult design documents to determine if water standing in aggregate sump more than 48 hours after a storm event is acceptable.

Figure 5-1 Bioretention Filter
(Source: Fort Belvoir DPW)

Table 5-1 Functional Components of a Bioretention Facility

Functional Components
Earthen Embankment
Principal Spillway
Energy Dissipater
Vegetation/Landscaping
Access
Observation Well or Clean Out

5.2 FILTER

Filters are capable of capturing and treating stormwater runoff to remove sediment, trash, debris, and other pollutants. They treat stormwater through physical, chemical, and biological means. Common filter media may include sand, fine gravel, peat, engineered soil, or even multiple layers of different media. They may be constructed in underground vaults, trenches, or open basins. Some filters are the primary treatment of stormwater, while other filters are placed around the perimeter of another BMP for pretreatment. Most filters include an underdrain or other system to collect filtered water and convey it to the storm sewer or a receiving channel. Some may rely on infiltration to remove the filtered water.

Figure 5-2 Sand Filter
(Source: Fort Belvoir DPW)

Table 5-2 Functional Components of a Filter

Functional Components
Earthen Embankment
Principal Spillway
Energy Dissipater
Access
Observation Well, Clean Out, or Manhole Access

5.3 INFILTRATION

Infiltration practices provide the best runoff controls than any other BMP. They capture and store runoff to allow it to exfiltrate the facility and infiltrate into the surrounding soil. Biological, chemical and physical processes in the soil remove pollutants to prevent groundwater contamination. The runoff may flow through pretreatment practices that trap sediment and other pollutants before they reach the infiltration practice. The captured runoff can be stored in underground vaults, trenches, open basins, or over-sized pipe systems to allow for infiltration before the next storm event.

Figure 5-3 Infiltration Basin
(Source: VSWMH)

Table 5-3 Functional Components of Infiltration

Functional Components
Earthen Embankment
Principal Spillway
Energy Dissipater
Access
Observation Well, Clean Out, or Manhole Access

5.4 DRY SWALE

A dry swale functions to convey stormwater, as well as temporarily store and filter stormwater through the soil. It utilizes an engineered soil media similar to that used in other stormwater treatment practices. The media may be permeable enough for infiltration; however dry swales may also have an underdrain within a gravel layer to convey treated stormwater back to the storm sewer system. Dry swales may vary in appearance from a simple grass channel to an elaborately landscaped channel with more vegetation.

Figure 5-4 Dry Swale
(Source: WEG)

Table 5-4 Functional Components of a Dry Swale

Functional Components
Underdrain
Vegetation/Landscaping
Observation Well or Clean Out

5.5 WET SWALE

A wet swale acts as a conveyance system, and may provide runoff filtering and treatment. It appears as a cross between a dry swale and a wet pond. They are typically found near shallow groundwater. The vegetation is similar to that found on the aquatic bench of a wet pond and provides the same sediment settling and biological treatment. A wet swale may have an underdrain for additional storage.

Figure 5-5 Wet Swale
(Source: VSWMH)

Table 5-5 Functional Components of a Wet Swale

Functional Components
Vegetation/Landscaping

6.0 MANUFACTURED BMP TYPES

6.1 TREE BOX FILTER

Tree box filters utilize the same treatment methods as a bioretention area. They are trees planted in a container with soil and mulch engineered for stormwater pollutant and sediment removal. The stormwater is directed to the tree box, where it is filtered through the vegetation and soil before entering the underground storage.

Figure 6-1 Tree Box Filter
(Source: Fort Belvoir DPW)

Table 6-1 Functional Components of a Tree Box Filter

Functional Components
Underdrain
Vegetation/Landscaping
Observation Well or Clean Out

6.2 HYDRODYNAMIC SEPARATORS

Hydrodynamic separators remove sediment and other pollutants from stormwater by physical separation before entering the storm sewer system. The inflow of stormwater causes a swirl action that allows heavy particles to settle to the bottom and lighter materials to float where they can be easily captured. They may be manufactured in many different sizes to fit in conventional manholes.

Figure 6-2 Hydrodynamic Separator
(Source: Fort Belvoir DPW)

Table 6-2 Functional Components of a Hydrodynamic Separator

Functional Components
Observation Well, Clean Out, or Manhole Access

7.0 OTHER BMPS

7.1 VEGETATED/GREEN ROOF

A vegetative roof may also be referred to as a green roof, living roof, or ecoroof. It is an engineered growing media that is designed to promote plant growth on the roof of a building. The media filters, absorbs, and detains stormwater runoff before it is conveyed to the storm drain. There may be multiple layers of media, including gravel, a waterproof membrane, filter fabric, and small layers of soil.

Figure 7-1 Vegetated/Green Roof

Table 7-1 Functional Components of a Vegetated/Green Roof

Functional Components
Underdrain
Filter Media
Principal Spillway

7.2 RAINWATER HARVESTING

Rainwater harvesting captures stormwater runoff from a rooftop and stores it in containers, such as cisterns, tanks, vaults, or barrels, in order to use it in the future. Storage can be underground, on the surface, or even on roof tops. Harvested rainwater is limited to flushing toilets, landscape irrigation, exterior washing, street sweepers, filling landscape ponds or fountains, or other non-potable uses. If there is no use for the harvested rainwater, it may be slowly released to another BMP or the soil at low rates that allow infiltration to the groundwater table between storm events when the soils are not frozen or saturated.

Figure 7-2 Rainwater Harvesting

Table 7-2 Functional Components of Rainwater Harvesting

Functional Components
Principal Spillway
Observation Well, Clean Out, or Manhole Access

7.3 PERMEABLE PAVEMENT

Permeable pavement allows stormwater runoff to filter through the voids in the pavement surface. It can include porous concrete, asphalt, or pavers. The runoff is stored in a gravel bed beneath the permeable pavement for infiltration to the surrounding soil. If the soil under the gravel bed has low infiltration rates, an underdrain system is used to return the stormwater to the storm sewer system, usually after detaining the runoff to control flow rates.

Figure 7-3 Permeable Pavers

Table 7-3 Functional Components of Permeable Pavement

Functional Components
Underdrain
Observation Well, Clean Out, or Manhole Access

8.0 INSPECTIONS

Periodic inspection of BMP facilities ensures they are functioning as designed and constructed. Inspections also verify that routine and preventative maintenance is being conducted, and provide an opportunity to identify non-routine maintenance needs. Table 8-1 provides a recommended inspections schedule for stormwater BMP facilities serving Fort Belvoir.

Table 8-1 Inspection Schedule

Type of Inspection	Minimum Frequency of Inspection
Operational	Annually
Maintenance	Every 5 Years
Technical	As Needed

8.1 OPERATIONAL INSPECTIONS

Operational inspections are recommended a minimum of annually to ascertain the operational status of the facility by visual observation. Operational inspections by trained staff should document the existence of standing water in dry facilities more than 72 hours after a runoff producing storm event. Operational inspections should also note the existence of insect or odor problems, dead or dying vegetation, visible erosion, rodent burrowing, embankment settling, and accumulation of trash and debris. If an operational inspection reveals deficiencies that require routine maintenance, the maintenance should be scheduled and completed before the next operational inspection. If the operational inspection reveals that more than routine maintenance may be needed, a maintenance inspection should be scheduled as a follow-up to determine if preventative or non-routine maintenance activities are required.

Operational inspection logs or records should be maintained for each BMP. See Appendix B for an example of an Operational Inspection Log form. Records could also be maintained electronically, provided the same information is recorded and maintained. While completion of a Maintenance Inspection Checklist is not required for Operational Inspections (see discussion below), the Maintenance Inspection Checklists provided in Appendix C can serve as a guide for use during the Operational Inspections.

8.2 MAINTENANCE INSPECTIONS

Maintenance inspections should be conducted a minimum of once every five (5) years by qualified staff holding a certificate of competency from the Virginia Department of Environmental Quality as a Stormwater Management Inspector, or when an operational inspection reveals issues that

may require more than routine maintenance. During maintenance inspections, a Maintenance Inspection Checklist should be completed (see Appendix C for Maintenance Inspection Checklists). Maintenance Inspection Checklists can also be maintained in electronic format provided the same level of information and detail is recorded and maintained.

The purpose of a maintenance inspection is to look beyond routine operational inspections to determine if preventative or non-routine maintenance is required. In addition to the items noted for operational inspections, a maintenance inspection should note the accumulation of sediment or other pollutants in the facility, the state of the contributing drainage shed, and the functionality of structural components such as embankments and spillways. As a facility matures, the maintenance inspection may include investigation of mulch, engineered soils, filter media, or vegetation to determine if it is time to replace these features in a facility. If a maintenance inspection reveals critical deficiencies that require extraordinary maintenance activities, a technical inspection should be scheduled immediately to determine what actions need to be taken to address the noted deficiencies.

8.3 TECHNICAL INSPECTIONS

Non-routine, technical inspections should follow extreme events, such as large, infrequent storms. They should also be triggered by a maintenance inspection that reveals deficiencies that are not addressed through routine or preventative maintenance activities. The purpose is to identify damage that has occurred from an extreme event or the aging and deterioration of a facility and its functional components. A technical inspection should be conducted by a qualified professional to determine what actions should be taken to address the deficiencies through non-routine maintenance activities. The qualified professional conducting the technical inspection should record the findings in a written document and provide the documentation to DPW for action and recordkeeping.

For the purpose of this inspection and maintenance program, a large, infrequent storm that triggers a technical inspection is defined by total rainfall depths summarized in Table 8-2 and based on a range of storm durations.

Table 8-2 Storm Events Triggering a Technical Inspection

Storm Duration	Total Precipitation Depth
2-hours	3.9 inches
6-hours	5.3 inches
12-hours	6.8 inches
24-hours	8.3 inches

8.4 BMP CONDITION RATING SYSTEM

The following scale is currently used by Fort Belvoir DPW to grade BMPs based on functionality. Each structure should be rated on a scale from 1 to 5 during maintenance and technical inspections. The Maintenance Inspection Checklists in Appendix C provide a place to record the BMP Condition based upon the rating system. These condition ratings correspond with the following definitions:

Condition 1: Fully Functional. Structure/Facility is not in need of non-routine maintenance and is operating as designed/intended. Continue routine maintenance.

Condition 2: Minor Structural or Functional defects. Operates to Design specifications. Should be scheduled for future inspection. Preventative or non-routine maintenance required.

Condition 3: Acceptable/Anticipated Structural & Functional Deterioration. Operating effectively. Should be scheduled for a technical inspection prior to the next operational inspection.

Condition 4: Major Structural or Functional defects. Does not operate as designed. Should be scheduled for immediate technical inspection.

Condition 5: Structurally/Functionally Deficient. In need of immediate replacement/rehabilitation and follow-up with technical inspection.

Condition ratings are useful for prioritizing and scheduling maintenance activities and follow-up inspections. Given limited resources to operate and maintain BMPs, it is critical to focus attention on the BMPs in the worst condition first.

9.0 MAINTENANCE

Maintenance can be categorized as routine, preventative, or non-routine. Routine maintenance includes removal of trash and debris, mowing, pruning of vegetation, and supplemental mulching. Preventative maintenance includes stabilization of erosion areas, filling of rodent burrows, removal of old mulch, and removal of sediment from forebays and other pre-treatment features. Non-routine maintenance includes replacement of engineered soil media, clean-out of underdrains, replacement of dead or dying vegetation, and dredging to remove sediment build-up in main facility.

Maintenance varies for different types of facilities, so the schedules are broken out by facility type. The following tables provide Routine, Preventative, and Non-Routine Maintenance Schedules for BMPs at Ft. Belvoir.

Table 9-1 Detention and Extended Detention Basin Maintenance Schedule

Task	Frequency
Mow (embankment, banks, bottom, auxiliary spillway, and upland areas)	Minimum of twice per year to manage groundcover, prevent growth of woody vegetation, and allow for observations and inspections
Remove Trash and Debris (inlets, basin, and spillways)	Minimum of twice per year and as needed to maintain flow
Overseed, lime, and fertilize groundcover as required to maintain adequate stabilization	As needed in the fall according to the results of soil testing
Repair Erosion (embankment, banks, bottom, auxiliary spillway, and upland areas)	Within 30 days of discovery during observations and inspections
Repair Rodent Burrows (embankment, banks, bottom, and auxiliary spillway)	Within 30 days of discovery during observations and inspections
Remove Sediment from forebay	As needed based upon observations and inspections
Remove Sediment and Replace Displaced Riprap in outlet protection	As needed based upon observations and inspections
Remove Sediment from main facility	As needed based upon inspections
Repair/Replace Spillway components as needed (corrosion of metal, cracking and spalling of concrete and plastic/PVC, dry rot in wood, etc.)	As needed based upon inspections

Table 9-2 Enhanced Extended Detention Basin Maintenance Schedule

Task	Frequency
Mow (embankment, banks, auxiliary spillway, and upland areas)	Minimum of twice per year to manage groundcover, prevent growth of woody vegetation, and allow for observations and inspections
Remove Trash and Debris (inlets, basin, and spillways)	Minimum of twice per year and as needed to maintain flow
Overseed, lime, and fertilize groundcover as required to maintain adequate stabilization	As needed in the fall according to the results of soil testing
Repair Erosion (embankment, banks, and auxiliary spillway)	Within 30 days of discovery during observations and inspections
Repair Rodent Burrows (embankment, banks, and auxiliary spillway)	Within 30 days of discovery during observations and inspections
Remove Sediment from forebay	As needed based upon observations and inspections
Remove Sediment and Replace Displaced Riprap in outlet protection	As needed based upon observations and inspections
Remove Sediment from main facility	As needed based upon observations and inspections
Repair/Replace Spillway components as needed (corrosion of metal, cracking and spalling of concrete and plastic/PVC, dry rot in wood, etc.)	As needed based upon observations and inspections
Remove dead or dying shallow marsh vegetation and replace with species, size, and density specified in the design plan	As needed based upon observations and inspections

Table 9-3 Retention Basin and Constructed Wetlands Maintenance Schedule

Task	Frequency
Mow (embankment, banks, auxiliary spillway, and upland areas)	Minimum of twice per year to manage groundcover, prevent growth of woody vegetation, and allow for observations and inspections
Remove Trash and Debris (inlets, basin, and spillways)	Minimum of twice per year and as needed to maintain flow
Overseed, lime, and fertilize groundcover as required to maintain adequate stabilization	As needed in the fall according to the results of soil testing
Repair Erosion (embankment, banks, and auxiliary spillway)	Within 30 days of discovery during observations and inspections
Repair Rodent Burrows (embankment, banks, and auxiliary spillway)	Within 30 days of discovery during observations and inspections
Remove Sediment from forebay	As needed based upon observations and inspections
Remove Sediment and Replace Displaced Riprap in outlet protection	As needed based upon observations and inspections
Remove Sediment from main facility	As needed based upon observations and inspections
Repair/Replace Spillway components as needed (corrosion of metal, cracking and spalling of concrete and plastic/PVC, dry rot in wood, etc.)	As needed based upon observations and inspections
Remove dead or dying aquatic and shallow marsh vegetation and replace with species, size, and density specified in the design plan	As needed based upon observations and inspections

Table 9-4 Underground Storage Maintenance Schedule

Task	Frequency
Remove Trash and Debris (inlets, basins, and spillways)	Minimum of twice per year and as needed to maintain flow
Remove Sediment from forebay or pretreatment area	As needed based upon observations and inspections
Remove Sediment from main facility	As needed based upon observations and inspections
Maintain hatches, doors, manholes, caps, locks, and other barriers	As needed to maintain access for inspections and maintenance and to limit access to the public
Repair/Replace components as needed (corrosion of metal, cracking and spalling of concrete and plastic/PVC, dry rot in wood, etc.)	As needed based upon observations and inspections

Table 9-5 Bioretention and Bioretention Filter Maintenance Schedule

Task	Frequency
Remove Trash and Debris (inlets, basins, and spillways)	Minimum of twice per year and as needed to maintain flow
Mow (vegetated embankment, banks, auxiliary spillway, and upland areas)	Minimum of twice per year to manage groundcover, prevent growth of woody vegetation, and allow for observations and inspections
Add supplemental mulch where thin or bare	Minimum of annually or within 30 days of discovery during observations and inspections
Repair Erosion (embankment, banks, and auxiliary spillway)	Within 30 days of discovery during observations and inspections
Repair Rodent Burrows (embankment, banks, and auxiliary spillway)	Within 30 days of discovery during observations and inspections
Remove Sediment from forebay or pretreatment area	As needed based upon observations and inspections
Remove Sediment and Replace Displaced Riprap in outlet protection	As needed based upon observations and inspections
Remove and replace mulch	As needed based upon observation that facility is not draining adequately
Remove Sediment from main facility	As needed based upon observations and inspections
Remove dead or dying vegetation and replace with species, size, and density specified in the design plan	As needed based upon observations and inspections
Clean out underdrain	As needed based upon observation that facility is not draining adequately
Replace Soil Media and Aggregate Sump	As needed based upon observation that facility is not draining adequately

Table 9-6 Filter Maintenance Schedule

Task	Frequency
Remove Trash and Debris (inlets, basins, and spillways)	Minimum of twice per year and as needed to maintain flow
Mow (vegetated embankment, banks, auxiliary spillway, and upland areas)	Minimum of twice per year to manage groundcover, prevent growth of woody vegetation, and allow for observations and inspections
Repair Erosion (embankment, banks, and auxiliary spillway)	Within 30 days of discovery during observations and inspections
Repair Rodent Burrows (embankment, banks, and auxiliary spillway)	Within 30 days of discovery during observations and inspections
Remove Sediment from forebay or pretreatment area	As needed based upon observations and inspections
Remove Sediment and Replace Displaced Riprap in outlet protection	As needed based upon observations and inspections
Remove Sediment from main facility	As needed based upon observations and inspections
Clean out underdrain	As needed based upon observation that facility is not draining adequately
Repair/Replace components as needed (corrosion of metal, cracking and spalling of concrete and plastic/PVC, dry rot in wood, etc.)	As needed based upon observations and inspections
Replace Filter Media	As needed based upon observation that facility is not draining adequately

Table 9-7 Infiltration Maintenance Schedule

Task	Frequency
Remove Trash and Debris (inlets, basins, and spillways)	Minimum of twice per year and as needed to maintain flow
Mow (vegetated embankment, banks, auxiliary spillway, and upland areas)	Minimum of twice per year to manage groundcover, prevent growth of woody vegetation, and allow for observations and inspections
Repair Erosion (embankment, banks, and auxiliary spillway)	Within 30 days of discovery during observations and inspections
Repair Rodent Burrows (embankment, banks, and auxiliary spillway)	Within 30 days of discovery during observations and inspections
Remove Sediment from forebay or pretreatment area	As needed based upon observations and inspections
Remove Sediment and Replace Displaced Riprap in outlet protection	As needed based upon observations and inspections
Remove Sediment from main facility	As needed based upon observations and inspections
Replace/Restore Storage Media (for facilities using sand or aggregate to store runoff for infiltration)	As needed based upon observation that facility is not draining adequately

Table 9-8 Dry Swale Maintenance Schedule

Task	Frequency
Remove Trash and Debris	Minimum of twice per year and as needed to maintain flow
Mow	Minimum of twice per year to manage groundcover, prevent growth of woody vegetation, and allow for observations and inspections
Overseed, lime, and fertilize as required to maintain adequate stabilization	As needed in the fall according to the results of soil testing
Repair Erosion	Within 30 days of discovery during observations and inspections
Repair Rodent Burrows	Within 30 days of discovery during observations and inspections
Remove Sediment	As needed based upon observations and inspections
Clean out underdrain	As needed based upon observation that facility is not draining adequately
Replace/Restore Soil Media	As needed based upon observation that facility is not draining adequately

Table 9-9 Wet Swale Maintenance Schedule

Task	Frequency
Remove Trash and Debris	Minimum of twice per year and as needed to maintain flow
Mow	Minimum of twice per year to manage groundcover, prevent growth of woody vegetation, and allow for observations and inspections
Overseed, lime, and fertilize as required to maintain adequate stabilization	As needed in the fall according to the results of soil testing
Repair Erosion	Within 30 days of discovery during observations and inspections
Repair Rodent Burrows	Within 30 days of discovery during observations and inspections
Remove Sediment	As needed based upon observations and inspections

Table 9-10 Tree Box Filter Maintenance Schedule

Task	Frequency
Remove Trash and Debris	Minimum of twice per year and as needed to maintain flow
Add supplemental mulch where thin or bare	Minimum of annually or within 30 days of discovery during observations and inspections
Repair Erosion	Within 30 days of discovery during observations and inspections
Remove Sediment	As needed based upon observations and inspections
Remove and replace mulch	As needed based upon observation that facility is not draining adequately
Remove dead or dying vegetation and replace with species, size, and density specified in the design plan	As needed based upon observations and inspections
Clean out underdrain	As needed based upon observation that facility is not draining adequately
Replace Soil Media	As needed based upon observation that facility is not draining adequately

Table 9-11 Hydrodynamic Device Maintenance Schedule

Task	Frequency
Remove Trash and Debris (inlets, basins, and spillways)	Minimum of twice per year and as needed to maintain flow
Remove Sediment from forebay or pretreatment area	As needed based upon observations and inspections
Remove Sediment from main facility	As needed based upon observations and inspections
Maintain hatches, doors, manholes, caps, locks, and other barriers	As needed to maintain access for inspections and maintenance and to limit access to the public
Repair/Replace components as needed (corrosion of metal, cracking and spalling of concrete and plastic/PVC, dry rot in wood, etc.)	As needed based upon observations and inspections

Table 9-12 Vegetated Roof Maintenance Schedule

Task	Frequency
Remove Trash and Debris	Minimum of twice per year and as needed to maintain flow
Remove dead or dying vegetation and replace with species, size, and density specified in the design plan	As needed based upon observations and inspections
Replace Panting Media and Vegetation	As needed based upon observation that vegetation is not thriving

Table 9-13 Rainwater Harvesting Maintenance Schedule

Task	Frequency
Remove Trash and Debris from Collection System	Minimum of twice per year and as needed to maintain flow
Clean Inlets and Pretreatment Systems	As needed based upon observations and inspections
Repair Leaks	As needed based upon observations and inspections
Manage unwanted biological growth	As needed based upon observations and inspections
Drain and clean storage units to remove sediment	As needed based upon observations and inspections

Table 9-14 Permeable Pavement Maintenance Schedule

Task	Frequency
Remove Trash and Debris (inlets, basins, and spillways)	Quarterly and as needed to maintain drainage
Sweep pavement and pavers to remove accumulated sediment	Minimum of twice per year and as needed to maintain drainage
Recover spills and leaks	As needed based upon observations and inspections
Wash and vacuum pavement and pavers	As needed based upon observations and inspections
Replace or repair cracked pavement and pavers	As needed based upon observations and inspections
Replace/Restore Storage Media (for facilities using sand or aggregate to store runoff for infiltration or detention)	As needed based upon observation that facility is not draining adequately

10.0 DISPOSAL OF STORMWATER RESIDUALS

Stormwater picks up and transports a variety of pollutants and sediment to include discharges from industrial plants, pet waste, automobiles, and construction sites. Stormwater BMPs are designed to improve water quality by removing these pollutants. However, if BMPs are not properly maintained, the accumulation of pollutants and sediment can become a source of pollution if resuspended. Periodic inspections and disposal of residuals will ensure stormwater BMPs are functioning properly, and not posing further threat to the environment. The type of pollutants found in stormwater varies greatly depending on surrounding site characteristics. Similarly, different BMPs have different removal methods and frequencies. Appendix E includes guidance from the EPA on the handling and disposal of stormwater residuals from the maintenance and dredging of BMPs. We recommend the use of the EPA guidance and applicable federal, state, and local regulations pertaining to the handling and disposal of waste products.

APPENDIX A

Summary of BMPs Serving Ft. Belvoir

Structure_Key	Watershed	Watershed_ Number	Subshed	Latitude	Longitude	Location_Description	Type	Condition	Date_Recorded
37	Dogue Creek	2	26	38.70972	-77.13458	George Washington Village	Underground Storage	1	20-Sep-10
38	Dogue Creek	2	26	38.70975	-77.13464	George Washington Village	Biofilter	4	21-Sep-10
42	Dogue Creek	2	26	38.70981	-77.13492	George Washington Village	Biofilter	3	21-Sep-10
47	Dogue Creek	2	26	38.70965	-77.13528	George Washington Village	Biofilter	1	21-Jul-11
69	Dogue Creek	2	27	38.70708	-77.13308	George Washington Village	Underground Storage	3	21-Sep-10
71	Dogue Creek	2	27	38.70717	-77.13319	George Washington Village	Underground Storage	3	21-Sep-10
72	Dogue Creek	2	27	38.70719	-77.13328	George Washington Village	Biofilter	3	21-Sep-10
93	Dogue Creek	2	25	38.70631	-77.13283	George Washington Village	Underground Storage	U	22-Sep-10
103	Dogue Creek	2	25	38.70656	-77.13406	George Washington Village	Biofilter	2	22-Sep-10
119	Dogue Creek	2	25	38.70661	-77.13450	George Washington Village	Underground Storage	2	22-Sep-10
120	Dogue Creek	2	25	38.70664	-77.13461	George Washington Village	Underground Storage	2	22-Sep-10
123	Dogue Creek	2	25	38.70658	-77.13492	George Washington Village	Underground Storage	2	22-Sep-10
132	Dogue Creek	2	25	38.70656	-77.13408	George Washington Village	Underground Storage	U	22-Sep-10
121	Dogue Creek	2	25	38.70667	-77.13489	George Washington Village	Biofilter	2	22-Sep-10
137	Dogue Creek	2	25	38.70689	-77.13494	George Washington Village	Underground Storage	U	23-Sep-10
138	Dogue Creek	2	25	38.70689	-77.13494	George Washington Village	Underground Storage	U	23-Sep-10
139	Dogue Creek	2	25	38.70689	-77.13500	George Washington Village	Biofilter	3	23-Sep-10
160	Dogue Creek	2	25	38.70458	-77.13778	Colyer Village	Detention Pond	1	23-Sep-10
203	Dogue Creek	2	25	38.70489	-77.13650	Colyer Village	Detention Pond	1	24-Sep-10
293	Dogue Creek	2	24	38.70485	-77.13292	George Washington Village	Underground Storage	U	1-Oct-10
294	Dogue Creek	2	24	38.70487	-77.13289	George Washington Village	Underground Storage	U	1-Oct-10
295	Dogue Creek	2	24	38.70490	-77.13291	George Washington Village	Underground Storage	1	1-Oct-10
296	Dogue Creek	2	24	38.70483	-77.13336	George Washington Village	Underground Storage	1	1-Oct-10
297	Dogue Creek	2	24	38.70491	-77.13337	George Washington Village	Underground Storage	1	1-Oct-10
298	Dogue Creek	2	24	38.70481	-77.13302	George Washington Village	Biofilter	2	1-Oct-10
325	Dogue Creek	2	24	38.70500	-77.13298	George Washington Village	Biofilter	1	1-Oct-10
328	Dogue Creek	2	24	38.70536	-77.13280	George Washington Village	Underground Storage	1	1-Oct-10
330	Dogue Creek	2	24	38.70524	-77.13283	George Washington Village	Underground Storage	U	1-Oct-10
331	Dogue Creek	2	24	38.70518	-77.13290	George Washington Village	Underground Storage	U	1-Oct-10
332	Dogue Creek	2	24	38.70504	-77.13286	George Washington Village	Underground Storage	U	1-Oct-10
335	Dogue Creek	2	24	38.70538	-77.13313	George Washington Village	Biofilter	U	1-Oct-10
357	Dogue Creek	2	24	38.70401	-77.13281	George Washington Village	Underground Storage	U	5-Oct-10
359	Dogue Creek	2	24	38.70359	-77.13294	George Washington Village	Underground Storage	U	5-Oct-10
360	Dogue Creek	2	24	38.70360	-77.13298	George Washington Village	Underground Storage	U	5-Oct-10
364	Dogue Creek	2	24	38.70327	-77.13320	George Washington Village	Biofilter	4	5-Oct-10
374	Dogue Creek	2	24	38.70317	-77.13302	George Washington Village	Biofilter	1	5-Oct-10
389	Dogue Creek	2	24	38.70252	-77.13290	George Washington Village	Underground Storage	3	5-Oct-10
390	Dogue Creek	2	24	38.70247	-77.13292	George Washington Village	Underground Storage	3	5-Oct-10
391	Dogue Creek	2	24	38.70246	-77.13293	George Washington Village	Underground Storage	3	5-Oct-10
392	Dogue Creek	2	24	38.70241	-77.13296	George Washington Village	Underground Storage	3	5-Oct-10
393	Dogue Creek	2	24	38.70241	-77.13297	George Washington Village	Underground Storage	3	5-Oct-10
396	Dogue Creek	2	24	38.70264	-77.13303	George Washington Village	Biofilter	2	5-Oct-10
397	Dogue Creek	2	26	38.70944	-77.13414	George Washington Village	Underground Storage	U	5-Oct-10
398	Dogue Creek	2	26	38.70936	-77.13405	George Washington Village	Underground Storage	U	5-Oct-10
399	Dogue Creek	2	26	38.70934	-77.13404	George Washington Village	Underground Storage	U	5-Oct-10
400	Dogue Creek	2	26	38.70932	-77.13405	George Washington Village	Underground Storage	U	5-Oct-10
401	Dogue Creek	2	26	38.70931	-77.13406	George Washington Village	Underground Storage	U	5-Oct-10
402	Dogue Creek	2	26	38.70956	-77.13431	George Washington Village	Underground Storage	U	5-Oct-10

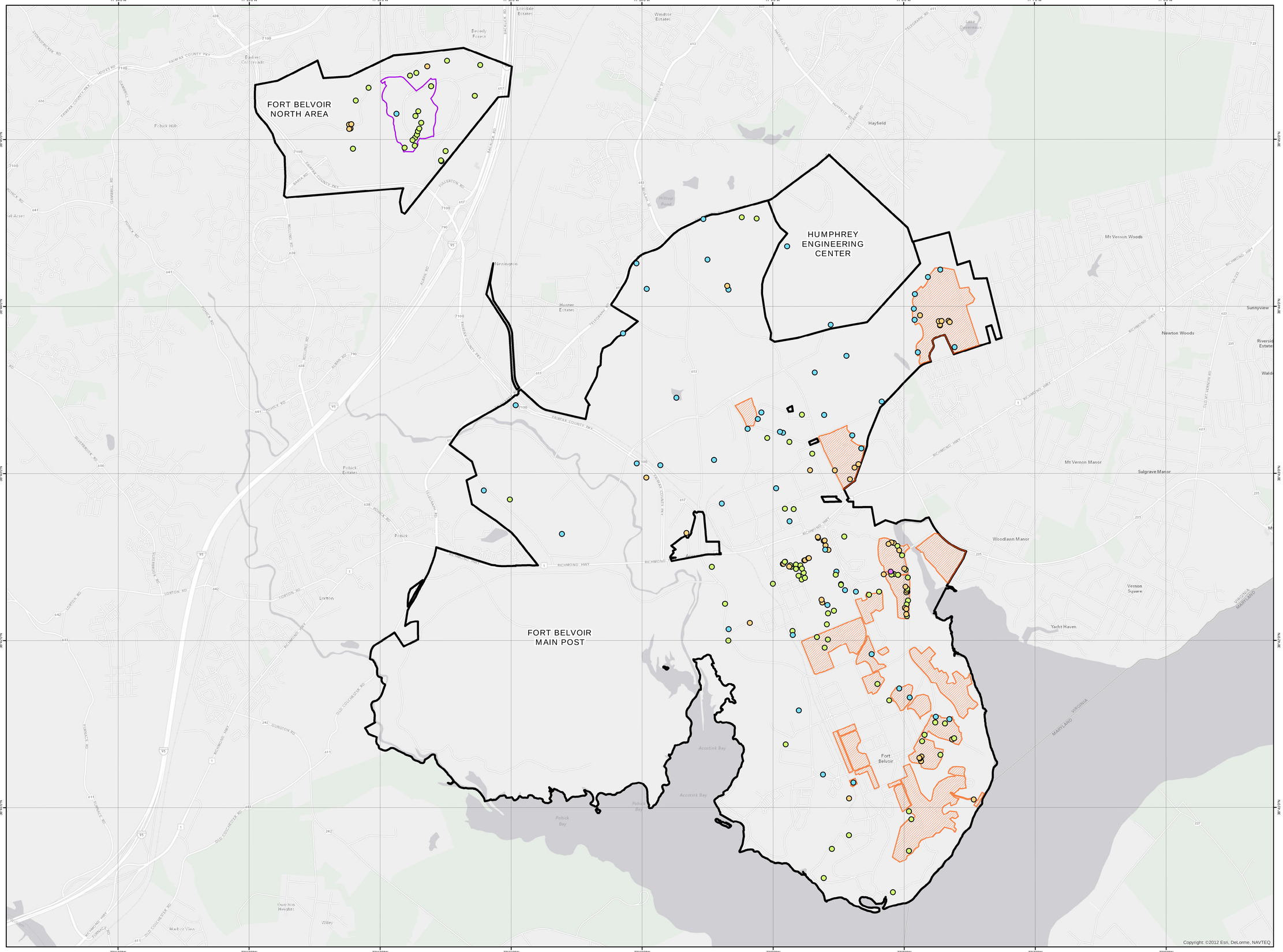
Structure_Key	Watershed	Watershed_ Number	Subshed	Latitude	Longitude	Location_Description	Type	Condition	Date_Recorded
403	Dogue Creek	2	26	38.70958	-77.13429	George Washington Village	Underground Storage	U	5-Oct-10
407	Dogue Creek	2	26	38.70853	-77.13355	George Washington Village	Underground Storage	2	6-Oct-10
408	Dogue Creek	2	26	38.70851	-77.13356	George Washington Village	Underground Storage	2	6-Oct-10
414	Dogue Creek	2	26	38.70907	-77.13392	George Washington Village	Underground Storage	U	6-Oct-10
415	Dogue Creek	2	26	38.70902	-77.13391	George Washington Village	Biofilter	1	6-Oct-10
534	Dogue Creek	2	24	38.69865	-77.13744	Cedar Grove Village	Detention Pond	1	11-Oct-10
624	Dogue Creek	2	22	38.69569	-77.13676	Cedar Grove Village	Underground Storage	U	13-Oct-10
625	Dogue Creek	2	22	38.69568	-77.13670	Cedar Grove Village	Underground Storage	U	13-Oct-10
626	Dogue Creek	2	22	38.69518	-77.13687	Cedar Grove Village	Underground Storage	U	13-Oct-10
627	Dogue Creek	2	22	38.69516	-77.13679	Cedar Grove Village	Underground Storage	U	13-Oct-10
797	Dogue Creek	2	22	38.69523	-77.13392	Park Village	Detention Pond	1	20-Oct-10
832	Dogue Creek	2	22	38.69432	-77.13260	Park Village	Detention Pond	1	21-Oct-10
933	Dogue Creek	2	21	38.69217	-77.12755	Jadwin Loop Village	Detention Pond	1	22-Oct-10
930	Dogue Creek	2	21	38.69174	-77.12811	Jadwin Loop Village	Rain Garden	1	22-Oct-10
937	Dogue Creek	2	21	38.69241	-77.12928	Jadwin Loop Village	Detention Pond	1	22-Oct-10
956	Dogue Creek	2	21	38.69184	-77.12935	Jadwin Loop Village	Rain Garden	1	25-Oct-10
1006	Potomac River	6	19	38.69015	-77.12720	Jadwin Loop Village	Biofilter	U	26-Oct-10
1007	Potomac River	6	19	38.69038	-77.12713	Jadwin Loop Village	Underground Storage	U	26-Oct-10
1008	Potomac River	6	19	38.69011	-77.12714	Jadwin Loop Village	Underground Storage	U	26-Oct-10
1009	Potomac River	6	19	38.69025	-77.12695	Jadwin Loop Village	Underground Storage	U	26-Oct-10
1017	Potomac River	6	19	38.69052	-77.13072	Jadwin Loop Village	Underground Storage	3	26-Oct-10
1018	Potomac River	6	19	38.69061	-77.13072	Jadwin Loop Village	Underground Storage	U	26-Oct-10
1030	Potomac River	6	19	38.68996	-77.13102	Jadwin Loop Village	Underground Storage	U	26-Oct-10
1040	Potomac River	6	19	38.68861	-77.12870	Rossell Village	Detention Pond	2	28-Oct-10
1071	Potomac River	6	19	38.68798	-77.13125	Rossell Village	Underground Storage	U	29-Oct-10
1072	Potomac River	6	19	38.68799	-77.13126	Rossell Village	Underground Storage	U	29-Oct-10
1073	Potomac River	6	19	38.68813	-77.13159	Rossell Village	Underground Storage	U	29-Oct-10
1074	Potomac River	6	19	38.68816	-77.13156	Rossell Village	Underground Storage	U	29-Oct-10
1075	Potomac River	6	19	38.68818	-77.13154	Rossell Village	Underground Storage	U	29-Oct-10
1076	Potomac River	6	19	38.68820	-77.13152	Rossell Village	Underground Storage	U	29-Oct-10
1077	Potomac River	6	19	38.68838	-77.13116	Rossell Village	Underground Storage	U	29-Oct-10
1078	Potomac River	6	19	38.68836	-77.13115	Rossell Village	Underground Storage	U	29-Oct-10
1079	Potomac River	6	19	38.68835	-77.13113	Rossell Village	Underground Storage	U	29-Oct-10
1080	Potomac River	6	19	38.68833	-77.13108	Rossell Village	Underground Storage	U	29-Oct-10
1081	Potomac River	6	19	38.68795	-77.13121	Rossell Village	Underground Storage	1	29-Oct-10
1083	Potomac River	6	19	38.68797	-77.13116	Rossell Village	Biofilter	U	29-Oct-10
1098	Potomac River	6	19	38.68840	-77.13108	Rossell Village	Underground Storage	2	29-Oct-10
1100	Potomac River	6	19	38.68844	-77.13110	Rossell Village	Biofilter	U	29-Oct-10
1116	Potomac River	6	19	38.68823	-77.13130	Rossell Village	Underground Storage	2	29-Oct-10
1118	Potomac River	6	19	38.68830	-77.13137	Rossell Village	Biofilter	U	29-Oct-10
1266	Gunston Cove	5	14	38.67901	-77.13271	Fairfax Village	Detention Pond	2	3-Nov-10
1373	Gunston Cove	5	14	38.68218	-77.13240	Fairfax Village	Detention Pond	2	8-Nov-10
1392	Gunston Cove	5	14	38.68297	-77.13270	Fairfax Village	Detention Pond	1	8-Nov-10
1528	Accotink Bay	4	5	38.68965	-77.14838	Museum Support Services	Detention Pond	4	10-Nov-10
1779	Gunston Cove	5	14	38.67491	-77.13475		Rain Garden	1	18-Nov-10
1947	Gunston Cove	5	12	38.67632	-77.14356	Wilson Road, by old nuclear reactor	Detention Pond	2	22-Nov-10
1948	Gunston Cove	5	12	38.67692	-77.14282		Stream Junction	1	22-Nov-10
1962	Gunston Cove	5	11	38.67923	-77.14253	300 Area	Detention Pond	1	22-Nov-10

Structure_Key	Watershed	Watershed_ Number	Subshed	Latitude	Longitude	Location_Description	Type	Condition	Date_Recorded
1963	Gunston Cove	5	11	38.67927	-77.14214		Stream Junction	1	22-Nov-10
2140	Gunston Cove	5	11	38.68058	-77.14035	OSEG (300 Area)	Detention Pond	3	2-Dec-10
2334	Accotink Bay	4	3	38.69987	-77.14307	Vernondale Village	Underground Storage	U	8-Dec-10
2335	Accotink Bay	4	3	38.70009	-77.14330	Vernondale Village	Underground Storage	U	8-Dec-10
2336	Accotink Bay	4	3	38.70015	-77.14332	Vernondale Village	Underground Storage	U	8-Dec-10
2338	Accotink Bay	4	3	38.69992	-77.14296	Vernondale Village	Underground Storage	U	8-Dec-10
2339	Accotink Bay	4	3	38.69990	-77.14297	Vernondale Village	Underground Storage	U	8-Dec-10
2340	Accotink Bay	4	3	38.69985	-77.14280	Vernondale Village	Underground Storage	U	8-Dec-10
2343	Accotink Bay	4	3	38.70029	-77.14335	Vernondale Village	Underground Storage	U	8-Dec-10
2344	Accotink Bay	4	3	38.70034	-77.14331	Vernondale Village	Underground Storage	1	8-Dec-10
2347	Accotink Bay	4	3	38.70011	-77.14302	Vernondale Village	Underground Storage	2	8-Dec-10
2416	Accotink Bay	4	3	38.69956	-77.14257	Vernondale Village	Underground Storage	U	10-Dec-10
2417	Accotink Bay	4	3	38.69952	-77.14254	Vernondale Village	Underground Storage	U	10-Dec-10
2419	Accotink Bay	4	3	38.69972	-77.14271	Vernondale Village	Underground Storage	U	10-Dec-10
2420	Accotink Bay	4	3	38.69977	-77.14270	Vernondale Village	Underground Storage	U	10-Dec-10
2421	Accotink Bay	4	3	38.69951	-77.14234	Vernondale Village	Underground Storage	U	10-Dec-10
2422	Accotink Bay	4	3	38.69947	-77.14234	Vernondale Village	Underground Storage	U	10-Dec-10
2423	Accotink Bay	4	3	38.69955	-77.14228	Vernondale Village	Underground Storage	2	10-Dec-10
2492	Dogue Creek	2	33	38.74226	-77.15394	ADF-E	Detention Pond	1	13-Apr-11
2502	Dogue Creek	2	33	38.74206	-77.15204		Underground Storage	U	13-Apr-11
2503	Dogue Creek	2	33	38.74209	-77.15205		Underground Storage	U	13-Apr-11
2504	Dogue Creek	2	33	38.74213	-77.15205		Underground Storage	U	13-Apr-11
2505	Dogue Creek	2	33	38.74216	-77.15206		Underground Storage	U	13-Apr-11
2506	Dogue Creek	2	33	38.74220	-77.15207		Underground Storage	U	13-Apr-11
2735	Accotink Creek	1	2	38.70116	-77.15564	Pohick Rd and Sharon Ln	Detention Pond	1	22-Dec-10
2831	Gunston Cove	5	11	38.68585	-77.13977	Gunston Road and 21st Street	Detention Pond	2	28-Dec-10
2926	Gunston Cove	5	11	38.68664	-77.14364	Clapp and Warren	Detention Pond	4	30-Dec-10
3028	Accotink Creek	1	1	38.70677	-77.14609		Rain Garden	1	7-Jan-11
3036	Accotink Creek	1	1	38.70738	-77.14769		Rain Garden	1	5-Jan-11
3038	Accotink Creek	1	1	38.70752	-77.14779		Rain Garden	1	5-Jan-11
3039	Accotink Creek	1	1	38.70740	-77.14793		Biofilter	3	5-Jan-11
3044	Accotink Creek	1	1	38.70760	-77.14707		Rain Garden	1	5-Jan-11
3054	Accotink Creek	1	1	38.70752	-77.14649		Rain Garden	3	7-Jan-11
3058	Accotink Creek	1	1	38.70720	-77.14631		Rain Garden	1	7-Jan-11
3082	Accotink Creek	1	1	38.70717	-77.14706		Rain Garden	1	7-Jan-11
3087	Accotink Creek	1	1	38.70648	-77.14673		Rain Garden	3	7-Jan-11
3089	Accotink Creek	1	1	38.70611	-77.14635		Rain Garden	1	7-Jan-11
3091	Accotink Creek	1	1	38.70628	-77.14594		Rain Garden	1	7-Jan-11
3096	Accotink Creek	1	1	38.70766	-77.14875		Biofilter	3	7-Jan-11
3097	Accotink Creek	1	1	38.70768	-77.14866		Biofilter	3	7-Jan-11
3101	Accotink Creek	1	1	38.70784	-77.14848		Underground Storage	U	7-Jan-11
3102	Accotink Creek	1	1	38.70785	-77.14849		Underground Storage	U	7-Jan-11
3107	Accotink Creek	1	1	38.70787	-77.14849		Underground Storage	U	7-Jan-11
3108	Accotink Creek	1	1	38.70790	-77.14849		Underground Storage	U	7-Jan-11
3109	Accotink Creek	1	1	38.70791	-77.14850		Underground Storage	U	7-Jan-11
3110	Accotink Creek	1	1	38.70794	-77.14851		Underground Storage	U	7-Jan-11
3105	Accotink Creek	1	1	38.70789	-77.14843		Biofilter	3	7-Jan-11
3354	Accotink Creek	1	30	38.71369	-77.15650	Foster Road and Stewart Road	Detention Pond	2	19-Jan-11

Structure_Key	Watershed	Watershed_ Number	Subshed	Latitude	Longitude	Location_Description	Type	Condition	Date_Recorded
3525	Accotink Creek	1	30	38.71521	-77.14960	Between Abbott and Goethals	Detention Pond	1	24-Jan-11
3709	Accotink Creek	1	30	38.71700	-77.14210	Lewis Village	Biofilter	1	3-Feb-11
3751	Accotink Creek	1	30	38.72116	-77.15322	th Post Shopette by Gunston and Gor	Detention Pond	2	7-Feb-11
3749	Accotink Creek	1	30	38.72121	-77.15314		Biofilter	2	7-Feb-11
3766	Accotink Creek	1	30	38.72023	-77.15072		Underground Storage	2	7-Feb-11
3778	Accotink Creek	1	30	38.72212	-77.15192	PX	Detention Pond	1	9-Feb-11
3788	Accotink Creek	1	30	38.72278	-77.15147	PX	Detention Pond	1	9-Feb-11
3828	Accotink Creek	1	30	38.72075	-77.14871	Commissary	Detention Pond	2	10-Feb-11
3832	Accotink Creek	1	30	38.72085	-77.14910	Commissary	Detention Pond	3	10-Feb-11
3870	Accotink Creek	1	30	38.71982	-77.14789		Underground Storage	U	11-Feb-11
3871	Accotink Creek	1	30	38.71984	-77.14789		Underground Storage	U	11-Feb-11
3883	Accotink Creek	1	30	38.71866	-77.14498	Woodlawn Chapel	Detention Pond	2	11-Feb-11
3886	Accotink Creek	1	30	38.71878	-77.14499	Woodlawn Chapel	Detention Pond	2	11-Feb-11
4061	Dogue Creek	2	31	38.71918	-77.13874	Lewis Village	Detention Pond	4	17-Feb-11
4064	Dogue Creek	2	31	38.72048	-77.13991	Lewis Village	Detention Pond	3	17-Feb-11
4155	Accotink Creek	1	30	38.71805	-77.15749	INSCOM	Detention Pond	1	22-Feb-11
4225	Dogue Creek	2	31	38.71762	-77.13911	Lewis Village	Biofilter	U	23-Feb-11
4230	Dogue Creek	2	31	38.71728	-77.13961	Lewis Village	Biofilter	U	23-Feb-11
4244	Dogue Creek	2	31	38.71610	-77.14018	Lewis Village	Biofilter	U	23-Feb-11
4324	Dogue Creek	2	32	38.72257	-77.14630		Rain Garden	1	26-Feb-11
4582	Dogue Creek	2	34	38.72930	-77.12685	Woodlawn Village	Detention Pond	3	9-Mar-11
4635	Dogue Creek	2	34	38.73191	-77.12762	Woodlawn Village	Biofilter	1	9-Mar-11
4637	Dogue Creek	2	34	38.73180	-77.12749	Woodlawn Village	Biofilter	1	9-Mar-11
4678	Accotink Creek	1	43	38.71067	-77.17686	Airfield	Detention Pond	1	14-Mar-11
4935	Accotink Creek	1	42	38.71501	-77.18680	Airfield	Detention Pond	2	22-Mar-11
5055	Dogue Creek	2	33	38.73804	-77.15831	ADF-E	Detention Pond	2	14-Apr-11
5223	Dogue Creek	2	33	38.73504	-77.15565	ADF-E	Detention Pond	1	20-Apr-11
5304	Dogue Creek	2	33	38.74208	-77.15884	ADF-E	Detention Pond	1	26-Apr-11
5340	Dogue Creek	2	33	38.73703	-77.12868	Woodlawn Village	Detention Pond	2	27-Apr-11
5375	Dogue Creek	2	33	38.73628	-77.13025	Woodlawn Village	Detention Pond	1	29-Apr-11
5381	Dogue Creek	2	33	38.73458	-77.13192	Woodlawn Village	Detention Pond	1	29-Apr-11
5394	Accotink Creek	1	41	38.72350	-77.18275	7100 and Telegraph	Detention Pond	1	2-May-11
5443	Dogue Creek	2	33	38.73312	-77.13203	Woodlawn Village	Detention Pond	1	3-May-11
5454	Dogue Creek	2	33	38.73201	-77.13194	Woodlawn Village	Detention Pond	3	3-May-11
5465	Dogue Creek	2	33	38.73247	-77.13124	Woodlawn Village	Detention Pond	3	3-May-11
5520	Accotink Creek	1	39	38.71769	-77.16732	Mosby Reserve	Detention Pond	1	6-May-11
5584	Accotink Creek	1	38	38.72426	-77.16228	Golf Course	Detention Pond	1	10-May-11
5616	Dogue Creek	2	32	38.72253	-77.14348	Belvoir Elementary School	Detention Pond	2	12-May-11
5621	Dogue Creek	2	25	38.70489	-77.13944	Belvoir Road, east of new hospital	Detention Pond	1	12-May-11
5645	Dogue Creek	2	32	38.72676	-77.14467	Earth Terminal Complex	Detention Pond	4	12-May-11
5748	Accotink Creek	1	37	38.72737	-77.17276	Golf Course	Detention Pond	1	20-May-11
5753	Accotink Creek	1	37	38.73055	-77.16936		Stream Junction	4	20-May-11
5755	Accotink Creek	1	37	38.73068	-77.16908	Golf Course	Detention Pond	1	20-May-11
5773	Accotink Creek	1	37	38.73512	-77.16606	Salvage and Surplus	Detention Pond	1	20-May-11
5811	Accotink Creek	1	2	38.70017	-77.15621		Underground Storage	1	26-May-11
5812	Accotink Creek	1	2	38.70010	-77.15619		Underground Storage	1	26-May-11
5813	Accotink Creek	1	2	38.70011	-77.15606		Underground Storage	1	26-May-11
5814	Accotink Creek	1	2	38.69976	-77.15557		Underground Storage	1	26-May-11

Structure_Key	Watershed	Watershed_ Number	Subshed	Latitude	Longitude	Location_Description	Type	Condition	Date_Recorded
5815	Accotink Creek	1	2	38.70001	-77.15569		Underground Storage	1	26-May-11
5816	Accotink Creek	1	2	38.70020	-77.15618		Underground Storage	1	26-May-11
5841	Accotink Creek	1	37	38.73765	-77.16736	lvage and Surplus, next to Telegraph	Detention Pond	2	27-May-11
5867	Dogue Creek	2	34	38.73145	-77.12871	Woodlawn Village	Biofilter	1	31-May-11
5868	Dogue Creek	2	34	38.73150	-77.12870	Woodlawn Village	Biofilter	1	31-May-11
5883	Dogue Creek	2	34	38.73188	-77.12887	Woodlawn Village	Biofilter	1	1-Jun-11
5886	Dogue Creek	2	34	38.73191	-77.12852	Woodlawn Village	Biofilter	1	1-Jun-11
5891	Accotink Bay	4	4	38.69305	-77.14672	Theote and 16th	Detention Pond	1	1-Jun-11
5913	Dogue Creek	2	22	38.69404	-77.13521		Underground Storage	1	3-Jun-11
5930	Dogue Creek	2	33	38.73935	-77.14818	Mulligan Road	Detention Pond	3	6-Jun-11
5979	Dogue Creek	2	33	38.73422	-77.14485	Mulligan Road	Detention Pond	1	9-Jun-11
5998	Dogue Creek	2	33	38.73153	-77.14263	Mulligan Road	Detention Pond	1	9-Jun-11
6006	Dogue Creek	2	33	38.72842	-77.14063	Mulligan Road	Detention Pond	1	9-Jun-11
6024	Dogue Creek	2	33	38.72386	-77.13615	Mulligan Road	Detention Pond	1	10-Jun-11
6048	Dogue Creek	2	33	38.72877	-77.13153	Woodlawn Village	Detention Pond	1	20-Jun-11
6079	Accotink Creek	1	1	38.70819	-77.15045		Underground Storage	1	1-Jul-11
6080	Accotink Creek	1	1	38.70834	-77.15014		Underground Storage	1	1-Jul-11
6098	Accotink Bay	4	3	38.70056	-77.14748	Gunston Road and Jackson Loop Sout	Detention Pond	1	21-Jul-11
6101	Dogue Creek	2	25	38.70564	-77.14133	Hospital	Detention Pond	1	1-Aug-11
6102	Dogue Creek	2	25	38.70505	-77.14083	Hospital	Detention Pond	1	1-Aug-11
6122	Dogue Creek	2	25	38.70690	-77.14191	Hospital	Detention Pond	1	1-Aug-11
6145	Accotink Creek	1	53	38.74920	-77.19689	Belvoir North Area	Detention Pond	3	2-Aug-11
6151	Dogue Creek	2	25	38.70628	-77.14205	Hospital	Underground Storage	1	15-Aug-11
6154	Dogue Creek	2	25	38.70658	-77.14202	Hospital	Underground Storage	2	15-Aug-11
6160	Dogue Creek	2	25	38.70681	-77.14200	Hospital	Underground Storage	2	15-Aug-11
6165	Dogue Creek	2	25	38.70570	-77.14155	Hospital	Underground Storage	2	15-Aug-11
6171	Dogue Creek	2	25	38.70558	-77.14132	Hospital	Underground Storage	2	15-Aug-11
6208	Accotink Creek	1	53	38.74941	-77.19560	Belvoir North Area	Detention Pond	2	17-Aug-11
6212	Accotink Creek	1	53	38.75019	-77.19556	Belvoir North Area	Detention Pond	1	17-Aug-11
6213	Accotink Creek	1	53	38.74996	-77.19588	Belvoir North Area	Detention Pond	1	17-Aug-11
6214	Accotink Creek	1	53	38.75050	-77.19532	Belvoir North Area	Detention Pond	1	17-Aug-11
6215	Accotink Creek	1	53	38.75085	-77.19520	Belvoir North Area	Detention Pond	1	17-Aug-11
6216	Accotink Creek	1	53	38.75111	-77.19503	Belvoir North Area	Detention Pond	1	17-Aug-11
6240	Accotink Bay	4	3	38.70355	-77.14306	Hospital	Detention Pond	3	19-Aug-11
6265	Accotink Bay	4	3	38.70381	-77.14371	Hospital	Sand Filter (downstream)	3	24-Aug-11
6266	Accotink Bay	4	3	38.70410	-77.14381	Hospital	Sand Filter (upstream)	3	24-Aug-11
6287	Accotink Bay	4	3	38.70191	-77.14401	Warriors in Transition	Underground Storage	U	25-Aug-11
6306	Accotink Bay	4	3	38.70163	-77.14313	Warriors in Transition	Rain Garden	1	25-Aug-11
6380	Accotink Bay	4	3	38.70273	-77.14300	Warriors in Transition	Rain Garden	1	29-Aug-11
6386	Accotink Bay	4	3	38.70300	-77.14225	Warriors in Transition	Rain Garden	1	29-Aug-11
6437	Accotink Creek	1	53	38.75259	-77.19794	Belvoir North Area	Detention Pond	1	12-Sep-11
6448	Dogue Creek	2	25	38.70487	-77.14027	Hospital	Biofilter	1	13-Sep-11
6450	Dogue Creek	2	25	38.70480	-77.14023	Hospital	Biofilter	1	13-Sep-11
6457	Accotink Creek	1	53	38.75169	-77.19477	Belvoir North Area	Detention Pond	2	13-Sep-11
6462	Accotink Creek	1	53	38.75237	-77.19552	Belvoir North Area	Rain Garden	2	13-Sep-11
6466	Accotink Creek	1	53	38.75283	-77.19515	Belvoir North Area	Detention Pond	1	13-Sep-11
6479	Accotink Creek	1	53	38.75534	-77.19351	Belvoir North Area	Detention Pond	2	15-Sep-11
6681	Accotink Creek	1	29	38.71192	-77.14788	OCAR	Detention Pond	1	21-Oct-11

Structure_Key	Watershed	Watershed_ Number	Subshed	Latitude	Longitude	Location_Description	Type	Condition	Date_Recorded
6683	Accotink Creek	1	29	38.71218	-77.14817	OCAR	Biofilter	1	21-Oct-11
6704	Accotink Creek	1	30	38.71317	-77.14848	OCAR	Rain Garden	1	21-Oct-11
6708	Accotink Creek	1	30	38.71313	-77.14735	OCAR	Rain Garden	1	21-Oct-11
6734	Accotink Creek	1	1	38.70349	-77.15605	Pohick Road	Underground Storage	1	2-Nov-11
6735	Accotink Creek	1	1	38.70369	-77.15609	Pohick Road	Underground Storage	1	2-Nov-11
6749	Accotink Creek	1	53	38.75699	-77.19412	Belvoir North Area	Detention Pond	1	9-Nov-11
6753	Accotink Creek	1	53	38.75667	-77.19539	Belvoir North Area	Rain Garden	1	9-Nov-11
6758	Accotink Creek	1	53	38.75639	-77.19620	Belvoir North Area	Rain Garden	1	9-Nov-11
6771	Accotink Creek	1	52	38.70564	-77.15672	Pohick Road	Underground Storage	U	10-Nov-11
6772	Accotink Creek	1	52	38.70579	-77.15697	Pohick Road	Underground Storage	1	10-Nov-11
6783	Accotink Creek	1	29	38.70747	-77.15807	Pohick Road	Underground Storage	4	10-Nov-11
6784	Accotink Creek	1	29	38.70725	-77.15786	Pohick Road	Underground Storage	1	10-Nov-11
6785	Accotink Creek	1	29	38.70738	-77.15779	Pohick Road	Underground Storage	1	10-Nov-11
6793	Accotink Creek	1	53	38.74888	-77.19167	Belvoir North Area	Detention Pond	2	15-Nov-11
6818	Accotink Creek	1	53	38.75438	-77.18795	Belvoir North Area	Detention Pond	4	18-Nov-11
6846	Accotink Creek	1	53	38.75746	-77.18726	Belvoir North Area	Detention Pond	1	23-Nov-11
6851	Accotink Creek	1	53	38.74911	-77.20348	Belvoir North Area	Detention Pond	1	23-Nov-11
6900	Accotink Creek	1	53	38.75391	-77.20310	Belvoir North Area	Detention Pond	1	28-Nov-11
6940	Accotink Creek	1	53	38.75151	-77.20396	Belvoir North Area	Filter	1	2-Dec-11
6942	Accotink Creek	1	53	38.75112	-77.20378	Belvoir North Area	Filter	1	2-Dec-11
6944	Accotink Creek	1	53	38.75107	-77.20394	Belvoir North Area	Filter	1	2-Dec-11
6946	Accotink Creek	1	53	38.75155	-77.20369	Belvoir North Area	Filter	1	2-Dec-11
6954	Accotink Creek	1	53	38.75518	-77.20147	Belvoir North Area	Detention Pond	1	2-Dec-11
7070	Dogue Creek	2	25	38.70907	-77.14293	Hospital	Filter	1	23-Dec-11
7072	Dogue Creek	2	25	38.70950	-77.14331	Hospital	Filter	1	23-Dec-11
7075	Dogue Creek	2	25	38.70996	-77.14353	Hospital	Filter	1	23-Dec-11
7077	Dogue Creek	2	25	38.70999	-77.14341	Hospital	Filter	1	23-Dec-11
7079	Dogue Creek	2	25	38.71026	-77.14424	Hospital	Filter	1	23-Dec-11
7081	Dogue Creek	2	25	38.71035	-77.14428	Hospital	Filter	1	23-Dec-11
7082	Dogue Creek	2	25	38.70909	-77.14334	Hospital	Detention Pond	1	23-Dec-11
7104	Accotink Creek	1	1	38.70800	-77.14601	Hospital	Filter	1	23-Dec-11
7106	Accotink Creek	1	1	38.70803	-77.14592	Hospital	Filter	1	23-Dec-11
7111	Accotink Creek	1	1	38.70823	-77.14549	Hospital	Filter	1	23-Dec-11
7112	Accotink Creek	1	1	38.70823	-77.14543	Hospital	Filter	1	23-Dec-11
7127	Dogue Creek	2	28	38.71040	-77.14092	CDC 338	Underground Storage	1	29-Dec-11
7158	Accotink Creek	1	53	38.75732	-77.19401	Belvoir North Area	Filter	1	29-Dec-11
7169	Accotink Creek	1	1	38.70654	-77.14895	USALSA	Underground Storage	1	6-Jan-12
7196	Accotink Creek	1	53	38.75789	-77.19148	Belvoir North Area	Rain Garden	2	6-Jan-12
7200	Accotink Creek	1	53	38.75727	-77.19269	Belvoir North Area	Detention Pond	1	6-Jan-12
7210	Accotink Creek	1	53	38.75824	-77.19082	Belvoir North Area	Detention Pond	1	6-Jan-12
7223	Accotink Creek	1	53	38.74793	-77.19226	Belvoir North Area	Detention Pond	2	12-Jan-12



LEGEND

BMP Type - General

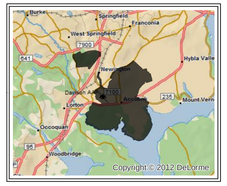
- Basin
- Filtration
- Infiltration
- Manufactured
- New Campus East Area
- Leased Areas
- Installation Boundary

WILLIAMSBURG ENVIRONMENTAL GROUP, INC.

INVENTORY OF EXISTING BMP'S

FORT BELVOIR

MAIN POST AND NORTH AREA



0 0.25 0.5 Miles

HORIZONTAL COORDINATE SYSTEM:
NAD 1983 State Plane Virginia North

Date: 9/25/2013

APPENDIX B

Operational Inspection Log Template

Fort Belvoir
VSMP Small MS4 General Permit No. VAR040093
General Plan for Stormwater Management Facility Inspection and Maintenance
Operational Inspection Log

BMP Identifier	Grid Location	BMP Type	Date	Inspector	Observations	Routine Maintenance Required?	Maintenance Inspection Required?

APPENDIX C

Maintenance Inspection Checklist Templates

	Fort Belvoir **General Plan for Stormwater Management Facility Inspection and Maintenance** **Maintenance Inspection Checklist** **Detention and Extended Detention Basins**

BMP Identifier	**Grid Location**	**BMP Type**
		☐ Detention ☐ Extended Detention
Date	**Time**	**Inspector**

Item	**Yes/No**	**Repair**	**Investigate**	**Comments**
EMBANKMENT				
A. Crest				
1. Visual settlement				
2. Misalignment				
3. Cracking				
B. Upstream slope				
1. Erosion				
2. Adequate groundcover				
3. Trees, shrubs or other				
4. Cracks, settlements or bulges				
5. Rodent holes				
C. Downstream slope				
1. Erosion				
2. Adequate groundcover				
3. Trees, shrubs or other				
4. Cracks, settlements or bulges				
5. Rodent holes				
D. Abutments				
1. Erosion				
2. Seepage				
3. Cracks				
E. Drainage, seepage control				
1. Seepage at toe				
2. Seepage clear (describe)				
PRINCIPAL SPILLWAY (Type ☐Box ☐Pipe ☐Overflow Weir ☐Other _____)				
A. Riser (Type ☐Concrete ☐Metal ☐HDPE ☐PVC ☐Other _____)				
1. Trash and debris present				
2. Sediment present				
3. Low-level drain functional				
B. Barrel (Type ☐Concrete ☐Metal ☐HDPE ☐PVC ☐Other _____)				
1. Seepage into conduit				
2. Trash and debris present				
3. Sediment present				
4. Displaced or offset joints				

Fort Belvoir
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Inspection Checklist
Detention and Extended Detention Basins

BMP Identifier	**Grid Location**	**BMP Type**
		☐ Detention ☐ Extended Detention
Date	**Time**	**Inspector**

Item	**Yes/No**	**Repair**	**Investigate**	**Comments**
EMERGENCY SPILLWAY (Type ☐Vegetated ☐Riprap ☐Other _____)				
1. Eroding or backcutting				
2. Obstructed				
3. Leaking				
4. Operational				
OUTLET PROTECTION (Type ☐Riprap Apron ☐Riprap Stilling Basin ☐Storm Sewer ☐Other _____)				
1. Obstructed				
2. Adequate riprap				
3. Undercutting at outlet				
4. Outlet channel scour present				
BASIN				
A. Low flow channel (Type ☐Vegetated ☐Riprap ☐Concrete ☐Other _____)				
1. Erosion				
2. Adequate vegetation				
3. Obstructed				
B. Basin bottom & side slopes				
1. Erosion				
2. Adequate stabilization				
3. Sediment accumulation				
4. Floating debris				
5. High water marks				
6. Shoreline protection				
7. Rodent holes				
C. Inflow channels/pipes				
1. Erosion/scour				
2. Sediment				
3. Trash and debris present				
4. Adequate stabilization				
5. Undercutting				
D. Landscaping				
1. Uplands vegetation				

Fort Belvoir
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Inspection Checklist
Detention and Extended Detention Basins

BMP Identifier	**Grid Location**	**BMP Type**
		☐ Detention ☐ Extended Detention
Date	**Time**	**Inspector**

Item	**Yes/No**	**Repair**	**Investigate**	**Comments**
PRETREATMENT (Type ☐Sediment Forebay ☐Vegetated filter strip ☐Other_____)				
A. Sediment forebay				
1. Sediment accumulation				
2. Trash and debris present				
3. Stable overflow into basin				
B. Vegetated Filter Strip				
1. Erosion/scour				
2. Sediment accumulation				
3. Adequate stabilization				
CONTRIBUTING WATERSHED				
1. Construction underway				
2. Changes in development				
3. Erosion				
4. Adequate stabilization				
OTHER				

OVERALL CONDITION ASSESSMENT
☐ Condition 1. Fully Functional ☐ Condition 2. Minor Structural or Functional defects ☐ Condition 3. Acceptable/Anticipated Structural & Functional Deterioration ☐ Condition 4. Major Structural or Functional defects ☐ Condition 5. Structurally/Functionally Deficient
COMMENTS ON OVERALL CONDITION ASSESSMENT
TECHNICAL INSPECTION NECESSARY? ☐ Yes ☐ No
PREVENTATIVE/NON-ROUTINE MAINTENANCE NECESSARY? ☐ Yes ☐ No
MAINTENANCE REQUIRED

Fort Belvoir
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Inspection Checklist
Enhanced Extended Detention, Retention, and Constructed Wetlands Basins

BMP Identifier	Grid Location	BMP Type
		☐ Enhanced Extended Detention ☐ Retention ☐ Constructed Wetlands
Date	**Time**	**Inspector**

Item	Yes/No	Repair	Investigate	Comments
EMBANKMENT				
A. Crest				
1. Visual settlement				
2. Misalignment				
3. Cracking				
B. Upstream slope				
1. Erosion				
2. Adequate groundcover				
3. Trees, shrubs or other				
4. Cracks, settlements or bulges				
5. Rodent holes				
C. Downstream slope				
1. Erosion				
2. Adequate groundcover				
3. Trees, shrubs or other				
4. Cracks, settlements or bulges				
5. Rodent holes				
D. Abutments				
1. Erosion				
2. Seepage				
3. Cracks				
E. Drainage, seepage control				
1. Internal drains flowing				
2. Seepage at toe				
3. Seepage clear (describe)				
PRINCIPAL SPILLWAY (Type ☐Box ☐Pipe ☐Overflow Weir ☐Other _____)				
A. Riser (Type ☐Concrete ☐Metal ☐HDPE ☐PVC ☐Other _____)				
1. Trash and debris present				
2. Sediment present				
3. Low-level drain functional				
B. Barrel (Type ☐Concrete ☐Metal ☐HDPE ☐PVC ☐Other _____)				
1. Seepage into conduit				
2. Trash and debris present				
3. Sediment present				
4. Displaced joints				

Fort Belvoir
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Inspection Checklist
Enhanced Extended Detention, Retention, and Constructed Wetlands Basins

BMP Identifier	Grid Location	BMP Type
		☐ Enhanced Extended Detention ☐ Retention ☐ Constructed Wetlands
Date	**Time**	**Inspector**

Item	Yes/No	Repair	Investigate	Comments
EMERGENCY SPILLWAY (Type ☐Vegetated ☐Riprap ☐Other _____)				
1. Eroding or backcutting				
2. Obstructed				
3. Leaking				
4. Operational				
OUTLET PROTECTION (Type ☐Riprap Apron ☐Riprap Stilling Basin ☐Storm Sewer ☐Other _____)				
1. Obstructed				
2. Adequate riprap				
3. Undercutting at outlet				
4. Outlet channel scour present				
BASIN				
A. Basin bottom & side slopes				
1. Erosion				
2. Adequate stabilization				
3. Sediment accumulation				
4. Floating debris				
5. High water marks				
6. Shoreline protection				
7. Rodent holes				
C. Inflow channels/pipes				
1. Erosion/scour				
2. Sediment				
3. Trash and debris present				
4. Adequate stabilization				
5. Undercutting				
D. Landscaping				
1. Shallow marsh vegetation				
2. Aquatic vegetation				
3. Uplands vegetation				

Fort Belvoir
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Inspection Checklist
Enhanced Extended Detention, Retention, and Constructed Wetlands Basins

BMP Identifier	Grid Location	BMP Type
		☐ Enhanced Extended Detention ☐ Retention ☐ Constructed Wetlands
Date	**Time**	**Inspector**

Item	Yes/No	Repair	Investigate	Comments
PRETREATMENT (Type ☐Sediment Forebay ☐Vegetated filter strip ☐Other_____)				
A. Sediment forebay				
1. Sediment accumulation				
2. Trash and debris present				
3. Stable overflow into basin				
B. Vegetated Filter Strip				
1. Erosion/scour				
2. Sediment accumulation				
3. Adequate stabilization				
CONTRIBUTING WATERSHED				
1. Construction underway				
2. Changes in development				
3. Erosion				
4. Adequate stabilization				
OTHER				

OVERALL CONDITION ASSESSMENT
☐ Condition 1. Fully Functional ☐ Condition 2. Minor Structural or Functional defects ☐ Condition 3. Acceptable/Anticipated Structural & Functional Deterioration ☐ Condition 4. Major Structural or Functional defects ☐ Condition 5. Structurally/Functionally Deficient
COMMENTS ON OVERALL CONDITION ASSESSMENT
TECHNICAL INSPECTION NECESSARY? ☐ Yes ☐ No
PREVENTATIVE/NON-ROUTINE MAINTENANCE NECESSARY? ☐ Yes ☐ No
MAINTENANCE REQUIRED

Fort Belvoir
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Inspection Checklist
Infiltration and Bioretention Checklist

BMP Identifier	Grid Location	BMP Type
		☐Infiltration Type: ☐Basin ☐Trench ☐Other_____ ☐Bioretention
Date	**Time**	**Inspector**

Item	Yes/No	Repair	Investigate	Comments
EMBANKMENT (Note some facilities may be excavated or contained without an earthen embankment)				
A. Crest				
1. Visual settlement				
2. Misalignment				
3. Cracks				
B. Upstream slope				
1. Erosion				
2. Adequate groundcover				
3. Trees or shrubs				
4. Cracks, settlements or bulges				
5. Rodent holes				
C. Downstream slope				
1. Erosion				
2. Adequate groundcover				
3. Trees or shrubs				
4. Cracks, settlements or bulges				
5. Rodent holes				
D. Abutments				
1. Erosion				
2. Seepage				
3. Cracks				
PRINCIPAL SPILLWAY (Type ☐Box ☐Pipe ☐Overflow Weir ☐Other _____)				
A. Riser (Type ☐Concrete ☐Metal ☐HDPE ☐PVC ☐Other _____)				
1. Trash and debris				
2. Sediment				
3. Leaks				
B. Barrel (Type ☐Concrete ☐Metal ☐HDPE ☐PVC ☐Other _____)				
1. Seepage into conduit				
2. Trash and debris				
3. Sediment present				
4. Displaced joints				
EMERGENCY SPILLWAY (Type ☐Vegetated ☐Riprap ☐Other _____)				
1. Erosion				
2. Obstructed				
3. Leaking				
4. Operational				

Fort Belvoir
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Inspection Checklist
Infiltration and Bioretention Checklist

BMP Identifier	**Grid Location**	**BMP Type**
		☐Infiltration Type: ☐Basin ☐Trench ☐Other_____ ☐Bioretention
Date	**Time**	**Inspector**

Item	**Yes/No**	**Repair**	**Investigate**	**Comments**
OUTLET PROTECTION (Type ☐Riprap Apron ☐Riprap Stilling Basin ☐Storm Sewer ☐Other _____)				
1. Obstructed				
2. Adequate riprap				
3. Undercutting at outlet				
4. Channel scour				
5. Trash and debris				
FACILITY				
A. Basin/Storage Media (Type ☐Basin ☐Aggregate ☐Engineered Media ☐Other _____)				
1. Erosion				
2. Sediment				
3. Trash and debris				
4. Standing water				
5. Saturated media				
B. Observation wells/Clean-outs (Type ☐Observation Well ☐Clean-out ☐Other _____)				
1. Standing water				
2. Sediment				
C. Basin side slopes				
1. Erosion				
2. Adequate stabilization				
4. Trash and debris				
5. High water marks				
6. Rodent holes				
D. Inflow channels/pipes/inlets				
1. Erosion/scour				
2. Sediment				
3. Trash and debris				
4. Adequate stabilization				
5. Undercutting				
E. Landscaping				
1. Trees and shrubs				
2. Groundcover				
3. Mulch				

Fort Belvoir
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Inspection Checklist
Infiltration and Bioretention Checklist

BMP Identifier	**Grid Location**	**BMP Type**
		☐Infiltration Type: ☐Basin ☐Trench ☐Other_____ ☐Bioretention
Date	**Time**	**Inspector**

Item	**Yes/No**	**Repair**	**Investigate**	**Comments**
PRETREATMENT (Type ☐Sediment Forebay ☐Vegetated filter strip ☐Other_____)				
A. Sediment forebay				
1. Sediment				
2. Trash and debris				
3. Stable overflow into basin				
B. Vegetated Filter Strip				
1. Erosion/scour				
2. Sediment				
3. Adequate stabilization				
CONTRIBUTING WATERSHED				
1. Construction				
2. Development				
3. Erosion				
4. Stabilization				
5. Trash and debris				
OTHER				

OVERALL CONDITION ASSESSMENT
☐ Condition 1. Fully Functional ☐ Condition 2. Minor Structural or Functional defects ☐ Condition 3. Acceptable/Anticipated Structural & Functional Deterioration ☐ Condition 4. Major Structural or Functional defects ☐ Condition 5. Structurally/Functionally Deficient
COMMENTS ON OVERALL CONDITION ASSESSMENT
TECHNICAL INSPECTION NECESSARY? ☐ Yes ☐ No
PREVENTATIVE/NON-ROUTINE MAINTENANCE NECESSARY? ☐ Yes ☐ No
MAINTENANCE REQUIRED

Fort Belvoir
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Inspection Checklist
Filtration, Bioretention Filter, and Tree Box Checklist

BMP Identifier	Grid Location	BMP Type
		☐ Bioretention Filter ☐ Tree Box ☐ Filtration (Type: _____)
Date	**Time**	**Inspector**

Item	Yes/No	Repair	Investigate	Comments
EMBANKMENT (Note some facilities may be excavated or contained without an earthen embankment)				
A. Crest				
1. Visual settlement				
2. Misalignment				
3. Cracks				
B. Upstream slope				
1. Erosion				
2. Adequate groundcover				
3. Trees or shrubs				
4. Cracks, settlements or bulges				
5. Rodent holes				
C. Downstream slope				
1. Erosion				
2. Adequate groundcover				
3. Trees or shrubs				
4. Cracks, settlements or bulges				
5. Rodent holes				
D. Abutments				
1. Erosion				
2. Seepage				
3. Cracks				
PRINCIPAL SPILLWAY (Type ☐Box ☐Pipe ☐Overflow Weir ☐Other _____)				
A. Riser (Type ☐Concrete ☐Metal ☐HDPE ☐PVC ☐Other _____)				
1. Trash and debris				
2. Sediment				
3. Leaks				
B. Barrel (Type ☐Concrete ☐Metal ☐HDPE ☐PVC ☐Other _____)				
1. Seepage into conduit				
2. Trash and debris				
3. Sediment present				
4. Displaced joints				
EMERGENCY SPILLWAY (Type ☐Vegetated ☐Riprap ☐Other _____)				
1. Erosion				
2. Obstructed				
3. Leaking				
4. Operational				

	Fort Belvoir **General Plan for Stormwater Management Facility Inspection and Maintenance** **Maintenance Inspection Checklist** **Filtration, Bioretention Filter, and Tree Box Checklist**

BMP Identifier	**Grid Location**	**BMP Type**
		☐ Bioretention Filter ☐ Tree Box ☐ Filtration (Type: _____)
Date	**Time**	**Inspector**

Item	**Yes/No**	**Repair**	**Investigate**	**Comments**
OUTLET PROTECTION (Type ☐Riprap Apron ☐Riprap Stilling Basin ☐Storm Sewer ☐Other _____)				
1. Obstructed				
2. Adequate riprap				
3. Undercutting at outlet				
4. Channel scour				
5. Trash and debris				
FACILITY				
A. Filter Media (Type ☐Sand ☐Engineered Soil ☐Other _____)				
1. Erosion				
2. Sediment				
3. Trash and debris				
4. Standing water				
5. Saturated media				
B. Underdrain/Filtrate Collection System (Access ☐Observation Well ☐Manhole ☐Port ☐Other _____)				
1. Standing water				
2. Sediment				
C. Basin side slopes				
1. Erosion				
2. Adequate stabilization				
4. Trash and debris				
5. High water marks				
6. Rodent holes				
D. Inflow channels/pipes/inlets				
1. Erosion/scour				
2. Sediment				
3. Trash and debris				
4. Adequate stabilization				
5. Undercutting				
E. Landscaping				
1. Trees and shrubs				
2. Groundcover				
3. Mulch				

Fort Belvoir
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Inspection Checklist
Filtration, Bioretention Filter, and Tree Box Checklist

BMP Identifier	Grid Location	BMP Type
		☐ Bioretention Filter ☐ Tree Box ☐ Filtration (Type: _____)
Date	**Time**	**Inspector**

Item	Yes/No	Repair	Investigate	Comments
PRETREATMENT (Type ☐Sediment Forebay ☐Vegetated filter strip ☐Other_____)				
A. Sediment forebay				
1. Sediment				
2. Trash and debris				
3. Stable overflow into basin				
B. Vegetated Filter Strip				
1. Erosion/scour				
2. Sediment				
3. Adequate stabilization				
CONTRIBUTING WATERSHED				
1. Construction				
2. Development				
3. Erosion				
4. Stabilization				
5. Trash and debris				
OTHER				

OVERALL CONDITION ASSESSMENT
☐ Condition 1. Fully Functional ☐ Condition 2. Minor Structural or Functional defects ☐ Condition 3. Acceptable/Anticipated Structural & Functional Deterioration ☐ Condition 4. Major Structural or Functional defects ☐ Condition 5. Structurally/Functionally Deficient
COMMENTS ON OVERALL CONDITION ASSESSMENT
TECHNICAL INSPECTION NECESSARY? ☐ Yes ☐ No
PREVENTATIVE/NON-ROUTINE MAINTENANCE NECESSARY? ☐ Yes ☐ No
MAINTENANCE REQUIRED

Fort Belvoir
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Inspection Checklist
Dry and Wet Swales Checklist

BMP Identifier	**Grid Location**	**BMP Type**
		☐Dry ☐Wet ☐Other _____
Date	**Time**	**Inspector**

Item	**Yes/No**	**Repair**	**Investigate**	**Comments**
OUTLET PROTECTION (Type ☐Riprap Apron ☐Level Spreader ☐Storm Sewer ☐Other _____)				
1. Obstructed				
2. Stabilization				
3. Erosion/scour				
4. Trash and debris				
FACILITY				
A. Swale bottom				
1. Erosion				
2. Sediment				
3. Stabilization				
4. Trash and debris				
5. Standing water				
6. Rodent holes				
B. Swale side slopes				
1. Erosion				
2. Stabilization				
3. Trash and debris				
4. High water marks				
5. Rodent holes				
C. Check Dams (Type ☐Riprap/Aggregate ☐Timber ☐Concrete ☐Other _____)				
1. Damaged/displaced				
2. Trash and debris				
3. Erosion				
4. Sediment				
5. High water marks				
6. Weep holes/orifices				
7. Sediment				
D. Underdrain/Clean-out (Dry swale feature)				
1. Standing water				
2. Sediment				
3. Trash and debris				
E. Inflow channels/pipes/inlets				
1. Erosion/scour				
2. Sediment				
3. Trash and debris				
4. Stabilization				
5. Undercutting				
F. Landscaping				
1. Groundcover				
2. Trees and shrubs				

Fort Belvoir
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Inspection Checklist
Dry and Wet Swales Checklist

BMP Identifier	**Grid Location**	**BMP Type**
		☐Dry ☐Wet ☐Other_____
Date	**Time**	**Inspector**

Item	**Yes/No**	**Repair**	**Investigate**	**Comments**
PRETREATMENT (Type ☐Sediment Forebay ☐Vegetated filter strip ☐Other_____)				
A. Sediment forebay				
1. Sediment				
2. Trash and debris				
3. Stable overflow				
B. Vegetated Filter Strip				
1. Erosion/scour				
2. Sediment				
3. Adequate				
CONTRIBUTING WATERSHED				
1. Construction				
2. Development				
3. Erosion				
4. Stabilization				
5. Trash and debris				
OTHER				

OVERALL CONDITION ASSESSMENT
☐ Condition 1. Fully Functional ☐ Condition 2. Minor Structural or Functional defects ☐ Condition 3. Acceptable/Anticipated Structural & Functional Deterioration ☐ Condition 4. Major Structural or Functional defects ☐ Condition 5. Structurally/Functionally Deficient
COMMENTS ON OVERALL CONDITION ASSESSMENT
TECHNICAL INSPECTION NECESSARY? ☐ Yes ☐ No
PREVENTATIVE/NON-ROUTINE MAINTENANCE NECESSARY? ☐ Yes ☐ No
MAINTENANCE REQUIRED

Fort Belvoir
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Inspection Checklist
Underground Storage, Hydrodynamic, and Other Manufactured Devices

BMP Identifier	Grid Location	BMP Type
		☐ Underground Storage ☐ Hydrodynamic ☐ Other Device _____
Date	**Time**	**Inspector**

Item	Yes/No	Repair	Investigate	Comments
COVER (Type ☐Concrete ☐Asphalt ☐Vegetated ☐Aggregate ☐Other _____)				
1. Visual settlement				
2. Erosion/sinkholes				
3. Cracking/spalling				
4. Standing water				
ACCESS (Type ☐Manhole ☐Port ☐Lid ☐Clean-out ☐Other _____)				
1. Corrosion, cracking, or spalling?				
2. Secured with lock or fasteners?				
3. Free of trash and debris?				
OBSERVATION WELLS/CLEAN-OUTS				
1. Covered and secure?				
2. Free of trash and debris?				
3. Depth of water?				
4. Depth of sediment?				
PRETREATMENT OR FLOW DIVERSION CELL/CHAMBER				
1. Corrosion, cracking, spalling, or other damage?				
2. Free of trash and debris?				
3. Depth of water?				
4. Depth of sediment?				
PRIMARY TREATMENT CELL(S)/CHAMBER(S)				
1. Corrosion, cracking, spalling, or other damage?				
2. Trash and debris present?				
3. Depth of water?				
4. Depth of sediment?				
OUTLET (Type ☐Pipe ☐Overflow Weir ☐Other _____)				
1. Trash and debris present?				
2. Sediment present?				
3. Signs of leakage?				
4. Flow present?				

Fort Belvoir
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Inspection Checklist
Underground Storage, Hydrodynamic, and Other Manufactured Devices

BMP Identifier	Grid Location	BMP Type
		☐ Underground Storage ☐ Hydrodynamic ☐ Other Device _____
Date	**Time**	**Inspector**

Item	Yes/No	Repair	Investigate	Comments
BYPASS CELL/CHAMBER				
1. Corrosion, cracking, spalling, or other damage?				
2. Free of trash and debris?				
3. Depth of water?				
4. Depth of sediment?				
OUTLET PROTECTION (Type ☐Riprap Apron ☐Riprap Stilling Basin ☐Storm Sewer ☐Other _____)				
1. Obstructed				
2. Adequate riprap				
3. Undercutting at outlet				
4. Outlet channel scour present				
CONTRIBUTING WATERSHED				
1. Construction underway				
2. Changes in development				
3. Erosion				
4. Adequate stabilization				
5. Trash, debris, spills, leaks, etc.				
OTHER				

OVERALL CONDITION ASSESSMENT
☐ Condition 1. Fully Functional ☐ Condition 2. Minor Structural or Functional defects ☐ Condition 3. Acceptable/Anticipated Structural & Functional Deterioration ☐ Condition 4. Major Structural or Functional defects ☐ Condition 5. Structurally/Functionally Deficient
COMMENTS ON OVERALL CONDITION ASSESSMENT
TECHNICAL INSPECTION NECESSARY? ☐ Yes ☐ No
PREVENTATIVE/NON-ROUTINE MAINTENANCE NECESSARY? ☐ Yes ☐ No
MAINTENANCE REQUIRED

Fort Belvoir
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Inspection Checklist
Vegetated/Green Roof Checklist

BMP Identifier	**Grid Location**	**BMP Type**
		☐Extensive ☐Intensive ☐Other _____
Date	**Time**	**Inspector**

Item	**Yes/No**	**Repair**	**Investigate**	**Comments**
OUTLET PROTECTION (Type ☐Riprap Apron ☐Splash Block ☐Storm Sewer ☐Other _____)				
1. Obstructed				
2. Stabilization				
3. Erosion/scour				
4. Trash and debris				
FACILITY				
A. Roofing Material (Type ☐Membrane ☐Asphalt ☐Metal ☐Other _____)				
1. Damaged				
2. Leaking				
3. Trash and debris				
4. High water marks				
5. Standing water				
B. Drainage (Type ☐Surface flow ☐Trench Drain ☐Underdrain ☐Other _____)				
1. Damaged				
3. Trash and debris				
4. Standing water				
C. Planting Media (Extensive: shallow media, aggregate, matting, etc.; Intensive: soil, engineered media, etc.)				
1. Erosion				
2. Stabilization				
3. Standing water				
4. Saturated media				
D. Landscaping (Extensive: sedums, groundcover, etc.; Intensive: groundcover, trees, shrubs, etc.)				
1. Groundcover				
2. Trees and shrubs				
3. Mulch				
OTHER				

OVERALL CONDITION ASSESSMENT
☐ Condition 1. Fully Functional ☐ Condition 2. Minor Structural or Functional defects ☐ Condition 3. Acceptable/Anticipated Structural & Functional Deterioration ☐ Condition 4. Major Structural or Functional defects ☐ Condition 5. Structurally/Functionally Deficient
COMMENTS ON OVERALL CONDITION ASSESSMENT
TECHNICAL INSPECTION NECESSARY? ☐ Yes ☐ No
PREVENTATIVE/NON-ROUTINE MAINTENANCE NECESSARY? ☐ Yes ☐ No
MAINTENANCE REQUIRED

Fort Belvoir
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Inspection Checklist
Rainwater Harvesting Checklist

BMP Identifier	Grid Location	BMP Type
		☐Cistern ☐Vault ☐Tank ☐Other_____
Date	**Time**	**Inspector**

Item	Yes/No	Repair	Investigate	Comments
HARVESTING SYSTEM				
A. Collection System (Type ☐Surface flow ☐Trench Drain ☐Gutter ☐Other_____)				
1. Damaged				
2. Leaking				
3. Trash and debris				
4. Standing water				
B. Pretreatment System (Type:_____)				
1. Obstructed				
2. Sediment				
3. Trash and debris				
4. Biological growth/contamination				
C. Storage System (☐Aboveground ☐Underground ☐Indoors ☐Other_____)				
1. Damaged				
2. Leaking				
3. Sediment				
4. Trash and debris				
5. Biological growth/contamination				
USE SYSTEM (☐Irrigation ☐Vehicle wash down ☐Make-up water ☐Laundry ☐Other_____)				
1. Damaged				
2. Leaking				
3. Functional				
OTHER				

OVERALL CONDITION ASSESSMENT
☐ Condition 1. Fully Functional ☐ Condition 2. Minor Structural or Functional defects ☐ Condition 3. Acceptable/Anticipated Structural & Functional Deterioration ☐ Condition 4. Major Structural or Functional defects ☐ Condition 5. Structurally/Functionally Deficient
COMMENTS ON OVERALL CONDITION ASSESSMENT
TECHNICAL INSPECTION NECESSARY? ☐ Yes ☐ No
PREVENTATIVE/NON-ROUTINE MAINTENANCE NECESSARY? ☐ Yes ☐ No
MAINTENANCE REQUIRED

Fort Belvoir
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Inspection Checklist
Permeable Pavement Checklist

BMP Identifier	**Grid Location**	**BMP Type**
		☐Cement ☐Asphalt ☐Pavers ☐Other _____
Date	**Time**	**Inspector**

Item	**Yes/No**	**Repair**	**Investigate**	**Comments**
PAVEMENT SYSTEM				
1. Spalling, cracking, displacement, differential settling				
2. Standing water				
3. Trash and debris				
4. Sediment				
5. Staining or other signs of spills				
COLLECTION/STORAGE SYSTEM (☐Aggregate ☐Underdrain ☐Vault ☐Other_____)				
1. Standing water				
2. Trash and debris				
3. Sediment				
4. High water mark				
DISPOSAL (☐Infiltration ☐Filtration ☐Detention ☐Other_____)				
1. Undercutting/scour at outlet				
2. Trash and debris				
3. Sediment				
4. Standing water				
CONTRIBUTING WATERSHED				
1. Construction				
2. Development				
3. Erosion/Sediment				
4. Stabilization				
5. Trash and debris				
Other				

OVERALL CONDITION ASSESSMENT
☐ Condition 1. Fully Functional ☐ Condition 2. Minor Structural or Functional defects ☐ Condition 3. Acceptable/Anticipated Structural & Functional Deterioration ☐ Condition 4. Major Structural or Functional defects ☐ Condition 5. Structurally/Functionally Deficient
COMMENTS ON OVERALL CONDITION ASSESSMENT
TECHNICAL INSPECTION NECESSARY? ☐Yes ☐No
PREVENTATIVE/NON-ROUTINE MAINTENANCE NECESSARY? ☐Yes ☐No
MAINTENANCE REQUIRED

APPENDIX D

Maintenance Log Template

Fort Belvoir
VSMP Small MS4 General Permit No. VAR040093
General Plan for Stormwater Management Facility Inspection and Maintenance
Maintenance Log

BMP Identifier	Grid Location	BMP Type	Date	Inspector	Maintenance Activities	Maintenance Provided By

APPENDIX E

EPA Guidance on Disposal of Stormwater Residuals

United States Environmental Protection Agency
Office of Water Washington, D.C.
EPA 832-F-99-015 September 1999

Storm Water O&M Fact Sheet

Handling and Disposal of Residuals

DESCRIPTION

Polluted urban runoff can be a major source of water quality problems in receiving waters. Road deicing activities, automobiles, atmospheric deposition, chemicals used in homes and offices, erosion from construction sites, discharges from industrial plants, wastes from pets, wastes from processing and salvage facilities, and chemical spills can all contaminate storm water runoff. These sources can contribute sediment (organic and inorganic), nutrients, bacteria, oil and grease, and heavy metals to receiving waters. Urban storm water Best Management Practices, or BMPs, are intended to remove these pollutants from runoff and to improve water quality in downstream waters. Yet if storm water BMPs are not properly operated and maintained, the BMPs themselves can become sources of storm water pollutants, as the material removed during previous storms becomes re-suspended by subsequent storm events. To prevent this, structural storm water BMPs must be periodically inspected and cleaned of residual materials and sediments. As described above, these residuals may contain a variety of pollutants, and thus proper handling and disposal of these materials is essential. This fact sheet describes structural BMP maintenance programs and discusses methods for handling and disposing of residual materials from storm water BMPs.

Properties of Storm Water Residuals

Storm water solids/residuals have properties that are very site specific, and it is difficult to precisely estimate "typical" storm water or sediment residual properties by the BMP employed or even by site classification. Therefore, this fact sheet presents information from several site-specific studies of the properties of storm water solids/residuals presented. A summary of this data is presented in Table 1.

A 1982 study performed at Marquette University, Milwaukee, Wisconsin, examined urban runoff residuals from a field-assembled sedimentation basin in Racine, Wisconsin, swirl and helical bend solids separators in Boston, Massachusetts, and an in-line upsized storm conduit in Lansing, Michigan. The residual samples from Racine and Boston were obtained from individual storms, while the Lansing samples represent a six- month accumulation of residuals. All of the sample locations were primarily residential (Marquette University, 1982). Results from the sampling are shown in Table 1. Table 1 also summarizes the findings presented in two other technical papers (Schueler and Yousef, 1994, and Field and O'Shea, 1992).

The 1994 study by Schueler and Yousef reviewed bottom sediment chemistry data from 37 wet ponds, 11 detention basins, and two wetland systems, as reported from 14 different researchers. This research covered a broad geographic range, although nearly half of the sites were located in Florida or in the Mid-Atlantic states. These storm water ponds had been in use from three to 25 years. Sampling and analysis were restricted to mean dry weight concentrations of the surface sediments that comprise the muck layer, which is usually the top five centimeters (Schueler and Yousef, 1994).

Schueler and Yousef gathered data for nutrients, trace metals (cadmium, copper, lead, zinc, nickel, chromium), hydrocarbons, and priority pollutants, and indicate that the properties of the solids/residuals from all BMPs are similar except for those from oil/grit separators. A noted exception was that grassed swale soils tend to have about

TABLE 1 PROPERTIES OF URBAN STORM WATER SOLIDS/RESIDUALS

Properties of Residuals	Wet Ponds[1]	Sedimentation Basin [2]	Swirl and Helical Bend Solids Separators[3]	In-Line Upsized Storm Conduit[4]	Urban Storm Water Runoff Residuals[5]
Solids					
Volatile Suspended Solids	6%	104 - 155 mg/l	107 310 mg/l	25,800 mg/l	90 mg/l
Total Suspended Solids	43%	233-793 mg/l	344 - 1,140 mg/l	161,000 mg/l	415 mg/l
Nutrients					
Phosphorus	583 mg/kg	< 5 mg/l	< 5 mg/l	0.3 - 2,250 mg/l	502 - 1,270 mg/kg
Total Kjeldahl Nitrogen	2,931 mg/kg	<5 mg/l	< 5 mg/l	0.3 - 2,250 mg/l	1,140 - 3,370 mg/kg
Heavy Metals					
Zinc	6 - 3,171 mg/kg	-	-	-	302 - 352 mg/kg
Lead	11 - 748 mg/kg	-	-	-	251 - 294 mg/kg
Chromium	4.8 - 120 mg/kg	-	-	-	168 - 458 mg/kg
Nickel	3 - 52 mg/kg	-	-	-	69 - 143 mg/kg
Copper	2 - 173 mg/kg	-	-	-	251 - 294 mg/kg
Cadmium	ND - 15 mg/kg	-	-	-	-
Iron	-	6.1 - 2,970 mg/l	6.1- 2,970 mg/l	6.1 - 2,970 mg/l	-
Hydrocarbons	2,087 - 12,892 mg/kg	-	-	-	-
Poly Chlorinated Biphenyls	-	0.19 - 24.6 ϒg/l	-	0.19 - 24.6 ϒg/l	-

(1) Schueler and Yousef, 1994.
(2) Marquette University, 1982 (Racine, Wisconsin).
(3) Marquette University, 1982 (Boston, Massachusetts).
(4) Marquette University, 1982 (Lansing, Michigan).
(5) Field and O'Shea, 1992.

twice as much phosphorus and lead as detention ponds. Only one sand filter had been sampled, but these characteristics in its residuals appeared similar to those of other BMPs (Schueler and Yousef, 1994). Characteristics of solids/residuals from BMPs are discussed in the following sections, with the exception of oil/grit separators, which are covered in a separate subsection.

Solids-General Composition

Solids from storm water and sediment BMPs can consist of organic and inorganic material. According to Schueler and Yousef (1994), the muck layer of a pond is high in organic matter. An average of nearly six percent volatile suspended solids was reported. Pond muck solids have a very soupy texture, with an average total solids content of 43 percent, although this parameter was reported

from only 15 out of the 50 site locations. These solids have a distinctive grey to black color and a low density, averaging approximately 1.3 g/cm^3.

According to the 1982 EPA study at Marquette University, total solids concentration of residuals samples from a sedimentation basin in Racine, Wisconsin, ranged from 233 to 793 mg/l, with 104 to 155 mg/l being volatile. Concentrations of total solids from swirl and helical bend solids separators in Boston, Massachusetts, ranged from 344 to 1,140 mg/l, with 107 to 310 mg/l being volatile. The six-month accumulated samples from the in-line upsized storm conduit in Lansing, Michigan had a total solids concentration of 161,000 mg/l with 25,800 mg/l being volatile. The 1992 paper by Field and O'Shea reported estimated annual residual/sludge volumes for urban storm runoff in the United States ranging from 27 to 547 million cubic meters (35 to 715 million cubic yards) at an average total solids content ranging from 0.5 to 12 percent.

Nutrients

The muck layer is enriched with nutrients. In the 1994 paper by Schueler and Yousef, phosphorus concentrations for 23 studies ranged from 110 to 1,936 mg/kg, with an average concentration of 583 mg/kg. Nearly all of the nitrogen found in pond muck is organic in nature. Total Kjeldahl nitrogen (TKN) concentrations were reported for 20 studies and ranged from 219 to 11,200 mg/kg, with an average concentration of 2,931 mg/kg. Nitrate was found to be present in very small quantities, indicating either that some denitrification is occurring in the sediments or perhaps that very little nitrate is initially trapped in the muck layer.

The nitrogen-to-phosphorus ratio in this pond study averages five to one. In comparison, the nitrogen to phosphorus ratio for incoming storm water usually averages about seven to one. Ponds appear to be more effective in trapping phosphorus-containing compounds than in trapping nitrogen-containing compounds. It is also possible that nitrogen-containing compounds decay faster than phosphorus-containing compounds in the muck layer. (Schueler and Yousef, 1994).

The 1982 Marquette University EPA report and the 1992 paper by Field and O'Shea reported urban sludge nutrient concentrations ranging from 502 to 1,270 mg/kg total phosphorus as P and 1,140 to 3,370 mg/kg TKN. These nutrient concentrations were reported as being lower than nutrient concentrations found in combined sewer overflows (CSOs) and in raw primary sludges (Rexnord, Inc., 1982 and Field and O'Shea, 1992). The 1982 Marquette University/EPA report presented the concentration of individual nutrients [total phosphorus, TKN, ammonia-nitrogen (NH_3), nitrite-nitrogen (NO_2), and nitrate-nitrogen (NO_3)] in storm water sediment samples from Boston, Massachusetts, and Racine, Wisconsin, as never exceeding 5 mg/l. Urban storm water sediment samples taken from Lansing, Michigan, were between 0.3 and 2,250 mg/l for individual nutrients (total phosphorus, TKN, NH_3, NO_2, and NO_3) (Marquette University, 1982).

Heavy Metals

Trace metal levels are typically 5 to 30 times higher in the muck layer of a pond than in the parent soil below the muck layer (Schueler and Yousef, 1994). Trace metal levels were also reported to follow a consistent pattern and distribution, with zinc having the highest concentration in the muck layer, followed by lead. Zinc and lead concentrations were much greater than chromium, nickel, and copper concentrations, which were approximately equal. Cadmium had the lowest concentration in the muck layer. In the 1994 Schueler and Yousef study, 50 ponds and wetlands were examined and found to have zinc concentrations ranging from 6 to 3,171 mg/kg (dry weight). Lead and chromium concentrations ranged from 11 to 748 mg/kg, and from 4.8 to 120 mg/kg, respectively. Nickel and copper concentrations ranged from 3 to 52 mg/kg, and from 2 to 173 mg/kg, respectively. Cadmium concentrations ranged from being non-detectable to 15 mg/kg (Schueler and Yousef, 1994).

Field and O'Shea reported that median concentrations of zinc, lead, copper, nickel, and chromium in urban runoff sludges and residuals were reported as 316, 268, 263, 131, and 189 mg/kg, respectively (Field and O'Shea, 1992). In the 1982 study at Marquette University, iron was

found as the highest concentration of metals in all of the samples ranging in concentration from 6.1 to 2,970 mg/l. Lead and zinc concentrations ranked second and third, respectively (Marquette University, 1982).

As with all pond parameters, trace metal concentrations are site specific. Ponds that primarily service roadways and highways are enriched with trace metals which are presumably associated with automotive loading sources (e.g., cadmium, copper, lead, nickel, and chromium). On the other hand, storm water ponds that service primarily residential areas have the lowest trace metal concentrations (Schueler and Yousef, 1994). In general, the muck layer is highly enriched with metals; however, in most cases it should not be considered an especially toxic or hazardous material. For example, none of over 400 muck layer samples from any of the 50 pond sites examined in the referenced 1994 study exceeded EPA's current land application criteria for metals (Schueler and Yousef, 1994).

The Northern Virginia District Planning Commission (NVPDC) also examined the toxicty of trace metals from pond sediments (NVPDC, 1995). One study, entitled "Investigation of Potential Sediment Toxicity From BMP Ponds," (Dewberry and Davis, 1990) analyzed sediments from 21 ponds in Northern Virginia under various land use conditions. Many of these ponds are owned and maintained by property owners or homeowners' associations. Testing was performed for the presence, concentration, and toxicity of metals found in the analyzed sediments. The report indicates that the storm water sediments tested were not hazardous and could be safely disposed of on-site or in a landfill. While Dewberry and Davis' study determined the specific material tested to be non-hazardous, they recommend that sediments should be tested further for their use as backfill material or for topsoil maintenance (Dewberry and Davis, 1990).

Hydrocarbons

There is limited data on hydrocarbon and poly-aromatic hydrocarbon (PAH) concentration in the muck layer of ponds. It was reported that the concentrations of total PAH and aliphatic hydrocarbons in the muck layer of a 120 year old London basin were three and 10 times greater, respectively, than the base "parent" sediments. Minor degradation of the hydrocarbons trapped in the muck layer appeared to have occurred in the basin in recent years. On the other hand, hydrocarbons were rarely detected in the muck of Florida ponds. Hydrocarbon concentrations were reported for two out of the 50 sites in the 1994 report by Schueler and Yousef. These concentrations were reported for an industrial and a residential site as 12,892 and 2,087 mg/kg, respectively (Schueler and Yousef, 1994).

Bacteria

Urban storm water solids may contain high levels of bacteria and viruses, including fecal streptococcus and fecal coliform from animal and human wastes. These microrganisms have the potential to be spread from land application of residuals or landfill sites unless the proper precautions are taken. Measures that reduce their concentration in the residuals and minimize any residuals-vector contact include stabilization of the solids; immediate covering of landfill trenches after disposal of solids; treatment by pasteurization, heat treatment, irradiation, etc.; and public and animal access control away from the site (Field and O'Shea, 1992).

Oil/Grit

As previously mentioned, the storm water and sediment solids collected by an oil/grit separator are often more heavily contaminated than solids from other storm water BMPs. The metal content of trapped sediments in an oil/grit separator may be up to 20 times higher than in other BMPs, especially if the separator services a gas station. Priority pollutant and hydrocarbon levels are also much higher, because most oil/grit separators service areas that may discharge higher pollutant levels, such as gas stations and industrial sites, and are designed to trap lighter fractions of oil than are usually trapped by other BMPs. Other BMPs, such as detention basins, usually drain larger watersheds, which causes dilution of the hydrocarbons and metals from gas stations or industries. Therefore, it is doubtful that solids from other BMPs would

approach metal and hydrocarbon concentrations as high as those recorded with oil/grit separators (Schueler and Yousef, 1994).

Other Pollutants

Other potentially toxic pollutants that may be found in storm water BMP sediments include pesticides and polychlorinated biphenyls (PCBs). Toxic wastes in fertilizers, herbicides, and household substances such as paints and cleaning materials may find their way into storm water solids/residuals. In the 1982 report from Marquette University, PCBs were observed in measurable concentrations in the Racine, Wisconsin and the Lansing, Michigan samples. These concentrations ranged from 0.19 to 24.6 μg/l. Of eight pesticides surveyed, only three (DDT, DDD, and Dieldrin) were observed in measurable concentrations (Marquette University, 1982).

APPLICABILITY

For any BMP to achieve maximum pollutant removal, storm water residuals and sediment solids must be periodically removed from the system. O&M procedures for removing and for handling storm water solids/residuals from BMPs should be planned in the design stages of the BMP. The removal frequency depends on many factors; however, some generalized O&M requirements for each of the structural BMP categories (i.e., detention basins, retention/infiltration devices, and vegetative controls) are provided below.

Detention Basins

Wet ponds will eventually accumulate enough sediment to significantly reduce the storage capacity of the permanent pool. This loss of capacity can affect both the appearance and the pollution removal efficiency of the pond. The best available estimate is that approximately one percent of the storage volume capacity associated with the two-year design storm can be lost annually (MWCOG, 1987). Even more storage capacity can be lost if the pond receives extra sediment input during the construction phase. A sediment clean-out cycle of 10 to 20 years is frequently recommended in the Washington, D.C., metropolitan area (MWCOG, 1987). According to the Center for Watershed Protection, storm water ponds require sediment clean-out every 15 to 25 years (Schueler and Yousef, 1994).

Most ponds are now designed with a forebay to capture the majority of sediments, decreasing the solids load to the wet pond. A common forebay sizing criterion is that it should constitute at least 10 percent of the total pool volume (Schueler and Yousef, 1994). This forebay could lose 25 percent of its capacity within 5 to 7 years based on a 1.25 cm/year (0.5 inch/year) muck deposition rate and the assumption that a forebay traps 50 percent of all muck deposited in the pond (Schueler and Yousef, 1994). However, using a forebay may extend the sediment removal interval for the main pond to 50 years (Schueler and Yousef, 1994).

To clean out a large wet pond, dragline or hydraulic dredge methods may be necessary. In ponds not large enough to warrant a hydraulic dredge method, mechanical dredge methods, such as dipper, clamshell, and bucket dredges are sometimes used. In smaller wet ponds, the pond level may be drawn down to a point where the residuals can begin to dry in place. After the material is dried, a front end loader can be used to remove it from the pond bottom.

Dry ponds and extended detention dry ponds also accumulate significant quantities of sediments over time. This sediment gradually reduces the available storage capacity within the pond and also reduces pollutant removal efficiency. In addition, sediment may tend to accumulate around the control device of the dry extended detention ponds. This sediment deposition increases the risk that either the orifice or the filter medium will become clogged. Sediment accumulation also gradually reduces storage capacity reserved for pollutant removal in the lower stage. Therefore, in an extended detention dry pond it is recommended that sediment be removed from the lower stage every five to ten years (MWCOG, 1987). Sediment removal from these systems is simple if access is available for the equipment. Therefore, access should be included in the pond design. Front-end loaders or backhoes can be used to remove the accumulated sediment.

Retention/Infiltration Devices

Infiltration basins are usually located in small residential watersheds that either do not generate large sediment loads or are equipped with some kind of sediment trap. Even when the sediment loads are low, they still impair the basin's performance: the sediment deposits reduce the storage capacity reserved for exfiltration and may also clog the surface soils.

Methods to remove sediment from infiltration devices are different from those utilized for detention basins. Removal should not begin until the basin has thoroughly dried out, preferably to the point where the top layer begins to crack. The top layer should then be removed using lightweight equipment, with care being taken not to unduly compact the basin surface. The remaining soil can then be deeply tilled with a rotary tiller or disc harrow to restore infiltration capacity. Vegetated areas disturbed during sediment removal should be replanted immediately to prevent erosion.

In infiltration trenches, the pretreatment inlets of underground trenches must be checked periodically and cleaned out when sediment depletes more than 10 percent of the available trench capacity. This can be done using a vacuum pump or it can be done manually. Inlet and outlet pipes should also be checked for clogging and vandalism. Dry wells should also be checked periodically for clogging.

Performance of sand filter systems may be sustained through frequent inspections and replacement of the filter medium every three to five years, depending on the pollutant load. Accumulated trash and debris should be removed from the sand filters every 6 months or as necessary. Sand filter systems are usually cleaned manually (Parsons ES, 1995).

Maintenance of porous pavement involves removing sediment from the pavement using vacuum sweeping. It has been recommended that the porous pavement be vacuum swept and hosed down by a high-pressure jet four times per year to keep the pores in the asphalt open (MWCOG, 1987).

Ideally, oil/grit separators should be cleaned out after every storm to prevent re-entry of any residuals or pollutants into the storm sewer system during the next storm. However, because of the O&M costs and manpower requirements associated with this schedule, in reality cleaning is less frequent--it may occur only when an oil/grit separator is no longer operating effectively. The Metropolitan Washington Council of Governments recommends that oil/grit separators be cleaned out at least twice per year (MWCOG, 1987). As with all BMPs, the cleaning frequency depends upon the site-specific pollutant load.

Oil/grit separators can be cleaned out using several methods. One method is to pump out the contents of each chamber. The turbulence of the vacuum pump in the chamber produces a slurry of water and sediment that can then be transferred to a tanker truck. Another method involves carefully siphoning or pumping out the liquid from each chamber (without creating a slurry). If needed, chemicals can then be added to help solidify the residuals. The solidified solids/residuals can then be removed manually from the separator.

Vegetative Controls

Vegetative controls (basin landscaping, filter strips, grassed swales, and riparian reforestation) rely on various forms of vegetation to enhance pollutant removal, habitat value, or appearance of a development site. Some natural systems require periodic sediment removal. For example, accumulated sediments deposited near the top of a filter strip will periodically need to be removed manually to keep the original grade.

ADVANTAGES AND DISADVANTAGES

Proper O&M of storm water BMPs and proper handling and disposal of storm water residuals will result in a greater efficiency of BMP pollutants and will help prevent resuspension of residuals during subsequent storms. This will protect the water quality of receiving waters. If BMPs are not properly maintained, pollutants removed during one storm may become resuspended during another storm and may pollute receiving waters. Improper disposal of storm water residuals may have the same result. If the residuals are stored too close to an area that tends to become flooded, they may return

directly into the storm flow. Finally, there has been no evidence to show that storm water residuals should be considered hazardous waste; however, many states have regulations that residuals be tested before they are disposed.

KEY PROGRAM COMPONENTS

As described above, the key to ensuring that storm water BMPs do not become a source of runoff pollutants is proper operation and maintenance (O&M), including periodic clean out to remove any accumulated residual materials. While the pollutant removal capabilities and efficiencies and the quantities and types of residuals generated are specific to each BMP, structural storm water BMPs can be grouped into categories based on the design of their pollutant removal mechanisms. The general categories of structural storm water BMPs, including detention basins, retention/infiltration devices, and vegetative controls, each have different design characteristics and removal mechanisms that will effect the types and quantities of residuals they generate. Some of the general characteristics of these categories of structural BMPs are provided below.

Detention basins are widely used and are very effective in reducing suspended solid particles. By temporarily holding the storm water runoff and allowing the sediments to settle, detention basins can reduce suspended solids concentrations by 50 to 90 percent. Examples of detention basins include dry ponds, wet ponds, and extended detention dry ponds.

Retention/infiltration devices retain runoff and allow it to percolate into the ground, thereby reducing the amount of pollutants released into the receiving water. Filtration and adsorption occur as the runoff percolates into the ground, trapping many pollutants (e.g., suspended solids, bacteria, heavy metals, and phosphorus) in the upper soil layers and preventing them from reaching groundwater. These devices, which can include infiltration basins, infiltration trenches, dry wells, and porous pavement, can remove up to 99 percent of some runoff pollutants, depending on the percolation rate and area, the soil type, the types of pollutants in the runoff, and the available storage volume.

Other types of retention devices, such as sand filters and oil/grit separators, can be used to pre-treat runoff before it enters the collection system or infiltrates into the ground. However, relative to the successes with other infiltration/retention structures, there has been limited success with some of these devices. For example, because of low average detention times, oil/grit separators are limited in their ability to remove pollutants. Further, these devices have the added risk that settled material may be resuspended or released during later storms.

Vegetative BMPs, which can include basin landscaping, filter strips, grassed swales, and riparian reforestation, are used to decrease the velocity of storm water runoff. This promotes infiltration and settling of suspended solids and also prevents erosion. Vegetative BMPs also remove organic material, nutrients, and trace metals. For maximum effectiveness, vegetative controls should be used as a first line of defense in removing pollutants in combination with other BMPs.

As described above, each of these BMP types has specific removal abilities, and thus each generates slightly different residual material. In most states, the responsibility for operating and maintaining these BMPs falls on the local jurisdiction, which is responsible for inspecting, maintaining, and ensuring proper operation of storm water BMPs. However, in reality, many local jurisdictions do not have the manpower to inspect all BMPs regularly. For example, many of the detention basins installed by local jurisdictions in the l980s are now requiring, or soon will require, cleaning and/or dredging for the first time. This will require these communities to develop a plan to handle and dispose of residuals from these O&M activities.

Storm water and sediment solids/residuals must be handled and disposed of properly. All sediment solids/residuals should first be tested to determine if they are hazardous. If the material is determined to be hazardous, it must be disposed as such. Even if the solids/residuals are determined not to be hazardous, they will usually require dewatering prior to disposal.

Historically, and in most cases, the disposal of sediments removed through BMPs has posed no

special regulatory or legal difficulty. Many municipalities and industries have disposed of such sediments in the same way that they would have any uncontaminated soil (Jones, *et al.*, 1994). In fact, after drying, storm water sediment has been mixed with other soil and reused as backfill on construction projects (Jones, *et al*., 1994) as well as cover for landfills (State of Florida, 1995).

However, if the residuals/solids from a BMP are determined to be hazardous, they must be managed according to the Resource Conservation and Recovery Act of 1976 (RCRA) requirements, which would require either treatment to decrease the concentration of the hazardous constituent or disposal in a hazardous waste landfill. RCRA defines waste as hazardous either because the waste has certain characteristics (such as ignitability, corrositivity, explositivity, or toxicity) or because the waste contains constituents specifically listed in the RCRA regulations. In nearly all cases involving storm water BMP solids, the sediments contain listed chemicals (Jones, *et al.*, 1994). However, if no sample contains more than ten percent of the listed chemical (by volume), or if contact with precipitation/runoff is unlikely, the sediment would not be classified as hazardous (Jones, *et al.*, 1994).

IMPLEMENTATION

The implementation of a storm water residual handling and disposal program will be site-specific and will depend on the types of BMPs used and the residuals that they generate. However, some generalized information on implementing a handling and disposal program, as well as some specific information from case studies, is provided below:

Storm Water/Sludge Handling Alternatives

Centralized Treatment (Bleed/Pump Back to the Dry Weather Treatment Plant): Centralized treatment involves temporary storage of storm water solids followed by their regulated release into a sanitary sewer during dry weather flow conditions. Advantages of this residuals handling alternative include the potential flow equalization through the timed addition of urban storm runoff to the dry weather influent, and the use of a central, pre-existing treatment facility and transportation system for solids handling. Disadvantages of this system include: the deposition of large amounts of grit in the sewer system; the potential for exceeding the capacity of the dry weather treatment facility; possible interference with the treatment plant's operation and efficiency due to differences in the characteristics of sanitary wastewater and urban storm runoff residuals; and additional cost for pumping and treatment (Field and O'Shea, 1992). The problems associated with bleed or pump back solids storm water sediment and solids are similar to those evaluated with regard to CSO solids.

Huibregtse determined that "centralized treatment" of solids was generally not practical (Huibregtse, *et al.*, 1977). In addition to the disadvantages already listed, some problems that may be associated with this type of system include: difficulties in effectively equalizing flow to the dry weather treatment plant due to the high solids/low volume characteristic of residual flow, and difficulties maintaining the quality of treatment plant residuals. Further, significant increases in heavy solids and toxic substance loadings will affect a treatment plant's operation and its effluent's quality. The addition of large amounts of gritty solids can grossly overload solids handling facilities at treatment plants and can impair overall solids quality. Moreover, the addition of these storm water and sediment residuals to the treatment system will increase the quantity of residuals that must be handled (Field and O'Shea, 1992). In a 1982 EPA report, research indicated that the number of days required for bleed/pump back of the residuals without overloading the dry weather treatment facility ranged from 2.8 to 3.9 (Huibregtse and Geinopolos, 1992). This is considered an unacceptable bleed/pump back period, considering the likelihood of overlapping rainfall events (Huibregtse *et al.*, 1977).

Storm Water Solids Handling at Satellite Treatment Facilities: Another handling alternative for urban storm water and sediment solids is treatment at a satellite facility. As described above, average characteristics of urban storm runoff differ substantially from those of sanitary wastewater. Because of the intermittent and varying quantity and quality of storm flow, as well as its low organic and nutrient content, biological processes are generally not employed for the treatment of storm water

runoff. The major design concerns for treatment of storm water flows are the runoff's high grit content, its low organic content, and the flow's intermittent nature and short flow duration (Field and O'Shea, 1992).

Evaluation of several CSO solids handling processes by Huibregtse found the most effective unit processes to be: conditioning through chemical treatment; gravity thickening; stabilization through lime addition; dewatering through vacuum or pressure filtration; and disposal through land application or landfill (Huibregtse et al, 1977).

On-Site Handling of Storm Water Solids/Sludge: The third alternative for handling/disposal of storm water runoff residuals in on-site handling. On-site handling of this material is usually very cost effective as it avoids transportation costs and landfill tipping fees. This option may be used after the residuals have been analyzed and determined to be composed of non-hazardous material. If this disposal method is intended for implementation, a dedicated area on the site should be set aside for land application or land disposal of the residuals during the design stage of a BMP. The area for disposal of residual material should be carefully selected to prevent residuals from flowing back into the BMP during rainfall events.

To dispose of residuals on- site, residuals must first be removed from the storm water runoff. Alternatives for removing solids were discussed previously. After the solids are removed they will usually require dewatering. Dewatering is accomplished by spreading the material out on the ground and occasionally turning it to help it dry. This material is then either land applied or land disposed. Land application involves spreading the material on dedicated land at approved application rates. This material cannot be applied to cropland and would probably be applied to a meadow or vegetated area. There is very little nutrient value associated with storm water residuals.

In some cases it may not be feasible to land apply or land dispose of the material on-site. This may be due to limited space. In any case, after the residuals are removed from the storm water runoff, they should be dewatered on-site if this is feasible. This will cut down on the volume of material to be transported. The material can then be loaded using a front-end loader and transported to either a landfill or another site for land application or land disposal.

The following sections describe specific case studies of BMP residual management programs. This section is not all-inclusive, but is presented to illustrate how some states, municipalities, and industries manage the solids/sediments from BMPs.

Waste Reduction, Disposal, and Recycling Services

A Baltimore, Maryland, firm cleans oil/grit separators for many commercial industries. They use a three man crew and two trucks. A liquid tanker truck is used to pump the oil and water out of the separator. This mixture is transported to their facility in Baltimore for treatment (All Waste-Clean America, 1995).

The solids in the oil/grit separator are further solidified using chemical addition. Once the material is solidified, it is shoveled out of the separator into 55-gallon drums. A composite sample is taken from each drum. This material is analyzed for toxicity, ignitability (flash test), and PCBs. If the material is determined to be non-hazardous, it is loaded into roll-off dumpsters and transported to an incinerator, where the company receives a certificate of destruction for the material (All Waste-Clean America, 1995).

If the solidified separator residuals are determined to be hazardous, treatment depends on the hazardous constituent of the waste. Analytical results are faxed to the generator. Additional testing is usually required to determine what constituent(s) make the sediment hazardous (All Waste-Clean America, 1995). Hazardous material is then handled on a case-by-case basis. In most cases, treatment to lower the hazardous chemical concentration to a non-hazardous level is preferred over landfilling in a hazardous waste landfill. For example, a sediment that contained a high hydrocarbon content, which may occur at a service station, would be spread out on an approved site for a period of time sufficient to allow the concentration

to decrease in the sediment (All Waste-Clean America, 1995).

As each cleaning and maintenance job is site specific, this firm charges by the hour. The cost for cleaning is $202/hr for the three employees and two trucks. In addition, the charge for disposal of the liquid waste is $0.09/liter, the charge for the chemical that aids in solidification is $9.95/bag, drum purchase cost is $25/drum, drum disposal cost is $100/full drum, analytical charge is $145, and transportation charge is $250. Additional analytical testing and handling will increase costs.

Prince George's County, Maryland

In Prince George's County, Maryland, ponds are dredged on an as-needed basis. In some cases, on-site disposal of the sediment was planned for in the design of the BMP. However, if on-site disposal is not possible then a disposal site must be located. Residual sand and gravel material from the BMP may be landfilled or transported to construction-sites for use (Prince Georges County, MD, 1999).

Prince Georges County is also experiencing problems with oil/grit separators and is phasing them out. Most of the problems pertain to residuals management, and include: problems with landfills accepting residual material from oil/grit separators; the frequent maintenance and cleaning requirements; difficulties in dewatering material generated from the separators; and the expenses assocaited with dewatering, hauling, and landfilling. In addition, the county does not have the personnel to routinely inspect and enforce the cleaning of oil/grit separators. As an alternative to this BMP, the county is focusing on pollution prevention and other structural BMPs (Prince Georges County, 1999).

Fairfax County, Virginia

Most of the wet ponds in Fairfax County are privately owned, and the owners are required to maintain the ponds. The regional wet ponds maintained by the county are designed to be fully functional even when filled with sediment, and the county does not have a formal dredging program. Individual ponds are dredged on an as-needed basis; the county is planning on dredging one pond in the fall of 1999 to remove an island that has formed in the pond. Removed residual material is retained in a decanting basin for a period oif time until it is landfilled (Fairfax County, VA, 1999).

Montgomery County, Maryland

Montgomery County has updated its guidance for the dredging of wet and dry ponds to require dredging if wet and dry ponds reach greater than 50 percent or greater than 30 percent of storage capacity, respectively. The State of Maryland has determined that the sediments from these ponds are a non-hazardous material; however, inspectors have the discretion to require testing of the residuals depending on the suspected content of the runoff. If the material is determined to be non-hazardous, it can be disposed of either on-site or in a landfill. State law requires that these ponds be inspected once every three years. Since November, 1998, the county has inspected approximately 1,000 ponds, and is currently in the process of searching its records to identify remaining ponds in the county (Montgomery County, MD, 1999).

Typical oil/grit separators require much maintenance attention, and Montgomery County is trying to phase them out. The county has many sand filters proposed to replace the oil/grit separators, but information on their maintenance is not available due to the limited experience with cleaning and maintaining these filters (Montgomery County, MD, 1995).

State of Florida

Many storm water BMPs in Florida were implemented in the early 1980s, and are just to the point where they require dredging (State of Florida, 1995). However, Florida does not have a specific regulation stating that each jurisdiction must dredge or remove material from BMPs periodically. Instead they have issued a "Guidance Manual" as a supplement to the regulations, which are considered inadequate for handling storm water sediments for BMPs.

The guidance manual recommends testing all BMP sediments using the Toxicity Characteristics Leaching Procedure (TCLP), before disposal. The state has performed numerous analytical studies on this material, and in no cases was BMP sediment from any location determined to be hazardous. However, oil/grit separators were not tested as part of this study.

Material must have the appropriate laboratory TCLP paperwork before most landfills in Florida will accept it. Some cities and counties avoid this testing by sending BMP residuals to construction/debris landfills, which are not as stringent. This practice is not supported by the state (State of Florida, 1995).

In addition to screening by the TCLP test, Florida has implemented a clean soil criterion to protect communities from exposure to elevated concentrations of materials which might not be classified hazardous. If a material does not pass the clean soil criterion, (e.g., if metal concentrations are high, but not hazardous) then it can be used only in an area where public access is controlled. Material such as this can be used as a landfill cover because public access is limited to most landfills.

Sediments from dry ponds in Florida are removed using a front-end loader and a dump truck. As discussed above, it is then recommended that a TCLP test be conducted on this material before either disposing on-site, landfilling, or disposing of in another manner. Wet ponds are dredged; however, these ponds are sometimes directly connected to a waterway so caution is needed to ensure solids are not resuspended in this operation. This material is usually spread out on the site to allow drying and is then disposed of on-site. If on-site disposal is not possible, then the sediments are usually transported to a landfill (State of Florida, 1995).

State of Delaware

The State of Delaware has followed Florida's lead in handling and disposal of storm water BMP residuals. The State of Delaware has conducted its own tests on storm water BMP sediments, but considers the material to be non-hazardous based on Florida's research and other research/reports. The state also has a storm water management program in which local jurisdictions are required to inspect BMPs on an annual basis (State of Delaware, 1995).

The state's storm water management plan includes BMP construction guidelines for ease of BMP maintenance and for on-site disposal of the storm water residuals. Oil/grit separators are not a BMP alternative in Delaware. In addition to detention basins, sand filters are commonly used. The cleaning schedule for a sand filter is site specific, but three to four times a year is a general estimate. Typically, a team of three is used to clean a Delaware filter manually by shoveling out the material. This process takes approximately 4 hours. Labor cost to clean the filter is approximately $120. The material is then transported to a landfill for disposal (State of Delaware, 1995).

State of Maryland

The State of Maryland conducted a four-year study on oil/grit separators with the Metropolitan Washington Council of Governments. This study evaluated material from oil/grit separators in Maryland to determine if it was hazardous. The study also evaluated maintenance of oil/grit separators, as well as disposal of the residuals/solids from an oil/grit separator. Results from the study indicated that the solids from oil/grit separators were not hazardous; therefore, this material could be disposed of at a landfill after dewatering. However, as this material is site specific it was recommended that it be tested before being sent to a landfill (State of Maryland, 1995).

All local jurisdictions are required to inspect BMPs. Every three years, the state reviews storm water programs and procedures utilized by the local jurisdiction. The state has noted that many BMPs are not being properly maintained, and attributes this to the cost and manpower requirements associated with regularly inspecting all BMPs. Further, many homeowner associations have BMP facilities on their property. Maintenance of these BMPs is another area of concern for the state because homeowner associations often do not implement proper O&M procedures to maintain the

BMP facility on their property (State of Maryland, 1995).

As long as they are not hazardous, sediments from wet ponds and dry ponds are usually dewatered and then disposed of on-site or landfilled. It is a common practice to spread this material out on a site for use as a soil amendment (State of Maryland, 1995).

COSTS

In a 1982 report by Huibregtse and Geinopolos, a cost analysis was performed specifically for the handling and disposal of urban storm runoff residuals. This cost analysis compared the following six alternative residuals handling scenarios for either swirl or sedimentation concentrated solids:

Gravity thickening, vacuum filtration and landfill.

Gravity thickening, vacuum filtration and landspreading.

Gravity thickening, pressure filtration and landfill.

Gravity thickening, pressure filtration and landspreading.

Gravity thickening and landspreading.

Landspreading.

These cost estimates are presented in terms of dollars per hectare for residuals handling in an urban storm runoff area of 6,000 hectares (15,000 acres). These estimates were updated to July 1995 dollars and are presented in Table 2.

As shown on Table 2, the most cost effective solids handling scenario based on annual costs is lime stabilization, gravity thickening, pressure filtration, and landfilling.

The 1982 EPA report from Marquette University concluded that, of the options evaluated, the most cost-effective means for handling and disposal of urban storm water runoff residuals is gravity thickening followed by lime stabilization and landspreading or landfilling (Marquette University, 1982). This conclusion was based on urban storm water studies from Boston, Massachusetts, Racine, Wisconsin, and Lansing, Michigan involving solids sampling, characterization, analysis, and treatability. The characterization study included analyses for nine metals, eight pesticides and PCBs, solids, nutrients, and organics. The treatability study included bench scale sedimentation tests, centrifugation tests, lime stabilization tests and capillary suction time tests (Marquette University, 1982).

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TABLE 2 COST ESTIMATE ($/HECTARE) FOR RESIDUALS HANDLING IN AN URBAN STORM WATER RUNOFF AREA OF 6071 HECTARES[1]

Sludge Handling Method	Capital	Sedimentation O&M	Annual	Capital	Swirl Concentration O&M	Annual
Lime Stabilization Gravity Thickening Vacuum Filtration Landfill	1174	176	331	1252	158	321
Lime Stabilization Gra Thickening Vacuum Filtration Landspreading	1253	188	423	1312	166	383
Lime Stabilization Gravity Thickening Pressure Filtration Landfill	1216	148	306	1359	121	289
Lime Stabilization Gravity Thickening Pressure Filtration Landfill	1290	158	385	1406	124	343
Lime Stabilization Gravity Thickening Landfill	-	-	-	974	215	410
Lime Stabilization Landfill	761	257	460	2533	2115	2950

(1) Huibregtse et al, 1982. Costs have been updated to July 1995 dollars using the Engineering News Record.

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