City of Duvall

Small Town. Real Life.

Stormwater Facility

Maintenance Manual

Public Works Department

Surface and Stormwater Management

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Chapter 1 Introduction

Background

This manual serves as an Operations and Maintenance Program to meet the NPDES Phase II Permit (Permit) pollution prevention and operation and maintenance requirements. It describes pollution prevention and operation and maintenance program activities the City has implemented and identifies how the programs comply with Permit requirements.

Purpose

Section S5.C.5 of the Permit requires the City to provide a Pollution Prevention and Operation and Maintenance Program for the area served by its Municipal Separate Storm Sewer System (MS4). The goal of this program is to prevent or reduce pollutant runoff from the City's operation and maintenance activities.

The program requirements include:

- Maintenance standards that are at least as protective as those specified in the 2005 Stormwater Management Manual for Western Washington. S5.C.5.a
- An inspection program that includes all City-owned or operated permanent stormwater treatment, flow control facilities, and catch basins at a frequency that meets Permit requirements unless a reduced frequency can be justified. S5.C.5.b
- Spot checks of potentially damaged permanent treatment and flow control facilities, other than catch basins after major (greater than 24-hour-10-year recurrence interval rainfall) storm events. S5.C.5.c
- Inspections of all catch basins and inlets owned or operated by the Permittee at least once before the end of the permit term. S5.C.5.d
- Compliance with inspection requirements in b, c, and d shall be determined by the presence of an established inspection program designed to inspect all sites. S5.C.5.e
- Practices to reduce stormwater impacts associated with runoff from streets, parking lots, road/highways owned or maintained by the City, and to reduce pollutants in discharges from all lands owned or maintained by the City. S5.C.5.f
- Establishment and implementation of policies and procedures to reduce pollutants in discharge from all lands owned or maintained by the Permittee
- An ongoing training program for City staff whose construction, operations, or maintenance job functions may affect stormwater quality. S5.C.5.h
- Development and implementation of a Stormwater Pollution Prevention Plan (SWPPP) for all heavy equipment maintenance or storage yards, and material storage facilities owned or operated by the City. S5.C.5.i
- Documentation of inspections, maintenance, or repair activities, as well as staff training. S5.C.5.j

Chapter 2 Operations and Maintenance Program

Maintenance Standards

Maintenance measures must follow guidelines from the City's adopted surface water design manual, the King County Surface Water Design Manual (KCSDWM). KCSWDM requires maintenance of all drainage facilities to be the responsibility of the applicant or property owner, except where the City assumes responsibility.

Inspection Program

- All City owned or operated permanent stormwater treatment and flow control best management practices (BMPs) and or facilities are inspected annually by a trained and certified in house Stormwater Inspector. Illicit Discharge Detection and Elimination (IDDE) screening is also completed at the time of inspection.
- All commercial property, privately owned and operated catch basins, conveyance systems, stormwater treatment, and flow control BMPs/facilities are inspected annually by a trained and certified in house Stormwater Inspector. IDDE screening is also completed at the time of inspection.
- Public Works staff perform inspections of all MS4 catch basins every two year. IDDE screening is also completed at the time of inspection.
- All City owned and maintained HDPE pipes located on steep grades are inspected annually. IDDE screening is also completed at the time of inspection.
- The City has established a standard operating procedure to conduct spot checks after all major storms.
- The City is working to update its existing system to maintain an electronic database (asset management) of all inspection reports.

Operations and Maintenance (O&M) Program

- The City currently operates a robust maintenance program.
- All City owned or operated permanent stormwater treatment and flow control BMPs/facilities are maintained as necessary within one year of inspection for typical maintenance and within two years for maintenance that requires capital construction of less than $25,000.
- All catch basins are cleaned as required after inspection every two years. Other typical maintenance of catch basins is completed within 6-months of inspection.
- All City owned and maintained HDPE pipes are cleared of fallen trees and vegetation as they are inspected annually. All other typical maintenance is completed within one year of inspection and within two years for maintenance that requires capital construction of less than $25,000.
- The City's current contract with a private contractor requires street sweeping throughout the City, every third Thursday of the month.
- The City has established an on-going O&M program to reduce pollutant discharges from all lands owned or maintained by the City such as parks, open space, rights-of-way, maintenance yards, and stormwater treatment and flow control facilities. This program includes components to address issues such as:
    - Street sweeping;
    - Integrated pest management;
    - Sediment and erosion control;
    - Landscape maintenance and vegetation disposal;
    - Trash management; and
    - Building exterior cleaning and maintenance.

Staff Training

- City staff have attended trainings associated with pollution reduction and management.
- The City has developed an on-going training program for all field staff responsible for inspecting and maintaining municipal operations. Both in-house and outside training resources are utilized.
- The on-going training program includes a system to document and maintain records of all training that has taken place.
- The City will use adaptive management as necessary to be compliant with the Permit.
- The City maintains and continually updates its Stormwater Pollution Prevention Plan (SWPPP).
- The City has identified all heavy equipment maintenance yards, storage yards, and material storage facilities and evaluating existing coverage under other permits and developed SWPPPs for all applicable facilities.

Chapter 3 Stormwater Structures

Catch Basins

Types of Catch Basins: their design & how they function

Type 1: Most common catch basin type

- It is a rectangular box with approximate dimensions of 34" x 30" and up to 5.5 feet deep.
- Type 1 CBs are utilized when the connected conveyance pipes:
  - Less than 18 inches in diameter; and
  - Depth from top of grate to the bottom (invert) of the pipe is 5-feet or less.

Type 1-L: Similar to the Type 1

- It is a rectangular box with approximate dimensions of 40" x 36" and up to 5.5 feet deep.
- Type 1 CBs are utilized when the connected conveyance pipes:
  - Maximum diameter of 28 inches;
  - Depth from top of grate to the bottom (invert) of the pipe is 5-feet or less.

Type 2: Second most common catch basin type (first being Type 1)

- Type 2 CBs range in diameter from 4 feet to 12 feet, and in depth from 5 feet to 30 feet and deeper.
- They are used when:
  - Conveyance pipe is 18 inches or greater in diameter; or
  - Depth from top of grate to pipe bottom exceeds 5.0 feet.
- Access into a Type 2 CB is through the access hole (covered with an iron grate or solid lid).
- Descent is typically aided by:
  - Iron ladder rungs mounted individually on the catch basin wall; or
  - A ladder attached to the wall.

Both Type 1 and Type 2 CBs typically have a sump (collection area) below the outlet pipe for stormwater storage to allow sediment, debris and some pollutants to settle out and remain in the catch basin.

Temporary Spill Control Structures: Many Type 2 Catch Basins in the roadway immediately upstream of a stormwater detention facility have a device in them to temporarily collect an oil spill (accidental or dumped intentionally) to prevent it from entering the facility. These types of structures are typically called Oil-Water Separator (OWS).

The spill control device resembles a Flow Control Structure standpipe (See Flow Control Structure) but is open either at both the top and bottom of the standpipe or just the bottom and has no orifices to regulate or control flow rates. The CB contains the oil, however, if the oil is not removed before a rain storm event, the runoff will fill the basin causing the oil (lighter than water) to float on the water surface. The oil on the water surface rises and falls depending on the storm intensity, and the standpipe allows the oil to move up and down without allowing it to leave the catch basin.

NOTE: Any oil in the Temporary Oil Spill Control Structure should be removed immediately after a storm event or as soon as the oil is discovered.

Some Type 1 and Type 2 Catch Basins, rather than collecting surface water through a grate, have a solid lid and merely function as a connecting point for two or more pipes. These catch basins are usually located in a travel lane (not in the gutter line), yards, fields, or forested areas. These are difficult to access and cleaning out their sumps is sometimes very difficult. For that reason, many of them have no sump, but instead have a channel molded in the bottom allowing the sediment and debris carried by stormwater to flow directly through, rather than collect in the bottom.

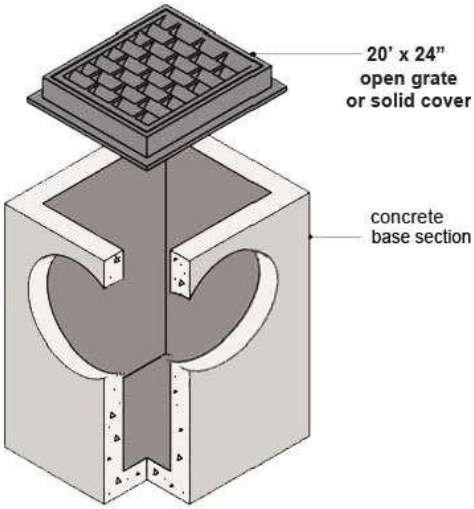
Common Maintenance Needs

The most common equipment for cleaning catch basins is a heavy-duty combination high-powered pressures washing and vacuum truck (Vac-truck). It provides:

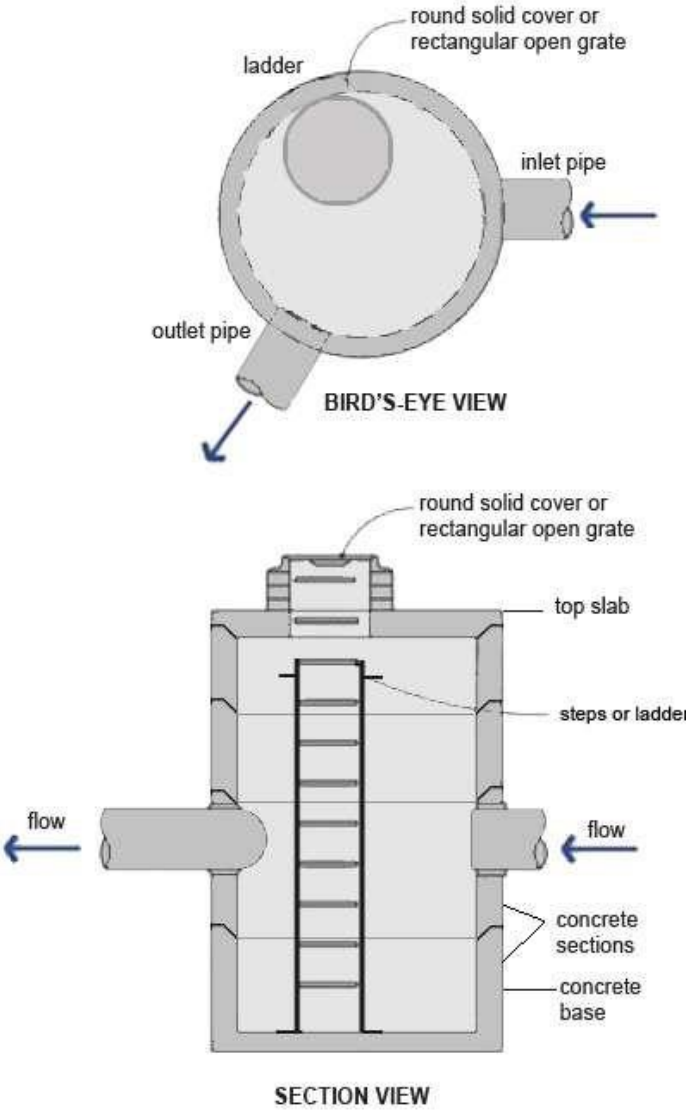
- High pressure washing for the walls and bottom of the catch basin, and
- A high-powered vacuum for removing water laden with:
  - sediment
  - oil/grease/gasoline
  - vegetative debris
  - trash

NOTE: If a Vac-truck is not available or not appropriate under some conditions, the option is to hand dig and remove the material.

Type 1 and Type 2 Catch Basins



Type 1 (30" x 34" rectangle shape)



Type 2 (cylinder shape)

Installation of Type 1 and Type 2 Catch Basins

TYPE 1 CATCH BASIN WITH VANE GRATE

TYPE 1 CATCH BASIN CONNECTING CONCRETE PIPE

TYPE 2 CATCH BASIN CONNECTING HDPE N-12 PIPE

TYPE 2 CATCH BASIN

TYPE 1 CATCH BASIN WITH VANE GRATE

TABLE 1 CATCH BASIN INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
General	Excessive accumulation of trash, debris, sediment or vegetation	• More than 10% of basin grate surface is clogged. Blockage in gutter flow line at upstream end of grate.	• Blockage removed.
		• Sump is filled more than 60 percent of its depth with material, as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the top of stuff down to the invert of the lowest pipe	• Accumulation of trash, debris, sediment or vegetation removed.
		• Pipe end blockage exceeds 20%.	• Blockage removed.
		• Vegetation that can generate odors that might cause complaints or dangerous gases (e.g., methane).	• Vegetation removed.
Structure	Damage to top slab, walls and bottom	• Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch. Water and/or soil seeping into basin.	• Top slab repaired or replaced. No water and/or soil seeping into basin.
		• Inspection or maintenance person judges that structure is unsound	• Basin or portion of basin repaired or replaced
	Settlement/ misalignment	• Grout has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	• Pipe is re-grouted and secure at basin wall.
		• If failure of basin has created a safety or function problem.	• Basin raised to proper elevation, realigned, or replaced.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Structure	Pollutants in stormwater or sediment	• For typical pollutants present such as gasoline, oil, herbicides, pesticides and fertilizer, identify and remove source and/or report to the Public Works Department. **If hazardous materials are present, call 911 and Duvall Public Works.**	• No pollutants present.
Catch Basin **opening or concrete slab Access Hole**	Solid lid or grate not in place	• Solid lid or grate is missing or ajar and not set securely in the metal frame. **This is a safety hazard.** Lid needs to be secured or replaced immediately.	• Missing solid lid or grate repaired or replaced. • Ajar solid lid or grate is fully in place.
Metal Grates and Grate Frames	Locking mechanism not working	• Mechanism cannot be opened by a maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	• Mechanism can be opened with proper hand tools.
	Solid lid or grate difficult to remove	• A maintenance person cannot remove lid or grate with normal lifting and proper hand tools.	• Solid lid or grate can be removed by a maintenance person.
	Grate opening unsafe	• Grate with slots or holes wider than standard 7/8 inch is a pedestrian and bike safety hazard**.** Replace grate.	• Substandard Grate is replaced with one having standard openings.
	Damaged or missing	• Grate with missing or broken member(s) of the grate. **This is a safety hazard.** Replace immediately.	• Grate has been replaced.
	Not set and/or properly secured on top slab	• Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab.	• Frame is sitting flush on the riser rings or top slab.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Metal Grates and Grate Frames	Not set and/or properly secured on top slab	• Frame not securely attached to top slab. **This is a safety hazard.** Replace immediately.	• Frame securely attached.
Ladder	Unsafe	• Missing rungs. • Not securely attached to basin wall • Misaligned • Rust • Cracks • Sharp edges. **This is a safety hazard**. Replace immediately.	• Ladder is safe. • Repaired to specifications, or • Replaced with OSHA standards compliant ladder.

CAUTION: A Type 2 Catch Basin is an enclosed space where harmful chemicals and gasses can collect. Therefore, the inspection and maintenance of these facilities should be conducted by individuals trained and certified to work in confined spaces under hazardous conditions.

Catch Basin Insert

What is a Catch Basin Insert?

Catch basin inserts are most widely used in commercial parking areas and private residential roadway and parking areas to trap sediment and oil entering the catch basins, as well as during construction activities.

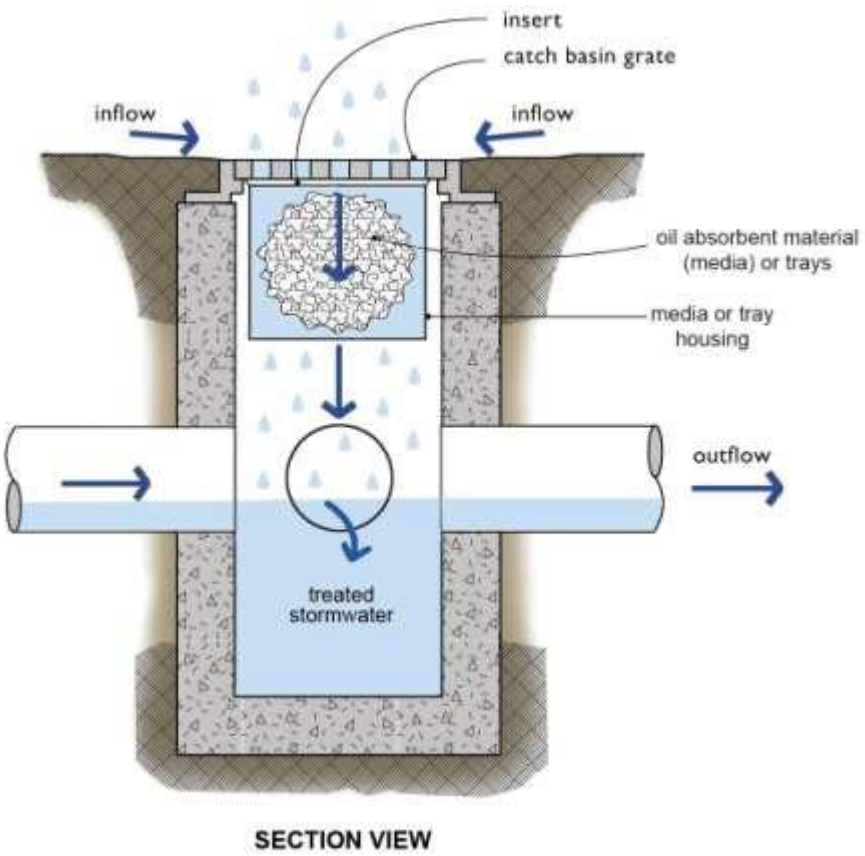
How does a Catch Basin Insert work?

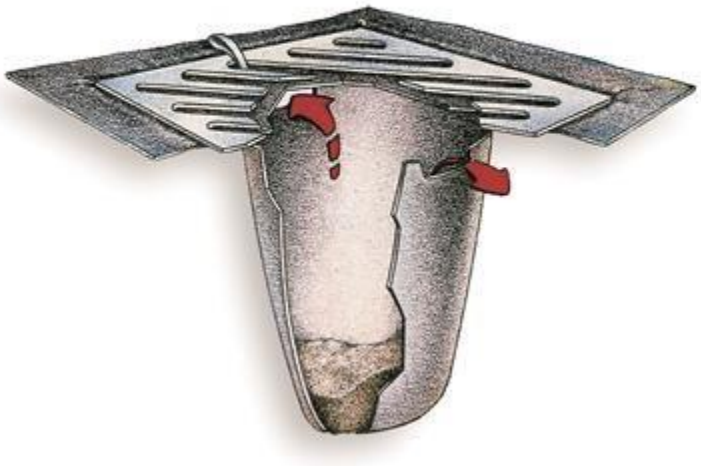
Most involve some type of filter media and oil-absorbent pads that are either attached to the basin or laid in trays/pans or some other container suspended within the basin. Some are just dropped in and float in the sump. There are a variety of metal or fiberglass pans (some with two or three levels that function as graduated sieve to catch different sizes of debris and sediment. These kinds of filters overflow their containers when they become clogged or when there are high storm flows.

Typical Catch Basin Insert designs

The most common types of catch basin inserts are: fabric bags; plastic or metal trays; or plastic basin.

Catch Basin Insert





CATCH BASIN INSERT (SOCK) – SECTION VIEW

Catch Basin Insert

3-TRAY CATCH BASIN INSERT

SOCK CATCH BASIN INSERT

TABLE 2 CATCH BASIN INSERT INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
General	Sediment accumulation	• When sediment forms a cap over the insert media of the insert and/or unit.	• No sediment cap on the insert media and its unit.
	Trash and debris accumulation	• Trash and debris accumulate on insert unit creating a blockage/restriction.	• Trash and debris removed from insert unit. • Runoff freely flows into catch basin.
	Media Insert-not removing oil	• Water flowing out from insert has visible oil sheen.	• Water flowing out from insert is free of oils and has no visible sheen.
	Media Insert-water saturated	• Insert saturated with water - no longer has capacity to absorb.	• Replace insert.
	Media Insert-oil saturated	• Insert saturated with oil, due to a petroleum spill or dump, draining to catch basin.	• Determine source. • Clean catch basin. • Replace insert.
	Media Insert-use beyond normal product life	• Media has been used beyond the typical average life of media insert product.	• Replace insert at regular intervals, according to manufacturer's directions.
Catch Basin	All potential defects	• See **Catch Basin**.	

Yard Drain & Cleanout

What is a Yard Drain?

A Yard Drain is similar to a Type 1 Catch Basin but smaller (most are 12 inches or less in diameter).

- Currently, the most frequently used type of yard drain is a Polyvinyl Chloride (PVC) pipe. They are typically installed by setting the pipe vertically on end, bell end up fitted with a grate, and bottom end resting on washed drain rock.
- There are older versions which are made of either clay, HDPE N-12, or Concrete Pipe.

How does a Yard Drain work?

Yard Drain systems usually consist of several yard drains and 6”-8” diameter HDPE pipe between them. They are designed for use in private residential or commercial property and **not for use in public or private roads**.

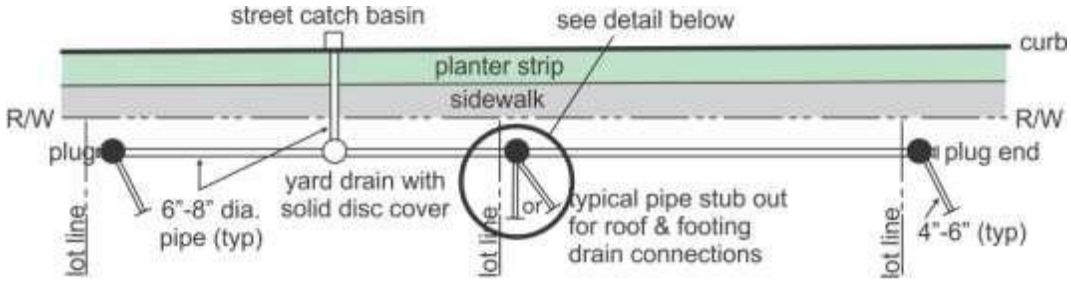
- They function as an intermediary stormwater conveyance system that connects roof and building foundation footing drains (4”-6” diameter PVC pipe) to the main stormwater conveyance system of:
  - Type 1 or 2 Catch Basins
  - 12” and larger diameter PVC pipe.
- Typically, in residential subdivisions these systems can be located along lot lines.
- Yard Drains also have commercial property applications, often being installed to connect building roof and footing drains to the parking area and driveway drainage systems.

NOTE: If Yard Drains are not visible, it is possible that Cleanouts were installed as a substitute. This is generally the case when the depth from the top of the Yard Drain grate to what would be the top of the washed drain rock exceeds 42 inches (See drawings below).

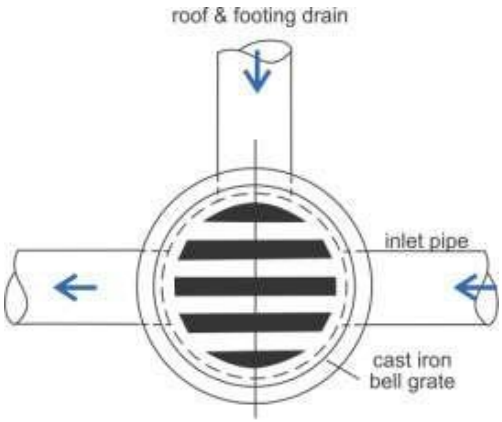
Common Maintenance Needs

The most common tool for cleaning Yard Drains or Cleanouts is a yard hose. Cleaning by a vac-truck with its very high pressure and volume washing and vacuum system can destroy both the older Yard Drains or Cleanouts and pipe. It is better to use a low-pressure washing system and scoop out by hand any debris collecting in the Yard Drains, pipe, or Cleanouts.

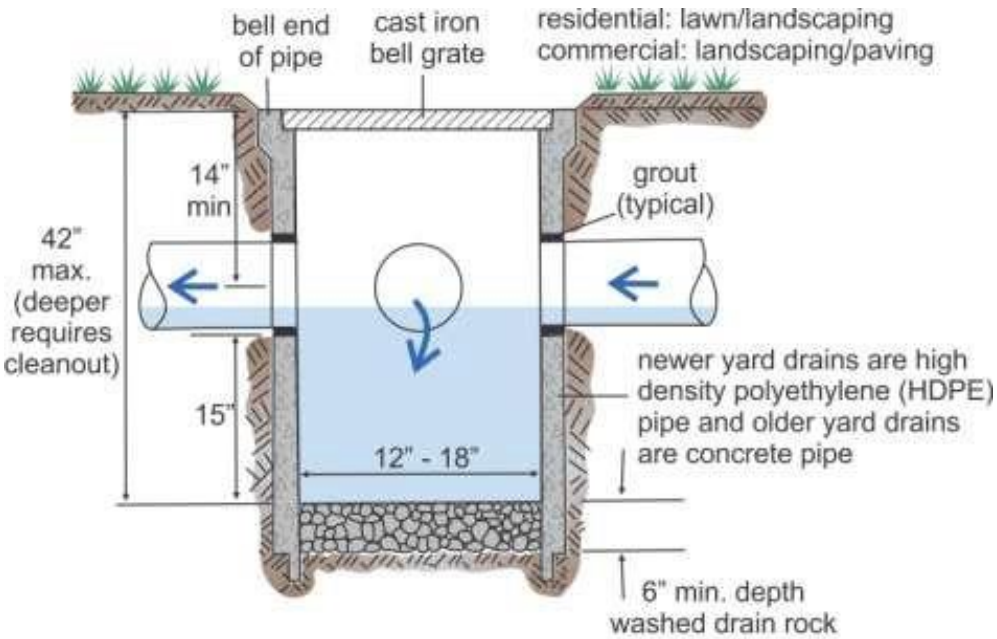
Yard Drain



BIRD'S-EYE VIEW
TYPICAL YARD DRAIN PLACEMENT FOR RESIDENTIAL LOTS

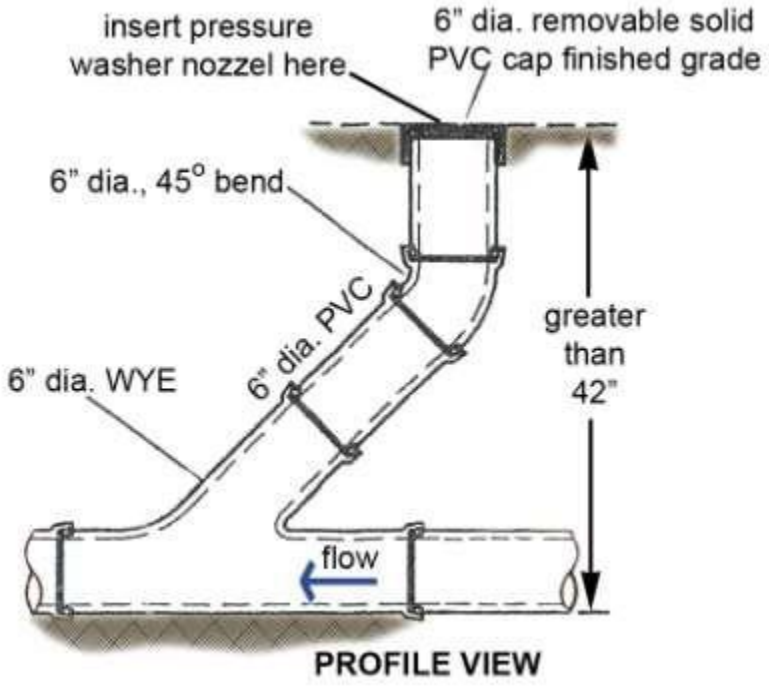


BIRD'S-EYE VIEW



SECTION VIEW

Cleanout


insert pressure
washer nozzel here
6" dia. removable solid
PVC cap finished grade
6" dia., 45° bend
6" dia. PVC
6" dia. WYE
greater
than
42"
flow
PROFILE VIEW

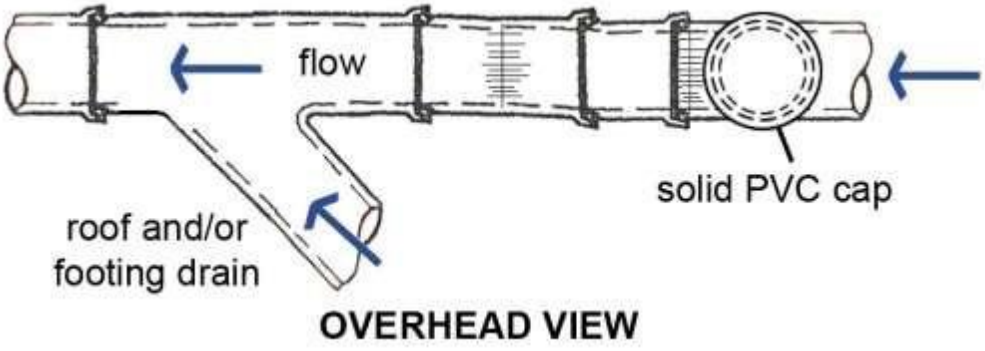

flow
solid PVC cap
roof and/or
footing drain
OVERHEAD VIEW

TABLE 3 YARD DRAIN AND CLEANOUT INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not
Metal Grates	Excessive accumulation of trash, debris, sediment and vegetation	• Obstruction Immediately in front of the drain grate or covering it is reducing flow causing ponding or partial flow bypass.	• Obstruction removed.
		• Obstructing more than 1/3 of inlet or outlet pipe diameter.	• Obstruction removed.
		• Decaying and generating odors that could cause complaints or dangerous gases (e.g., methane).	• Vegetation removed.
	Not in place	• Missing or only partially in place.	• Grate in place, repaired or replaced.
	Damaged	• Broken	• Grate repaired or replaced.
Sump	Sediment, accumulation	• Sediment exceeds 60 percent of the sump depth. • Measure from bottom of basin to invert of the lowest, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe.	• Sediment removed.
Structure	Cracks in wall	• Cracks in wall	• Basin repaired or replaced. • Pipe is re-grouted and secure at basin wall.
	Settlement or misalignment	• Settlement or misalignment	• Basin raised, realigned, repaired or replaced.
	Pollutants in water or sediment	• Most commonly occurring are herbicides and insecticides. • Identify and remove source.	• Pollutants removed.

Energy Dissipater

What is an Energy Dissipater?

An Energy Dissipater is usually installed at the outlet (downstream) end of a pipe discharging its flow to either a natural receiving water (stream, lake, wetland, or Puget Sound) or an engineered ditch or pond (See Stormwater Facility Discharge Point). It is designed to reduce the energy of runoff to prevent erosion at the point of discharge. Often, energy dissipation is also applied to dampen the flow of water at the inlet (upstream) end of a pipe before it enters a pipe.

Types of Energy Dissipaters

There are several kinds of Energy Dissipaters which include:

- Rock armoring splash pads;
- Rock filled metal wire gabion baskets;
- Dispersion trenches;
- Excavated stilling pools or basins; and
- Type 2 Catch Basins (with or without a lid).

Typical Energy Dissipater Design

The most common Energy Dissipater is the rock armoring splash pad. It is typically designed:

- 4-feet to 10 feet long by 2-feet to 6-feet wide and a minimum of 1-foot deep,
- 8-inch to 12-inch angular rocks,
- Pipe end resting on top of the rock pad, and
- The width of the pad extending up the slope to an elevation at least 12 inches above the top of pipe.

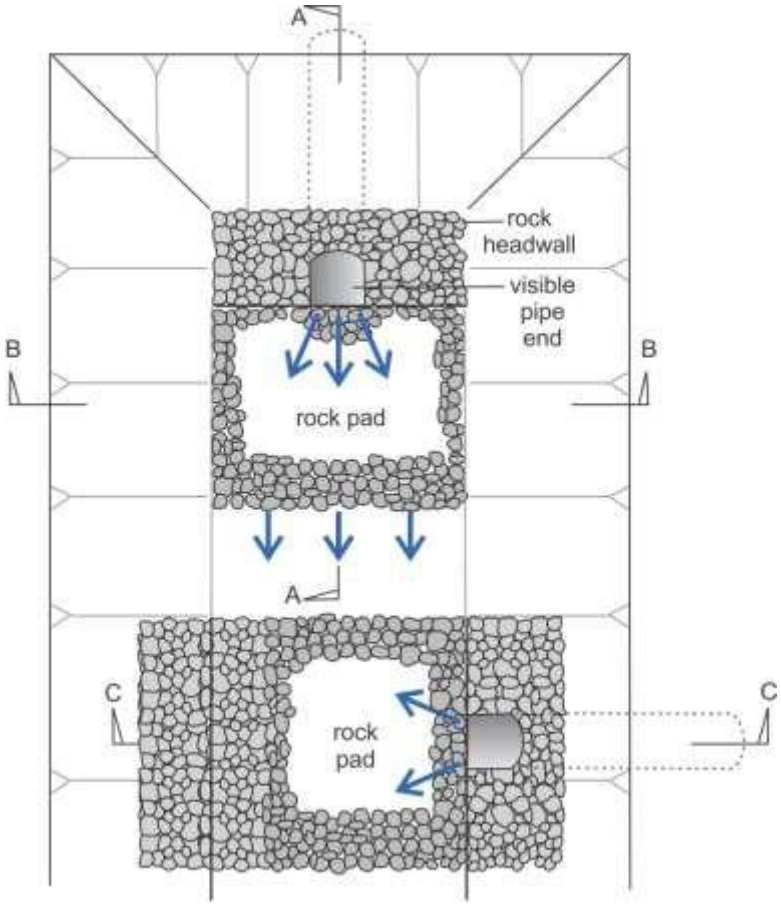
NOTE: Often a sheet of geotextile fabric lines the bottom of the rock pad, sandwiched between the rock layer and the soil sub-grade wrapping around the Pipe**.**

Common Maintenance Needs

Remove sediment, vegetation debris and man-made trash to prevent:

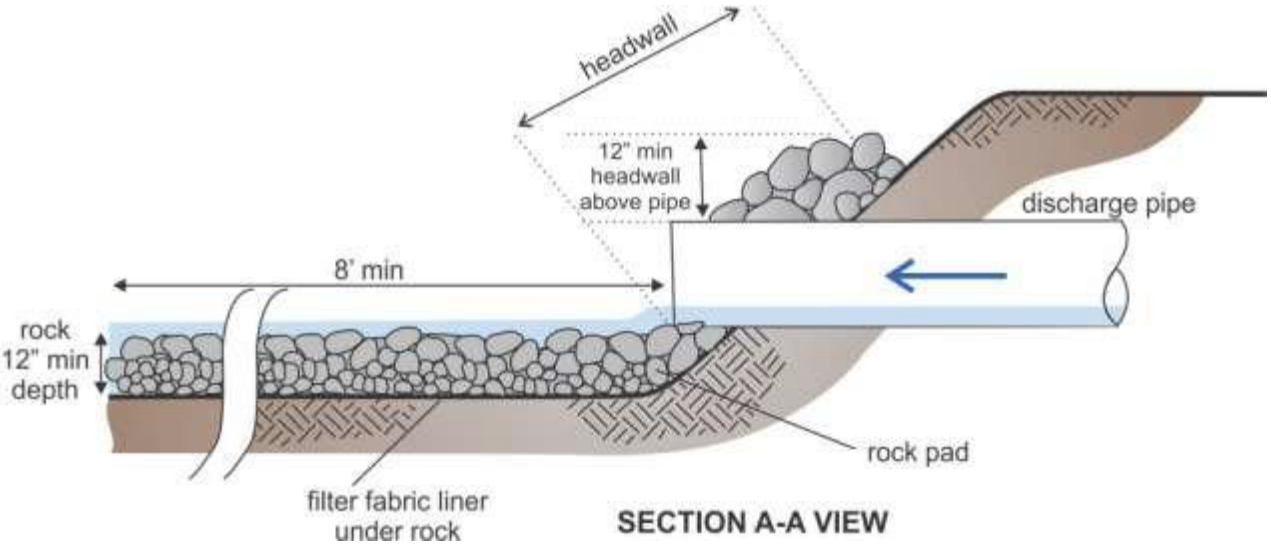
- Clogging of outlet pipe end so flow will not back up;
- Full or partial burying of an energy dissipater to reduce loss of flow energy dissipation.

Rock Energy Dissipation Pad and Headwall

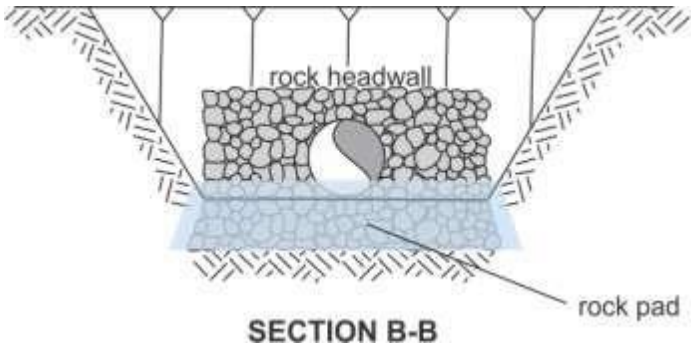


BIRD'S EYE VIEW

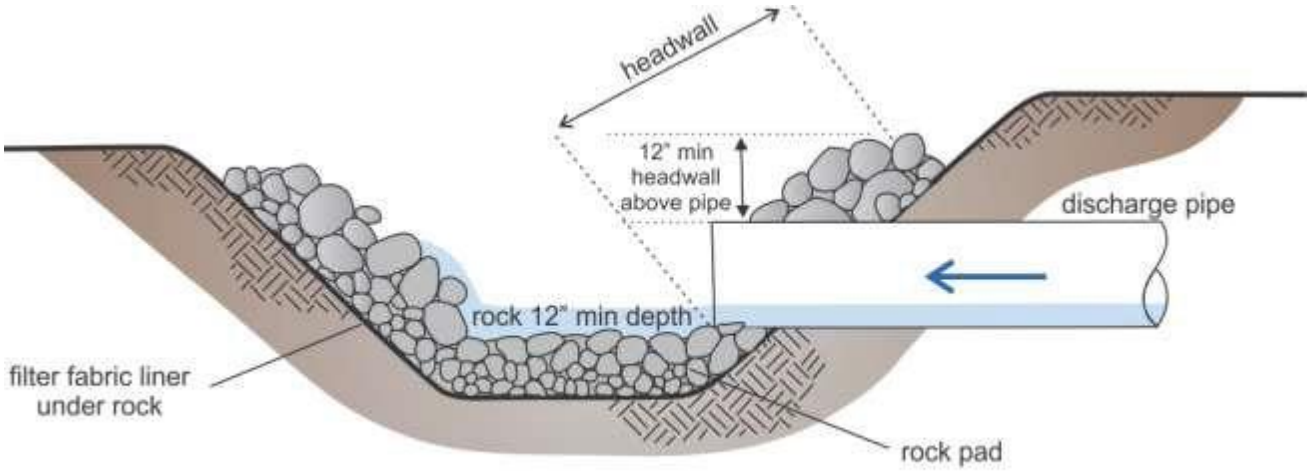
Rock Energy Dissipation Pad and Headwall



SECTION A-A VIEW



SECTION B-B



SECTION C-C (ALTERNATIVE) VIEW

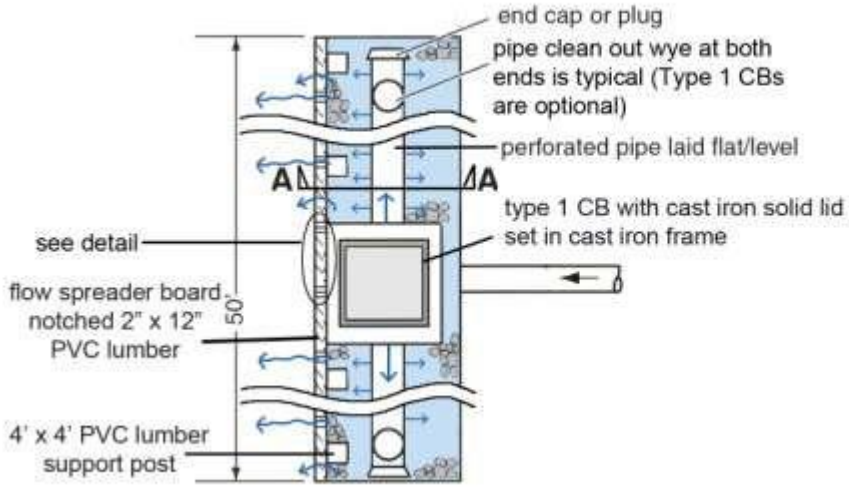
Rock Energy Dissipation Pad and Headwall

16”-20” QUARRY SPALL HEAD WALL AND ENERGY DISSIPATER PAD

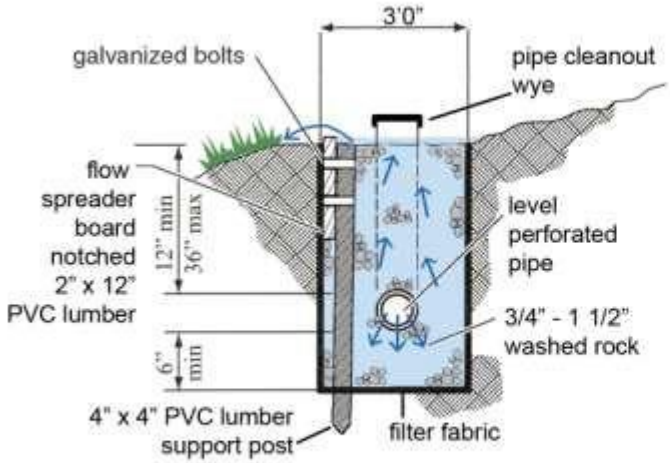
8”-12” QUARRY SPALL HEAD WALL AND ENERGY DISSIPATER PAD

12”-16” QUARRY SPALL HEAD WALL

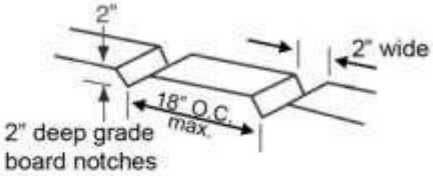
4”-6” QUARRY SPALLS



BIRD'S-EYE VIEW



SECTION A-A



FLOW SPREAD BOARD NOTCH DETAIL

NOTES:

1. Perforated pipe and flow spreader board must be level.
2. Type 1 catch basin top of grate frame not to be higher than top of 2" x 12" level spreader bar.
3. Support post spacing as required by soil conditions to ensure spreader board remains level.

Slope Drain Diffuser Tee

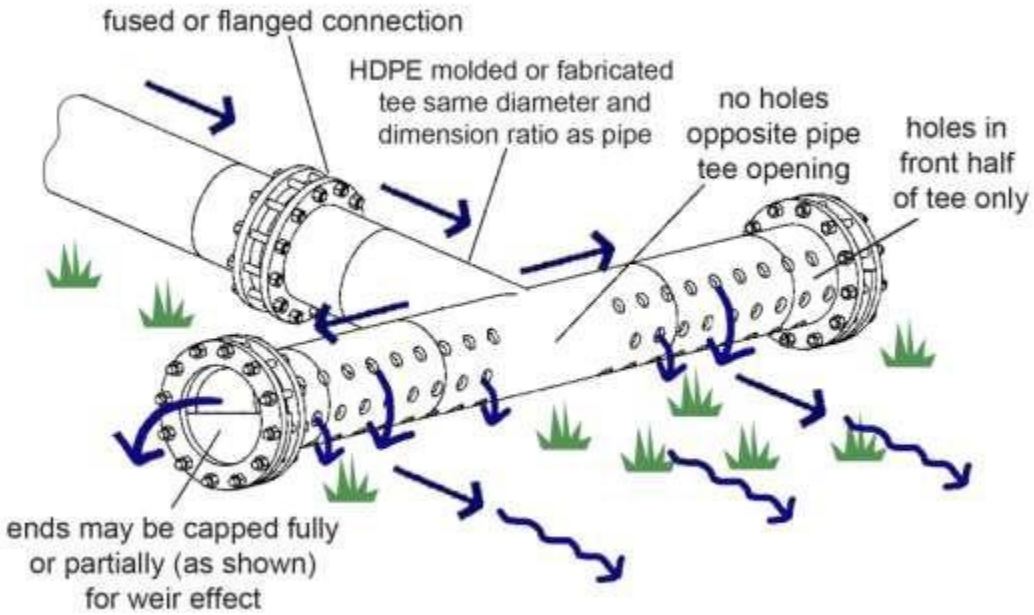


TABLE 4 ENERGY DISSIPATER INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Rock Splash Pad	Missing or moved rock	• Only one layer of rock exists above native soil sub-grade in area five square feet or larger, or any exposure of native soil. Structure dissipating flow deteriorates to 1/2 of original size or any concentrated worn spot exceeding one square foot which would make structure unsound.	• Rock armoring replaced. Splash pad is restored to full length, width and depth.
	Erosion	• Soil erosion in or adjacent to rock pad.	• Rock pad replaced.
Dispersion Trench	Not discharging water properly	• Water discharging at a few concentrated points along lip of trench rather than flowing uniformity along the entire length of trench lip.	• Trench redesigned and/or rebuilt.
	Pipe clogged with sediment	• Accumulated sediment and debris exceed 20% of design depth.	• Accumulation removed, and clogging eliminated
	"Distributor" **Catch Basin** overflows	• Water flowing out of top of basin during any storm less than the design storm indicating trench or perforated pipe is clogged or basin outlets are plugged.	• Facility redesigned and/or rebuilt.
	Receiving area over-saturated	• Water in receiving area is causing or has potential of causing landslide problems.	• No danger of landslides.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Rock Gabion Structures	All or portion of metal wire basket matrix deteriorated or broken. Rocks may be missing.	• Deterioration determined to be near to breaking. Broken wire results in holes large enough to allow rocks to fall out of basket. Basket has collapsed.	• Basket rewired or replaced. • Rocks replaced as necessary.
Rock Gabion Structures	Metal wire baskets misaligned	• Baskets have shifted and no longer providing full energy dissipation or may be prone to tipping or collapse.	• Realign or relocate as necessary.

Flow Control Structure

What is a Flow Control Structure?

Flow Control Structures (FCS) are the most critical component of the many types of stormwater facilities that collect and remove pollutants (see list below). Their function is to:

- Regulate the volume of stormwater flowing out of a facility to prevent flooding and/or destruction of property and stream habitat; or
- Split off a portion of flow in a conveyance system (pipe or ditch) so that amount will bypass an area to avoid flooding it and/or avoid disrupting the effectiveness of a downstream detention or pollutant reduction treatment facility.

It is crucial that the flow of stormwater is always released at the engineered design rate.

Typical Flow Control Structure Design

In Duvall the most commonly utilized Flow Control Structure is the Standpipe Flow Control Structure**.** The housing is a Type 2 Catch Basin (CB) which contains the vertical metal standpipe apparatus, secured to the interior face of the CB wall with metals straps (See photos and details below).

There is also a Weir Flow Control Structure which is relatively common, but mostly used in detention ponds built in the 1980s and 90s. The weir is a concrete wall set in a pond's perimeter berm (functions as a dam) with a notch precisely formed at the top to release stormwater runoff at a specific rate. The shape of a "notch" is either, rectangular with one or more steps narrowing from top to bottom or a "V". The shape of the notch affects the flow rates. The choice of shape is a site-specific engineering consideration for how best to control the rate of flow leaving a stormwater facility. (See photos and details below).

Location of Flow Control Structures

Location is critical for efficient flow regulation and passage downstream as well as for maintenance accessibility. For a facility like a pond, they are generally located at the "downstream end" of a pond, which is the point where flow from the pond will most effectively merge with the natural or man-made receiving water body downstream. The control structure can be located on top of the berm damming the water or on either the interior (inside the water impoundment area) or exterior side slope of the berm.

- A concrete weir structure can only be located at the top of the berm.
- In the case of an underground detention vault or pipe, the flow control structure is located at the "downstream end" and is outside of the vault or pipe.
- Some vaults, especially those installed in the 1980s and 90s have the Flow Control Standpipe located inside the Vault. For the underground large sized Detention Pipe, the structure is separated by a Pipe of smaller diameter (usually 36"), from the Detention Pipe at the "downstream" end.

Common Maintenance Needs

Lack of maintenance is the chief factor contributing to flow disruption, often resulting in downstream flooding which can cause property damage and destruction of fish and wildlife habitat.

Flooding is usually the result of stormwater runoff backing up and overflowing a facility. This backup is typically due to a plugged or broken flow control device, thereby allowing the flow out of a facility to greatly exceed the design flow rate.

The usual culprits for plugging are floating debris and trash such as vegetation, plastic bags, tennis or soccer balls which can cover or partially block the flow. Sediment may also build up in the bottom of the Control Structure whereby the flow control device becomes fully or partially buried.

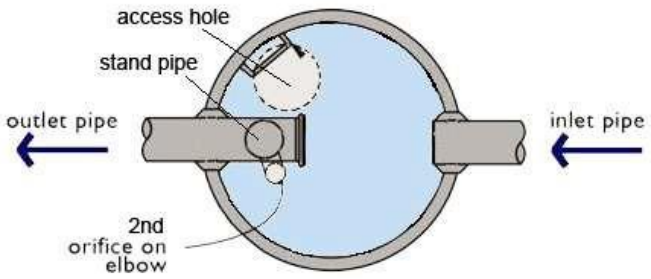
If a Flow Control Structure appears to be malfunctioning, the Duvall Public Works (PW) Department should be notified as soon as possible so that the structure can be inspected promptly.

If any immediate maintenance, repair or replacement is necessary, the County requires that the owner of the facility complete the necessary work within 30 days of receiving notification from PW documenting the nature of the problem and what work needs to be done.

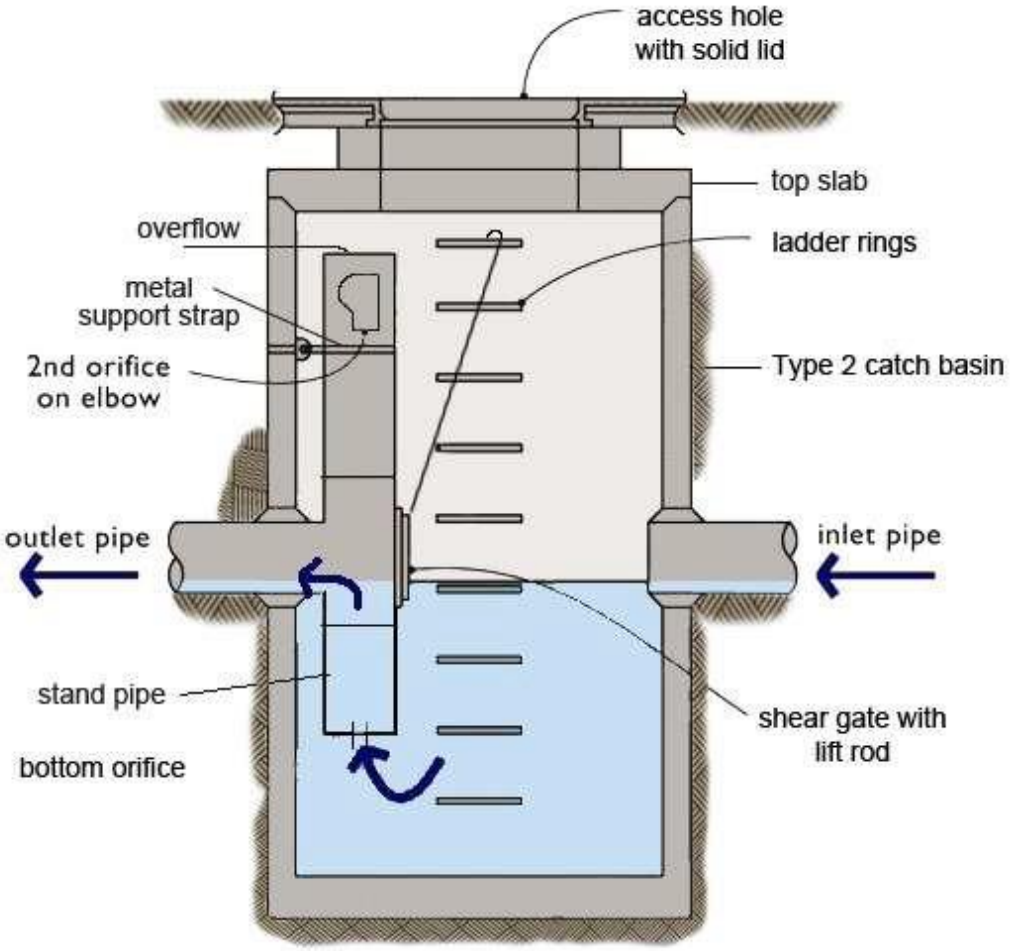
Facilities typically associated with a control structure/flow restrictor include:

- Detention Pond
- Detention Vault
- Detention Pipe (Tank)
- Proprietary Media Filter Vault
- Conveyance Pipe (bypass)
- Biofiltration Swale
- Constructed Wetland
- Wet Pond
- Wet Pond w/detention
- Wet Vault
- Wet Vault w/detention

FROP-T (Standpipe) Control Structure



BIRD'S-EYE VIEW
(top slab removed)



SECTION VIEW

TYPICAL LOCATION OF A TYPE 2 CATCH BASIN WITH FROP-T CONTROL STRUCTURE FOR A STORMWATER POND

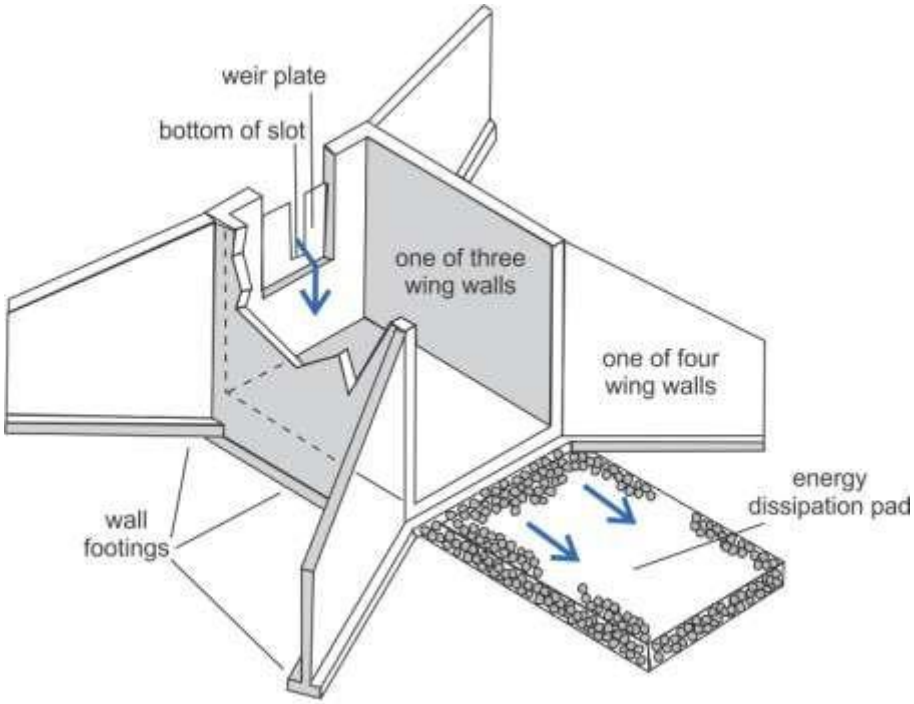
VIEW FROM OPEN ROUND ACCESS LID SHOWING THE FROP-T WITH ORIFICE ELBOW AND SHEAR GATE AND LIFT ROD

VIEW FROM RECTANGULAR ACCESS LID SHOWING THE LADDER, FROP-T WITH ORIFICE ELBOW, AND SHEAR GATE AND LIFT ROD

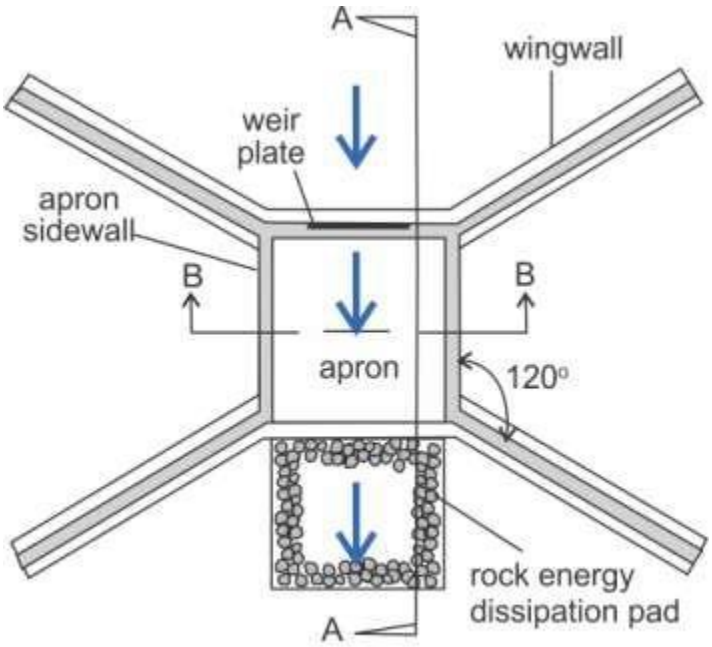
TYPE 2 CATCH BASIN FROP-T WITH DEBRIS (TREE LIMBS AND FIR NEEDLES)

TYPE 2 CATCH BASIN FROP-T WITH DEBRIS (PAPER, PLASTIC CUPS, AND CONTAINERS)

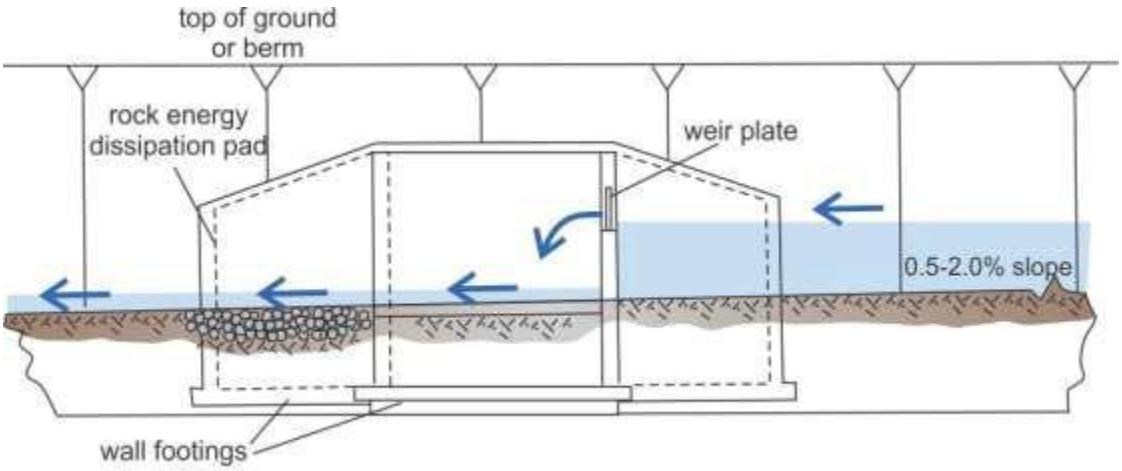
FROP-T CONTROL STRUCTURE. NOTE: HOLE IN THE BOTTOM OF THE FROP-T IS THE FLOW CONTROL ORIFICE



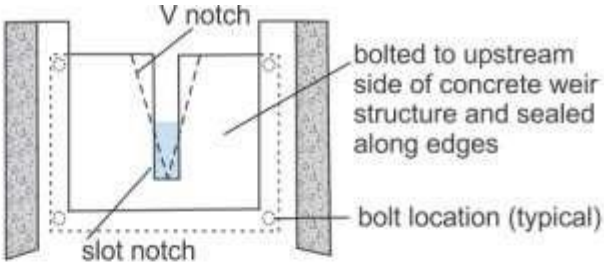
3-Dimensional View



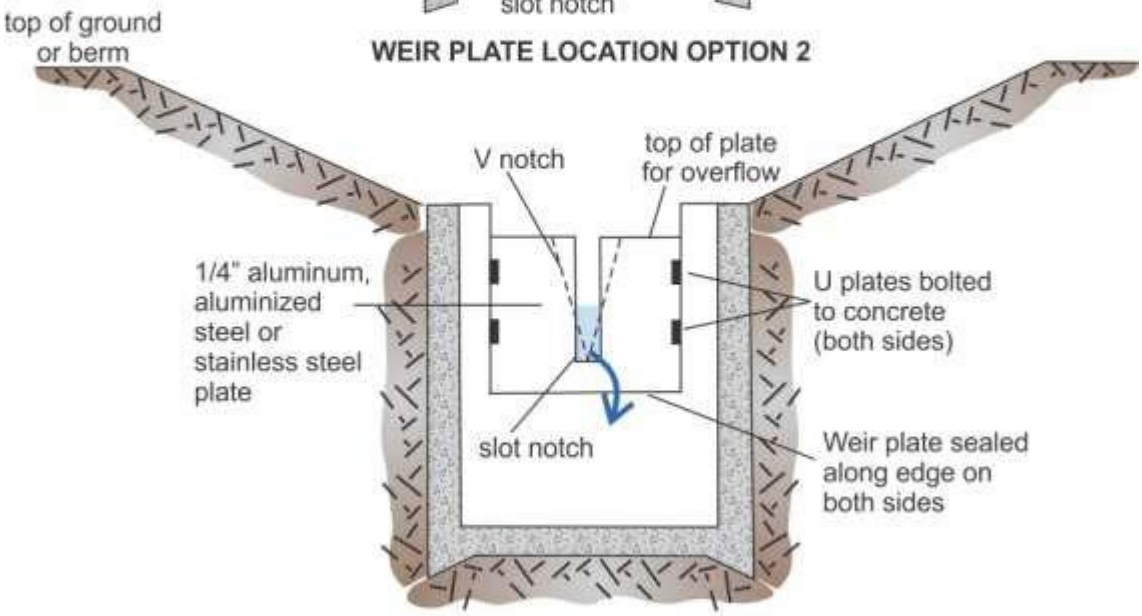
BIRD'S-EYE VIEW



SECTION A-A VIEW



WEIR PLATE LOCATION OPTION 2



WEIR PLATE LOCATION OPTION 1

SECTION B-B (ENLARGED)

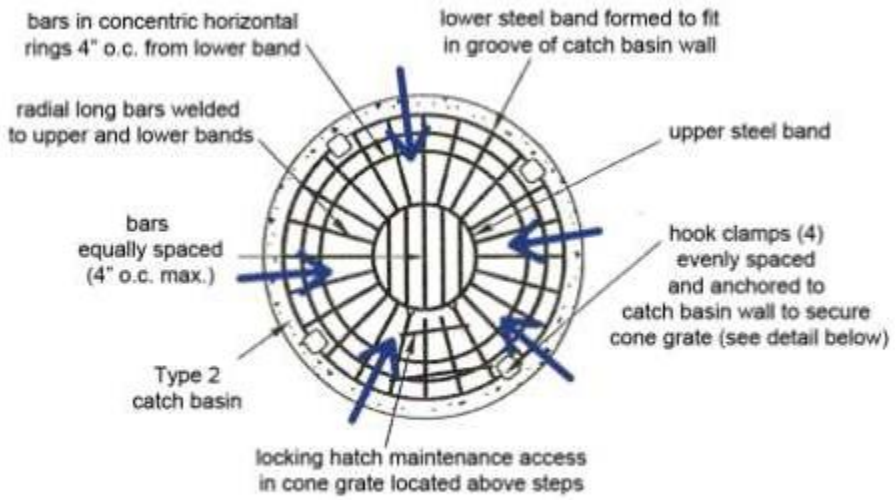
Weir Flow Control Structure

WEIR IS METAL PLATE WITH DEEP RECTANGULAR NOTCH

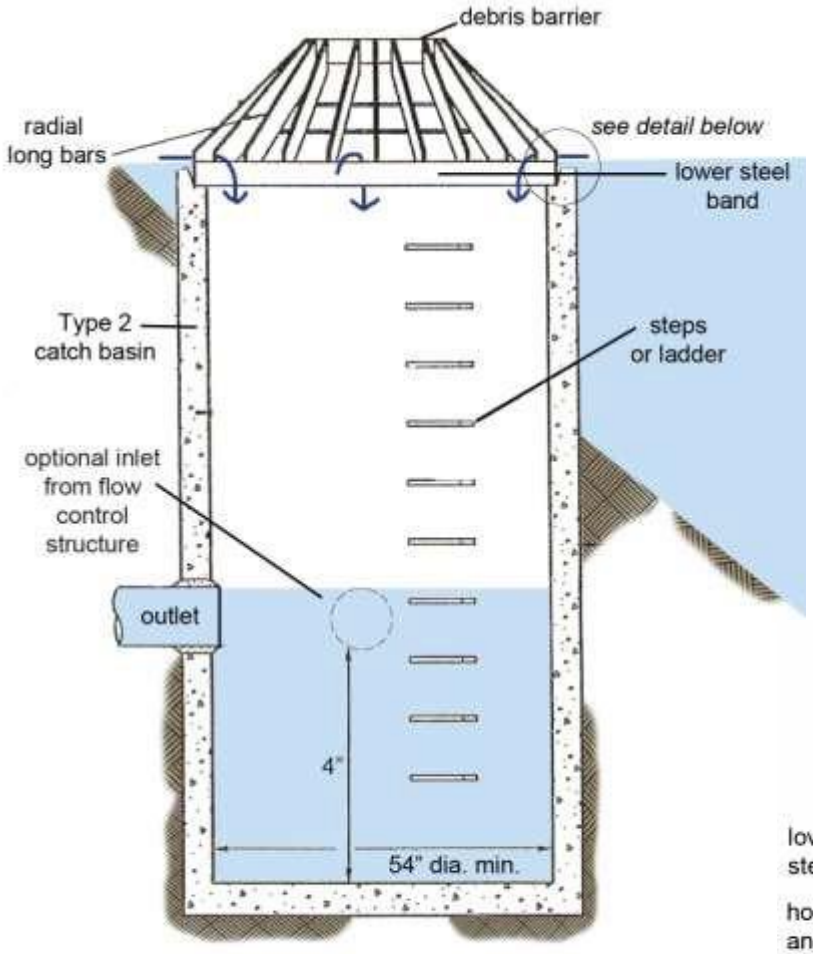
WEIR IS A METAL PLATE WITH A COMBINATION OF A LOWER "V" NOTCH AND UPPER WIDE RECTANGULAR NOTCH

WEIR IS A "V" NOTCH IN A CONCRETE WALL

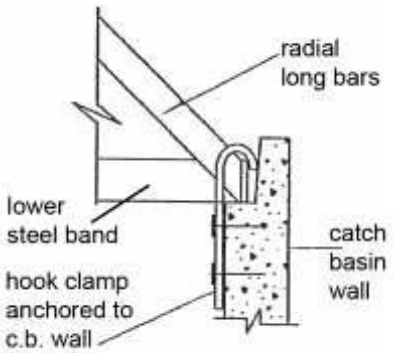
Type 2 Catch Basin Pond Overflow Structure



BIRD'S-EYE VIEW



SECTION VIEW



DETAIL

TABLE 5 FLOW CONTROL STRUCTURE INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
FROP-T (Standpipe)	Structural damage	• Structure is not securely attached to **Catch Basin** or **Vault** wall.	• Structure securely attached to wall and outlet **Pipe**.
		• Structure is not in upright position (allow up to 10% from plumb).	• Structure in correct position.
		• Connections to outlet **Pipe** are not watertight and show signs of rust.	• Connections to outlet pipe are water tight. • Structure repaired or replaced and works as designed.
		• Any holes, other than designed holes, in the structure.	• Structure has no holes other than designed holes.
		• Any material blocking or having the potential of blocking the **Pipe** overflow.	• Top of pipe overflow is free of all obstructions and works as designed.
Cleanout Gate	Damaged or missing	• Cleanout gate is not watertight or is missing.	• Gate is watertight and works as designed.
		• Gate cannot be moved up and down by one maintenance person.	• Gate moves up and down easily and is watertight.
		• Chain/rod leading to gate is missing or damaged.	• Chain is in place and works as designed.
		• Gate is rusted over 50% of its surface area.	• Gate is repaired or replaced to meet design standards.
FROP-T Orifice Plate & Orifice Elbows.	Damaged or missing	• Control device is not working properly due to missing, out of place, or bent orifice plate.	• Plate is in place and works as designed.
Weir Plate	Obstructions	• Any trash, debris, sediment, or vegetation blocking the plate.	• Plate is free of all obstructions and works as designed.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Type 2 Catch Basin	All potential defects	• See Catch Basin.	
Weir Walls (other than Type 2 Catch Basin **wall)**	All potential defects	• See Detention Vault Walls	
Top Conical Debris Barrier	All potential defects	• See Conical Debris Barrier & Type 2 Catch Basin Pond Overflow Structure	

ATTENTION: A Type 2 Catch Basin Flow Control Structure is considered an enclosed space where harmful chemicals and gasses can collect. Therefore, the inspection and maintenance of these facilities should be conducted by individuals trained and certified to work in confined spaces under hazardous conditions.

Chapter 4 Stormwater Conveyance

Drainage Pipe

What is Drainage Pipe?

Storm Drainage Pipes are an alternative to open ditches or grass-lined swales for conveying storm water runoff.

- Most drainage pipes are installed underground as part of a drainage network connected by catch basins for sending runoff to an engineered collection facility or to a natural receiving water such as a stream.
- Culverts are also drainage pipe but are generally short runs of pipe open at both ends and typically associated with connecting ditches between driveways and stream crossings under roads.

Other aspects to conveying storm water runoff through Drainage Pipe which has been fabricated with perforations:

- Discharging runoff directly into the ground through the perforated pipe bedded in a gravel filled trench (i.e., Infiltration Trench) so that the water will infiltrate through the soil to remove pollutants,
- Discharging runoff through perforated pipe as sheet flow over the ground surface to a body of water, and;
- Collecting excess surface and ground water in perforated pipe bedded in a gravel filled trench (i.e., French Drain) to direct it away from buildings or soggy ground and to be discharged to an approved site.

Another very important utilization of Drainage Pipe is for the temporary storage of runoff in large diameter pipes (See Detention Pipe).

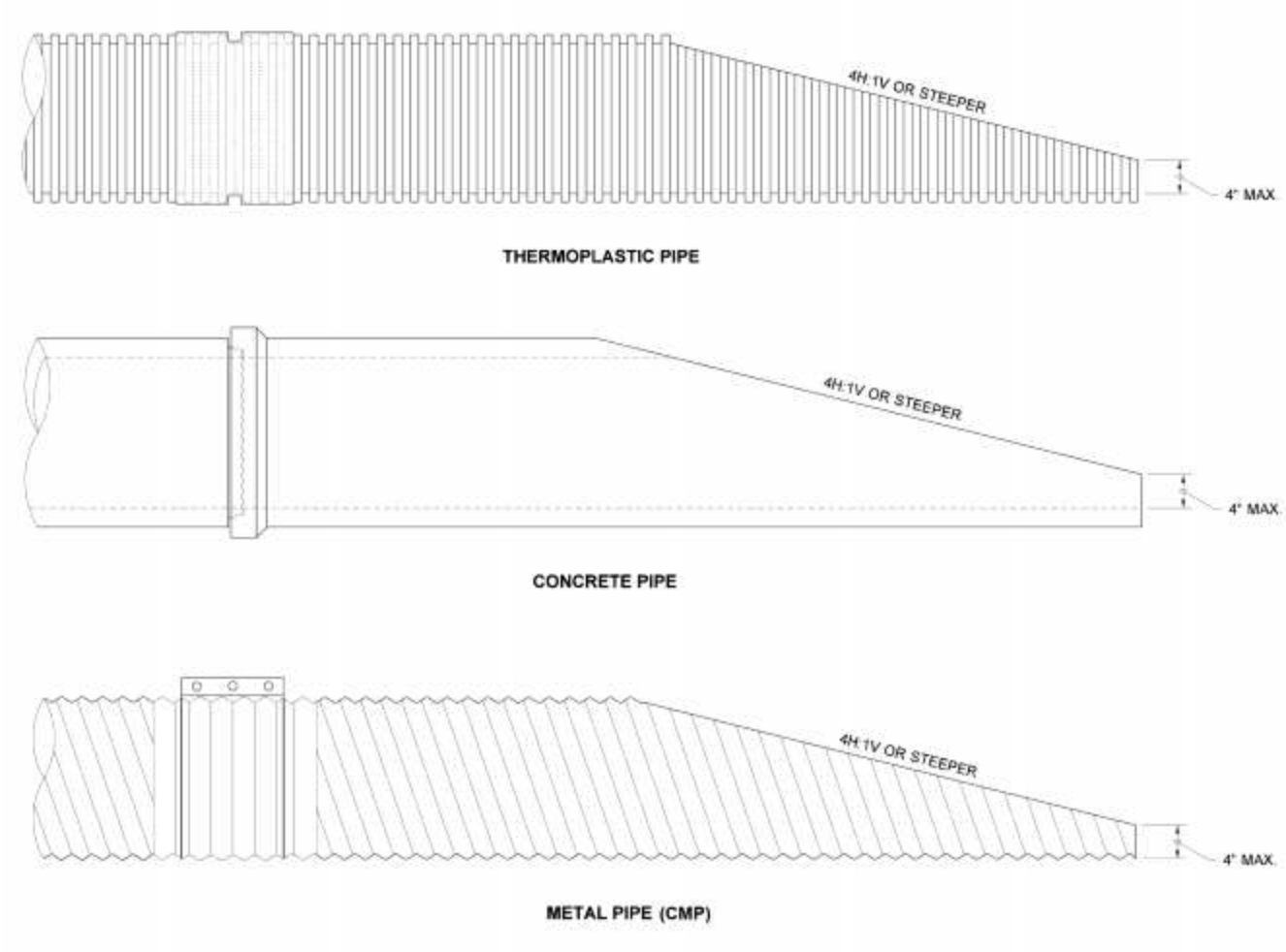
Cleaning Drainage Pipe

Pipes are usually cleaned by a heavy-duty vac-truck (see Catch Basins) to remove flow blockages caused by sediment, trash, debris, roots, or vegetation accumulation either in a pipe or a catch basin.

- It is important that the pipe network is clear of anything that would inhibit a vac-truck equipment from entering the pipe to clean it out (See Catch Basin). Stormwater pipes must be clear of obstructions and not have structural defects (such as warps, cave-ins, penetrating cracks, holes, or breaks at pipe joints to prevent water leakage. Both obstructions and structural defects could result in localized soil saturation, erosion, sink holes or flooding.
- If the blockage cannot be removed by pressure washing and vacuuming or by hand, then the pipe should be inspected by mobile closed-circuit TV (CCTV) to determine the extent and nature of the blockage. This will also help determine whether to continue with standard maintenance procedures, or repair or replace the pipe segment to solve the problem.

CAUTION: A Storm Drain Pipe connected to a Catch Basin is considered an enclosed space where harmful chemicals and gasses can collect. Therefore, the inspection and maintenance of such Drain Pipe connected to Catch Basins should be conducted only by individuals trained and certified to work in confined spaces under hazardous conditions.

Types of Storm Drainage Pipe



CLEAN CORRUGATED METAL PIPE (CMP) WITH SOME CAKED SEDIMENT STICKING ABOVE NORMAL FLOW ZONE

CLEAN CMP WITH SOME RUSTING AND SCALING IN THE NORMAL FLOW ZONE

TABLE 6 DRAINAGE PIPE INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not
Pipe	Root obstruction	• Root enters or deforms pipe, reducing flow.	• Roots removed by mechanical methods **NOTE**: The use of approved root-dissolving chemicals requires notification to the Public Works Department.
	Dented or broken	• Inlet/outlet Pipe damaged or broken and needs repair.	• Pipe repaired and/or replaced.
	Rusted or deteriorated	• Any part of the Pipe that is crushed or deformed more than 20% or any other failure to the pipe.	• Pipe repaired and/or replaced.
	Excessive accumulation of trash, debris, sediment and vegetation	• Depth is greater than 20% of pipe diameter.	• Trash, debris, sediment and vegetation accumulation removed.
	Debris Barrier/Trash Rack missing	• Pipe, other than road/driveway cross culverts not connected to Catch Basins, greater than 18-inch diameter need Debris Barriers**.**	• Missing Debris Barriers replaced on 18" diameter or larger Pipe ends other than culverts.
	Joint/seal separated, cracked, or broken	• Separation or crack wider than 1/2 inch and longer than 1 foot; or any evidence of soil particles entering pipe through cracks.	• Joint/seal is repaired or replaced. If necessary, one or both pipes replaced.

Debris Barrier (Trash Rack)

What is a Debris Barrier?

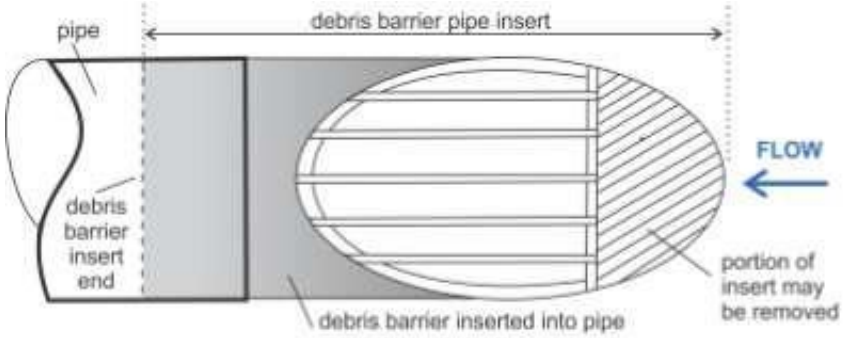
A Debris Barrier (DB) is a metal bar grate over the intake end of a storm drainage conveyance pipe. The purpose for such a barrier is to prevent man-made and vegetative debris from clogging or plugging a closed pipe system. It also provides a deterrent for keeping animals and people from entering them.

- Debris Barrier have historically been installed on:
  - Upstream (intake) end of pipe 18" in diameter or greater
  - Occasionally on the downstream (outlet) end.
- Debris Barrier are required on all opened ended pipe, other than culverts, that are 18" in diameter or greater.
- Culverts are generally associated with:
  - Driveway crossings of roadside ditches
  - Roads crossings of streams.

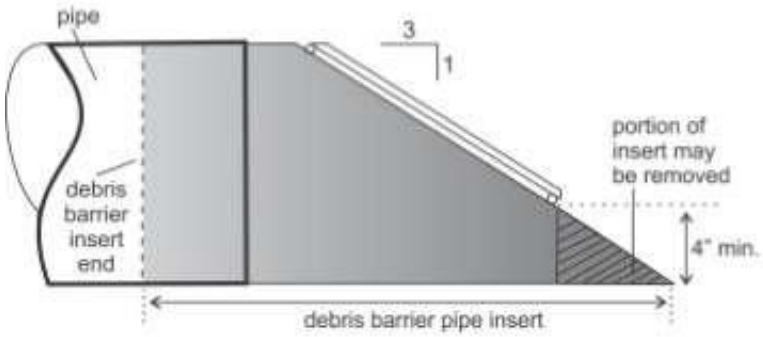
Common Maintenance Needs

The primary concern with Debris Barriers is excessive debris and sediment accumulation clogging the rack causing water to backup causing flooding damage to downstream roadways, property, and fish and wildlife habitat. Preventing clogging requires on-going and frequent maintenance.

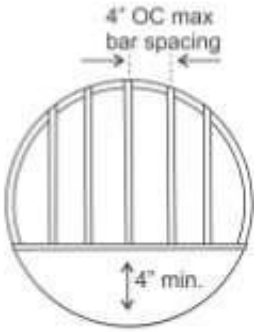
Horizontal Debris Barrier



BIRD'S-EYE VIEW



PROFILE VIEW



END VIEW

Horizontal Debris Barrier

HORIZONTAL ALUMINUM DEBRIS BARRIER

HORIZONTAL ALUMINUM DEBRIS BARRIER WITH BENT BAR NEEDING REPAIR

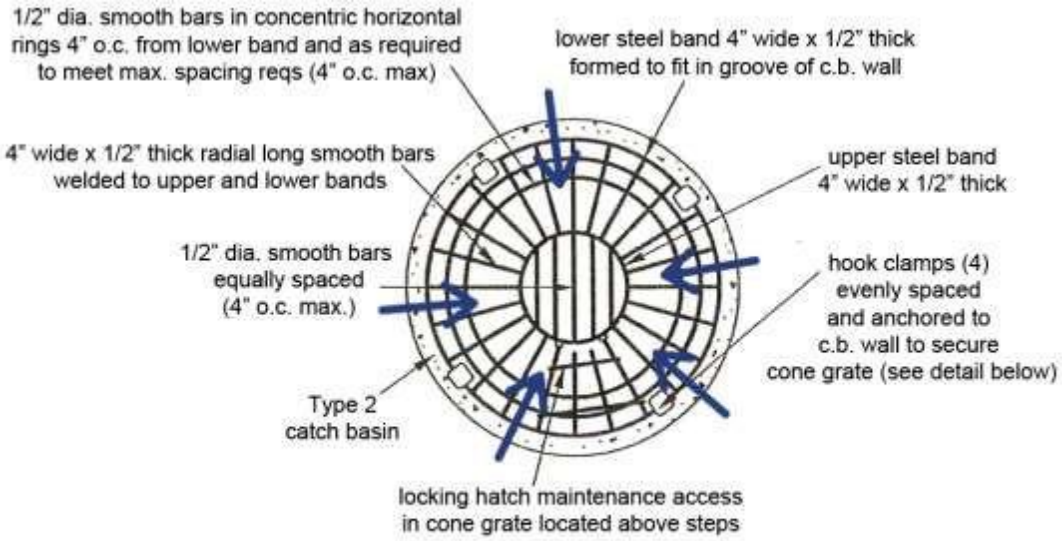
HORIZONTAL ALUMINUM DEBRIS BARRIER

HORIZONTAL ALUMINUM DEBRIS BARRIER WITH METAL FLARED END SIDE WALLS AND BOTTOM FLOW PAD

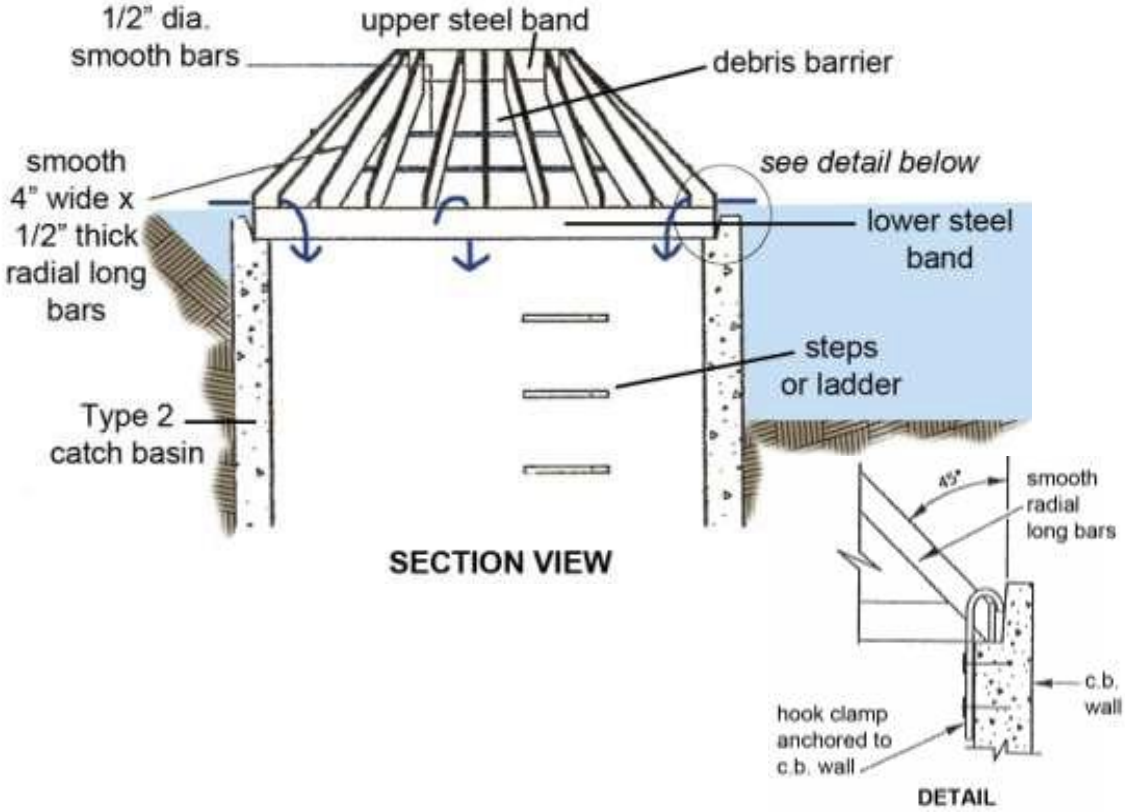
HORIZONTAL ALUMINUM DEBRIS BARRIER PARTIALLY CLOGGED WITH ALGAE

HORIZONTAL ALUMINUM DEBRIS BARRIER WITH BARS COVERED WITH LEAF AND TWIG DEBRIS, BUT WATER FLOWING BELOW THE BARRIER

Vertical Debris Barrier



BIRD'S-EYE VIEW



SECTION VIEW

DETAIL

Common Vertical Debris Barriers

STORMWATER POND TYPE 2 CATCH BASIN OVERFLOW

STRUCTURE WITH VERTICAL CONICAL GALVANIZED STEEL DEBRIS BARRIER

STORMWATER POND OVERFLOW STRUCTURE WITH VERTICAL "TOP HAT" ALUMINUM DEBRIS BARRIER SET IN "PEA" GRAVEL FILTRATION CONE

STORMWATER POND WITH TYPE 1 CATCH BASIN WITH GALVANIZED STEEL "BEE HIVE" DEBRIS BARRIER

TABLE 7 DEBRIS BARRIER INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not
Debris Barrier	Trash, sediment and vegetation accumulation	• More than 20% of the barrier obstructed.	• Obstruction removed.
	Damaged or missing bars.	• Bars bent out of shape more than 3 inches.	• Bars no more than 3/4 inch out of alignment.
		• Bars missing or entire barrier missing.	• Bars in place.
		• Bars loose and rust causing 50% deterioration to any part of barrier.	• Bars repaired or replaced. • Barrier replaced if necessary.
	Pipe ends	• Debris Barrier missing or not attached to pipe. **Replace immediately**.	• Barrier replaced and/or firmly attached to pipe.

Stormwater Facility Discharge Point (Outfall)

What is a Stormwater Facility Discharge Point?

A Stormwater Facility Discharge Point is the location where runoff flows from a facility's outfall merges with either a natural or man-made receiving water.

- The Outfall may be as distinct as a single Pipe with an Energy Dissipater
- It could be less distinguishable, such as:
  - A single pipe outlet to an underground infiltration trench
  - Infiltration Pond with no flow outlet except seepage through the bottom of the Pond down to groundwater

TABLE 8 DISCHARGE POINT (OUTFALL) INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Pipe or Ditch/Swale Outfall	Obvious signs of pollutants being discharged to receiving water body	• For typical pollutants such as gasoline, oil, herbicides, pesticides and fertilizer: Identify & remove source and/or report to Public Works **For Hazardous Material call 911 and Public Works**	• Typical pollutants and/or hazardous material eliminated or reduced. **NOTE**: If the source cannot be eliminated, the outfall will be monitored, and on-going action will be taken by Public Works or the Washington State Department of Ecology.
	Soils in and around receiving area are saturated	• Water in receiving area is causing soils to become saturated and unstable.	• Receiving area solids are stable.
	Off-site bank erosion upstream and/or downstream	• Erosion in ditch or stream banks due to flow channelization, or higher flows. • NOTE: Report to Public Works for Evaluation	• Ditch or stream banks stable.
Energy Dissipater	Trash, debris, sediment or vegetation accumulation	• More than 10% of energy dissipater pad surface is covered, and or accumulation depth is greater than 20% of the outlet pipe diameter.	• No blockage or clogging of pad surface

Detention Pond

What is a Detention Pond?

A stormwater Detention Pond is a constructed open earthen basin which temporarily stores stormwater runoff originating from impervious surfaces such as streets, sidewalks, driveways, parking lots and roofs. The runoff is conveyed to a Detention Pond either by a pipe system, ranging in diameter from 8" to 30", or combined drainage ditch and pipe system. The pond is either fully dug out of the ground, or partially dug out with the remainder of the basin's perimeter formed by a compacted earthen berm (embankment) which functions as a dam. There are some Detention Ponds with walls completely or partially constructed of poured-in-place concrete, concrete blocks or large quarry rock. Detention Ponds are usually located at the lowest spot possible on a site and as close as possible to either a natural receiving water body (stream, wetland, lake or Puget Sound) or an engineered drainage system.

How does a Detention Pond work?

A Detention Pond temporarily stores runoff and slowly discharges the runoff through a Flow Control Structure outlet. The flow out of a pond is regulated (restricted) to prevent damage to downstream property damage and fish/wildlife habitat. Detention Ponds are designed to completely drain whatever amount of runoff is stored up over several days after a storm event has lessened considerably or ceased.

Typical Detention Pond designs

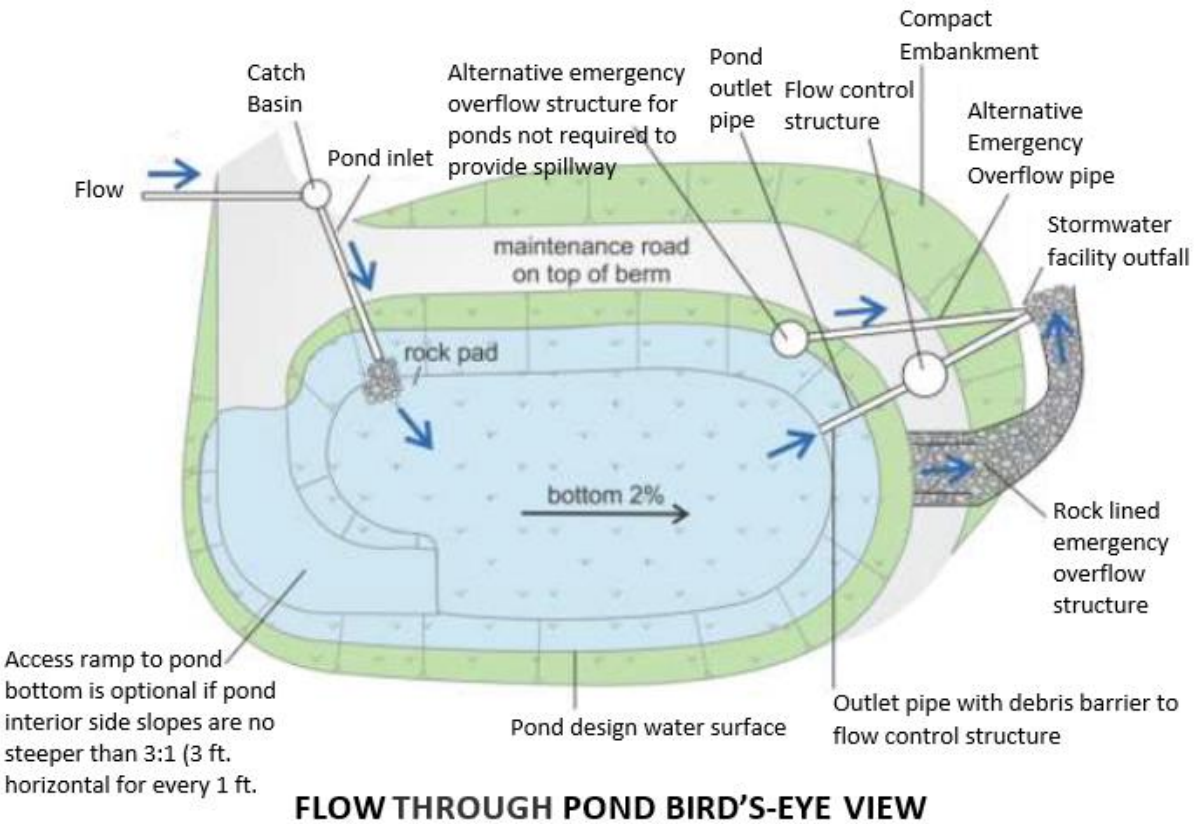
The "Flow Through" Pond is the simplest design and most utilized throughout the area. Stormwater runoff flows in one end of the pond and flows out the other through the Flow Control Structure. (See "Flow Through" Pond drawing).

The other type is a "Backup" Pond. Backup Ponds were common from the 1970s through the 1980s. It is still utilized when site conditions warrant it, but only as an alternative to the "flow through" pond. This is designed for runoff to both enter and exit the pond through the Flow Control Structure. Stormwater will bypass the pond until the volume is great enough, due to the increased intensity of a storm that the flow can no longer just go out the outlet pipe from the Flow Control Structure. The runoff is forced to also enter (be backed up) into the pipe from the Flow Control Structure to the pond to be stored (detained) until the storm subsides. As the storm subsides and the flow volume decreases, the runoff stored in the pond is released back to the Flow Control Structure and the outlet pipe. (See drawing below – "Backup Detention Pond).

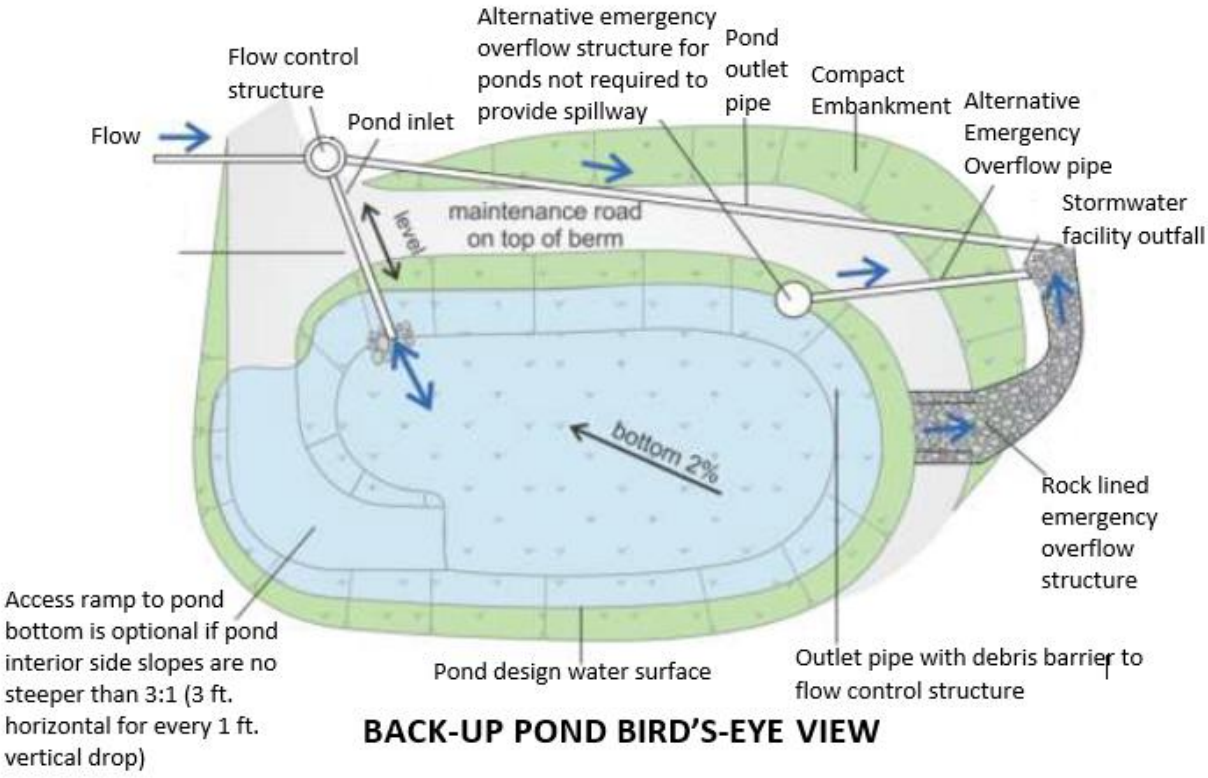
Ponds can vary greatly in size, shape, depth, as well as appearance which can range from little or no vegetation to well-manicured or the natural look garnished with native vegetation. Generally, a more natural-appearing pond with native vegetation is preferred for reduced maintenance purposes and enhanced wildlife habitat. Some facilities are even designed to appear as natural water bodies or are set in park-like settings.

Common Maintenance Needs

Over time, ponds accumulate a sufficient amount of sediment, trash, and vegetative debris that reduce the pond's storage capacity. When storage capacity becomes unacceptably compromised, the accumulation will need to be removed to prevent pond and pipe system clogging.



FLOW THROUGH POND BIRD'S-EYE VIEW



BACK-UP POND BIRD'S-EYE VIEW

POND WITH WALL MADE OF GABION BASKET (WIRE MESH RECTANGULAR BASKETS FILLED WITH ROCK CHUNKS)

POND WITH WALL MADE OF GABION BASKET (WIRE MESH RECTANGULAR BASKETS FILLED WITH ROCK CHUNKS)

TABLE 9 DETENTION POND INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
General Site Conditions Surrounding Pond	Trash and debris accumulation	• Site generally littered with trash & debris.	• Trash and debris removed.
		• Evidence of dumping.	• Neighbors notified that dumping is prohibited. • "No dumping" signs installed.
	Poisonous vegetation and noxious weeds	• Poisonous or nuisance vegetation constituting a hazard to maintenance personnel or the public. **NOTE**: Evidence of noxious weeds as defined by the King County Noxious Weed Control Board requires eradication based on the Board's recommendation of Herbicide application or mechanical means.	• Poisonous vegetation eradicated on site. **NOTE**: Complete eradication of noxious weeds may not be possible. Compliance with State and County Noxious Weed Control Boards is required.
	Contaminants and pollutants	• Any evidence of oil, gasoline, contaminants or other pollutants in or near the pond area. **For hazardous material, call Public Works.**	• No contaminants or pollutants present.
	Beaver dams	• Dammed up Flow Control Structure either in pond or downstream of facility results in change of facility function. **NOTE**: Coordinate trapping of beavers and removal of dams with appropriate state and county permitting agencies.	• Facility is fully functional.
	Rodent holes	Evidence of rodent holes on site, but not in pond area.	• Rodents eliminated.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Surrounding Pond	Insects	• Insects such as wasps and hornets interfere with maintenance activities. **NOTE**: Apply insecticides in compliance with manufacturer's directions.	• Insects eliminated.
	Tree growth and hazard trees	• Specific trees hinder maintenance access or interfere with maintenance activity (i.e., slope mowing, silt removal, vactoring or equipment movements).	• Only Trees hindering maintenance activity removed.
		• Hazard trees (dead, diseased, or dying) are identified. **NOTE**: A certified arborist should be consulted to determine health of tree or removal requirements.	• Hazard trees removed. • NOTE: Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood).
	Erosion	• Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.	• Slopes stabilized using appropriate erosion control measures; e.g., rock reinforcement, planting of grass, compaction.
Pond Side Slopes (natural or excavated)	Tree growth	• Trees growing below pond Emergency Overflow elevation subject to blowing over, uprooting the root wad due to water saturated soil. An exposed wad and hole in left in the soil can be a major source of continued erosion.	• Trees removed. • Roots removed as necessary.
	Erosion	• Eroded damage over 2-inches deep where cause of damage is still present or where there is potential for continued erosion.	• Slopes stabilized using appropriate erosion control measures; e.g., rock reinforcement, planting of grass, compaction.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Pond Perimeter Concrete Walls	Cracks, holes, scaling or exposed steel structural reinforcement bars (rebar)	• Professional inspection determines that wall(s) is not structurally sound, or leaks are present.	• Wall(s) repaired and structurally sound or replaced.
Pond Bottom (floor)	Excessive sediment	• Accumulation exceeds 10% of the as- built pond depth.	• Sediment accumulation removed to designed depth. • Pond bottom returned to original shape and depth. • If necessary, pond reseeded to control erosion.
	Tree growth	• Trees growing on any portion of pond bottom NOTE: A licensed geotechnical engineer should be consulted to determine if roots need to be removed.	• Trees removed. • Roots removed as necessary.
	Damaged liner (if applicable)	• Fabric or clay liner is visible (12" min. soil cover removed) and has punctures or deep gouges in it.	• Liner repaired or replaced. Liner is fully covered to design depth below pond bottom.
Pond Perimeter Structural Berms (Dams)	Soil Settlement	• A portion of structural berm (compacted earthen embankment) has settled 4 inches lower than the as-built elevation.	• Berm is repaired and returned to as-built elevation.
	Tree Growth	• Trees growing on any portion of pond interior and exterior slopes as well as the top	• Trees removed • Roots removed as necessary. • Slopes stabilized.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Pond Perimeter Structural Berms (Dams)	Piping	• Discernable water flow through a compacted structural berm due to tree roots and/or rodent holes/tunnels, can lead to erosion within a berm and structural failure. **NOTE**: A Geotechnical engineer should be consulted to inspect, evaluate, and recommend a repair solution plan. **NOTE**: If pond volume exceeds 10 acre-feet, coordinate with the Washington State Department of Ecology, Dam Safety Office.	• Piping and erosion eliminated.
Pond Clay or Geotextile Liner	Exposed or damaged	• Portion of liner is visible.	• Liner is covered with minimum 12" compacted soil.
		• Geotextile liner is punctured.	• Puncture(s) repaired, or liner replaced as necessary.
		• Clay liner has deep gouge(s).	• Gouge(s) repaired, or liner replaced as necessary.
Emergency Overflow Spillway	Rock armoring missing	• Rock layer on sub-grade is less than 1.0' deep and sub-grade is exposed.	• Rock depth restored to design depth of 1.0'.
	Erosion	• Eroded damage over 2-inches deep where cause of damage is still present or where there is potential for continued erosion. **NOTE**: licensed civil engineer should be consulted to inspect, evaluate, and recommend a repair plan.	• Spillway stabilized using appropriate erosion control measure(s); e.g., rock reinforcement or compaction.
Emergency Overflow Structure	All potential defects	• See Type 2 Catch Basin Pond Overflow Structure.	

Detention Vault

What is a Detention Vault?

A Stormwater Detention Vault is a large underground reinforced concrete Structure, which temporarily stores stormwater runoff originating from impervious surfaces such as streets, driveways, sidewalks, parking lots and roofs, through pipes or drainage ditches. The runoff is conveyed to the Detention Vault either by a pipe system ranging in diameter from 8" to 30" or a combined drainage ditch and pipe system. Detention Vaults are typically located at the lowest spot possible on a site and as close as possible to a natural receiving water body (stream, wetland, lake or Puget Sound) or an engineered drainage system.

How does a Detention Vault work?

A Detention Vault temporarily stores runoff during storm events and slowly releases the runoff through a Flow Control Structure outlet. The flow out of a vault is regulated (restricted) to prevent damage to downstream property and fish/wildlife habitat. A Detention Vault is designed to completely drain whatever amount of water is stored within several days after a storm event has lessened considerably or ceased.

Typical Detention Vault designs

The "Flow Through" is the simplest design and most utilized throughout the area. Stormwater runoff flows in one end of the vault and out the other through the Flow Control Structure (See drawing labeled "Flow Through" Detention Vault).

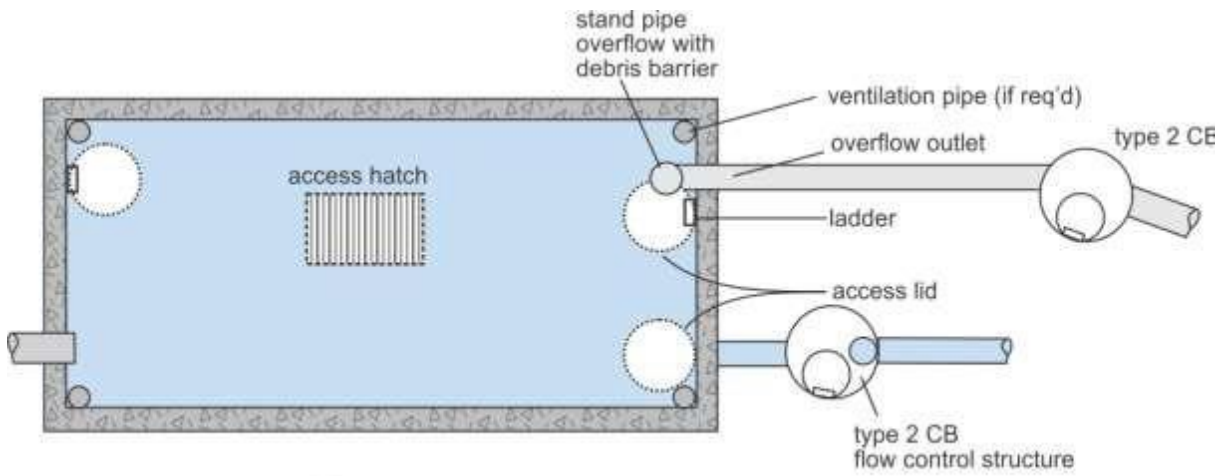
The other type is a "Backup" Vault. It is an alternative to the 'Flow Through," utilized only when conditions warrant it. This is designed for runoff to both enter and exit a vault through the Flow Control Structure. Stormwater will bypass the vault until the volume is great enough, due to the increased intensity of a storm that the flow can no longer just go out the outlet pipe from the Flow Control Structure. It is forced to also enter (be backed up) into the pipe from the Flow Control Structure to the vault to be detained until the storm subsides. As the storm subsides and the flow volume decreases, the runoff stored in the vault is released back to the Flow Control Structure and the outlet pipe (See drawing labeled "Backup Detention Vault).

A Detention Vault is typically utilized at a site that does not have space available for a ground level Detention Pond system such as in:

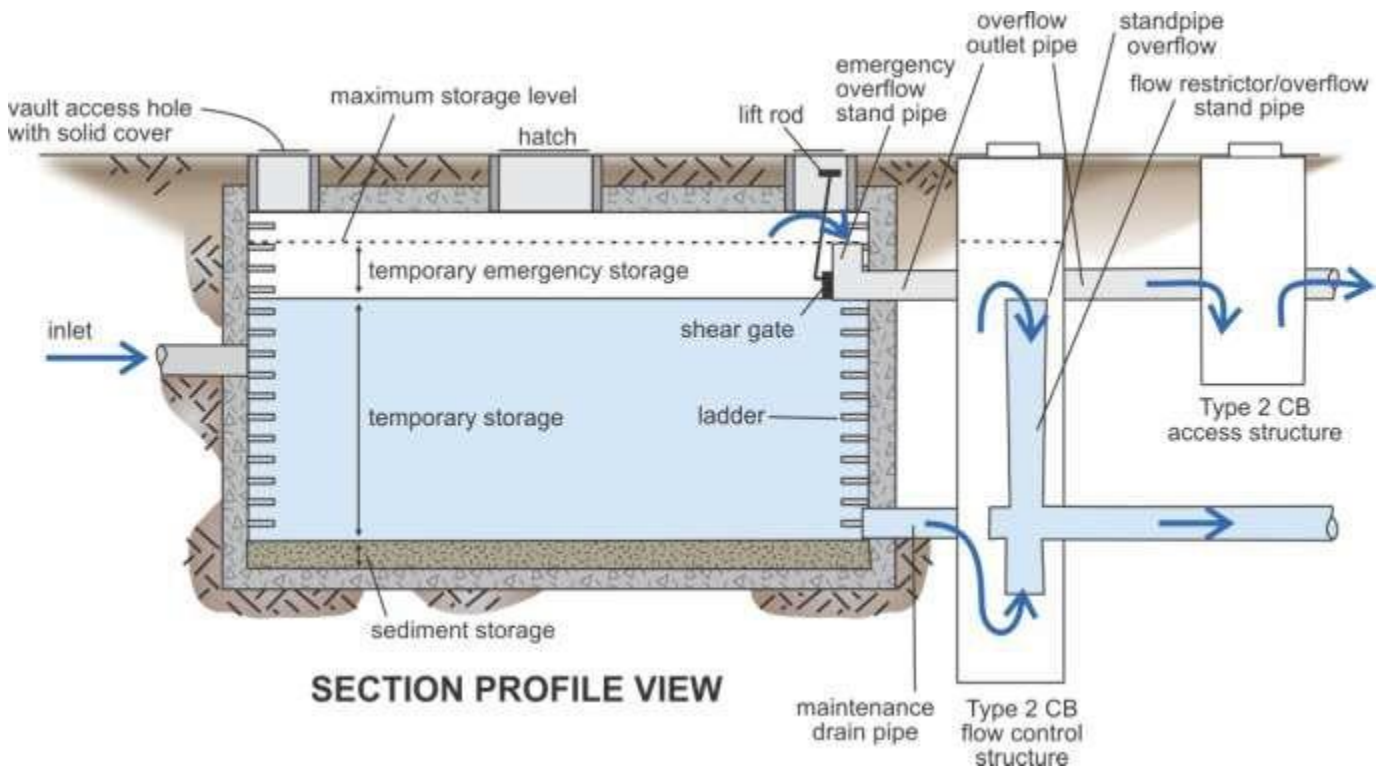
- Commercial projects they are usually installed beneath parking lots and driveways;
- In residential projects (plats) they are located primarily in separate tracts of land dedicated for drainage purposes where a play area/sport court can be installed on top of vault's concrete lid, and occasionally in drainage easements across sides and backs of lots or under private streets.

Common Maintenance Needs

Over time a vault accumulates a sufficient amount of sediment along with vegetation debris and trash, which reduces its storage capacity. When storage capacity becomes unacceptably compromised, the accumulation will need to be removed to prevent pond and pipe system clogging.



BIRD'S-EYE VIEW



SECTION PROFILE VIEW

TABLE 10 DETENTION VAULT INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not
Vault Chamber(s)	Floating debris accumulation	• Any debris accumulated in vault, pipe or inlet/outlet.	• All floating debris removed.
	Sediment and non-floating debris accumulation	• Accumulation on bottom exceeds 6-inches.	• All sediment and debris removed from bottom.
	Plugged or damaged pipes	• Inlet/outlet pipe(s) plugged, damaged or broken and needs repair.	• Pipe unplugged, repaired and/or replaced.
Vault Concrete Lid	Access hole cover damaged/not working or missing	• Cover cannot be opened or removed by an individual. • Missing cover is safety hazard.	• Cover repaired or replaced.
Vault Bottom, Walls & Lid	Cracks, holes, scaling & steel structural reinforcement bars (rebar) exposed	• Professional inspection determines that vault is not structurally sound, or leaks are present.	• Vault repaired and structurally sound or replaced.
		• Cracks wider than ½-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	• Cracks repaired, and no cracks exist wider than ¼-inch.
Baffles	Signs of structural failure	• Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection staff.	• Baffles repaired or replaced to specifications.
Ladder	Unsafe	• Missing rungs. • Not securely attached to basin wall • Misaligned • Rust • Cracks • Sharp edges. **This is a safety hazard**. Replace immediately.	• Ladder is safe. • Repaired to specifications, or • Replaced with OSHA standards compliant ladder.

CAUTION: A Detention Vault is considered an enclosed space where harmful chemicals and gasses can collect. Therefore, the inspection and maintenance of these facilities should be conducted by individuals trained and certified to work in confined spaces under hazardous conditions

Detention Pipe

What is a Detention Pipe?

Detention Pipes are large underground aluminum or steel corrugated pipe, typically 48" to 120" in diameter, which temporarily store stormwater runoff originating from impervious surfaces such as streets, sidewalks, driveways, parking lots and roofs. The runoff is conveyed to the Detention Pipes either by a pipe system ranging in diameter from 8" to 30" or a combined drainage ditch and pipe system. Detention Pipes are usually located at the lowest spot possible on a site and as close to a natural receiving water body or an engineered stormwater system as possible.

How does a Detention Pipe system work?

A Detention Pipe system temporarily stores runoff during storm events, and slowly releases the runoff through a Flow Control Structure to either a natural receiving water body (stream, wetland, lake or Puget Sound) or an engineered conveyance system. The outlet is regulated (restricted) to prevent damage to either downstream property or fish and wildlife habitat. A Detention Pipe system is designed to completely drain whatever amount of runoff is stored within several days after a storm event has lessened considerably or ceased.

Typical Detention Pipe system designs

The "Flow Through" Detention Pipe is the simplest design and most utilized throughout the area. Stormwater runoff flows in one end of the Pipe and out the other through a Flow Control Structure (See drawing labeled "Flow Through" Detention Pipe system).

The other type is a "Backup" system. In this design, the runoff both enters and exits the pipe through the Flow Control Structure**.** It is an alternative to the "flow through" vault when site conditions warrant it. This is designed for runoff to both enter and exit a Detention Pipe system through a Flow Control Structure**.** Stormwater will bypass the Detention Pipe until the volume is great enough, due to the increased intensity of a storm that the flow can no longer just go out the outlet pipe from the Flow Control Structure**.** It is then forced to backed up into the pipe from the Flow Control Structure to the vault to be stored (detained) until the storm subsides. As the storm subsides and the flow volume decreases, the runoff stored in the vault is released back to the Flow Control Structure and the outlet pipe. (See drawing below – "Backup Detention Pipe**).**

These Detention Pipe systems are typically utilized at sites that do not have space available for a ground level pond system in:

- Commercial projects they are usually installed beneath parking lots and driveways;
- In residential projects they are located, within drainage easements across sides and backs of lots, under streets or in tracts of land where a play area/sport court can be installed above the pipe.

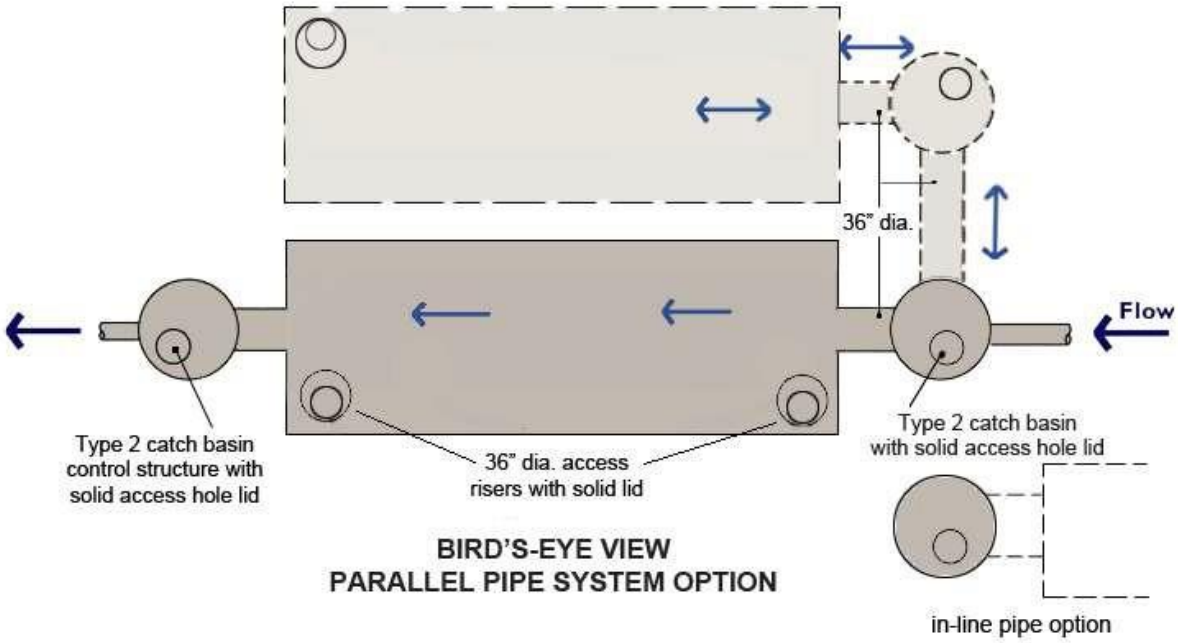
Typically, these pipes are arranged in one of three configurations:

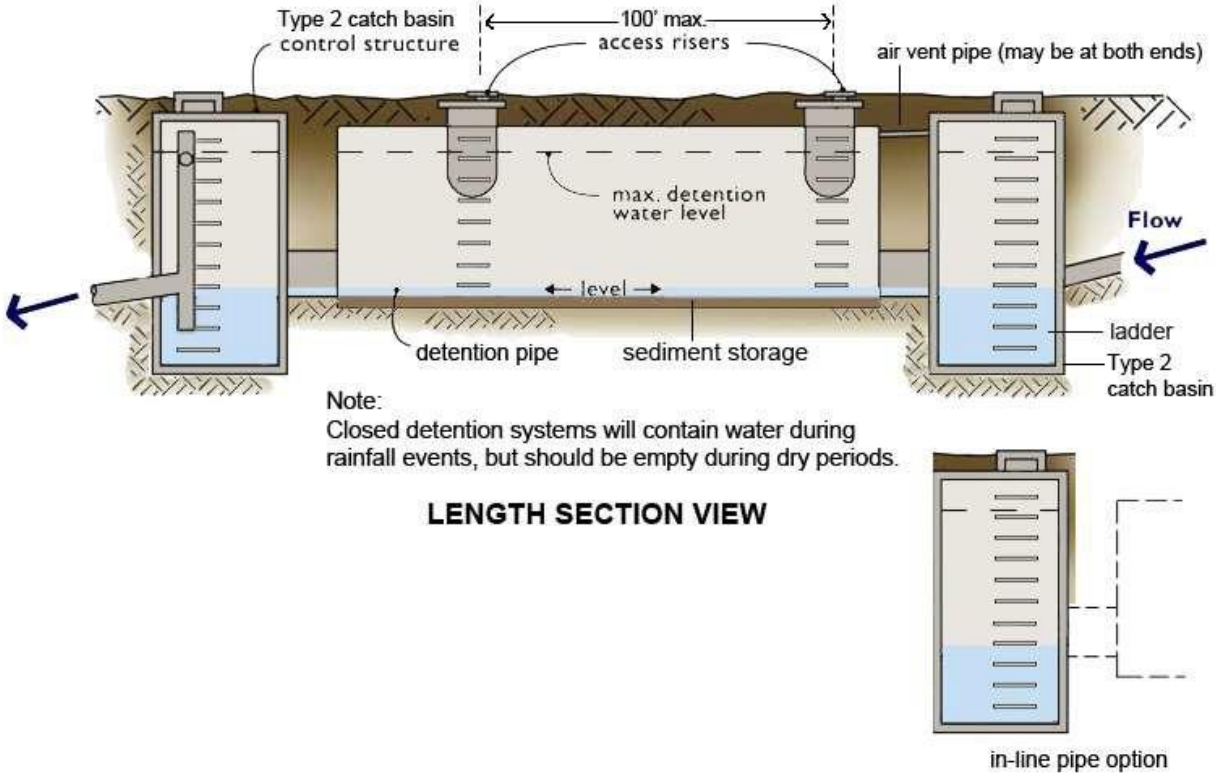
- As a single pipe under 150' in length;
- With two or more in a line strung together like link sausages with Type 2 Catch Basins connecting them; or
- With two or more pipes parallel in two or more rows with a connecting manifold at one end and Type 2 Catch Basins at the other end of each row.

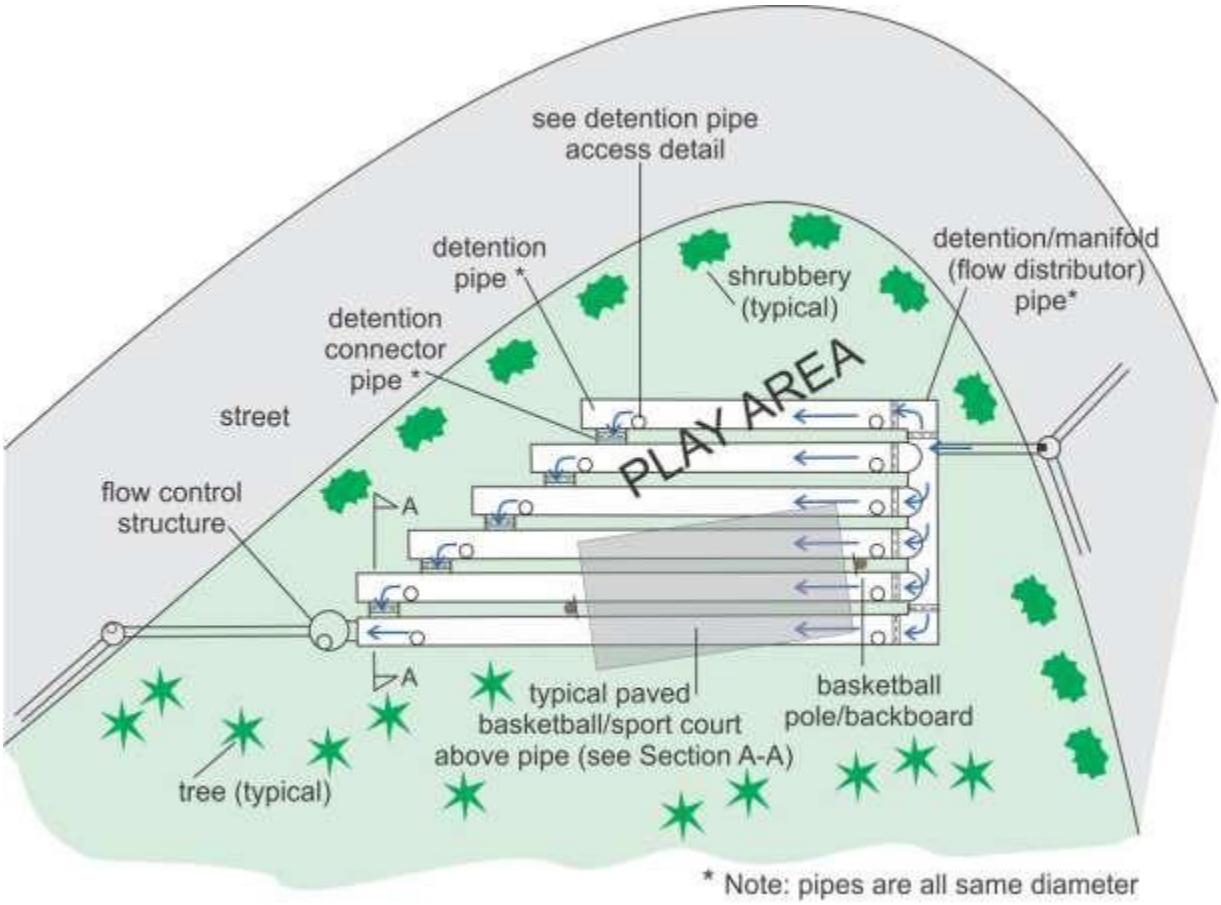
Common Maintenance Needs

Over time, Detention Pipe systems accumulate a sufficient amount of sediment, trash, vegetative debris that reduce their storage capacity. When storage capacity becomes unacceptably compromised, the accumulation will need to be removed to prevent pond and pipe system clogging.

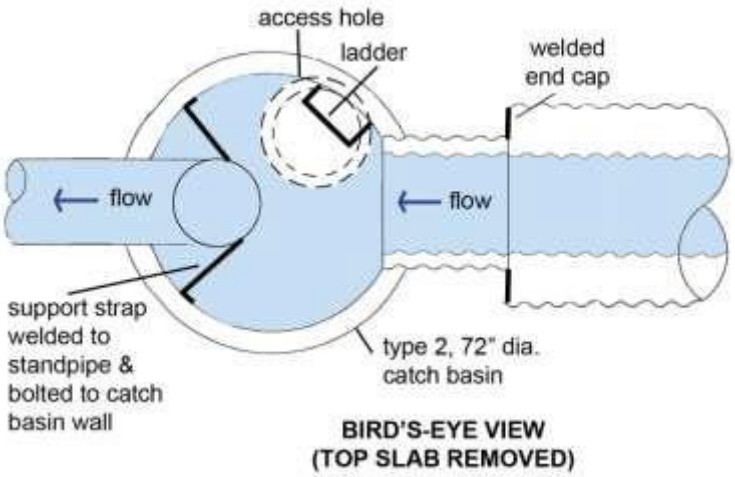
Detention Pipe

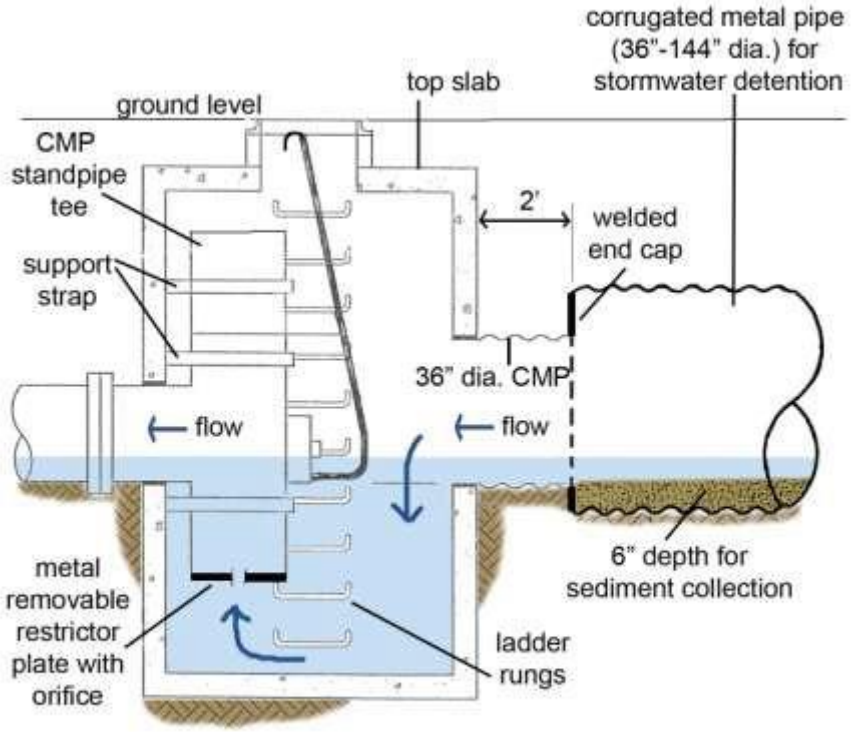


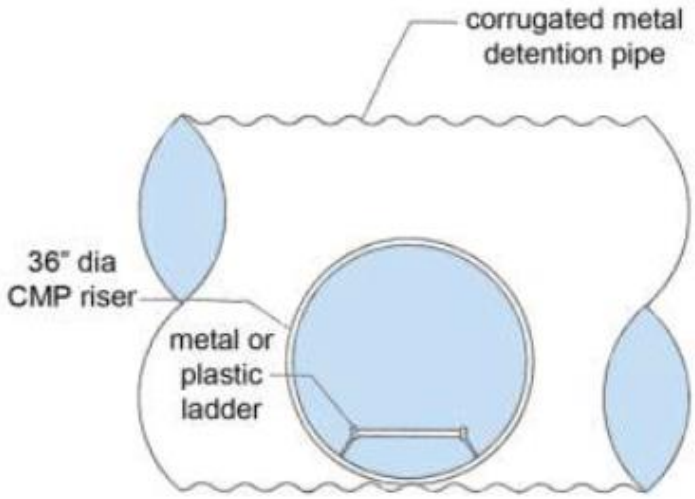




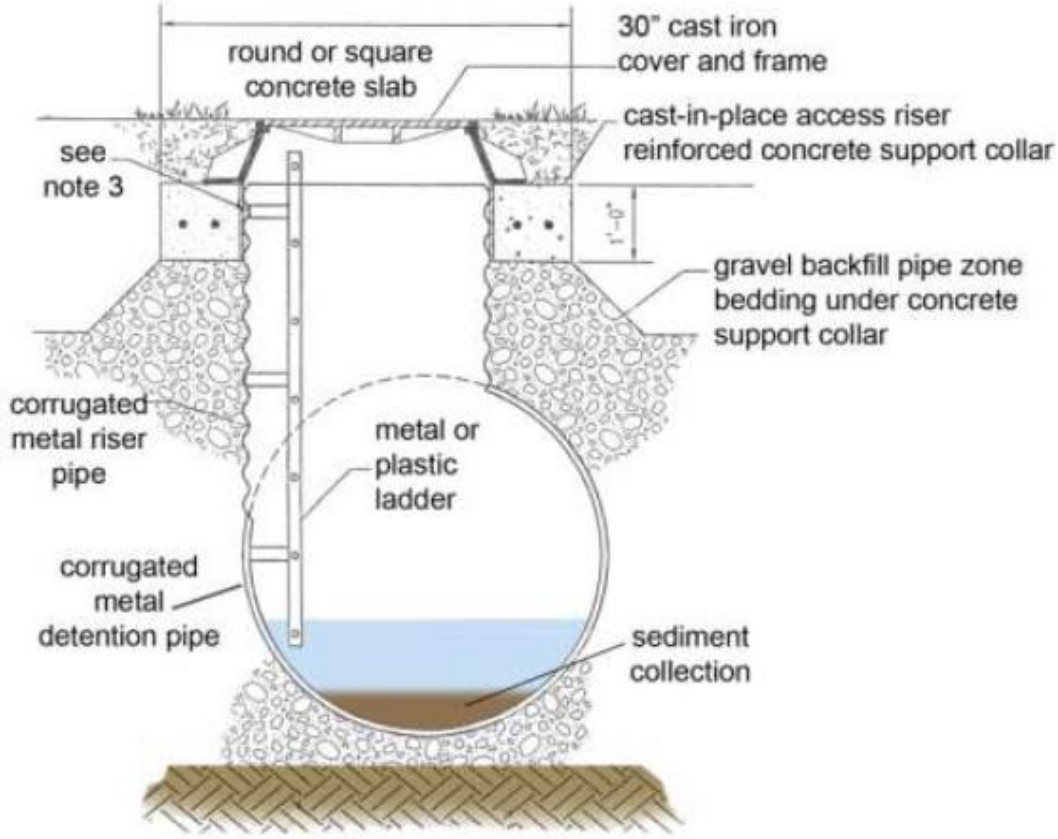
TYPICAL DETENTION PIPE GALLERY LAYOUT


access hole
ladder
welded
end cap
flow
flow
support strap
welded to
standpipe &
bolted to catch
basin wall
type 2, 72" dia.
catch basin
BIRD'S-EYE VIEW
(TOP SLAB REMOVED)

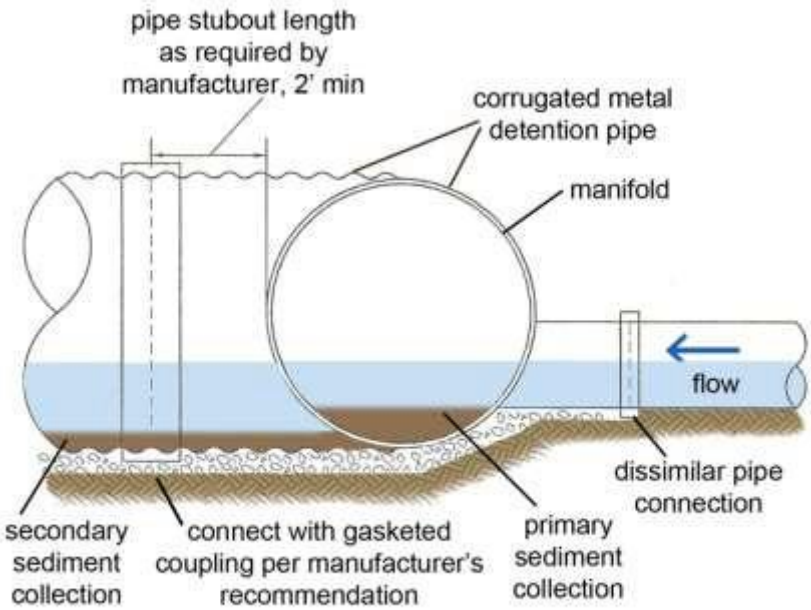

corrugated metal pipe
(36"-144" dia.) for
stormwater detention
top slab
ground level
CMP
standpipe
tee
2'
welded
end cap
support
strap
36" dia. CMP
flow
flow
6" depth for
sediment collection
metal
removable
restrictor
plate with
orifice
ladder
rungs
DETENTION PIPE & FLOW CONTROL
STRUCTURE CONNECTION SECTION



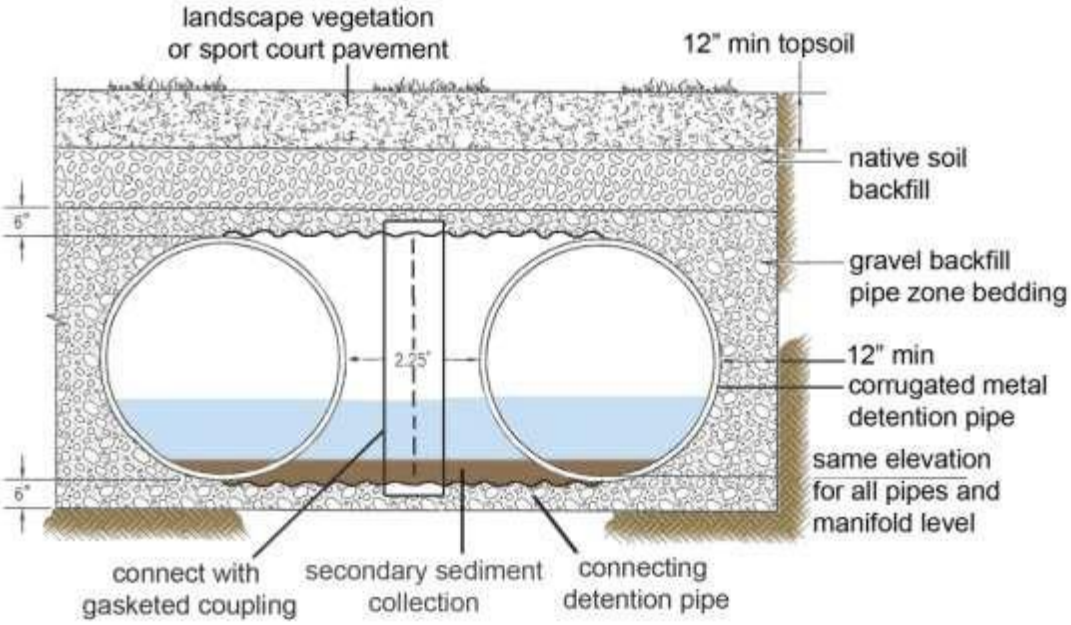
DETENTION PIPE ACCESS RISER PLAN VIEW



DETENTION RISER AND COVER



DETENTION INLET



DETENTION PIPE SYSTEM - SECTION A-A

Detention Pipe Gallery Installation

DETENTION PIPE GALLERY IN PLACE AND BEING COVERED UP WITH COMPACTED SOILS

DETENTION PIPE GALLERY WITH VIEW OF ACCESS RISERS

LOOKING AT DOWNSTREAM END OF DETENTION PIPES WITH END CAPS AND CONNECTION PIPE STUBS TO ADJACENT DETENTION PIPES.

LOOKING AT UPSTREAM END OF DETENTION PIPE CONNECTING TO PIPE MANIFOLD (CLOSEST PIPE IN VIEW RUNNING PERPENDICULAR TO THE ROWS OF DETENTION PIPE).

TABLE 11 DETENTION PIPE INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Stormwater Water Storage Area	Air vent pipe plugged	• Over one-half of cross section is blocked at any point in length of vent pipe or is	• Vent open and functioning.
	Debris and sediment accumulation	• Accumulated sediment depth exceeds 10% of pipe diameter.	• All sediment, debris, and organic material removed from storage area.
Pipe Structural Problems		• Any openings or voids at section joints allowing material to seep into or water to leak out. **NOTE**: This will require engineering analysis to determine structural stability.	• All pipe sections sealed.
		• Any part bent out of shape more than 10% of its design shape. (Review required by engineer to determine structural stability).	• Pipe section repaired or replaced to design.
		• Any visible holes or any cracks wider than ¼"; or • Material seeping in; or • Water leaking out; or • Maintenance/inspection personnel determine that pipe is not structurally sound.	• Pipe repaired or replaced to design specifications and is structurally sound
Pipe Riser Access Hole	Solid metal lid cover	• Solid lid is missing or ajar and not set securely in metal frame. **This is a safety hazard.** Lid needs to be secured or replaced immediately.	• Missing solid lid repaired or replaced. • Solid lid or is set securely in metal frame.
		• Locking mechanism cannot be opened by a maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	• Mechanism opens with proper hand tools.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Pipe Riser Access Hole	Solid metal lid cover	• A maintenance person cannot remove lid with normal lifting and proper hand tools.	• Solid lid can be removed by a maintenance person.
		• Solid lid missing or broken. **This is a safety hazard.** Replace immediately.	• Solid lid replaced.
	Metal frame for solid metal lid	• Frame not secured or sitting flush on top of concrete slab.	• Frame is secure on top slab.
		• There is more than 3/4-inch separation of frame from the top slab.	• Frame sitting flush on the riser rings or top slab.
		• Frame not securely attached to top slab. **This is a safety hazard.** Replace immediately.	• Frame securely attached to top slab.
	Locking mechanism not working	• Locking Mechanism cannot be opened, or lock bolts removed by one maintenance person with proper tools.	• Mechanism or bolts open with proper tools.
	Cover difficult to remove	• One maintenance person cannot remove lid after applying normal lifting pressure.	• Cover can be removed and reinstalled by one maintenance person.
Ladder	Unsafe	• Missing rungs; • Rungs not securely attached to basin wall; • Misaligned; • Rust; • Cracks; or • Sharp edges.	• Ladder is safe. • Repaired to specifications, or • Replaced with OSHA standards compliant ladder.
Flow Control Structure	All potential defects	• See **Type 2 Catch Basin Flow Control Structure** w/ Standpipe	

CAUTION: A Detention Pipe system is considered an enclosed space where harmful chemicals and gasses can collect. Therefore, the inspection and maintenance of these facilities should be conducted by individuals trained and certified to work in confined spaces under hazardous conditions.

Wet Pond

What is a Wet Pond?

A Wet Pond (also known as a Retention Pond) is typically a constructed earthen basin that retains a permanent pool of water throughout the year or at least through the wet season, to remove pollutants from stormwater runoff**.** Runoff is conveyed to a Wet Pond either by a pipe system, ranging in diameter from 8" to 30", or combined drainage ditch and pipe system. The pond is either fully dug out of the ground, or partially dug out with the remainder of the basin's perimeter formed by a compacted earthen berm (embankment) which functions as a dam**.** The sides are usually sloped however, to reduce the size of a pond's "footprint" the sides are cut vertical and lined with either large quarry rock boulders or concrete blocks forming a wall. There are Wet Ponds with the entire perimeter or a portion of it with walls constructed of poured-in-place concrete. Wet Ponds are usually located at the lowest spot possible on a site and as close as possible to either a natural receiving water body (stream, wetland, lake or Puget Sound) or an engineered drainage system.

How does a Wet Pond work?

Pollutants, such as trace metals, nutrients, sediments and organics, are suspended or dissolved in the runoff flowing into a Wet Pond. They are removed as the runoff mixes with the water in the pond's permanent pool. The greater the length of the time between storm events (quiescent time), the greater the amount of pollutants removed.

Several pollutants may be removed during this process. The primary pollutant removal mechanism is the settling out of suspended (floating) pollutant particles in stormwater runoff that are then deposited as sediment on the permanent pool bottom. A less significant portion of pollutants are removed when runoff enters the pond *en masse* (as a flood) and displaces the existing water retained in the pond's permanent pool. There are also natural occurring chemical processes that occur in the stormwater runoff soup, which detach dissolved contaminants from the water by:

- Attraction to suspended sediment particles and to sediment building up on the pond bottom;
- Coagulation (clotting), a process which causes pollutant particles to combine and form flakes that eventually settle to the pond bottom; and
- Bacterial decomposition.

Some nutrients, such as nitrogen, phosphorus and potassium, typically found in fertilizers, are easily dissolved in stormwater runoff. They are susceptible to removal in Wet Ponds. This capability helps reduce the impact of elevated concentrations (nutrient loading). Nutrient loading can trigger the abnormal increase in the supply of organic matter (eutrophication), which results in the depletion of oxygen available to aquatic organisms. Lack of oxygen in rivers, streams, wetlands, and lakes diminishes fish food sources and eliminates their aquatic vegetative habitat.

Typical Wet Pond Design

Wet Ponds function as a Retention Pond and are designed either with a single cell or with two or more cells. Each cell holding a permanent pool of water is a retention cell. The source of the water can be precipitation, ground water or storm runoff. When there are two or more cells, the first cell in line (called "forebay"), receives the storm runoff, calms the turbulence of the flow and captures the bulk of sediment transported by the runoff. As the runoff moves to the second pool it is cleaner, having a reduced load of trash, debris, sediment and suspended and dissolved pollutants. Ultimately, by focusing more on pollutant removal at the forebay, overall pond maintenance is more manageable and less costly.

When <u>only</u> water quality treatment (pollutant removal from runoff) is required, a permanent pool or pools may be adequate. However, when reduction of downstream flooding is also necessary, a Wet Pond is designed to accommodate additional <u>temporary</u> volume. This allows the Wet Pond to become a combination of a Retention Pond

and a Detention Pond. Essentially, the added temporary volume is stored above the permanent pool(s) top water surface elevation; virtually stacking the detention volume on top of the retention volume contained in the cell or cells. The additional flood control volume mixes with the permanent pool(s) of storm runoff. The temporarily stored (detained) portion of the pond's volume is released in stages through a Stormwater Flow Control Structure to a downstream water body or engineered drainage system**.** The flow is regulated (restricted) to prevent downstream erosion and flood damage to and fish/wildlife habitat.

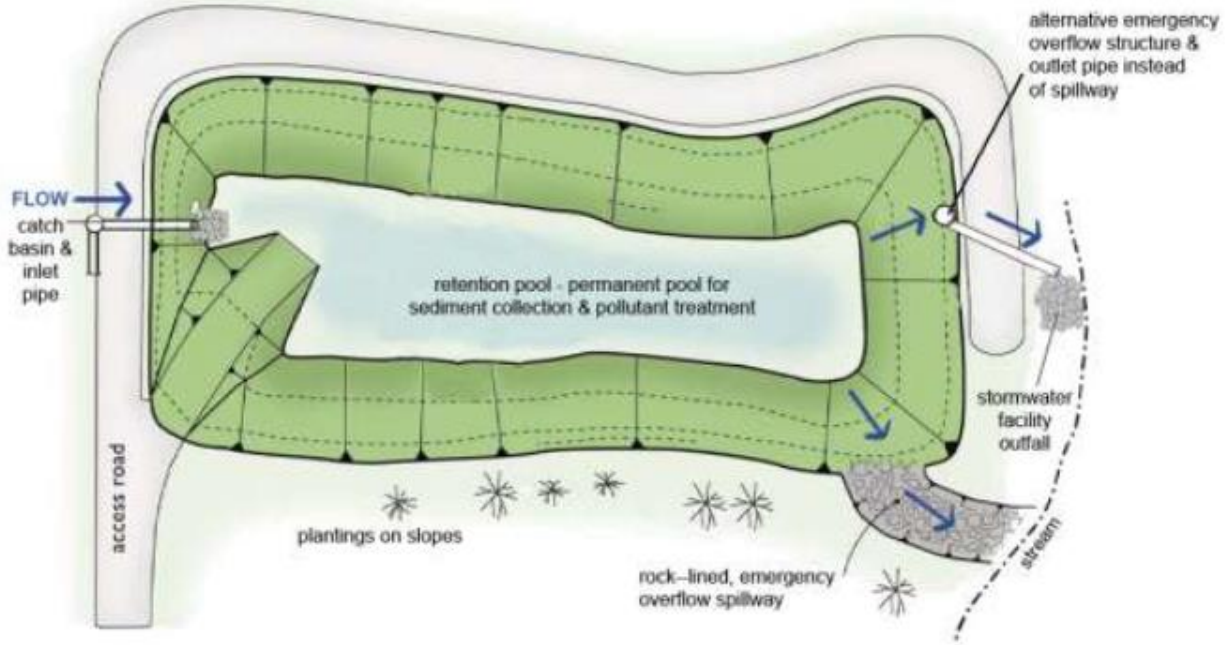
Combining detention flood control volume with retention pollutant removal volume in a pond can also result in additional pollutant capture. Wet Ponds with or without detention vary greatly in size, shape, depth and visual attraction. Visual attraction is subjective, landscape design ranges from none with bare unadorned concrete or rock walls and sparsely vegetated earthen side slopes to natural but untidy wildlife habitat vegetated with native plants, and even some with well-manicured park like features. Generally, Wet Ponds are designed to be somewhat natural-appearing. Planting with native vegetation is preferred for enhanced wildlife habitat and reduced site maintenance. Some ponds are designed to have plants that grow in the "permanent pool", which provide additional pollutant removal.

Common Maintenance Needs

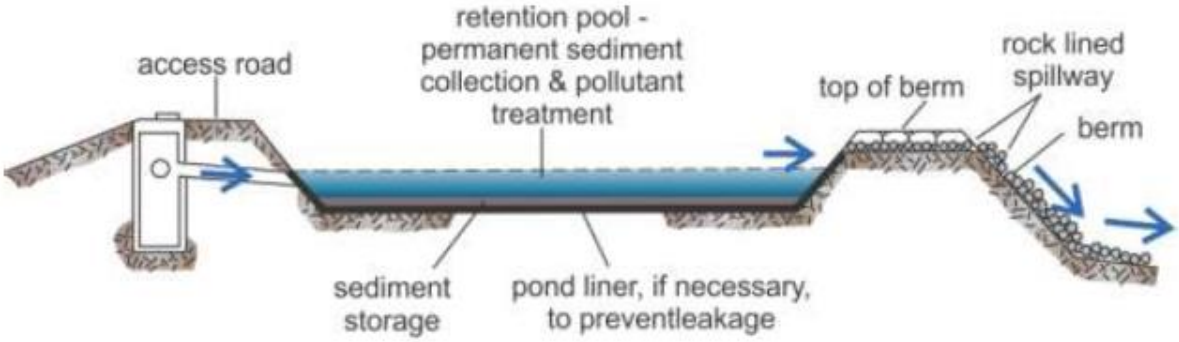
Over time, ponds accumulate a sufficient amount of sediment, trash, and vegetative debris which clog pipes and flow control structures and reduce a pond's storage capacity. Preventing clogging is an on-going maintenance operation. Sediment removal is usually necessary after five to ten years of accumulation. When pond storage capacity becomes unacceptably compromised, the accumulation will need to be removed.

- Vegetation growth in the area surrounding the pond:
  - Keeping the proper balance of plants and grass based on the original design;
  - Allowing adequate access for maintenance.
- Vegetation growth in the pool(s):
  - Keeping the proper balance of plants;
  - Allowing adequate access for maintenance.
- Pond and pipe system clogging due to:
  - Sediment deposition;
  - Trash; and
  - Vegetation growth.

Single-cell Wet Pond (Retention Pool)

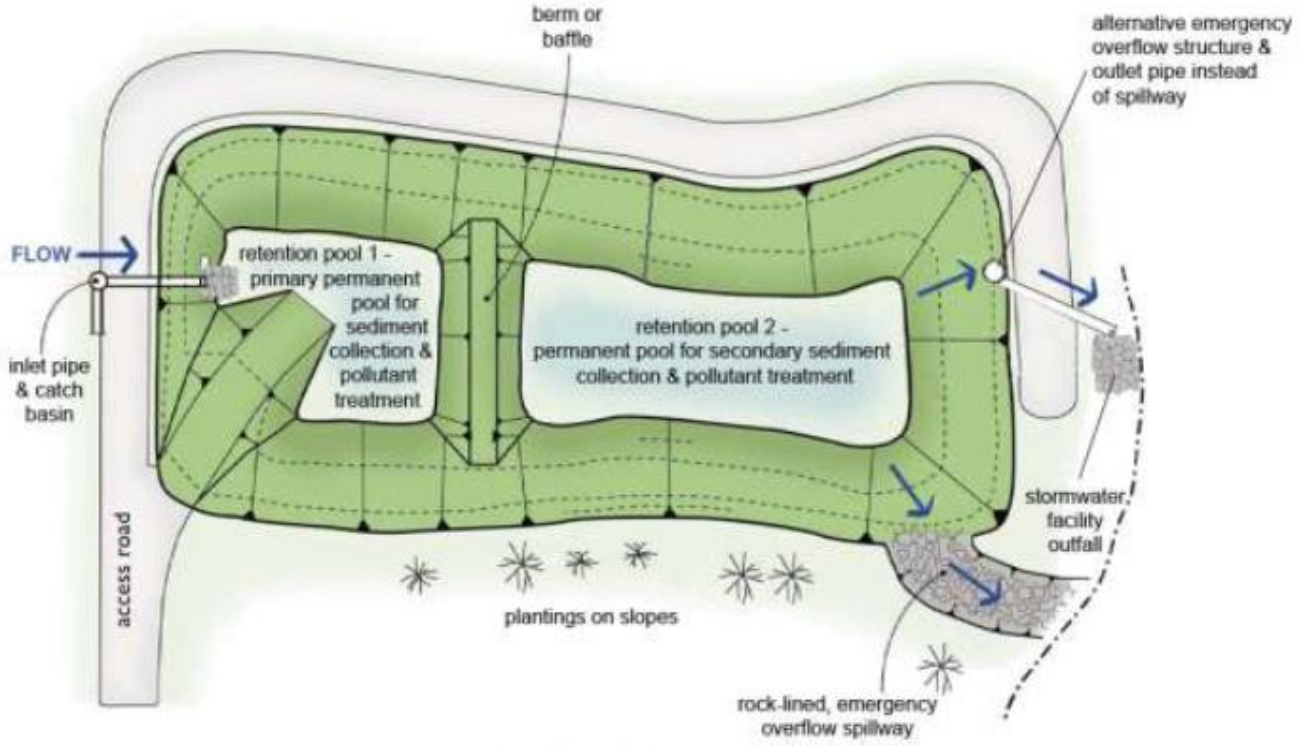


BIRD'S-EYE VIEW

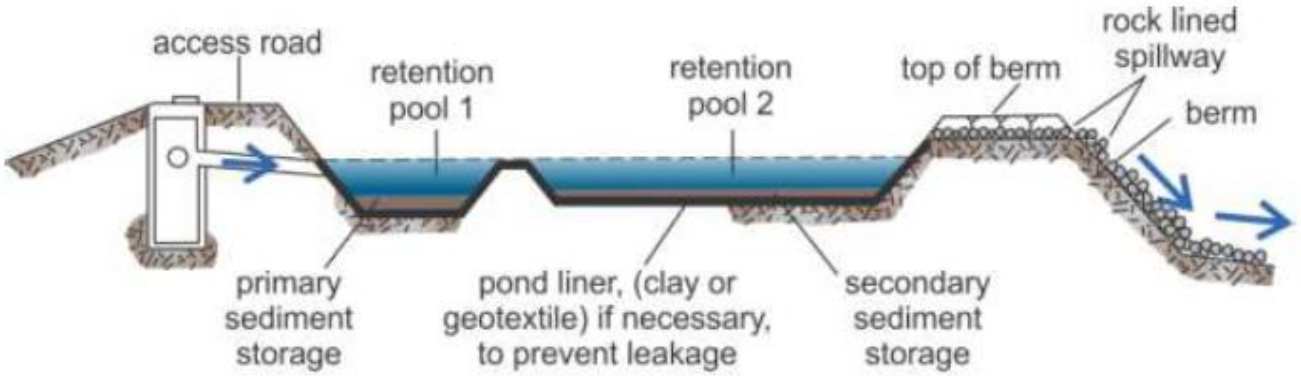


PROFILE

Two-cell Wet Pond (Two Retention Pools)

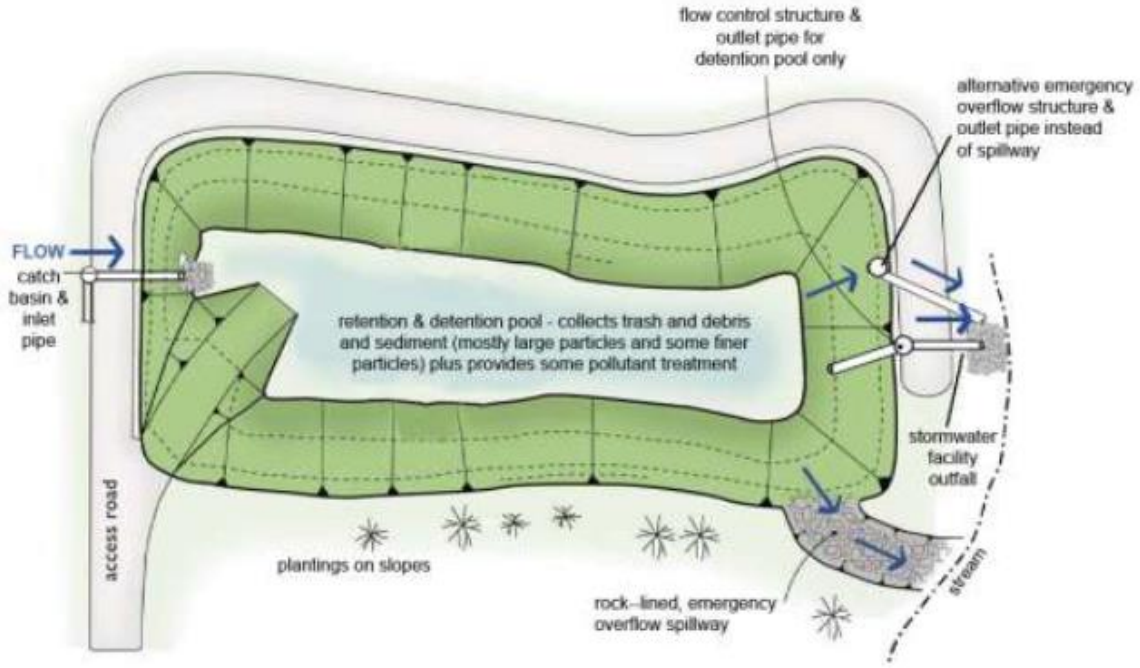


BIRD'S-EYE VIEW

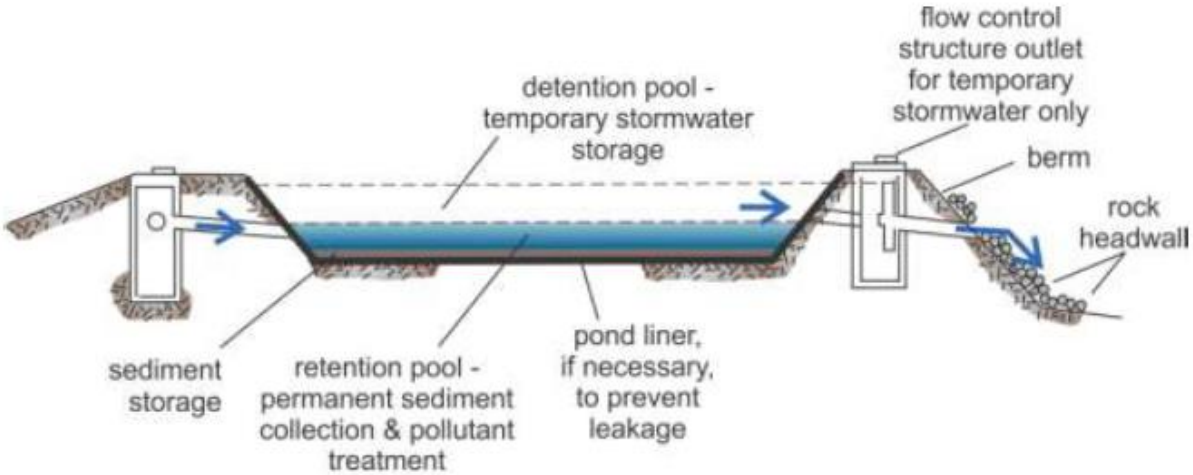


PROFILE

Single-cell Wet/Detention Pond (Retention Pool Combined with a Det. Pool)

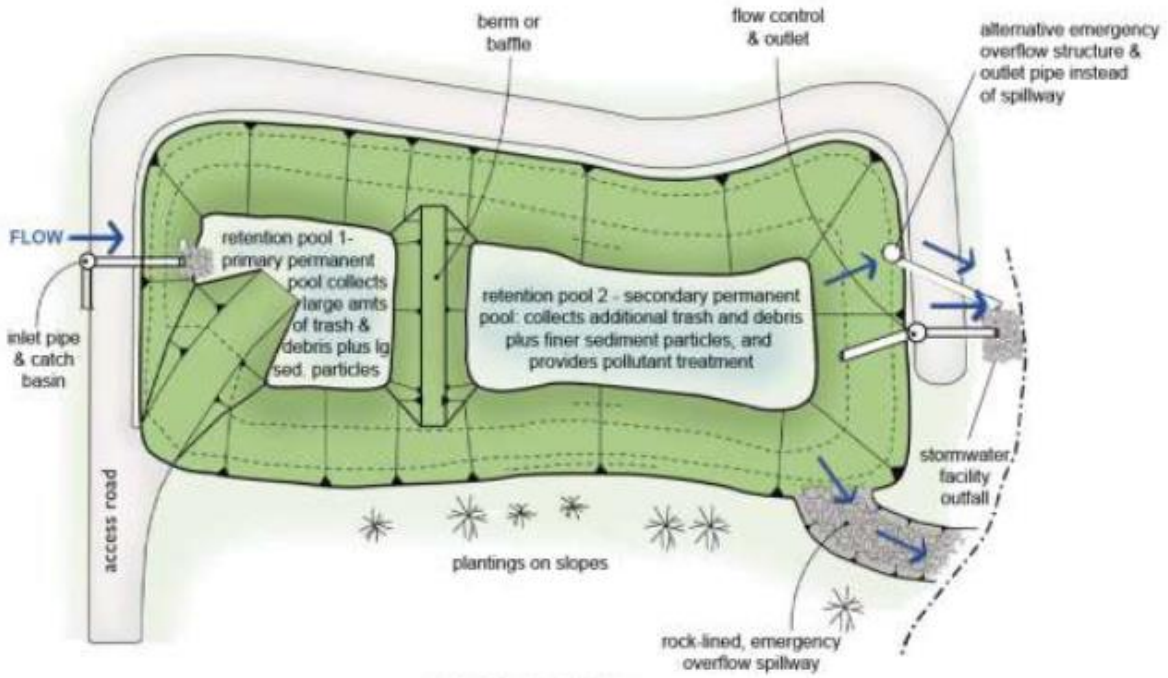


BIRD'S-EYE VIEW

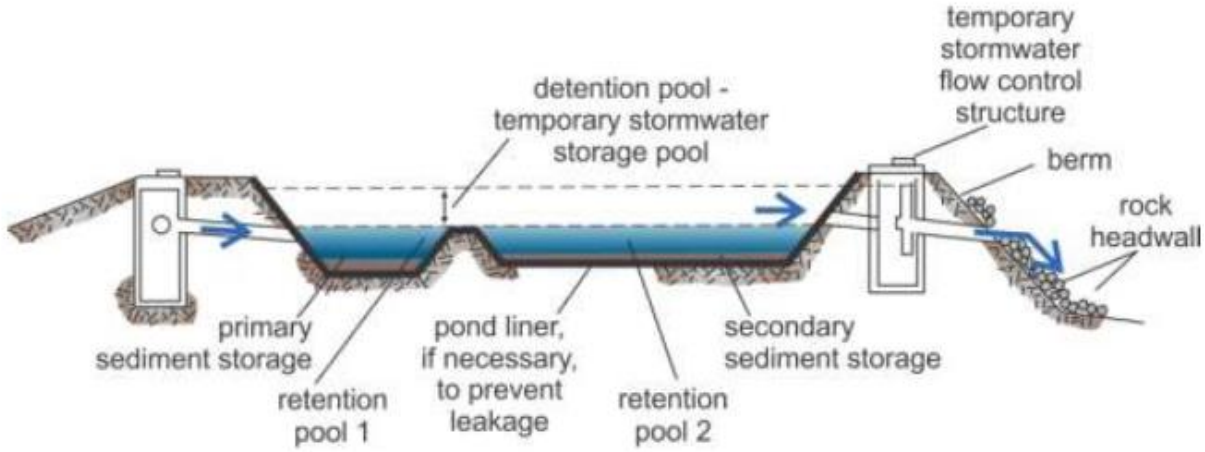


PROFILE

Two-cell Wet/Detention Pond (Retention Pool Combined with a Det. Pool)



BIRD'S-EYE VIEW



PROFILE

2-celled DEEP-WATER quality pond with cell dividing berm and rock walls on three sides – Cell 1 is on the left of sediment collection.

Before Maintenance: 2-celled shallow water quality pond with cell dividing berm for sediment collection.

After Maintenance: Cell 1 is on the left.

2-celled DEEP-WATER quality pond – Cell 1 in the back is for sediment collection, cell 2 in front has an access road to cell 1 running through it and over the cell dividing berm.

2-celled water quality pond – cell for sediment collection is undergoing dredging for sediment and cattail (biomass) removal.

2-celled DEEP-WATER Quality Pond with concrete cell divider and perimeter walls – cell 1 in the foreground is for sediment removal

Close-up of submerged concrete block (also known as "Ecology Block") cell divider wall

2-celled Water Quality Pond with concrete cell divider and perimeter walls during non-routine maintenance of dredging and cattail (biomass) removal

After Maintenace

2-celled Water Quality Pond with concrete cell divider and perimeter walls.

TABLE 12 WET POND INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
General Site Conditions Surrounding Pond	Trash and debris accumulation	• Site generally littered with debris and Evidence of dumping trash and debris.	• Trash and debris removed from site. • Neighbors notified that dumping is prohibited. • "No dumping" sings installed.
	Poisonous vegetation and noxious weeds	• Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. **NOTE**: Any evidence of noxious weeds as defined by the King County Noxious Weed Control Board requires eradication based on the	• Poisonous vegetation eliminated. **NOTE**: Complete eradication of noxious weeds may not be possible. Compliance with State and County Noxious Weed Control Boards are required.
	Contaminants and pollutants	• Any evidence of oil, gasoline, contaminants or other pollutants in or near the pond area. **For hazardous material, call 911 and Public Works**	• Contaminants or pollutants removed.
	Beaver dams	• Dam in Flow Control Structure, either in pond, or downstream of facility results in change of function of the facility. **NOTE**: Coordinate trapping of beavers and removal of dams with appropriate state and county permitting agencies.	• Facility fully functional.
	Rodent holes	Evidence of rodent holes on site, but not in pond area.	• Rodents eliminated.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
General Site Conditions Surrounding Pond	Insects	• Insects such as wasps and hornets interfere with maintenance activities. **NOTE**: Apply insecticides in compliance with manufacturer's directions.	• Insects eliminated.
	Tree growth and hazard trees	• Specific trees hinder maintenance access or interfere with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements)	• Only trees hindering maintenance activities removed.
		• Hazard trees (dead, diseased, or dying) are identified. NOTE: A certified arborist should be consulted to determine health of tree or removal requirements.	• Hazard trees removed. • **NOTE**: Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood).
Pond cell Side Slopes (natural or excavated)	Tree growth	• Trees growing below pond Emergency Overflow elevation subject to blowing over, uprooting the root wad due to water saturated soil. An exposed wad and hole in left in the soil can be a major source of continued erosion.	• Trees removed. • Roots removed as necessary.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Pond cell Side Slopes (natural or excavated)	Erosion	• Eroded damage over 2-inches deep where cause of damage is still present or where there is potential for continued erosion. • Any erosion observed on a compacted berm embankment. **NOTE**: A licensed civil engineer should be consulted to resolve source of erosion.	• Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.
	Cracks, holes, scaling & steel structural reinforcement bars (rebar) exposed	• Professional inspection determines that wall(s) is not structurally sound, or leaks are present.	• Wall(s) repaired and structurally sound or replaced.
	Excessive sediment accumulation	• Accumulation exceeds 10% of as-built pond cell depth.	• Sediment accumulation removed.
	Permanent water pool leaking out of cell	• One or both cell pools are empty. • Pond cells must have a pool of water to remove pollutants.	• Cell(s) lined to prevent water pool from leaking out.
	Tree growth	• Trees growing on any portion of pond bottom NOTE: A licensed geotechnical engineer should be consulted to determine if roots need to be removed.	• Trees removed. • Roots removed as necessary.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Pond Cell(s) Geotextile or Clay Liner	Exposed or damaged	• Portion of liner is visible.	• Liner is covered with minimum 12" compacted soil.
		• Geotextile liner is punctured.	• Puncture(s) repaired, or liner replaced as necessary.
		• Clay liner has deep gouge(s)	• Gouge(s)-repaired or liner replaced as necessary
Pond Perimeter and Cell Divider Structural Berms (Dams)	Soil Settlement	• Any part of a compacted structural berm which has settled 4 inches lower than the design elevation. • Settling can be an indication of more severe problems with the berm or outlet works. **NOTE**: If settlement is apparent, measure berm to determine amount of settlement. **NOTE**: A licensed civil engineer should be consulted to determine the source of the settlement.	• Berm is repaired and returned to design elevation.
	Tree Growth	• Trees growing on any portion of pond interior and exterior slopes as well as the top	• Trees removed • Roots removed as necessary. • Slopes stabilized.
	Piping	• Discernable water flow through a compacted structural berm due to tree roots and/or rodent holes/tunnels, can lead to erosion within a berm and structural failure.	• Piping eliminated. Erosion potential resolved.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Emergency Overflow Spillway	Rock armoring missing	• Rock layer on sub-grade is less than 1.0' deep and sub-grade is exposed.	• Rock depth restored to design depth.
	Erosion	• Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.	• Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.
		• Any erosion observed on a compacted structural berm embankment.	

Wet Vault

What is a Wet Vault?

A Wet Vault is an underground rectangular reinforced concrete tank which collects and removes pollutants from stormwater runoff originating from impervious surfaces such streets, sidewalks, driveways, parking lots and roofs through pipes or drainage ditches. The runoff is conveyed to a Wet Vault either by a pipe system, ranging in diameter from 8" to 30", or combined drainage ditch and pipe system. Wet Vaults are usually located at the lowest area on a site and as close as possible to a natural receiving water body (stream, wetland, lake or Puget Sound) or an engineered drainage system. Vaults are a convenient structure on which to place an outdoor sports court, play field, or play equipment over the top of the vault lid.

How does a Wet Vault work?

Pollutants, such as trace metals from cars and trucks, nutrients from fertilizers, sediments and organics, are suspended or dissolved in the runoff flowing into a Wet Vault. The Wet Vault, unlike a Wet Pond, removes only sediment and some trace metals as storm runoff mixes with the water in a vault's permanent pool. The only pollutant removal mechanism is the settling out of suspended (floating) pollutant particles in stormwater runoff that are then deposited on the vault bottom. A less significant portion of pollutants are removed when runoff enters the vault *en masse* (as a flood) and displaces the existing water retained in the vault's permanent pool.

The Wet Vault is designed to collect stormwater during the rainy season and store it as a semi-permanent pool. This pool is commonly called a wet pool or dead storage area. When stormwater runoff is conveyed to the vault, it mingles with the stormwater in the wet pool. As this occurs, a portion of the pollutants which are either dissolved in the stormwater or attached to sediment particles, settle out and accumulate on the vault bottom. During storm events Wet Vaults slowly discharge the runoff, less whatever pollutants have been filtered out into the dead storage area, through a Flow Control Structure outlet. The flow is regulated (restricted) to prevent damage and possible poisoning to downstream property and fish and wildlife habitat associated with receiving water bodies.

Wet Vault design

In most cases the common type of Wet Vault design is a "permanent" pollutant removal pool of water combined with an additional pool of stormwater runoff temporarily "stacked" (detained) on top of the "permanent" pool for flood control and erosion reduction purposes. Therefore, the vault is both a retention and detention facility. Being underground, the Wet Vault lacks the biological pollutant removal mechanisms that would be present in a Wet Pond. This effectively eliminates the possibility of removing dissolved pollutants such as soluble nutrients found in fertilizers or trace metals such as copper from automobiles. However, the primary pollutant removal mechanism of settling out of suspended (floating) pollutant particles attached to sediment particles and being deposited on the vault floor is viable.

Vault configurations:

- The most common configuration utilizes the entire vault as a single cell for both the "permanent" pollutant laden sediment removal pool plus the temporary flood control storage pool stacked on top.
- A less common configuration is having the bulk of pollutant laden sediment collection taking place in a separate cell or "forebay" at the upstream end of the vault. The forebay can take up to 25% of the vault's volume. This allows for:
  - Cleaner runoff to collect in the primary cell before being discharged downstream; and
  - Easier/less costly maintenance with most of the sediment collected in a more compact space.
- With either single or double cell configuration (forebay plus primary cell), there is a
  - Permanent pollutant removing pool from end to end of the vault, single cell or with a primary cell plus the additional forebay; and

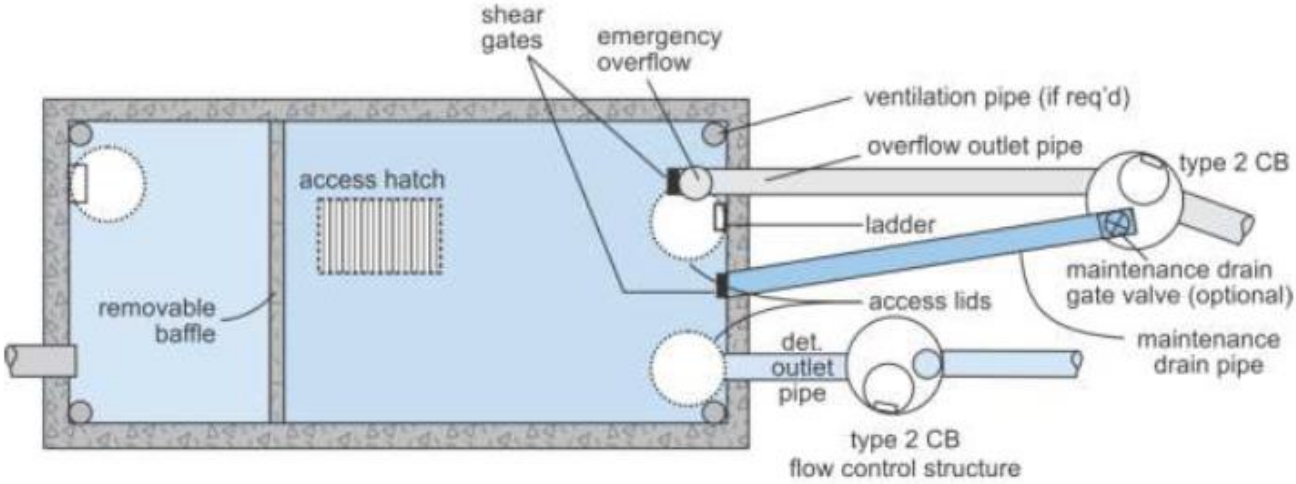
- Temporary flood control pool stacked on top of the pollutant removal pool.

- The additional temporary stormwater runoff capacity is slowly released through a Flow Control Structure as the outlet to a natural or engineered stormwater system.
  - The flow out is designed to completely drain the temporary capacity within 24-48 hours after a storm event has lessened considerably or ceased, down to the top of the dead storage volume.

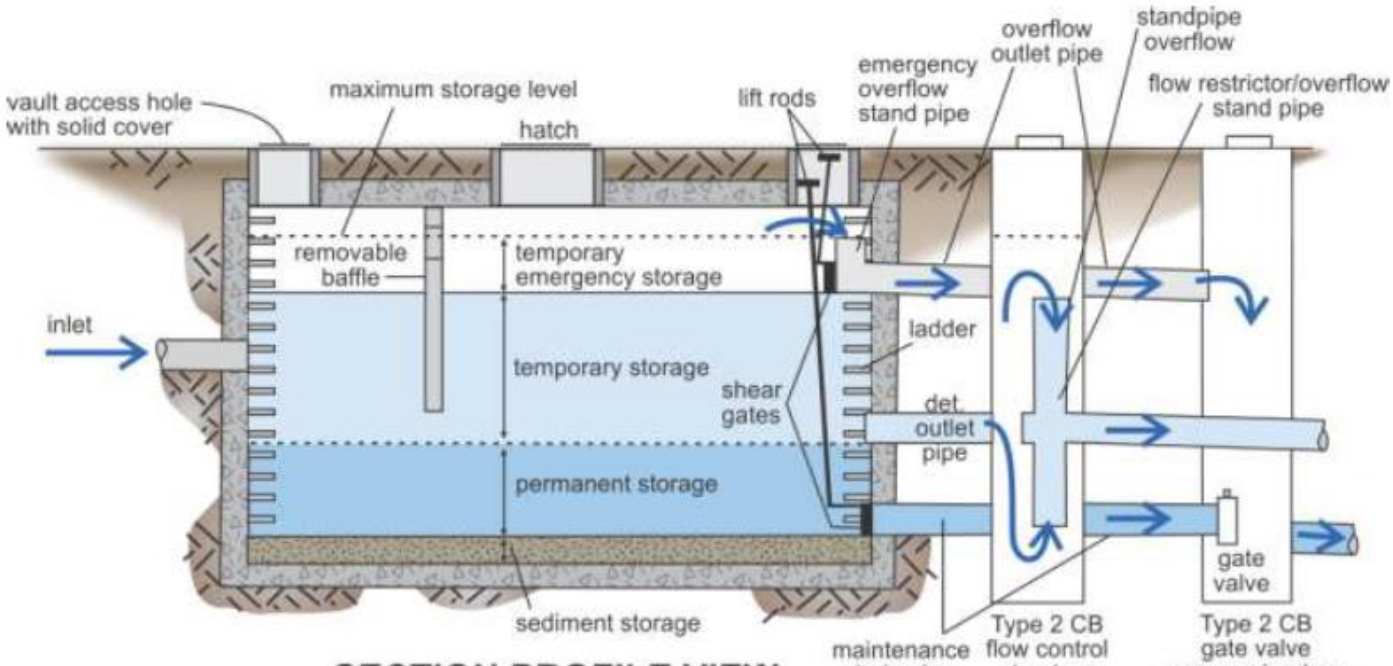
Common Maintenance Needs

Eventually the sediment and other pollutants will have to be removed to prevent the vault and pipe system from clogging with accumulated trash, vegetation debris, and sediment.

Wet Vault



BIRD'S-EYE VIEW



SECTION PROFILE VIEW

Wet Vault with Sport Court on Top

Normal dual use of a Water Quality Vault with an asphalt game court, play set and lawn placed on top – all four photos of same vault

TABLE 13 WET VAULT INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not
Vault Chamber(s)	Floating debris accumulation	• Any debris accumulated in vault, pipe or inlet/outlet.	• All floating debris removed.
	Sediment and non-floating debris accumulation	• Accumulation on bottom exceeds 6-inches.	• All sediment and debris removed from bottom.
	Plugged or damaged pipes	• Inlet/outlet pipe(s) plugged, damaged or broken and needs repair.	• Pipe unplugged, repaired and/or replaced.
Vault Concrete Lid	Access hole cover damaged/not working or missing	• Cover cannot be opened or removed, especially by one person. Missing cover is safety hazard.	• Cover repaired or replaced.
Vault Bottom, Walls & Lid	Cracks, holes, scaling & steel structural reinforcement bars (rebar) exposed	• Professional inspection determines that vault is not structurally sound, or leaks are present.	• Vault repairs or replaced made so that it meets design specifications and is structurally sound.
		• Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	• Cracks repaired, and no cracks exist wider than 1/4-inch.
Baffles	Signs of structural failure	• Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection staff.	• Baffles repaired or replaced to specifications.
Ladder	Damaged or detached	• Ladder is corroded or deteriorated, not functioning properly, not attached to structure wall, missing rungs, has cracks and/or misaligned	• Ladder repaired or replaced to specifications and is safe to use as determined by inspection personnel. • Ladder complies with OSHA standards.

CAUTION: A wet vault is considered an enclosed space where harmful chemicals and gasses can accumulate. Therefore, the inspection and maintenance of these facilities should be conducted by individuals trained and certified to work in confined spaces under hazardous conditions.

Biofiltration Swale

What is a Biofiltration Swale?

Biofiltration Swales (bioswales) have been the engineered method of choice since the early 1990s to meet requirements for reducing the amount of sediment and automobile related pollutants entering streams and lakes from real estate development and public road projects. They use grasses and plants in channels for stormwater runoff to filter through, capture pollutants and biologically degrade them.

Bioswales can act as either a stand-alone stormwater water quality treatment facility or be incorporated with a variety of stormwater facilities as a component to provide pollutant removal treatment.

How do they work?

A bioswale uses a carpet of wet/dry and sun/shade tolerant grasses or other densely planted wetland like vegetation to filter out sediment and oily substances. Most bioswales remain dry, except during and immediately after a storm event when storm runoff flows through it slowly and at a shallow depth. As runoff migrates down the swale and passes through the plants, pollutants are removed by the combined effects of filtration, settling and infiltration through soil.

Typical Bioswale design

Basic Biofiltration Swale configurations:

- A grass lined flat bottom channel from upstream end to downstream end set at a slightly sloped grade (within a range of 1-5% of flat); and
- Gently sloping sides:
  - Usually three feet horizontal for each foot of depth
  - Ranging in depth from two to eight feet.
  - Carpeted with grasses or densely planted vegetation
- Swales, depending on the nature of the topography, can be either
  - Straight; or
  - Gently curved.

Typical channel bottom design:

- Length of 200 feet, and
- Minimum width of two feet.

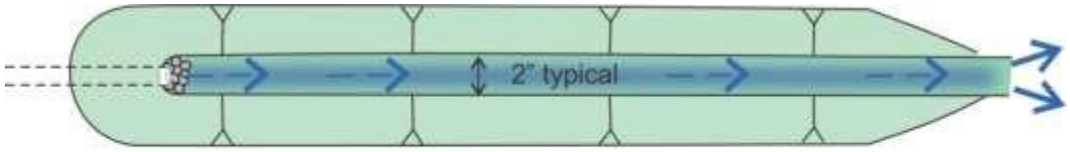
Some bioswales are shorter:

- Usually not less than 100 feet, but
- Require a greater width than two feet. As a rule of thumb, add one foot of width for each 50-foot reduction in length.

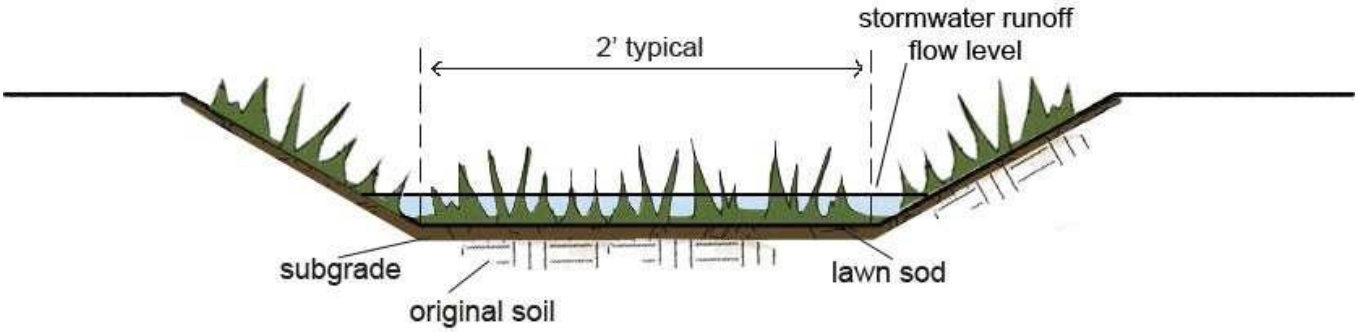
Location options when incorporated with a stormwater facility:

- preferred - immediately downstream
- other – immediately upstream

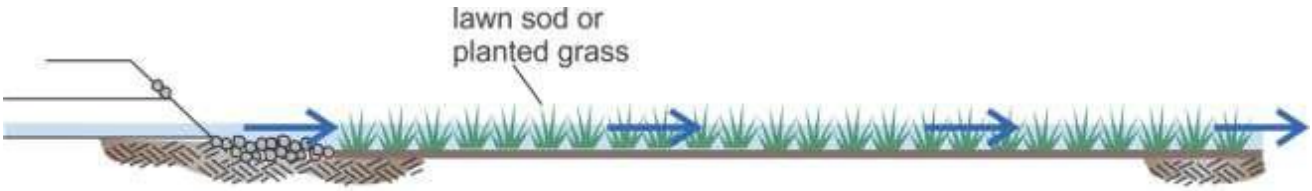
Basic Bioswale – First Generation Standard



BIRD'S-EYE VIEW



WIDTH SECTION VIEW



LENGTH SECTION VIEW

Basic Bioswales – Well Maintained

IN RESIDENTIAL LOT BACK YARD

ALONG RESIDENTIAL STREET

IN RETAIL STRIP MALL PARKING AREA MEDIAN

CHURCH PARKING AREA

Basic Bioswales – Poorly Maintained

IN RESIDENTIAL LOT BETWEEN FRONT YARD AND STREET

IN RESIDENTIAL OPEN SPACE TRACT

IN RESIDENTIAL PLAT NATIVE GROWTH PROTECTION AREA (NGPA) TRACT

IN THIS RURAL RESIDENTIAL OPEN SPACE TRACT, WHERE'S THE BIOSWALE?

Basic Bioswale – Before and After Maintenance

BIOSWALE IN EXTREMELY NARROW SPACE – BEFORE MAINTENANCE

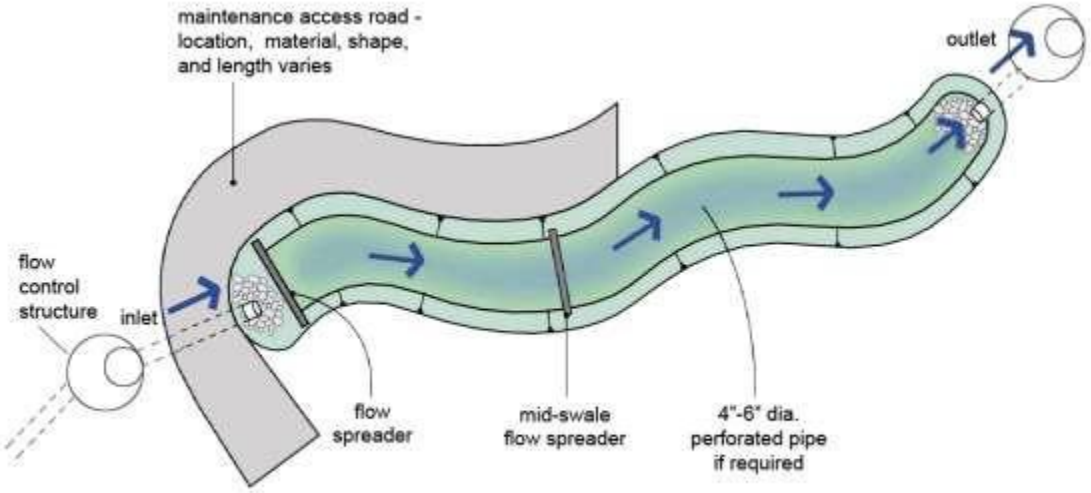
AFTER MAINTENANCE

Basic Bioswales – Before, During and After Maintenance

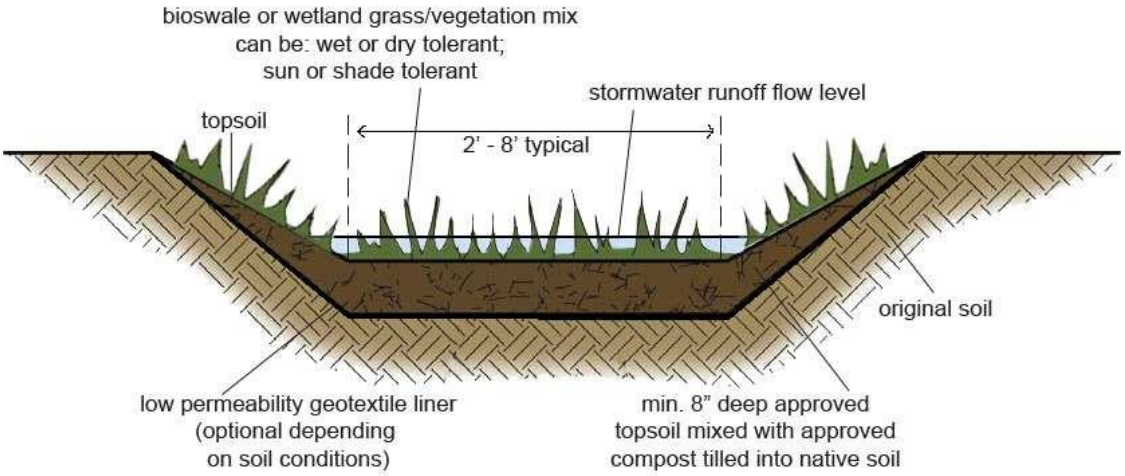
BEFORE MAINTENANCE

DURING MAINTENANCE

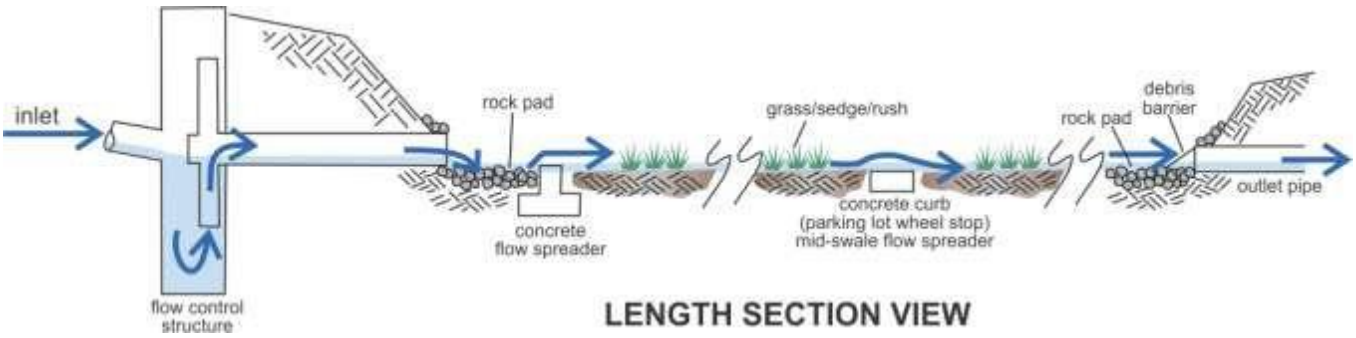
AFTER MAINTENANCE



BIRD'S-EYE VIEW

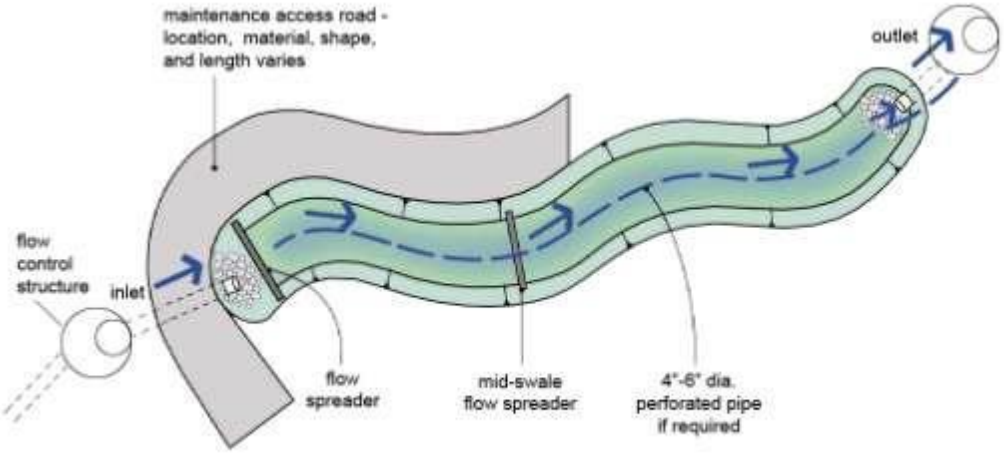


WIDTH SECTION VIEW

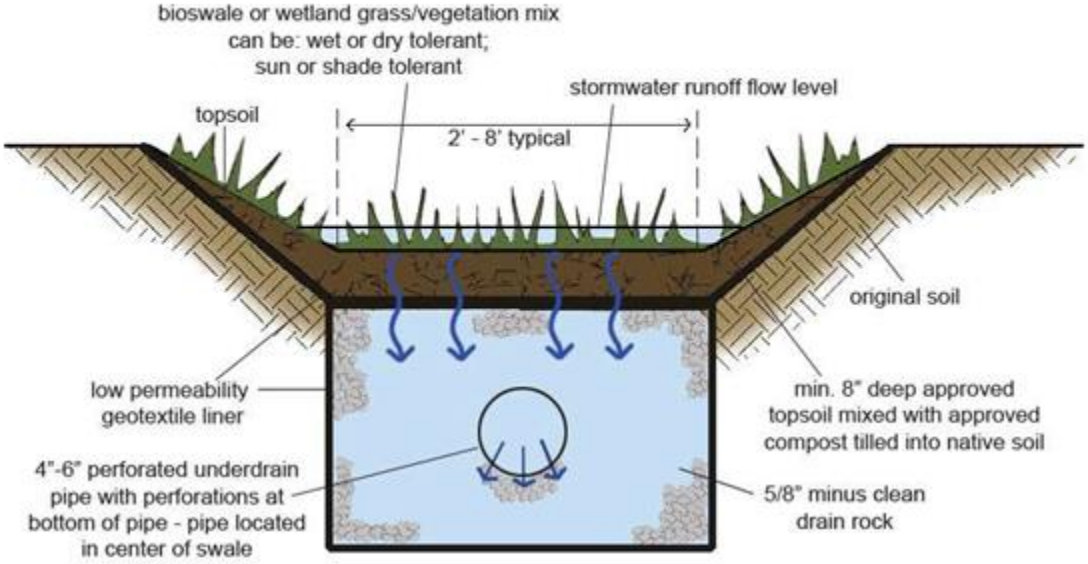


LENGTH SECTION VIEW

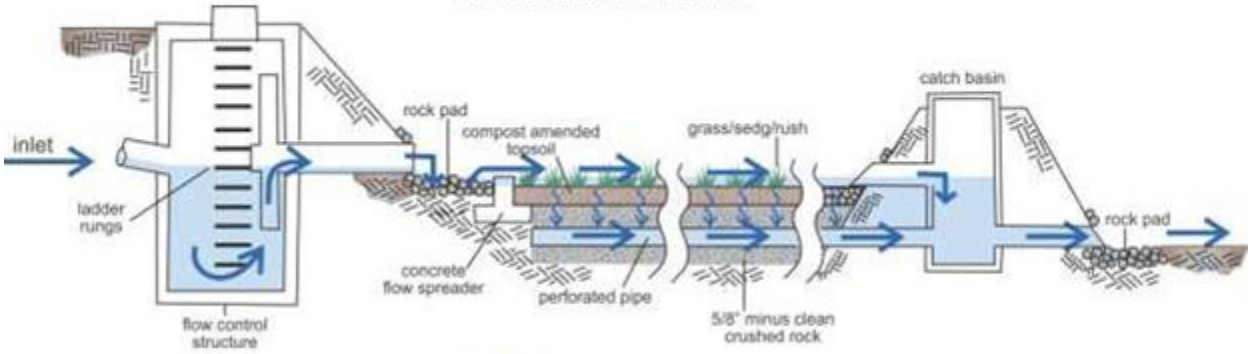
Wet Bioswale with Under drain – Current Standard



BIRD'S-EYE VIEW



Cross-section View



Side-section View

TABLE 14 BIOSWALE INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
General Area Around Swale	Accumulation of trash and debris	• Site generally littered.	• Trash and debris removed.
		• Evidence of dumping.	• Neighbors notified of dumping. • "No Dumping" signs installed.
	Contaminants and pollutants	• Any evidence of oil, gasoline, contaminants or other pollutants in or near the Biofiltration Swale area. **For hazardous material, call 911 and Public Works**	• Contaminants or pollutants removed.
	Rodent holes	Evidence of rodent holes on site, but not in pond area.	• Rodents eliminated.
	Insects	• Insects such as wasps and hornets interfere with maintenance activities. **NOTE**: Apply insecticide in compliance with manufacturer's directions.	• Insects eliminated.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
	Poisonous vegetation and noxious weeds	• Poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. **NOTE**: Any evidence of noxious weeds as defined by the King County Noxious Weed Control Board requires eradication based on the Board's recommendation of Herbicide application or by mechanical means.	• Poisonous vegetation eliminated. **NOTE**: Complete eradication of noxious weeds may not be possible. Compliance with State and County Noxious Weed Control Boards is required.
General Area Around Swale	Tree growth and hazard trees	• Specific trees hinder maintenance access or interfere with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements.	• Only trees hindering maintenance activities removed.
		• Hazard trees (dead, diseased, or dying) are identified. **NOTE**: A certified arborist should be consulted to determine health of tree or removal requirements.	• Hazard trees removed. **NOTE**: Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood).

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Swale Structural Berm (embankment) Side Slope	Piping	• Discernable water flow through a compacted structural berm due to tree roots and/or rodent holes/tunnels, can lead to erosion within a berm and structural failure. **NOTE**: A Geotechnical engineer should be consulted to inspect, evaluate, and recommend a repair solution plan.	• Piping eliminated. Erosion potential resolved.
Swale Channel Bottom	Standing water	• Water does not drain freely - standing water in swale between storms.	• Any of the following may apply: Sediment or trash blockages removed. • Grade from upstream end to downstream end of swale is level. • Check dams replaced with level spreaders. • Under drain installed as necessary. • <u>If all the above fail</u>, Basic Bioswale is converted to Wet Bioswale.
		• Water not retained to a depth of about 4-inches during the wet season.	• Build up or repair outlet berm so that water is retained in the wet swale.
	Flow spreader	• Flow spreader not uniformly level or clogged so that flows are not evenly distributed across entire swale width.	• Flow Spreader leveled. • Clogging eliminated. • Flow spreads evenly over entire swale width.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Swale Channel Bottom	Constant base flow	• Muddy Channel(s) in swale bottom formed by erosion due to continuous flow, even during extended dry periods.	• Low-flow pea-gravel drain installed the length of the swale; • Or the base flow was diverted to bypass around swale.
	Inlet/outlet (including underdrain)	• Inlet/outlet areas clogged with sediment and/or debris.	• Clogging/blockage eliminated.
	Poor vegetation coverage	• When grass is sparse, or bare or eroded patches occur in more than 10% of the swale bottom.	• Poor grass cover is determined. • Condition is corrected by re-planting with grass plugs from on site or purchased: Plugs planted in swale bottom at 8-inch intervals; • Or re-seed into loosened, fertile soil.
	Vegetation	• When the grass becomes excessively tall (greater than 10-inches); when nuisance weeds and other vegetation starts to take over.	• Vegetation mowed to 4" height or removed as necessary so that flow not impeded. • Grass clippings removed.
	Wetland vegetation	• Vegetation becomes sparse and does not provide adequate filtration, OR vegetation is crowded out by very dense clumps of cattail, which do not allow water to flow through the clumps.	• Determine cause of lack of vigor of vegetation and correct. Replant as needed. For excessive cattail growth, cut cattail shoots back and compost off-site. **NOTE**: normally wetland vegetation does not need to be harvested unless die-back is causing oxygen depletion in downstream waters.
	Excessive shading	• Grass growth is poor because sunlight does not reach swale.	• Over-hanging limbs trimmed back as much as possible. • Brushy vegetation on adjacent slopes removed as necessary.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Swale Channel Bottom	Erosion/scouring	• Eroded or scoured swale bottom due to high flows or channelization forming ruts in channel bottom.	• Ruts or bare areas less than 12 inches wide repaired by filling damaged areas with crushed gravel. • Larger areas re-graded and re-seeded. • Smaller bare areas over seeded or planted with grass plugs at 8-inch intervals. • Check design flows to assure swale is large enough to handle flows. By-pass excess flows or enlarge swale. Replant eroded areas with fibrous-rooted plants such as Juncus effusus (soft rush) in wet areas or snowberry (Symphoricarpos albus) in dryer areas.
		• Eroded damage over 2-inches deep where cause of damage is still present or where there is potential for continued erosion. • Any erosion observed on a compacted berm embankment. **NOTE**: A licensed civil engineer should be consulted to resolve source of erosion.	• Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.
	Sediment accumulation	• Sediment depth exceeds 2-inches in 10% of the swale treatment area.	• Remove sediment deposits in treatment area.

Vegetated Filter Strip

What is a Vegetated Filter Strip?

A Vegetated Filter Strip is a narrow densely carpeted band of low growing vegetation (usually grasses) planted in deep soil, sloping downward from the edge of a paved roadway or parking area that provides a high level of stormwater pollutant removal (treatment). The strip is designed to filter out runoff sediment and automobile related pollutants as runoff sheet flows across pavement and then flows through planted vegetation as well as down through a deep layer of topsoil mixed with compost.

How does a Vegetated Filter Strip work?

When stormwater runoff passes through the vegetation, pollutants are removed by the combined effects of filtering through the vegetation, as well as infiltrating through the compost enhanced topsoil. These effects are aided by the reduction of runoff velocity as the water leaves the pavement and begins passing through the vegetation.

Typical Vegetated Filter Strip design

There are two important elements which make up a Vegetated Filter Strip:

- A deep bed of topsoil mixed with approved compost to:
  - Enhance health, growth and survivability of the vegetation; and
  - Promote deep rooting of the vegetation allowing for effective infiltration.
- The proper downward slope of the strip to ensure that the stormwater runoff is flowing through the vegetation at a rate that allows:
  - Effective collection/removal of sediment throughout the vegetated strip; and
  - Maximum amount of runoff infiltrating through amended topsoil, removing automobile related pollutants.

When the width of the strip is too narrow for runoff to completely filter through the vegetation, there are two options to transport the excess runoff downstream. Either, a drainage swale or a below ground drainage (with underdrain) trench are added at the base of the strip.

Common Maintenance Needs

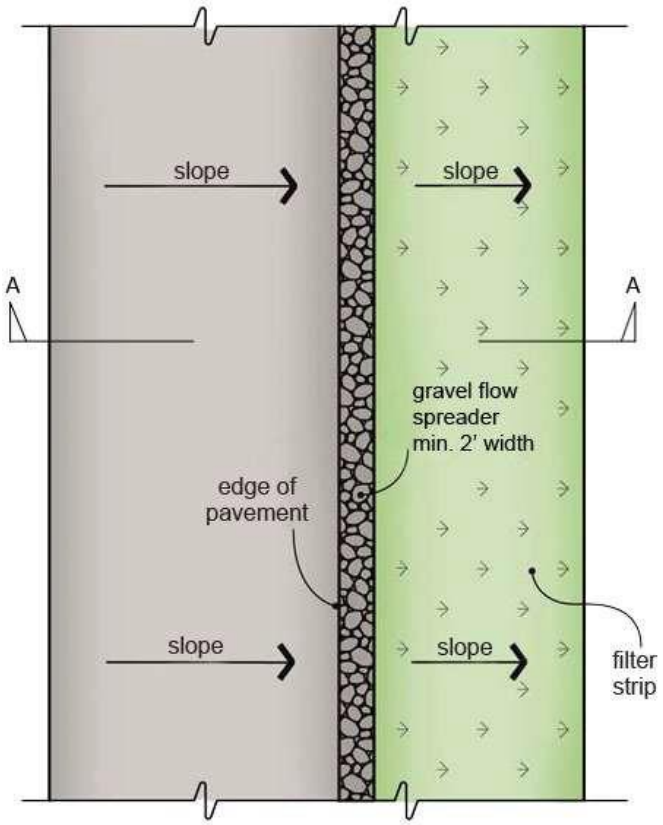
Vegetated Filter Strips should be frequently maintained to sustain their ability to remove sediment and pollutants:

- More frequently: Strips along roadways with shoulders.
- Less frequently: Strips in parking areas.

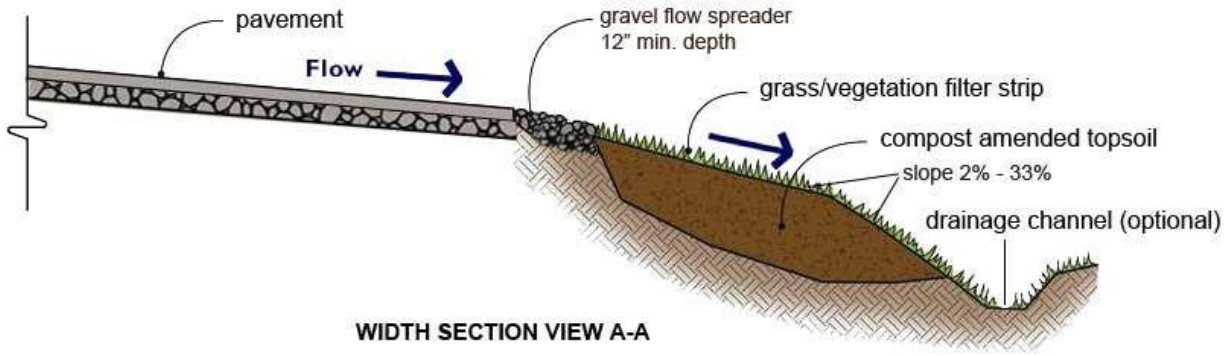
Level of Maintenance:

- Along roadways - Filter strips installed along roadways with shoulders require grading to remove sediment, soil, vegetation and debris buildup to provide an even transition from pavement to gravel or dirt shoulder to allow uniform sheet flows coming off the road.
- Parking areas - Filter strips in parking areas usually only need the build up to be vacuumed up or hand shoveled and swept away. Since water takes the path of least resistance, it will flow to the point where there is little, or no sediment build up and becoming more concentrated, increasing the probability of erosion occurring at that point. Just a few of these points along a strip will cause a great deal of erosion damage and reduce its pollutant removal function. This level of maintenance will reduce the need for the more difficult and costlier repair or replacement of an eroded vegetated strip, drainage channel, or a clogged underdrain.

Vegetated Filter Strip



BIRD'S-EYE VIEW



WIDTH SECTION VIEW A-A

TABLE 15 VEGETATED FILTER STRIP INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
General Filter Strip Area	Accumulation of trash and debris	• Site generally littered.	• Trash and debris removed.
		• Evidence of dumping.	• Neighbors notified of dumping. • "No Dumping" signs installed.
	Contaminants and pollutants	• Any evidence of oil, gasoline, contaminants or other pollutants in or near the Biofiltration Swale area. **For hazardous material, call 911 and Public Works**	• Contaminants or pollutants removed.
	Insects	• Insects such as wasps and hornets interfere with maintenance activities. **NOTE**: Apply insecticide in compliance with manufacturer's directions.	• Insects eliminated.
	Poisonous vegetation and noxious weeds	• Poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. **NOTE**: Any evidence of noxious weeds as defined by the King County Noxious Weed Control Board requires eradication based on the Board's recommendation of Herbicide application or by mechanical means.	• Poisonous vegetation eliminated. **NOTE**: Complete eradication of noxious weeds may not be possible. Compliance with State and County Noxious Weed Control Boards is required.
	Sediment accumulation on grass	• Sediment depth exceeds 2-inches.	• Sediment accumulation removed. • Slope is re-leveled so slope is uniform for the length of the strip. • Flows pass evenly through strip.

Infiltration Pond

What is an Infiltration Pond?

An Infiltration Pond is an earthen basin excavated out of permeable soil for storing stormwater runoff to both provide a small level of flood control and allow the stored runoff to infiltrate through the pond for pollutant removal and ground water recharge rather than discharge to a downstream surface water drainage system.

How does an Infiltration Pond work?

When a pond receives stormwater runoff, the water immediately begins to infiltrate through the pond bottom. As water collects faster than it can infiltrate and pond volume increases, the runoff will also begin to infiltrate through the sides of a pond. As runoff percolates through porous soil, the toxicity of various pollutants is depleted. Eventually, the runoff migrates to groundwater which in turn helps maintain low flow to streams, wetlands and lakes.

During some extreme storm events stormwater can build up to a level that exceeds the pond's capacity. When that occurs, an initial overflow structure inside the pond releases the excess water downstream. If runoff continues to build up and exceed the capacity of the initial overflow structure, water will seep out over a secondary or emergency overflow spillway.

Typical Infiltration Pond design

Infiltration Ponds are typically designed in two configurations. The most common is a single pool (cell) for both collecting stormwater runoff for flood control and soil infiltration for pollutant removal. The other configuration has a smaller pool or forebay added at the upstream end. The function of the forebay is two-fold: collect stormwater runoff for flood control purposes; and remove sediment and other pollutants to reduce the loads flowing to the larger downstream pool. The purpose of the downstream pool is not only for flood control, but also to receive cleaner water allowing it to infiltrate and reduce contaminants that migrate to groundwater.

Another major design parameter is whether to provide an access road down to the Infiltration Pond bottom or not. The City may require that if heavy equipment is necessary for maintenance purposes to rake and/or dredge a pond, the pond should be designed with an access road along the entire perimeter (See Common maintenance needs below). Such a requirement demands that the Infiltration Pond system be designed long and narrow, but no more than 30 feet wide at the bottom.

Common Maintenance Needs

Over time, an infiltration pond accumulates sediment, vegetation debris, and man-made trash which covers the porous soil, clogs pipe inlets and outlets, underdrain systems, and flow control structures. This reduces the infiltration pond's performance and is a major concern.

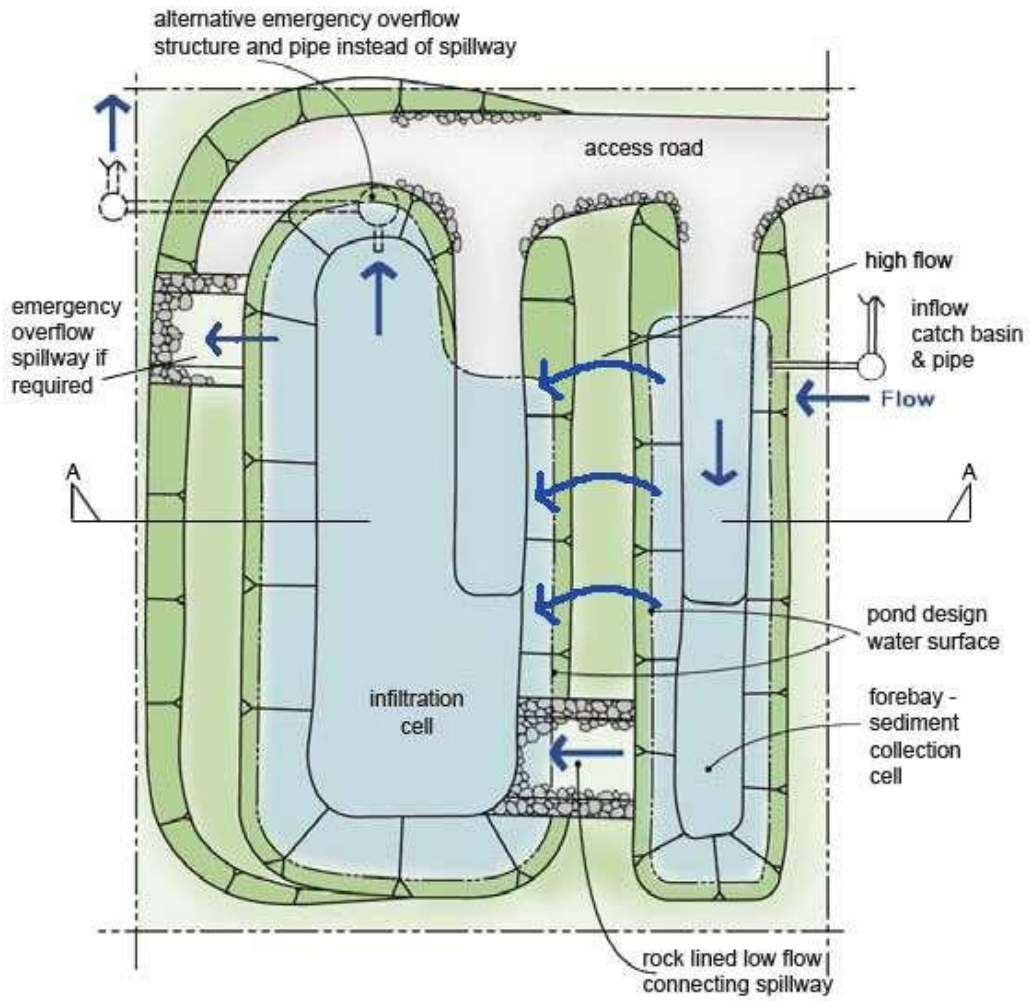
The prevention of covering or icing (as on a cake) of the porous soil with sediment is an on-going maintenance operation. The removal of sediment is usually required every several years, while the removal of debris, trash, and unwanted vegetation growth (trees, bushes, grass patches) along the pond bottom and sides can be necessary two to four times per year.

Soil slumping and compaction are also major concerns. The cause is usually the misuse of the pond basin as a recreational area for BMX bike and motorcycle practice tracks and ramps, fort building, dog walking, etc., and the use of large/heavy excavators and other heavy equipment for dredging, raking or vegetation removal**.** Heavy equipment should not be used in an infiltration pond if the weight of the equipment will compact the porous soil on the pond bottom and sides. The alternative for large and heavy equipment is small and light equipment, which must be operated carefully and not hurried so as not to scar the pond bottom and sides. For small, "pocket sized" infiltration

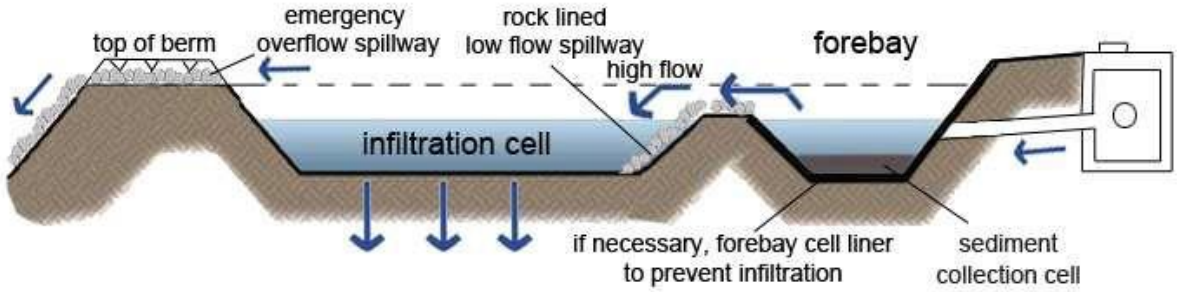
ponds, or larger ones with extremely sensitive soil conditions, raking and/or dredging can be done by hand, as an alternative for using heavy or small equipment.

NOTE: Whether heavy or small equipment is used, all oil and hydraulic fluid spills must be totally removed along with all dredged-out material.

Infiltration Pond



BIRD'S-EYE VIEW



SECTION A-A VIEW

Infiltration Pond

INFILTRATION POND

TABLE 16 INFILTRATION POND INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
General Site Conditions Surrounding Pond	Trash and debris accumulation	• Site generally littered with trash and debris.	• Trash and debris removed.
		• Evidence of dumping.	• Neighbors notified that dumping is prohibited. • "No Dumping" signs installed.
	Contaminants and pollution	• Evidence of oil, gasoline, contaminants or other pollutants in or near the pond. For hazardous material, call 911 and Public Works	• No contaminants or pollutants present.
	Rodent holes	Evidence of rodent holes on site, but not in pond area.	• Rodents eliminated.
	Beaver dams	• Dam results in change or function of the facility. NOTE: Coordinate trapping of beavers and removal of dams with appropriate permitting agencies.	• Facility is returned to design function.
	Insects	• When insects such as wasps and hornets interfere with maintenance activities. **NOTE**: Apply insecticide in compliance with manufacturer's directions.	• Insects eliminated.
	Tree growth and hazard trees	• Specific trees hinder maintenance access or interfere with maintenance activity (i.e., slope mowing, silt removal, vactoring or equipment movements).	• Only Trees hindering maintenance activity removed.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Pond Perimeter Structural Berms (Dams)	Soil Settlement	• A portion of structural berm (compacted earthen embankment) has settled 4 inches lower than the as-built elevation. • Any part of berm which has settled 4 inches lower than the as-built elevation. • Estimate amount of settlement. Settling can be an indication of more severe problems with the berm. • If settlement is apparent, measure berm to determine amount of settlement. • Settling can be an indication of more severe problems with the berm or outlet works. **NOTE**: A licensed civil engineer should be consulted to determine the source of the settlement.	• Berm is repaired and returned to as-built elevation.
	Piping	• Discernable water flow through a compacted structural berm due to tree roots and/or rodent holes/tunnels, can lead to erosion within a berm and structural failure. **NOTE**: A Geotechnical engineer should be consulted to inspect, evaluate, and recommend a repair solution plan. **NOTE**: If pond volume exceeds 10 acre-feet, coordinate with the State Department of Ecology, Dam Safety Office.	• Piping and erosion eliminated.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Emergency Overflow/ Spillway	Rock missing	• Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of flow path of spillway. (Rip-rap on inside slopes need not be replaced.)	• Rocks and pad depth are restored to design standards.
	Erosion	• Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.	• Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.
		• Any erosion observed on a compacted berm embankment **NOTE**: A licensed civil engineer should be consulted to resolve the source of erosion.	• Erosion on compacted berm is eliminated and slope stabilized.
Pre-settling Pool, Pond or Vault	Excessive accumulation of sediment and/or debris	• 6" or designed sediment trap depth of sediment.	• Sediment and/or debris removed.
Infiltration Pool	Excessive accumulation of sediment	• Water ponding in infiltration pond after rainfall ceases and appropriate time allowed for infiltration. • If depth of sediment exceeds two inches, it needs to be removed. **NOTE**: Soil sampling or a percolation test may need to be done to determine if infiltration is less than 90% of designed capabilities.	• Sediment is removed and/or facility is cleaned so that infiltration system works according to design.
Rock Filters	Excessive accumulation of sediment and/or debris	• By visual inspection, little or no water flows through filter during heavy rain storms.	• Gravel in rock filter is replaced.

Fencing and Gates

What is the need for a fence?

Six-foot-high galvanized chain-link security fencing and maintenance access gates are required by Duvall Code and Development Design Standards.

- For reasons of:
  - safety to prevent injury, and
  - security to prevent malicious damage that may impair the function of a facility.
- To enclose stormwater facilities that are either:
  - a steep sloped open stormwater detention/retention pond/swale, or
  - a concrete vault with tall exposed walls from the top of the vault lid (creating a ledge) to ground level.
- In some cases, after a developer has relinquished responsibility for a project with a stormwater facility that was not required to have a fence around it, the new owner's liability insurance may require fencing.

Typical Fence design

Galvanized chain-link fences are to be:

- six feet high, and
- located along the perimeter at the:
  - top of earthen bank of a pond or swale with:
    - a pool side slope steeper than 1.0' vertical for every 3.0' horizontal
    - a pool with a full water depth exceeding 3.0'
  - top of a concrete, block or rock wall of a pond or swale that is exposed more than 3.0'
  - edge of a concrete vault lid on top of a wall exposed more than 3.0'

Notes:

The City has selected chain-link fencing because:

- It not only prevents animals and unauthorized people from entering;
- It also allows the pond to be open to view.
  - Any unauthorized activity within the fenced off area can be witnessed.
  - This would be difficult if the fence were a wood or plastic wall.

The width of a 16'-20' wide double hung gate is necessary to:

- Adequately accommodate maintenance machinery and vehicles; and
- In some instances, there may be a need for:
  - An additional 4-foot wide man-gate;
  - In rare instances, a man-gate is the only access required for inspection and maintenance activities.

Common Maintenance Needs

Fence maintenance is a safety and security issue. A stormwater facility is considered an "attractive nuisance." Over time trees fall on fences, soil erodes away from post holes, vandals cut the wire, tree trunks or limbs push the fence over or lift it up. These are several problems which need to be checked out routinely and maintenance action taken immediately.

6-FOOT HIGH BLACK VINYL-COATED CHAIN LINK FENCE ALONG PERIMETER OF DETENTION POND

6-FOOT AND 4-FOOT HIGH GALVANIZED CHAIN LINK FENCE WITH POSTS SET IN THE TOP OF A WATER QUALITY PERIMETER WALL

6-FOOT GALVANIZED CHAIN LINK FENCE SET ALONG AN ACCESS ROAD

TABLE 17 FENCING AND GATE INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Site	Erosion	• Erosion has resulted in an opening under a fence that allows entry to people or pets.	• Replace soil under fence so that no opening exceeds 4-inches in height.
Fences	Damaged parts	• Posts out of plumb more than 6-inches.	• Post plumb to within 1-1/2 inches of plumb.
		• Top rails bent more than 6-inches.	• Top rail free of bends greater than 1-inch.
		• Any part of fence (including posts, top rails, and fabric) more than 1-foot out of design alignment.	• Fence is aligned and meets design standards.
		• Missing or loose tension wire.	• Tension wire in place and holding fabric.
		• Missing or loose barbed wire that is sagging more than 2-1/2 inches between posts.	• Barbed wire in place with less than ¾-inch sag between posts.
		• Extension arm missing, broken, or bent out of shape more than 1-1/2 inches.	• Extension arm in place with no bends larges than ¾ inch.
	Deteriorated paint or protective coating	• Part or parts that have a rusting or scaling condition that has affected structural adequacy.	• Structurally adequate posts or parts with a uniform protective coating.
	Openings in fabric	• Openings in fabric are such that an 8-inch diameter ball could fit through.	• No openings in fabric.
Gates	Locking mechanism damaged or missing	• Mechanism cannot be opened by one maintenance person.	• Locking mechanism repaired or replaced.
	Damaged or missing components	• Broken or missing hinges such that gate cannot be easily opened and closed by a maintenance person.	• Hinges intact and lubed. Gate working freely.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Gates	Damaged or missing components	• Gate is out of plumb more than 3 inches and more than 6 inches out of design alignment.	• Gate is aligned and plumb.
		• Missing stretcher bar, bands, and ties.	• Stretcher bar, bands, and ties in place.

Stormwater Facility Access

Drainage Easements & Covenants

Privately owned stormwater facilities are in tracts of land dedicated solely for drainage purposes, or easements/tracts across residential lots dedicated for purposes other than drainage.

The City requires a Drainage Covenant between it and the owner/developer of a newly developed property with a drainage system and their assigns (future purchasers). For a residential plat the assignee would be the HOA and for a condominium project it would be the condo association (CA). This covenant establishes not only a property owner's, HOA's/CA's ownership of any stormwater facility or conveyance system in a drainage easement dedicated to the City, but also the responsibility for inspecting and maintaining them. Even though the drainage easement is dedicated to the City, it only grants the City the right of access to inspect or maintain at its discretion, but no responsibility for inspecting or maintaining a facility/system.

Residential plat inspection and maintenance responsibilities are delineated in three documents:

- Duvall Municipal Code (DMC);
- The Final Plat Document which outlines the responsibilities of all parties having any interest in the plat; and
- The Covenants, Conditions and Restrictions (CC&Rs) which outline the responsibilities of all property owners.

NOTE: Commercial property owners (including condominium and low-density multi-family residential projects) have always owned and been responsible for maintenance of their stormwater facilities.

Stormwater Facility Access Roads

Many stormwater facilities have access roads to and into a stormwater facility. These access roads need to be maintained so that maintenance vehicles and heavy equipment have an unobstructed path to any area needing maintenance or repair.

Most pond type facilities have access roads (more like driveways) extending from the street to the top rim of the pond. In addition, many have roads that continue around the top of a pond perimeter, structural fill berm along the entire perimeter, or only so far as the location of the Flow Control Structure. Some detention ponds have roads that go down into the pond itself so that heavy excavation equipment and dump trucks can have easier access in and out of especially deep ponds. Access roads should be maintained for ease of inspection and ease of maintenance equipment access.

NOTE: See Infiltration Pond for special access road requirements.

ASPHALT POND ACCESS ROAD BEFORE MAINTENANCE

AFTER MAINTENANCE

WATER QUALITY POND GRAVEL ACCESS ROAD BEFORE MAINTENANCE

AFTER MAINTENANCE

GRAVEL/DIRT ACCESS ROAD OF WATER QUALITY POND GOING OVER BERM BETWEEN CELL 1 AND 2

ACCESS ROAD BEHIND GATE COMPLETELY OVER GROWN WITH TREES AND VEGETATION MAKING IT IMPOSSIBLE TO ACCESS THE FACILITY

TABLE 18 STORMWATER FACILITY ACCESS INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
General Site Access Conditions	Exposed soil	• Soils are bare or eroded.	• Ground reseeded or vegetation replanted.
	Road Surface	• Condition of road surface may lead to erosion of the facility or limit access.	• Road repaired.
	Erosion of ground surface	• Noticeable rills are observed in landscaped areas.	• Causes of erosion identified. • Erosion eliminated or reduced. • Eroded areas are filled, contoured, and seeded. • Affected areas regarded as necessary.
	Trash & debris	• Accumulation of litter across site.	• Trash and debris removed.
	Poisonous vegetation and noxious weeds	• Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. • Any evidence of noxious weeds as defined by State or local regulations. **NOTE**: Apply herbicides in accordance with requirements of King County Noxious Weed Board.	• Poisonous vegetation eliminated. **NOTE**: Complete eradication of noxious weeds may not be possible. Compliance with State or local eradication policies required.
	Tree growth and hazard trees	• Specific trees hinder maintenance access or interfere with maintenance activity (slope mowing, silt removal, vactoring, or equipment movements).	• Only trees hindering maintenance activities removed.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
General Site Access Conditions	Tree growth and hazard trees	• Dead, diseased, or dying trees identified. **NOTE**: Use a certified Arborist to determine health of tree or removal.	• Hazard trees removed. **NOTE**: Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood).
		• Trees or shrubs that have been blown down or knocked over.	• Replant tree, inspecting for injury to stem or roots. Replace if severely damaged.
	Poisonous or nuisance Vegetation	• Any vegetation which may constitute a hazard to maintenance personnel or the public. • Evidence of noxious weeds as defined by State or local regulations. **NOTE**: Apply herbicides in accordance with requirements of King County Noxious Weed Board.	• Poisonous or nuisance vegetation eliminated. **NOTE**: Complete eradication of noxious weeds may not be possible. Compliance with State or local eradication policies is required.
	Weeds	• Weeds growing in more than 20% of the landscaped area (trees and shrubs only).	• Weeds removed, with less than 5% remaining in access area.
	Insects	• When insects such as wasps and hornets interfere with maintenance activities. **NOTE**: Apply insecticide according to manufacturer's directions.	• Insects eliminated.

General Grounds Keeping and Landscape Plantings Care

Integral part of stormwater facility maintenance program

Establishing a Grounds Keeping and Landscape Plantings Care plan should not only be an integral part of any residential subdivision or commercial property stormwater facility maintenance program but should be incorporated into the property management program as well.

Depending on a stormwater facility's function and the overall intent of the project design, general grounds keeping ranges from making a stormwater facility and its surrounding area neat and tidy to keeping the facility and its surroundings wild and natural.

Required care

Required grounds keeping and maintenance of landscape plantings care includes cultivating the various desirable plant and tree species essential for a stormwater facility's function and eliminating or controlling undesirable species especially noxious weeds (see below). Control plant and tree growth throughout the growing season and into the rainy season especially on earthen berms; and around concrete structures such as flow control and overflow structures. It is also important to keep access roads, gates and fences clear of trees and brush.

Control noxious weeds

Noxious weeds need to be eliminated or vigorously controlled. Common noxious weeds found in or near stormwater runoff facilities include: Knotweeds, Yellow Archangel, Atlantic and English Ivy, Yellow Flag Iris, Fragrant Water Lily and Purple or garden Loosestrife. The less noxious, but still obnoxious plants and trees also need to be vigorously controlled, such as reed canary grass, blackberry and morning glory vines, scotch broom, cottonwood and alder trees. For more information about noxious weeds go to the King County Noxious Weed Board website: http://www.kingcounty.gov/environment/animals-and-plants/noxious-weeds.aspx

Maintenance for aesthetic reasons encouraged

Maintenance for aesthetic purposes, ranging from totally "wild and natural" to totally "manicured" is ***strongly encouraged but not required***. Going beyond what is required can not only improve a facility's appearance but also enhance its function as well. Taking this approach can help even more to:

- Reduce the potential for flooding property;
- Provide for a healthier fish and critter habitat;
- Improve residential property values; and
- Make commercial property more attractive for clients and customers.

TABLE 19 GENERAL GROUNDS KEEPING AND LANDSCAPE INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Facility Site	Poisonous or nuisance Vegetation	• Any vegetation which may constitute a hazard to maintenance personnel or the public. • Evidence of noxious weeds as defined by State or local regulations. **NOTE**: Apply herbicides in accordance with requirements of King County Noxious Weed Board.	• Poisonous or nuisance vegetation eliminated. **NOTE**: Complete eradication of noxious weeds may not be possible. Compliance with State or local eradication policies is required.
	Weeds (nonpoisonous)	• Weeds growing in more than 20% of the landscaped area (trees and shrubs only).	• Weeds present in less than 5% of the landscaped area.
	Insect hazard or poisonous vegetation	• Any presence of poison ivy or other poisonous vegetation or insect nests.	• No poisonous vegetation or insect nests present in landscaped area.
	Erosion of ground surface	• See ponds checklist	• See ponds checklist.
	Dead or damaged	• Noticeable rills are seen in landscaped areas.	• Causes of erosion are identified and steps taken to slow down/spread out the water. Eroded areas are filled, contoured, and seeded.
Trees and Shrubs	Missing or broken parts in visual screen	• Limbs or parts of trees or shrubs that are split or broken which affect more than 25% of the total foliage of the tree or shrub.	• Trim trees/shrubs to restore shape. Replace trees/shrubs with severe damage.
		• Trees or shrubs that have been blown down or knocked over.	• Replant tree, inspecting for injury to stem or roots. Replace if severely damaged.

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Trees and Shrubs	Missing or broken parts in visual screen	• Trees or shrubs which are not adequately supported or are leaning over, causing exposure of the roots.	• Place stakes and rubber coated ties around young trees/shrubs for support.
Visual Buffer Screen	Unruly shrubbery and vegetation	• Any gap in screen that permits easy entry to facility	• Shrubs replaced to for a solid screen.
		• Shrubbery is growing out of control or is infested with weeds.	• Shrubbery is trimmed and weeded to provide appealing aesthetics. Do not use chemicals to control weeds.

Chapter 7 Low Impact Development Best Maintenance Practices

What is low impact development (LID)?

Low impact development (LID) are principles and practices that mimic the natural hydrologic processes. Due to increases in impervious surfaces by Urban Development, less stormwater can infiltrate into to soil and groundwater table therefore causing surface water levels to fluctuate, drastically damaging fish habitat and the surround environment. LID principles include: reducing impervious surfaces (footprint); retaining native vegetation; and reducing overall surface runoff leaving a site.

Some LID or flow control best management practices (BMPs) are more effective than others at mimicking hydrologic features and minimizing impacts. Minimum design requirements, specifications and maintenance practices can be found in the King County Stormwater Design Manual Appendix C. Other resources that may be helpful include:

- Puget Sound Water Quality Action Team's *Low Impact Development Technical Guidance Manual for Puget Sound* (December 2012);
- Washington State University Extension's *Rain Garden Handbook for Western Washington* (June 2013);
- King County's *Surface Water Design Manual* (2016); and
- Washington Department of Ecology's *Stormwater Management Manual for Western Washington* (2012).

How is LID implemented?

LID BMPs can be accomplished by utilizing dispersion, infiltration, and pervious pavement options. By incorporating these stormwater and land use strategies into project designs, on-site natural features will slow down, soak in, and increase water quality for surface runoff. Some examples of these system include, but are not limited to:

- Full Dispersion
- Full Infiltration
- Limited Infiltration
- Basic Dispersion
- Bioretention
- Permeable Pavement
- Rainwater Harvesting
- Rain Gardens
- Reduced Impervious Surface
- Native Growth Retention
- Perforated Pipe Connection

Dispersion

What is Dispersion?

Dispersion techniques include: splash blocks, rock pads, dispersion trenches, and sheet flow. Benefits of managing on-site stormwater runoff by dispersion or infiltration reduces the discharge volumes and flow rates to off-site facilities thus mitigating and reducing the size and number of formal flow control and treatment facilities.

Splash Blocks/Rock Pads/Pop-Up Emitter

Splash blocks are located underneath downspouts and are essential in directing runoff away from structure foundations. Rock pads used for full dispersion are pads of crushed rock, 2-feet wide by 3-feet long by 6-inches deep that may be used to disperse small amounts of concentrated runoff. Pop-up emitters are used for diverting and dispersing a specific square footage of impervious surface area runoff. During high flows the pop-up emitter opens to release water and closes with no flow to help keep debris from collecting in the pipe. The pop-up emitter must drain to at least a 25-foot vegetated flow path.

Design specifications for splash blocks and rock pads:

- No more than 700 square feet of impervious surface per rock pad;
- Maximum impervious surface area of 1,400 square feet may be drained to a single rock pad if the native vegetative flow path segment is at least 200 feet long;
- For impervious areas between 700 and 1,400 square feet the flow path segment may vary proportionally between 100 and 200 feet;
- For limited dispersion, no more than 700 square feet of impervious area to a 50-foot-long vegetated flow path.

Dispersion Trench

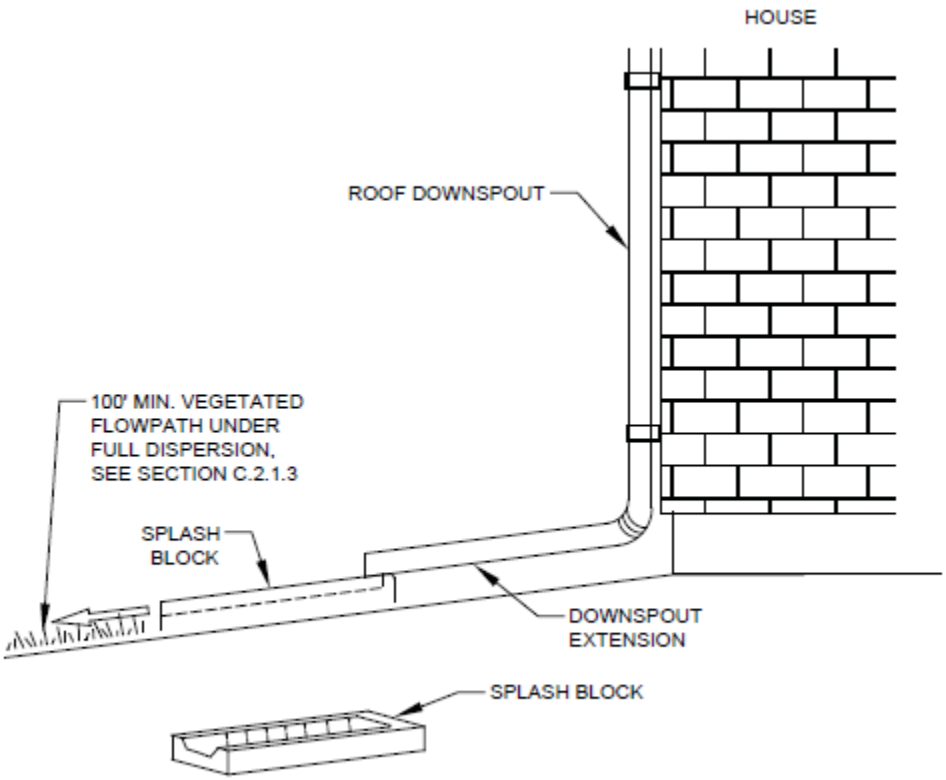
Dispersion trenches are filled with gravel to spread the discharge of concentrated runoff from any type of developed surface. Trenches are filled with ¾- to ½-inch washed rock and must be placed at least 10-feet from any building. A simple 10-foot-long trench must be at least 2-feet wide by 18-inches deep.

Design specifications for simple 10-foot dispersion trench:

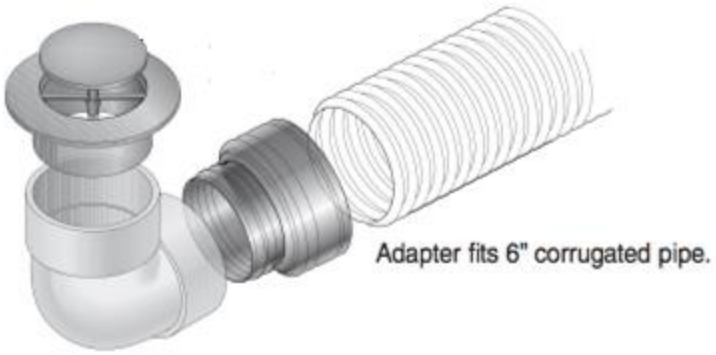
- No more than 1,400 square feet may be drained to a simple dispersion trench with a native vegetated flow path of 100 feet;
- Maximum impervious surface area of 2,800 square feet may be drained to a simple dispersion trench if the native vegetative flow path of at least 200 feet long;
- For impervious areas between 1,400 and 2,800 square feet, the native vegetative flow path may vary proportionally between 100 and 200 feet long;
- For limited dispersion, no more than 700 square feet of impervious area to a 25-foot-long vegetated flow path.

Sheet Flow

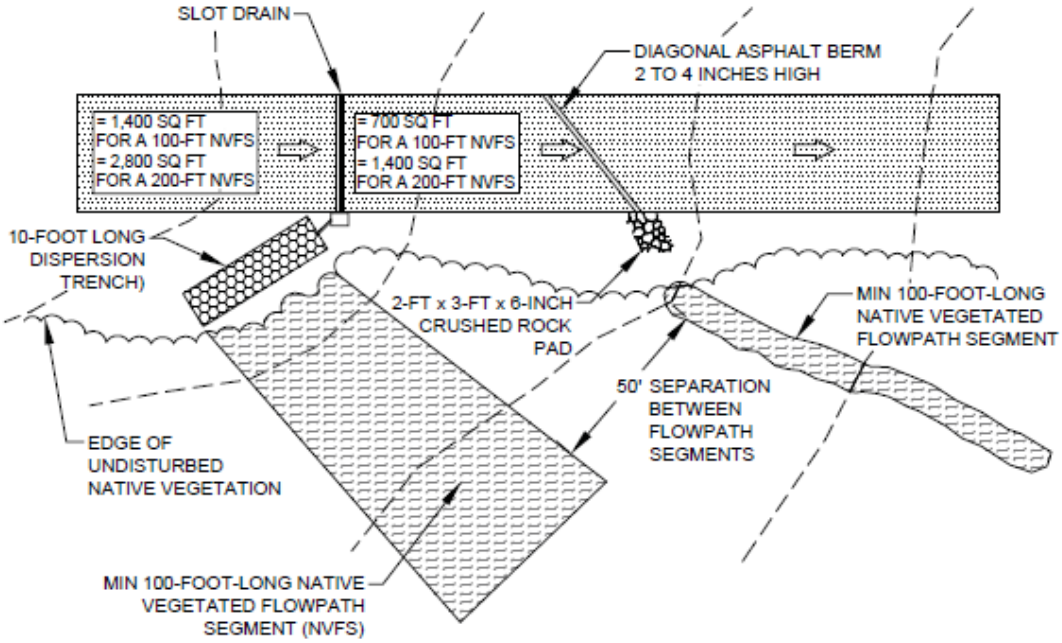
Sheet flow, as used for dispersion, is the grading of a developed surface as needed to avoid the concentration of runoff before and after discharge from the surface. There are two types of sheet flow, one for impervious surface and one for pervious surface, slot drains may be used to discharged to a strip of crushed rock or extended base course of a road or driveway to facilitate dispersal of runoff.



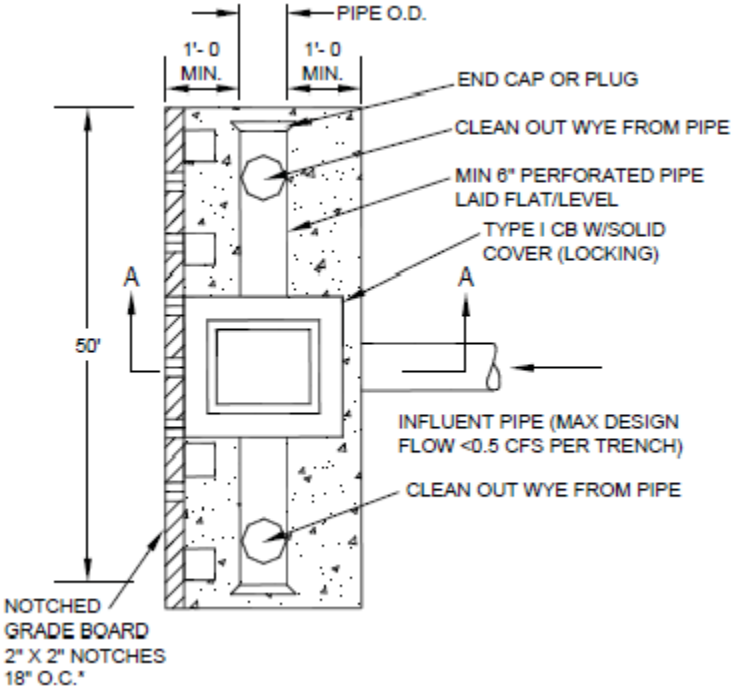
Splash Block - Side View

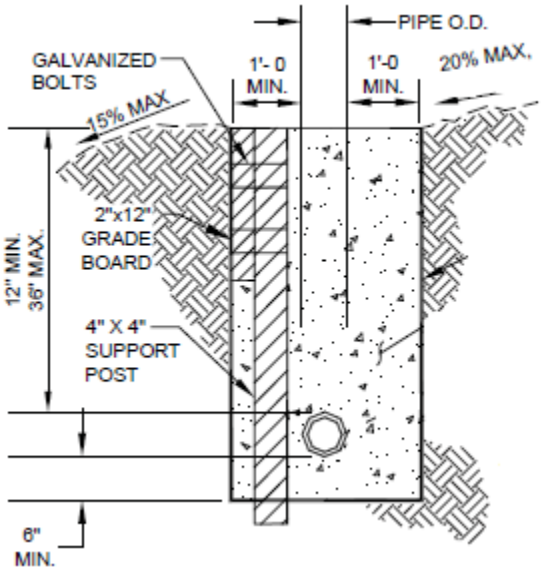


Pop-up Emitter - typical



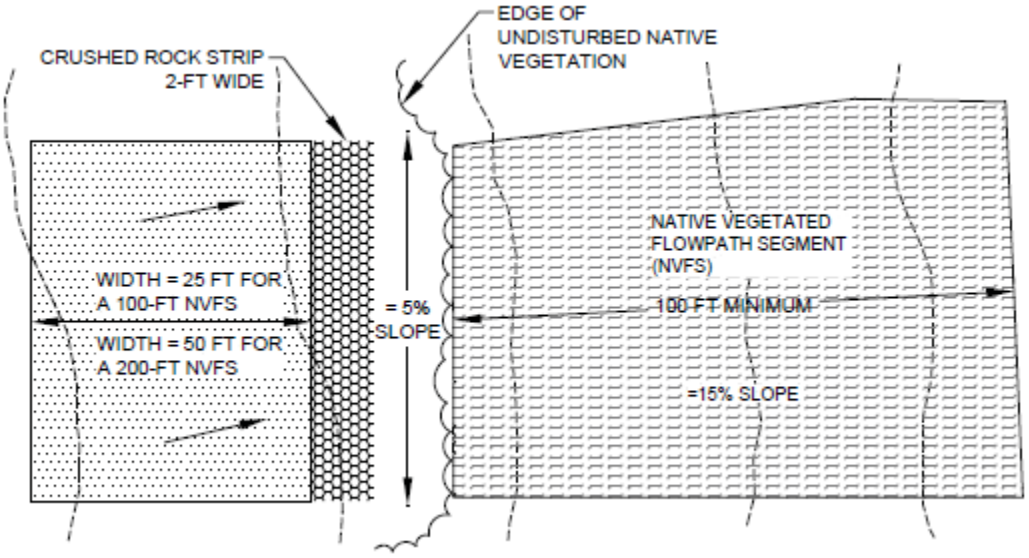
Dispersion Trench and Rock Pad (Driveway application)





Cross-section A-A

Plan View of 50-foot Dispersion Trench



Plan View of Sheet Flow

Dispersion

SPLASH BLOCKS

POP-UP EMITTER

DISPERSION TRENCH

DRIVEWAY/WALKWAY SLOT DRAIN

TABLE 20 DISPERSION BMP INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
General Area	Exposed soil or lack of vegetated path	• Soils are bare or eroded.	• Ground reseeded or vegetation replanted. • Identify sources or causes of erosion
	Missing or broken parts	• Any part that is missing/broken which impedes the dispersion of water	• Replace missing/broken parts
	Trash and debris accumulation	• Trash and debris accumulated	• Trash and debris removed.
	Ponding	• Standing/ponded water after a storm event or during normal wet weather seasons	• Level the edge of pervious area and or/ regrade or replenish the rock in the dispersion device to mitigate concentrated flows

Infiltration

What is Infiltration?

Full Infiltration is the use and application of BMPs to reliably infiltrate or soak runoff into the ground and may be applied to any non-pollution generating impervious surface. Infiltration techniques include: raingardens, drywells, infiltration trench, and pervious pavements.

Raingarden

Raingardens may also act in slowing down surface runoff and allowing it to infiltrate/soak into the ground. The size, placement, and design of the raingarden is intended to act as a bioretention flow control BMP for retaining and filtering stormwater from an impervious surface area or non-native pervious surface. The design of these raingardens supports vigorous plant growth to filter water and depending on soil conditions. Raingardens may retain and hold water throughout the wet season with the potential to overflow during major storm events.

Drywell

Drywells are gravel filled holes that allow for a more compact design when compared to trenches and are best applied in areas where the depth to groundwater, during the max wet weather season, is relatively deep (e.g. greater than 6-feet). Drywells are intended to infiltrate runoff from impervious surface areas by holding the runoff long enough to soak it into the ground for a reasonable number or years.

Design specifications for drywells:

- When located in coarse sands and cobbles, drywells must contain a volume of gravel equal to or greater than 60 cubic feet per 1,000 square feet of impervious surface served. When in medium sands, drywells must contain at least 90 cubic feet of gravel per 1,000 feet of impervious surface served;
- Must be at least 48 inches in diameter and deep enough to contain the gravel amounts specified above for the soil type and impervious area served;
- Gravel used must be 1½- to 3-inch washed drain rock that may be covered with backfill material or remain exposed at least 6 inches below the lowest surrounding ground surface;
- Filter fabric must be placed on top of the drain rock and the drywell sides prior to filling with drain rock;
- Spacing between drywells shall be a minimum of 10-feet; and
- Drywells must have a setback of at least 15-feet from buildings with crawl space or basement elevations at or below the overflow point of the drywell.

Infiltration Trench

Infiltration trenches may be used when there are site constraints on creating a settling pond. These BMPs may be installed on single family residences, parking areas, or other suitable linear areas. These gravel filled trenches are feasible where the depth to maximum wet season groundwater or hardpan is between 3- and 6-feet.

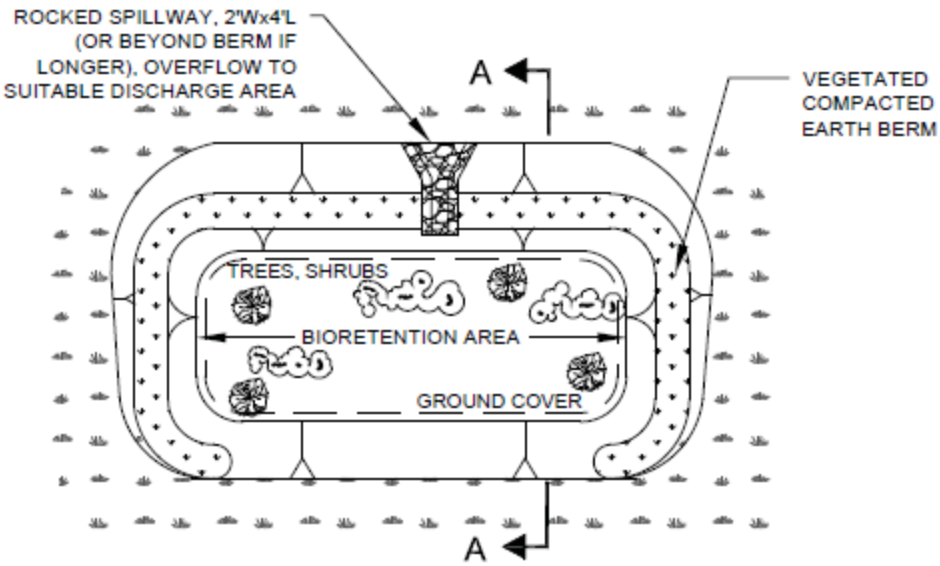
Design specifications for infiltration trenches:

- When located in coarse sands and cobbles, trenches must be at least 20 feet in length per 1,0000 square feet of impervious surface served. When in medium sands, infiltration trenches must be at least 30 feet in length per 1,000 feet of impervious surface served;
- Maximum trench length must not exceed 100 feet from the inlet sump and trench width must be a minimum of 2-feet;
- The trench must be filled with at least 18 inches of ¾- to 1½-inch washed drain rock that may be covered with backfill material or remain exposed at least 6 inches below the lowest surrounding ground surface;
- Filter fabric must be placed on top of the drain rock and the trench sides prior to filling with drain rock;
- Spacing between trench centerlines is at least 6-feet; and
- Infiltration trenches must have a setback of at least 15 feet from buildings with crawl space or basement elevations at or below the overflow point of the trench.

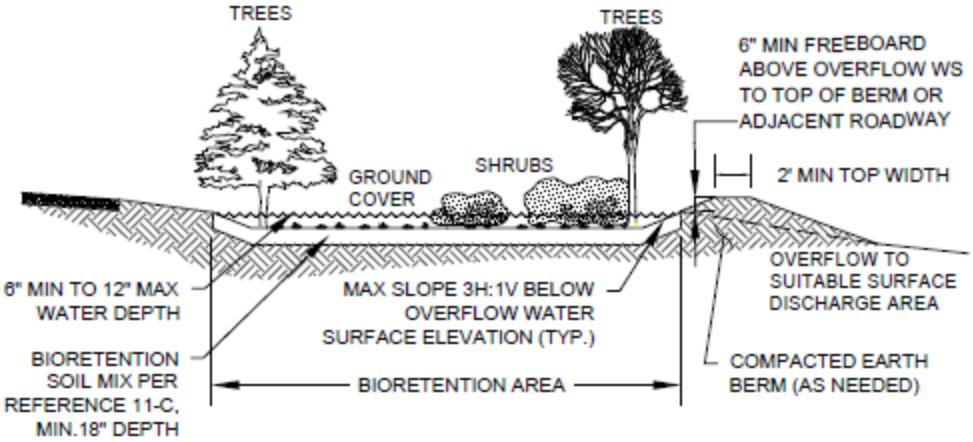
To prevent damage to overlaying pavement, trenches located near pavement shall be constructed such that the trench pipe is connected to a small yard drain or catch basin with a grate cover so that if capacity is exceeded, the overflow would occur out of the catch basin at an elevation at least one foot below that of any overlaying pavement, and in a location, that provides a safe path for overflow. Runoff from roadways, driveways, and parking areas shall pass through a yard drain or catch basin fitted with a down-turned elbow prior to entering the infiltration trench, to trap spilled material for easy cleanup.

Permeable Pavements

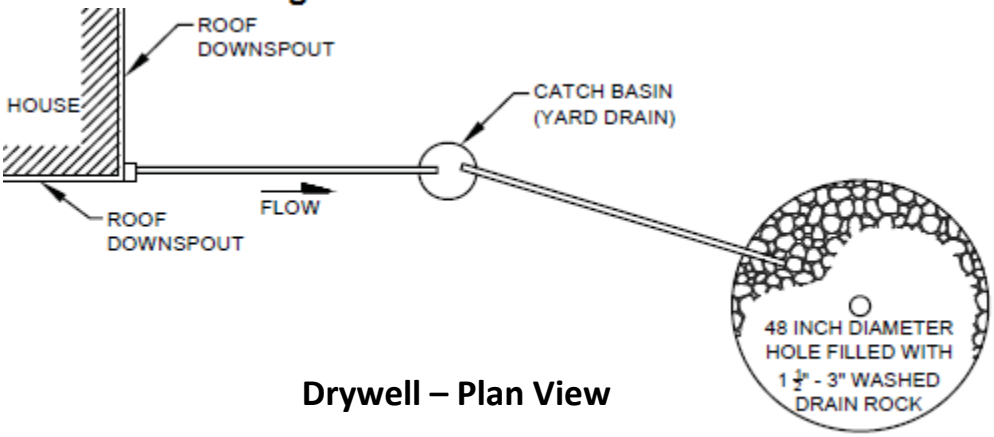
There are many different types of permeable pavement options, which include: porous concrete, porous asphalt, grass modular grid systems, and pavers. Dependent upon design requirements and specifications, permeable pavement may be applied to non-pollution generating impervious surfaces, and restricted pollution generating surfaces such as driveways and parking areas. Ideally, permeable pavement slopes should be less than 5%, and not in an area with a high groundwater table or highly impervious soils.



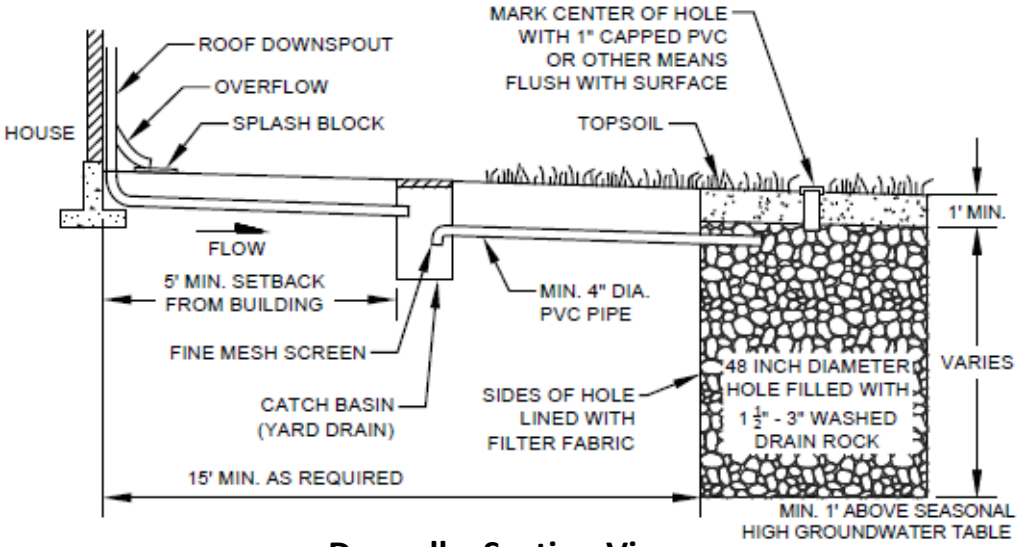
Typical Raingarden - Plan View



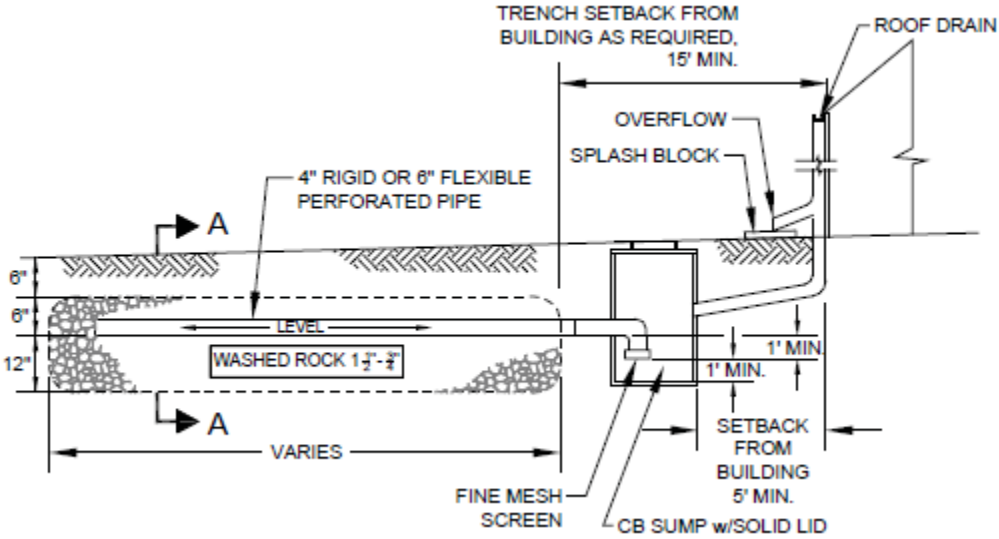
Raingarden - Section A-A View



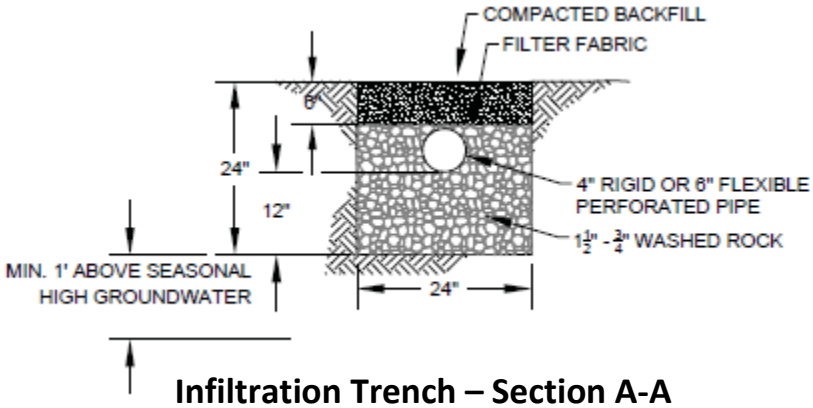
Drywell – Plan View



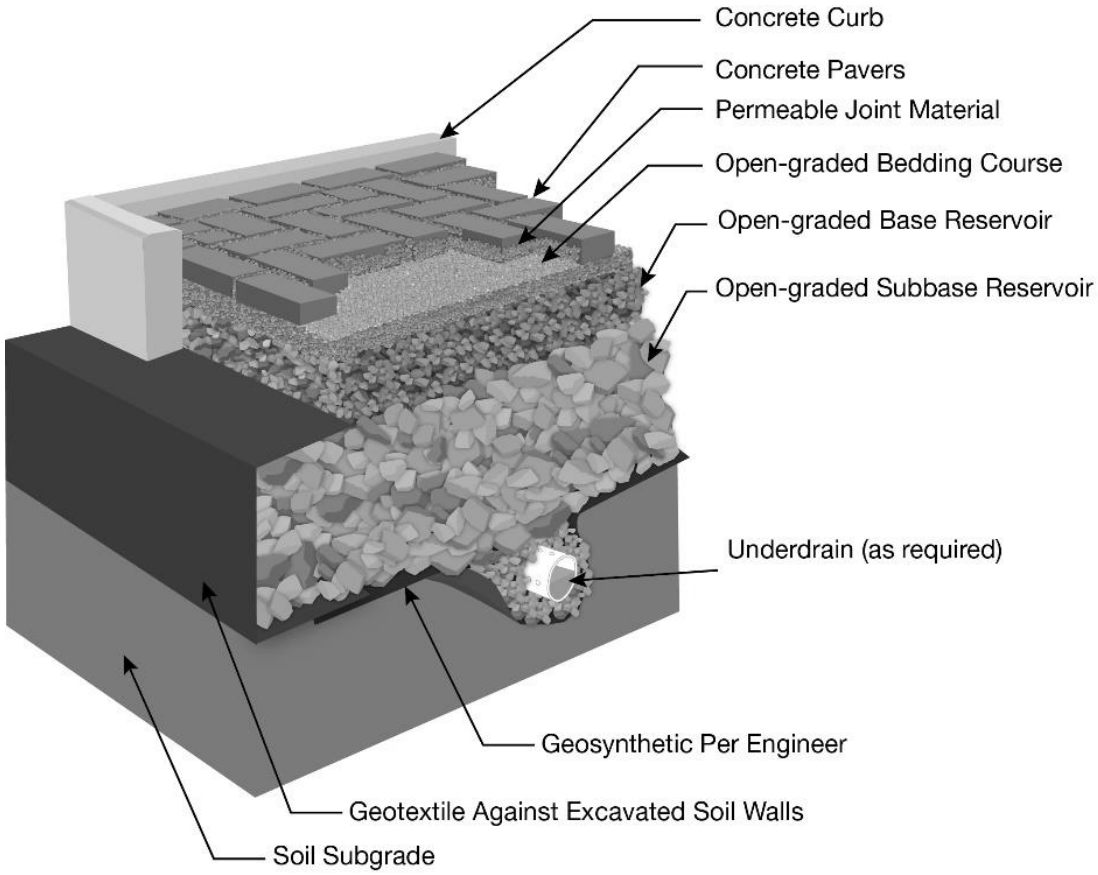
Drywell – Section View



Typical Infiltration Trench - Section View

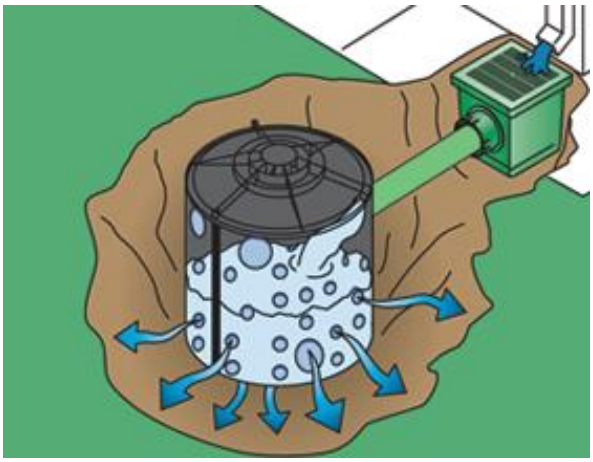


Infiltration Trench – Section A-A



Typical Permeable Surface - Cross Section

RAINGARDEN



DRYWELL

INFILTRATION TRENCH

POROUS PAVEMENT, MODULAR GRASS GRID, PERMEABLE PAVER

TABLE 21 INFILTRATION BMP INSPECTION

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Raingarden	Vegetation	• When vegetation starts to take over • Failing/dead vegetation • Noxious vegetation **NOTE**: Do not use herbicides or pesticides in or during maintenance of a raingarden	• Annual pruning, as well as keeping overly vigorous vegetation back from roadways and walkways • Replace all dead vegetation as soon as possible • Remove all noxious weeds and vegetation when discovered
	Soils	• Proper soil mix with enough porosity (avoiding compacted earth in infiltration cells)	• Replace soil with mulch layer for good infiltration and plant nutrients
	Trash and debris	• Trash and debris accumulated	• Trash and debris removed.
	Erosion	• Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion. • Any erosion observed on a compacted berm embankment. **NOTE**: A licensed civil engineer should be consulted to resolve source of erosion.	• Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass
Drywell	Preventative	• Any cause limiting flow into drywell	• Drywell able to receive full flow prior to and during wet season
	Trash and debris	• Trash or debris that could end up in the drywell is evident	• No trash or debris that could get into the drywell are found

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
Drywell	Pipes	• Inlet is plugged, or pipe free flow diminished due to sediment, trash or debris • Vegetation/roots that reduce free movement of water through the pipes • Damage to pipes or joints allowing water to seep out	• Inlet and connecting pipes are not restricted and may flow freely • Water flows freely through pipes • Pipes do not allow water to exit other than intended outlet
	Structure	• Holes or breaks in the basin which allow water to leave the basin at locations other than per design	• Basin is sealed and allows water to exit only where designed
	Filter Media	• Filter media plugged	• Flow through filter media is normal
Infiltration Trench	Preventative	• Any cause limiting flow to infiltration trench	• Infiltration trench able to receive full flow prior to and during we season
	Trash and Debris	• Trash or debris that could end up in the drywell is evident	• No trash or debris that could get into the drywell are found
	Pipes	• Inlet is plugged, or pipe free flow diminished due to sediment, trash or debris • Vegetation/roots that reduce free movement of water through the pipes • Damage to pipes or joints allowing water to seep out	• Inlet and connecting pipes are not restricted and may flow freely • Water flows freely through pipes • Pipes do not allow water to exit other than intended outlet
	Structure	• Flows are not getting into trench as designed • The cleanout/inspection access is no available	• Water enters and exits trench as designed • Cleanout/inspection access is available
	Filter Media	• Filter media plugged	• Flow through filter media is normal
Permeable Pavement	Preventative	• Media surface vacuumed or pressure washed annually, vegetation controlled to design maximum. Weed growth suggesting sediment accumulation	• No dirt, sediment, or debris clogging permeable media, or vegetation limiting infiltration

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
	Trash and Debris	• Trash and debris on the pavement interfering with infiltration; leaf drop in fall season	• No trash or debris interfering with infiltration
Permeable Pavement	Sediment Accumulation	• Sediment accumulation in the surface interfering with infiltration; runoff from adjacent areas depositing sediment/debris on surface	• Surface infiltrates as designed; adjacent areas stabilized
	Infiltration Rate	• Surface does not infiltrate at a rate of 10 inches per hour • Poor infiltration due to soil compaction between pavers	• Surface infiltrates at a rate greater than 10 inches an hour • No soil compaction in the interstices of the pavers limiting infiltration
	Broken, Spalling, or cracked material	• Surface is broken, spalling, cracked, or missing pavers	• No broken, spalling, cracked or missing materials
	Settlement	• Uneven surface indicating settlement of the subsurface layer or • Uneven surface due to scour of fill between pavers	• Surface is uniformly level
	Moss growth	• Moss growth on surface preventing infiltration	• No moss interfering with infiltration
	Inflow	• Inflow to the surface is diverted, restricted, or depositing sediment and debris	• Inflow to the surface is unobstructed and not bringing sediment or debris
	Underdrain	• Underdrain is not flowing when pavement has been infiltrating water	• Underdrain flows freely when water is present
	Overflow	• Overflow not controlling excess water to desired location; native soil is exposed, or other signs of erosion damage are present	• Overflow permits excess water to leave the site at the desired location; and is stabilized and appropriately armored

Drainage system feature	Potential defect	Conditions when maintenance is needed	Results expected when maintenance is performed or not needed
	Dead Grass	• Grass in the interstices of the pavers is dead	• Healthy grass is growing in the interstices of the pavers

Chapter 8 Water Quality and Flow Control

Purpose

This section applies to city operations, as well as public or privately owned and operated systems in the incorporated areas of the City. Drainage systems are often located in or near areas that are also fish and wildlife habitat. This section helps make sure that storm system owners and/or managers perform their maintenance in a way that conforms to current regulations protecting fish and wildlife.

Why Maintain Water Quality or Flow Control Facilities?

Along with keeping properties from flooding, properly designed and maintained stormwater facilities can help reduce surface water and groundwater pollution. Many newer sites have stormwater control facilities that are designed to limit the environmental damages as well as protect the property form flooding caused by stormwater runoff. These systems cost many thousands of dollars to install and require more maintenance than a system of pipes and catch basins.

Stormwater maintenance is necessary to protect our bays, streams, lakes, wetlands, and groundwater. Proper maintenance helps assure that:

- Stormwater facilities operate as they were designed;
- Stormwater facilities are cleaned of the pollutants that they trap, such as sediment and oils so that the site's stormwater facilities are not overwhelmed and become pollutant sources;
- Sources of pollutants (such as leaky dumpsters) to stormwater facilities are removed.

Stormwater Facilities or Activities

Stormwater facilities are specific drainage features such as catch basins, pipes, ditches, ponds, and biofiltration swales. Activities are maintenance tasks associated with operating and maintaining stormwater facilities such as vegetation management and small repair projects.

Outcomes

Stormwater facilities maintenance is performed to meet desired outcomes. Maintenance desired outcomes are specified for each drainage feature or activity. They include maintaining performance and appearance of the facility, and the need to prevent maintenance work itself from becoming a pollutant source or damaging habitat.

The Water Quality Outcomes are:

- Avoid or minimize sediment and pollutant discharges from the construction area;
- Prevent parking areas, roads, drainage systems, facilities and property from becoming pollutant sources;
- Avoid or minimize vegetation removal; and
- Preserve native plants.

The Infrastructure Maintenance Outcomes are:

- Protect public safety and health;

- Prevent catastrophic infrastructure failures;
- Maintain or restore the intended infrastructure function;
- Prevent or reduce onsite and downstream flooding;
- Protect infrastructure; and
- Meet public expectations for aesthetics.

BMP Operation and Maintenance Practices

The maintenance and water quality best management practices are necessary to meet water quality and infrastructure maintenance outcomes for each feature or activity. Some operations may be able to handle storm system maintenance themselves. Often, property owners' contract for maintenance. Landscapers are often employed to maintain vegetated facilities such as swales and pond areas. Heavier work, like cleaning catch basins or drywells often requires special equipment such as trucks that can vacuum sediment. A limited number of contractors perform this type of work.

Check with the contractor to ensure that all materials are disposed of according to solid waste and hazardous materials regulations. Ultimately, the generator of the waste or hazardous material is responsible for proper disposal.

Special Facilities Maintenance Requirements

This manual provides a set of minimum standards and practices for maintaining stormwater facilities. Manufactured stormwater facilities such as leaf compost filters and oil/water separators often have maintenance requirements and manuals specified or written by the manufacturer. Also, larger or more complex stormwater facilities may include specifications for maintenance and vegetation management that provide specific detail above this manual.

Manufacturer or Designer's Maintenance Manuals

Where the City Engineer determines that manuals or plans provide equal or greater level of maintenance and water quality protection, they shall be followed by the owner. These individual maintenance plans, specifications, or manuals must be approved by the City Engineer. Review of the manuals and plans should include the City's maintenance staff.

One of a Kind Facility

The City Engineer may require development and implementation of a site-specific maintenance plan for complex or unusual facilities. The plan is required when the general provisions of this manual do not provide enough detail for inspection, maintenance, vegetation management, and repair practices to operate the facility.

Stormfilter

The Stormfilter is a patented system for treating stormwater. The systems have evolved over the last 15 years from very simple above ground filter beds to a variety of vault devices containing cylindrical filters filled with leaf compost pellets. Stormfilter facilities consist of cartridges filled with one or a combination of media. Media can be selected to target pollutants specific to a site. The cartridges are housed in pre-cast, cast-in-place, concrete vaults, or in a steel catch basin configuration. Each configuration uses baffles to promote settling of solids and separation of oils and other floatable materials. Most pollutants are captured by the media and held in the cartridges. Some additional settling will occur in the inlet and cartridge bays of each vault. Manufacturers have detailed maintenance manuals for these facilities that should be used. The following practices are general requirements.

BMP Operation and Maintenance Practices

Inspection

- Inspect the Stormfilter every 6-months to determine sediment depth and the specific maintenance and repairs needed;
- Annually check for cracks large enough to let soil enter the vault, broken or defective plates and baffles, and crushed or damaged pipes; and
- Periodically inspect the catch basin and surrounding areas for pollutants such as leaks from dumpsters, minor spills, and oil dumping.

Cleaning

- Remove trash and litter from the vault, inlet, and piping;
- Remove sediment when it accumulates to 6-inch depth in settling chambers; and
- Remove sediment when it accumulates on filter media.

Safety

- Work inside underground structures requires approved Occupational Safety and Health Administration (OSHA) confined space training.

Material Handling

- Dispose of waste from maintenance in accordance with federal, state, and local regulations.
- Return used compost or canisters to the manufacturer for proper disposal or dispose of them in the garbage as solid waste as applicable.

Repairs

- Repair any cracked or defective plates or baffles; cracks are repaired so that no cracks greater than ¼-inch are found.
- Replace media cartridges if it takes longer than an hour for water to empty through media or if water frequently overflows the treatment chamber.
- Replace defective cartridges.
- Repair all security and access features so they are fully functional. This includes locking manhole lids, covers, and ladder rungs.

Dry Drainage Ditches

Ditches are manmade open channels that carry only stormwater. This does not include ditches that have water flowing in them during dry weather. Ditches are often maintained for drainage to prevent localized flooding by draining stormwater. Maintenance includes removing sediment, debris and overgrown vegetation. Protecting water quality dictates minimizing vegetation removal and preventing erosion.

BMP Operation and Maintenance Practices

Inspection

- Inspect ditches during routine site maintenance or at least once per year.

Cleaning

- Land disturbing activities that remove vegetation or disturb soil are subject to erosion control requirements. A good time to clean is during the growing season, when it's easiest to reestablish vegetation. This is generally April through June and September through October.
- Cleaning or excavating stormwater facilities within natural or altered streams will likely require a Hydraulic Project Approval (HPA) from the Washington Department of Fish and Wildlife (WDFW). Work within seasonally dry or ditched watercourses may also require an HPA. Consult the official state Department of Natural Resources (DNR) water type maps for assistance in determining whether watercourses are typed streams (e.g., type 1, 2, 3, 4 or 5) that are regulated by WDFW.
- If there is an emergency (e.g., immediate threat to life or property, or threat of environmental degradation), a verbal HPA may be obtained by calling the WDFW Puget Sound office at (425) 775-1311 or the Statewide Emergency Hotline HPA Hotline (360) 902-2537.

Repairs

- If feasible, remove small amounts of sediment by hand when performing routine site maintenance.
- Vegetation should only be removed when it reduces free movement of water through the ditch. Never remove more vegetation than is absolutely needed.
- Only remove sediment when it reaches 20 percent of the ditch depth or affects the historic or designed hydraulic capacity.
- Alternate cleaning areas with undisturbed areas, leaving undisturbed sections to act as sediment-trapping filters between worked areas.
- Trap sediment that is generated by ditch maintenance to keep it from entering water bodies. Use sediment-trapping BMPs such as fabric fencing or filter bags at the lower end of each excavated area
- Prevent sediment from eroding when ditch work is performed. Perform work during dry weather unless there is an emergency such as property or road flooding.
- Vegetate bare soils by hydro seeding or cover bare soils with an approved BMP. Hand seed for smaller areas.

Water-Bearing (base flow) Drainage Ditches

Many man-made drainage ditches carry water when it is not raining. This water comes from groundwater seeps and wetlands. These ditches can be recognized by the presence of wetland plants such as cattails. Any work that disturbs these channels is probably subject to a variety of environmental regulations and will probably require an HPA permit

from the WDFW. Water-bearing drainage ditches require permits for work. Requirements of city, county, state, and federal laws and permits may apply. Contact the WDFW and the King County DNR and Parks before beginning work.

Minor Culvert Repair (*not in a Stream*)

This activity is the replacement or repair of culverts and inlets less than 3-feet in diameter. It applies only to structures that are in ditches and specifically for drainage that do not carry water during dry weather. If there is any question about whether the ditch is a storm drain or a stream consult with the Washington Department of Fish and Wildlife.

BMP Operation and Maintenance Practices

- Comply with stormwater and erosion control requirements of DMC 9.06.
- Avoid or minimize vegetation removal. If work is near a stream or wetland, there are likely regulatory requirements.
- Other than to address a threat to public safety or property due to flooding, perform work during the dry season.
- Minimize soil disturbance.
- Use sediment controls to trap any sediment and prevent sediment from entering storm sewer and water bodies. Sediment trapping BMPs are used to the extent practical during emergencies.
- Use cover BMPs to prevent erosion of bare soil. Vegetate bare soils.
- Cleaning or excavating a stormwater facility within natural or altered streams will likely require an HPA from WDFW. Work within seasonally dry or ditched watercourses may also require an HPA.

Major Culvert Repair (*at a Stream Crossing*)

This activity is the replacement or repair of culverts and inlets greater than 3 feet 'in diameter or bridging a stream or ditch with flowing water during dry weather. If there is any question about whether the ditch is a storm drain or a stream consult with the Washington Department of Fish and Wildlife.

These projects must meet all regulatory requirements:

- SEPA
- Shoreline Management
- State HPA
- Flood Plain

Chapter 9 Stormwater Maintenance Activities

For all stormwater maintenance activities, consult the official state DNR water type maps for assistance in determining whether watercourses are typed streams (e.g., type 1, 2, 3, 4 or 5) that are regulated by WDFW. Contact WDFW Puget Sound Regional office for additional information on whether specific watercourses are regulated under the State Hydraulic Code, or if unmapped streams are encountered.

If there is an emergency (e.g., immediate threat to life or property, or threat of environmental degradation), a verbal HPA may be obtained by calling the Washington Department of Fish and Wildlife Puget Sound regional office (425) 775-1311 or the Statewide Emergency Hotline HPA Hotline (360) 902-2537.

Installation, Repair and Replacement of Enclosed Drainage Systems

This activity includes tasks such as repair and replacement of pipe, catch basins, drywells and manholes. It also includes drainage projects that add new pipes, catch basins, or infiltration structures. Source control BMPs is required for activities such as concrete cutting.

BMP Operation and Maintenance Practices

- Avoid or minimize vegetation removal. If work is near a stream or wetland, there are regulatory requirements needed prior to starting the project.
- Follow any construction permit requirements of DMC Title 9.06
- If work is performed under contract, specify BMP performance under inspection/contract administration.
- Prevent debris, oils, cleaning agents, and sediment from entering waterways.
- Avoid or minimize work in wet weather. This will reduce the problems of containing sediment.
- Carry spill control kit to contain and clean up possible small spills in the work area.
    - Protect storm drains.
    - Cover storm system inlets catch basins and open manholes to block sediment-bearing water.
    - If runoff contains sediment, use gravel-filled filter bags or an equivalent product to build berms around inlets. Gravel-filled bags are more stable than chip-filled bags.
- Catch basin inserts are also an acceptable sediment trapping option.
- At stream crossings, trap materials using screens or another form of containment. Use containment BMPs to protect roadside ditches during wet weather.
- Avoid using water to clean up work sites. Sweep or vacuum dust and debris from the repair job. Do not wash materials into storm sewers.
- Place stockpiles away from drainage ways, wetlands, and natural wetland and habitat buffers. Cover stockpiles or contain them with berms or other containment devices if there is a chance that materials will erode into a storm drain or water body.
- Cleaning or excavating a stormwater facility within natural or altered streams will likely require an HPA from WDFW. Work within seasonally dry or ditched watercourses may also require an HPA.

Street Sweeping and Debris Removal

Streets, roads, highways and parking lots accumulate significant amounts of pollutants that contribute to stormwater pollutant runoff to surface waters. Pollutants, including sediment, debris, trash, road salt, and trace metals can be minimized by regular street sweeping. Street sweeping can also improve the aesthetics of municipal roadways, control dust and decrease the accumulation of pollutants in catch basins, reducing the annual catch basin cleaning effort. An effective municipal street sweeping program can meet regulatory requirements, assess street sweeping effectiveness, and minimize pollutants in roadways.

BMP Operation and Maintenance Practices

Street sweeping material often includes sand, leaves, and debris removed from roads. Often the collected sweepings contain pollutants and must be tested prior to disposal to determine if the material is hazardous.

The City utilizes a third-party contractor to provide street sweeping activities throughout the city, every third Thursday of the month.

Sweeping is performed to remove sand and litter from streets and curb gutters. Sweeping also reduces dust during dry weather. Street sweeping is also storm sewer maintenance practice because it limits sediment washed into stormwater facilities. Water quality practices for street sweeping focus on sediment disposal, reducing the amount of sediment washed into catch basins, detention facilities, drywells, and other facilities can save money. Sweeping also helps protect facilities from clogging with sediment.

Debris removal activities includes the removal and disposal of trees, tree limbs and other debris that has fallen into or upon the right-of-way. This activity is usually associated with weather-related events such as high wind. Debris should be removed and disposed of either by mulching through a wood chipper or hauled to an appropriate landfill. Upon completion, the area should be free of debris and swept or blown clean.

Outcomes

- Maintain or restore the intended infrastructure function
- Protect public safety and health
- Meet public expectations for aesthetics

BMP Operation and Maintenance Practices

- Sweep the site if it will help keep sediment and from storm sewers or water bodies.
- Sweeping is especially useful for cleaning up work areas.
- Sweepings should be disposed of as solid waste

Vegetation Management

General Practices

The City recognizes the special importance of the streams, wetlands, ponds, and stormwater control and treatment facilities under our care. Due to the sensitive nature of such habitats and their direct link with other waterways require that we establish specific policies to ensure their health. All landscape management decisions for controlling unwanted vegetation, diseases, and pests should follow best management practices, principles and decision-making rationale including:

- Proper planning and management decisions;
- Native vegetation retention and methods of vegetation and pest control are preferred and are first employed;
- Mechanical means of vegetation and pest control are next in line of preference, and are utilized where feasible;
- Biological methods of vegetation and pest control are considered before chemical means, where they are feasible; and
- Botanical and synthetic pesticides are used only when no other feasible methods exist.

Mulching

Mulches and other ground coverings are useful during the installation and restoration of landscapes as well as their ongoing maintenance. Mulches meet a variety of needs. They suppress weeds, help to retain moisture around plants, reduce possible erosion, and provide visual enhancement.

Always consider the possible impacts when using mulches, which may include:

- Inadvertent introduction of non-native weeds and diseases to the site;
- Leaching of substances such as tannins from the mulch into nearby waterways;
- Migration of mulch material into waterways; and
- Nutrient leaching into waterways.

Vegetation and Pest Management in Stormwater Control Facilities

Stormwater control facilities include biofiltration treatment swales, treatment wetlands, treatment ponds, detention ponds, open channels, and infiltration basins. Stormwater control facilities discharge to surface water or groundwater either directly or through pipes or ditches. Many facilities are built to remove pollutants from stormwater.

Generally, vegetation should be maintained to blend into surrounding areas. Stormwater facilities can provide habitat for aquatic life and birds. Promoting natural vegetation where feasible improves habitat. Swales often blend into intensively managed landscapes. Pond perimeters can include natural vegetation.

The use of pesticides and, in most cases fertilizer, is not compatible with the task of pollutant removal or the direct connection of stormwater facilities to streams and groundwater. The use of fertilizers, pesticides, and herbicides should comply with instructions for their intended use. Measures should be taken to reduce nutrients and pesticides by using alternatives that minimize environmental impacts in sensitive areas.

Features of Stormwater Facilities:

- There is a mix of native and non-native plants;
- Passive areas not generally used by the public;
- Include areas managed to promote design function, such as turf in swales;
- Managed landscapes may be nearby; and

- May be used by fish and wildlife

Objectives for Stormwater Facilities:

- Maintain healthy plant communities
- Avoid or minimize need for chemical intervention
- Control invasive plants where feasible
- No bare soil areas are allowed
- Tolerance for natural appearance and weeds

BMP Operation and Maintenance Practices

The vegetation management focus is establishing and maintaining healthy low-maintenance native plantings and sustaining the design function of vegetated filters such as biofiltration swales. This includes controlling invasive plants where feasible, and planting cover on bare soils. In some cases, the original plantings may not be appropriate for the actual condition at a facility. One example is a frequently flooded swale that cannot support normal turf. In cases like this, replace turf with appropriate wetland plants if the underlying drainage problem cannot be fixed.

- Consider the use of soil amendments such as compost before using fertilizer;
- Limit mulch use to covering bare soil while establishing plantings;
- Chemical use should be avoided within 25 feet of any area that holds or conveys surface water or stormwater. This includes the base of a biofiltration swale;
- Trees or shrubs that block access roads may be trimmed (or removed if within the access road) at the time of when access is required for maintenance by heavy equipment; and
- Trees that pose a risk to stormwater structures due to root growth may be removed and replaced by smaller shrubs.

Building Exterior Cleaning and Maintenance

This activity includes washing buildings with a pressure washer. Periodically buildings need to be washed for routine maintenance or prewash prior to painting.

BMP Operation and Maintenance Practices

- Clean up as much as possible using dry cleaning methods (e.g., sweeping or vacuuming) before pressure washing;
- Do NOT discharge any wash water or cleaning products into a storm drain;
- Identify nearby storm drains and protect them from wash water;
- Use sand bags or a portable berm to block off storm drain, if necessary;
- Temporarily plug storm drains in vicinity using specially designed mats or by covering with a weighed down plastic liner, if necessary;
- Contain and collect wash water;
- Use a wet/dry vacuum to collect the wash water; and
- Dispose of wash water appropriately.

Pollutants generated during washing activities (e.g., paint or metal chips, oil & grease, sediment, trash/debris, food waste) must be collected and properly disposed of to avoid potential discharge into a storm drain or sanitary sewer. During cleaning activities, ensure that the measures taken to contain the water are working adequately. Surface cleaning should not occur during rain events, and employees shall be trained on proper surface cleaning and wash water disposal procedures, and conduct “refresher” training on a regular basis.

Dust Control

Minimize the wind-borne transport of sediment off-site and onto roadways, drainage features, and other surface waters.

BMP Operation and Maintenance Practices

- Limit clearing to the minimum area necessary;
- Minimize amount or ground disturbance at one time, and limit it to areas where construction or other activity will occur immediately;
- Cover exposed soils with mulch or vegetation and establish vegetation at the earliest possible opportunity (using irrigation if necessary to ensure survival);
- Use gravel or other larger materials to stabilize roadways and other areas where mulch or vegetation is impractical;
- Establish alternate routes where possible;
- Lower speed limits on the site;
- Install barriers and windbreaks to protect vulnerable areas and prevent dust from blowing off site;
- During dry periods, keep haul roads, detours, and other bare areas moist by sprinkling them with water several times per day or as necessary; and
- Do not apply so much water that it runs off the site.

Maintenance

- Regularly check areas protected by mulch, adhesive emulsions, or barriers;
- Remove sediments that accumulate behind any sediment fence or barrier; and
- Dispose of the sediments only in an approved location.

Snow Plowing

With the typically limited amount of snowfall and accumulation, a measurable deposit on roadways is a relatively rare occurrence. Many winter events are responded to effectively by the timely placement of anti-icing materials that may preclude the need for snow and ice removal activity, activity that may have more of a potential impact on environmental quality than the prevention of ice accumulation.

BMP Operation and Maintenance Practices

- Reduce plowing (truck) speed in identified resource-sensitive areas;
- Clean culvert inlets prior to the on-set of winter weather conditions; and
- Modify snowplow blade angles in identified resource-sensitive areas.

Ice Removal

The application of a liquid deicer on roadway surfaces is a way to provide for motorist safety. Last resort or option the City would use is a sand and salt mixture.

Ice Control

Weather conditions are monitored to anticipate winter weather potential. The City Public Works crew acts to prevent ice and snow build-up whenever possible, reducing the necessity of a post-event response. Initial response efforts are concentrated on traditional (public safety) problem locations and in areas where the application of anti-icing agents is preferable from an environmental perspective to other methods.

BMP Operation and Maintenance Practices

- Follow Winter Roadway Operations procedures;
- Recycle anti-skid material into roadway shoulders;
- Capture anti-skid materials from around bridges and near streams where possible; and
- Deploy sweepers to capture anti-skid materials, whenever possible.

This activity involves the placement of roadway striping (centerline or edge-line) using air-delivered, water-borne, non-toxic paint and reflective glass beads. The roadway surface must be dry and reasonably warm to allow paint to dry quickly.

Additional BMPs for striping

Extra caution must be used when applying the materials near resource waters to prevent accidental discharge to those waters.

Road Repair, Resurfacing and Grinding Maintenance

This activity involves removal and replacement of failed or poor-quality portions of paved roadways to strengthen the road, extend its life and improve the ride quality. Work consists of removing the problem material, back-filling with hot mix asphalt (HMA) in 3-inch lifts, compacting, repeating until level with the road grade. Add shoulder aggregate if needed.

Work may be accomplished during summer months when the weather is sufficiently warm and dry. Restrictions include working during rain and cold weather; working near resource waters, which may require additional erosion control measures; or working on steep roadway grades or next to down-slopes which may add to erosion concerns. When activity is complete, asphalt should make a smooth transition from old to new.

BMP Operation and Maintenance Practices

- Re-fuel equipment outside of the 250-foot Riparian Management Area;
- Eliminate diesel fuel as a releasing or cleaning agent;
- Use environmentally sensitive cleaning and releasing agents;
- Use heat sources to heat and clean distributor nozzles during operations;
- Carry adequate erosion control supplies to keep materials out of protected water;
- Dispose of excess materials at appropriate sites;
- Use commercial asphalt plants for asphalt materials supply;
- Provide areas for concrete truck chute clean-out with proper containment of wet concrete;
- Clean trucks and equipment at the Maintenance Operations Center or materials supply facilities;
- Avoid working during heavy rainfall;
- Avoid working in cold weather;
- Additional caution when working next to down-slopes; and
- Use dust control measures if needed.

The placement of appropriate (temporary and permanent) erosion control measures is required for project areas where the ground surface will be disturbed by clearing, grading, filling, excavating or other construction activities. Erosion control measures such as bio-filtration bags, sediment fences and straw bales should be monitored to ensure continued effectiveness. Temporary erosion control devices should be checked daily or weekly depending on the type of activity being performed.

On roadways, this work consists of repairing erosion on shoulders by adding aggregate to stabilize the shoulder. A minimum one-foot gravel shoulder is preferred. When placing rock on shoulder, the aggregate should be compacted. Other restrictions may require additional erosion control measures, for instance when working near resource waters or working on steep roadway grades or next to hillsides. When the activity has been completed, the aggregate should be level with the edge of the pavement and sloping down (away) and tightly compacted with a uniform width and straight edges. The pavement should be swept or flushed.

BMP Operation and Maintenance Practices

- Establish permanent erosion controls as soon as possible after construction activity;
- Regularly monitor temporary controls to ensure continued effectiveness;
- Remove sediments and debris collected by erosion controls and dispose of properly;
- Replace controls or place additional measures when necessary;
- Remove temporary controls when permanent controls become established; and
- Document performance of controls and any maintenance performed upon them.

Concrete, Asphalt Cutting

Fresh concrete and mortar activities are frequent sources of urban runoff pollution. Materials and wastes blown or washed into a street, gutter or storm drain, have a direct impact on the ocean. Sediment is the most common pollutant washed from worksites, creating multiple problems once it enters the ocean. Sediment clogs the gills of fish, blocks light transmission and increases ocean temperature, all of which harm sea life, disrupting the food chain upon which both fish and people depend upon. Sediment also carries with it other worksite pollutants such as cement wash, gravel, asphalt, pesticides, cleaning solvents, motor oil, grease and fuel. Thus, poorly maintained equipment and vehicles leaking fuel and oil at the worksite, also contribute to ocean pollution.

BMP Operation and Maintenance Practices

- When cleaning up after roadway, driveway or sidewalk construction, prevent wash water and debris from entering the street or storm drain;
- Wash out concrete mixers and equipment only in designated wash-out areas;
- Use a wet/dry vacuum to pick up water from concrete cutting operations;
- Recycle cement wash water by pumping it back into cement mixers for reuse;
- Never dispose of cement washout into driveways, streets, gutters, storm drains or drainage ditches; and
- Place erosion controls (i.e. berms or temporary vegetation) down-slope to capture runoff carrying mortar or cement before it reaches the storm system.