City of Tacoma

Environmental Services

Stormwater Management Manual
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Tacoma WA

Notice:

This manual was developed and written by Environmental Services and Planning and Development Services Staff.

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Preface

City of Tacoma Watersheds and Special Areas

This section provides a short description of the nine watersheds located within the City of Tacoma (Figure P - 1: City of Tacoma Watersheds), the South Tacoma Groundwater Protection District (Figure P - 2: South Tacoma Groundwater Protection District (STGPD), and Sensitive Habitat Areas (Figure P - 3: NRDA Areas and Sensitive Habitat Areas (West Tacoma Area) and Figure P - 4: NRDA Areas and Sensitive Habitat Areas (East Tacoma Area)). Additional information about each watershed can be found in the City of Tacoma Watershed Management Plan available at tacoma.gov/watershed_planning

The Minimum Requirements are based upon the type of receiving waterbody and the project scope. Various types of receiving waterbodies including flow control exempt waterbodies, wetlands, streams, and lakes exist in the City of Tacoma watersheds. It is the applicant's responsibility to determine the receiving waterbody specific to their project. tacomaMap (tMap) - the City's public GIS data viewer can be used to find receiving waterbodies and other sensitive areas in the City.

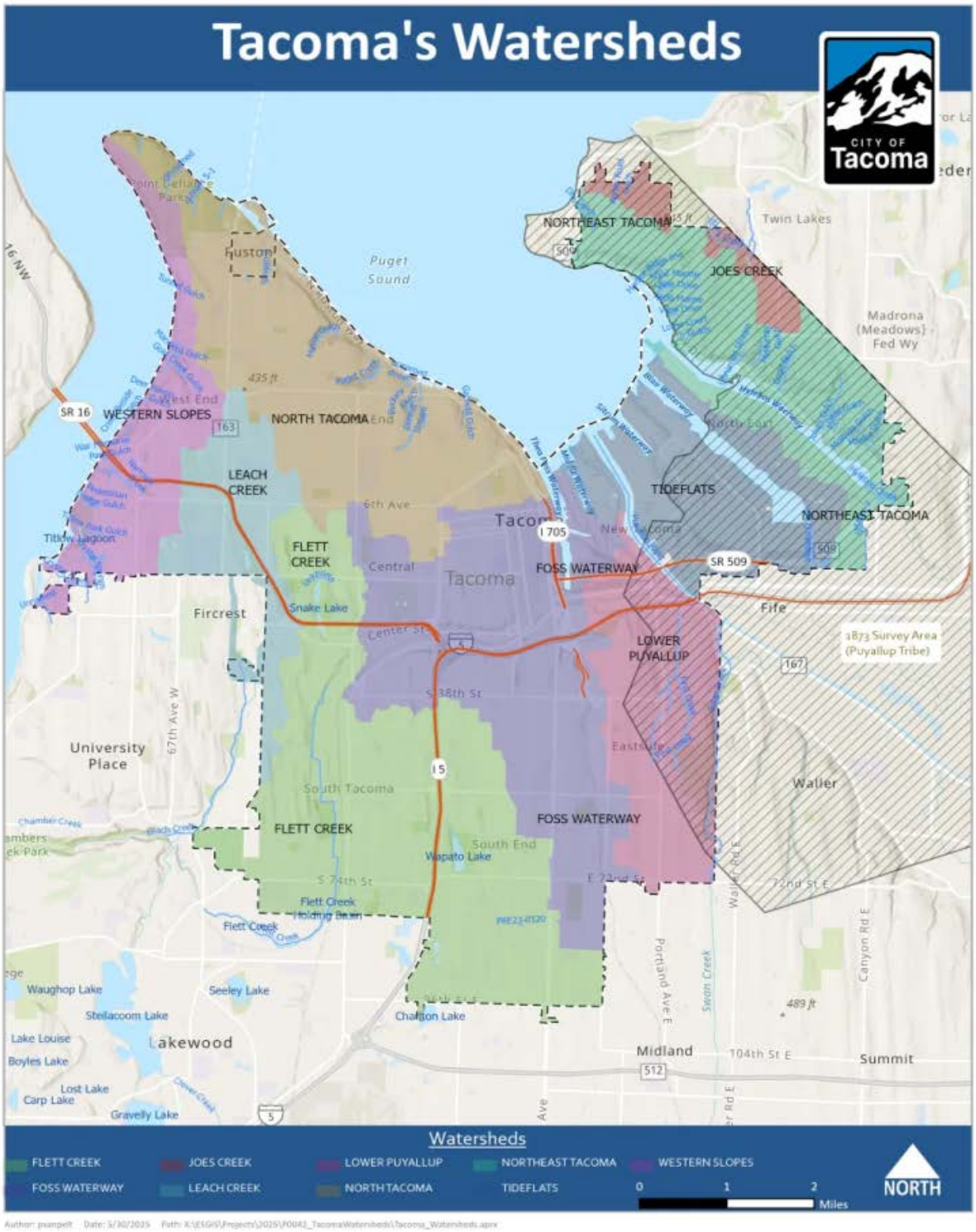


Figure P - 1: City of Tacoma Watersheds

Flett Creek Watershed

The Flett Creek Watershed is approximately 7,100 acres and is located predominately in the South Tacoma and South End Neighborhood Council Districts. Stormwater within this watershed flows through a series of ponds known as the Hosmer System prior to discharging into the Flett Creek Holding Ponds. The Hosmer System consists of the Hosmer Holding Basin, Ward's Lake, and the Gravel Pit. A pump station at the last of the four Flett Creek Holding Basins pumps stormwater to the Old Flett Dairy Wetland that drains into Flett Creek. Flett Creek flows into Chambers Creek, which discharges to the Narrows Passage.

Snake Lake, the Delong Wetland, Wapato Lake, and the South Tacoma Groundwater Protection District are located within the City of Tacoma boundaries of the Flett Creek Watershed.

Leach Creek Watershed

The Leach Creek Watershed is approximately 1,700 acres and is located predominately in the South Tacoma, West End, and Central Neighborhood Council Districts. Stormwater within this watershed is piped into the Leach Creek Holding Basin which discharges into Leach Creek. In heavy rainfall events, stormwater is pumped from the holding basin to the Thea Foss Waterway to avoid sending high flows to Leach Creek.

China Lake and the South Tacoma Groundwater Protection District are located within the City of Tacoma boundaries of the Leach Creek Watershed.

Northeast Tacoma Watershed

The Northeast Tacoma Watershed is approximately 2,600 acres and is located in the Northeast Neighborhood Council Districts. The majority of stormwater is piped directly into Commencement Bay or the Hylebos Waterway.

Dry Gulch, an intermittent stream, is located within the City of Tacoma boundaries of the Northeast Tacoma Watershed.

Joe’s Creek Watershed

The Joe's Creek Watershed is approximately 150 acres and is located in the Northeast Neighborhood Council District. Stormwater discharges to the upper reaches of Joe's Creek. Joe's Creek is located in Federal Way. Joe's Creek flows northwest where it discharges into Dumas Bay.

North Tacoma Watershed

The North Tacoma Watershed is approximately 4,700 acres and is located predominately in the North End and West End Neighborhood Council Districts. Stormwater ultimately discharges to Commencement Bay and the Puget Sound.

Ruston Creek, Asarco Creek, Puget Creek, Mason Creek, and Garfield Gulch are located within the City of Tacoma boundaries of the North Tacoma Watershed.

Thea Foss Watershed

The Thea Foss Watershed is approximately 5,700 acres and is located predominately in the New Tacoma, Central, and South End Neighborhood Council Districts. Stormwater ultimately discharges to the Thea Foss Waterway.

Portion of the South Tacoma Groundwater Protection District are located within the City of Tacoma boundaries of the Thea Foss Waterway Watershed.

Tideflats Watershed

The Tideflats Watershed is approximately 2,100 acres and is located predominately in the New Tacoma Neighborhood Council District. Stormwater ultimately discharges to Commencement Bay in this watershed.

The Sitcum Waterway, the Blair Wateway, the Hylebos Waterway, Hylebos Creek, and Wapato Creek are located within the City of Tacoma boundaries of the Tideflats Watershed.

Lower Puyallup Watershed

The Lower Puyallup Watershed is approximately 2,900 acres and is located predominately in the Eastside Neighborhood Council Districts. Stormwater discharges to the Puyallup River in this watershed.

The Puyallup River, Swan Creek, and First Creek are located within the City of Tacoma boundaries of the Lower Puyallup Watershed.

Because of its size, the Puyallup River does not require metals treatment even though it is a freshwater designated for aquatic life use. The Puyallup River is a Flow Control Exempt Receiving Waterbodies.

Western Slopes Watershed

The Western Slopes Watershed is approximately 2,000 acres and is located in the West End Neighborhood Council District. Stormwater discharges to various creeks and gulches and the Narrows.

Gold Creek, Narrows Creek, Crystal Creek, Crystal Springs Creek, Marinera Creek, and Titlow Park Gulch Creek are located within the City of Tacoma boundaries of the Western Slopes Watershed.

South Tacoma Groundwater Protection District

The South Tacoma Groundwater Protection District (STGPD) was created to help protect the South Tacoma Aquifer which is used as a drinking water supply for the City of Tacoma. The STGPD is protected by a program administrated by the Tacoma Pierce County Health Department (TPCHD) and the City of Tacoma. See https://www.tpchd.org/healthy-places/waste-management/business-pollution-prevention/south-tacoma-groundwater-protection-district for additional information including specific permitting information.

Projects that infiltrate pollution generating stormwater in the South Tacoma Groundwater Protection District must provide treatment as specified in the South Tacoma Groundwater Protection District Infiltration Policy Document available at https://www.tpchd.org/healthy-places/waste-management/business-pollution-prevention/south-tacoma-groundwater-protection-district.

Sensitive Habitat Areas

Sensitive habitat areas, which include restoration sites and mitigation sites may require additional protection from stormwater. The City of Tacoma will determine if additional protection is necessary based upon project scope and discharge location.

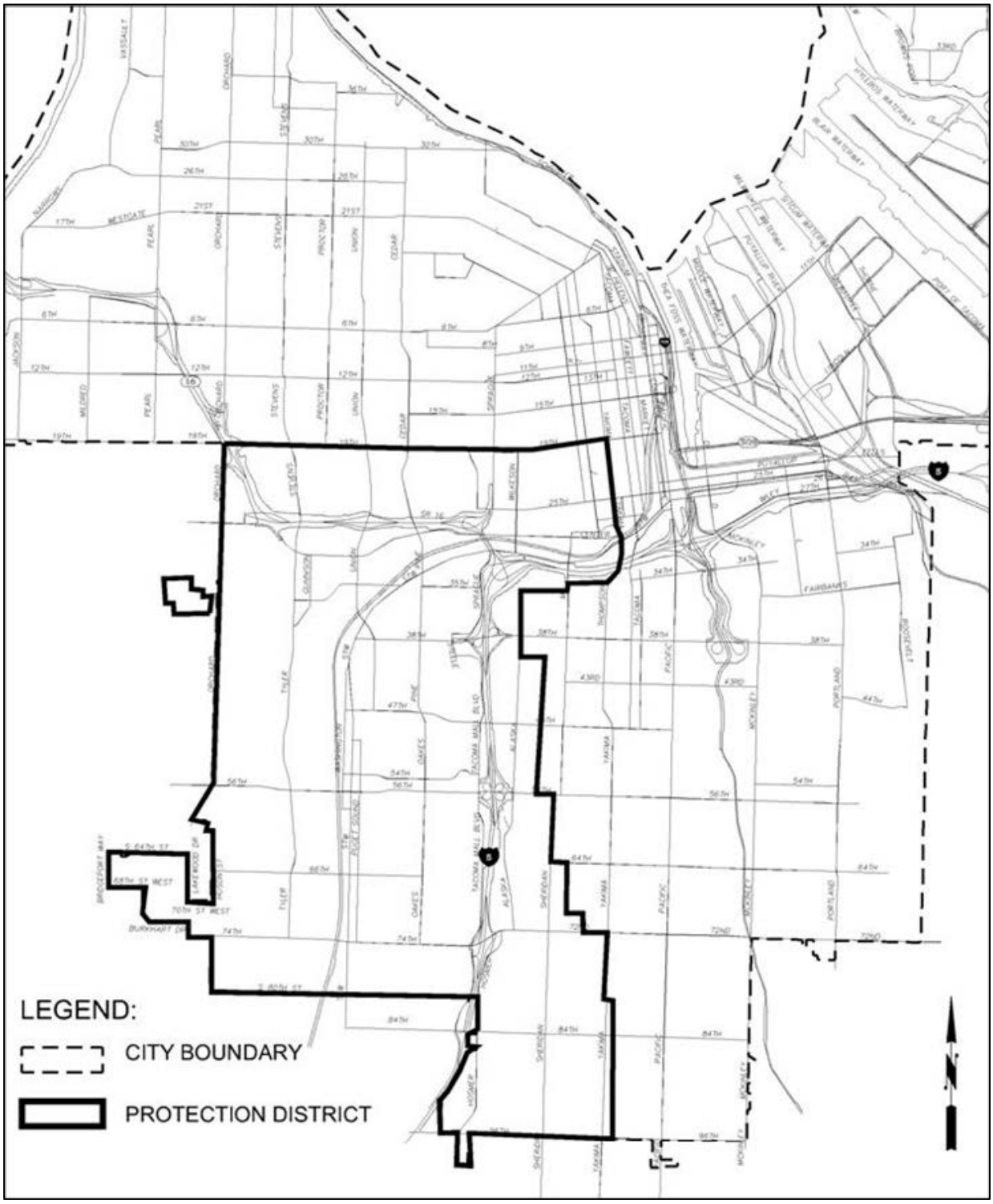


Figure P - 2: South Tacoma Groundwater Protection District (STGPD)

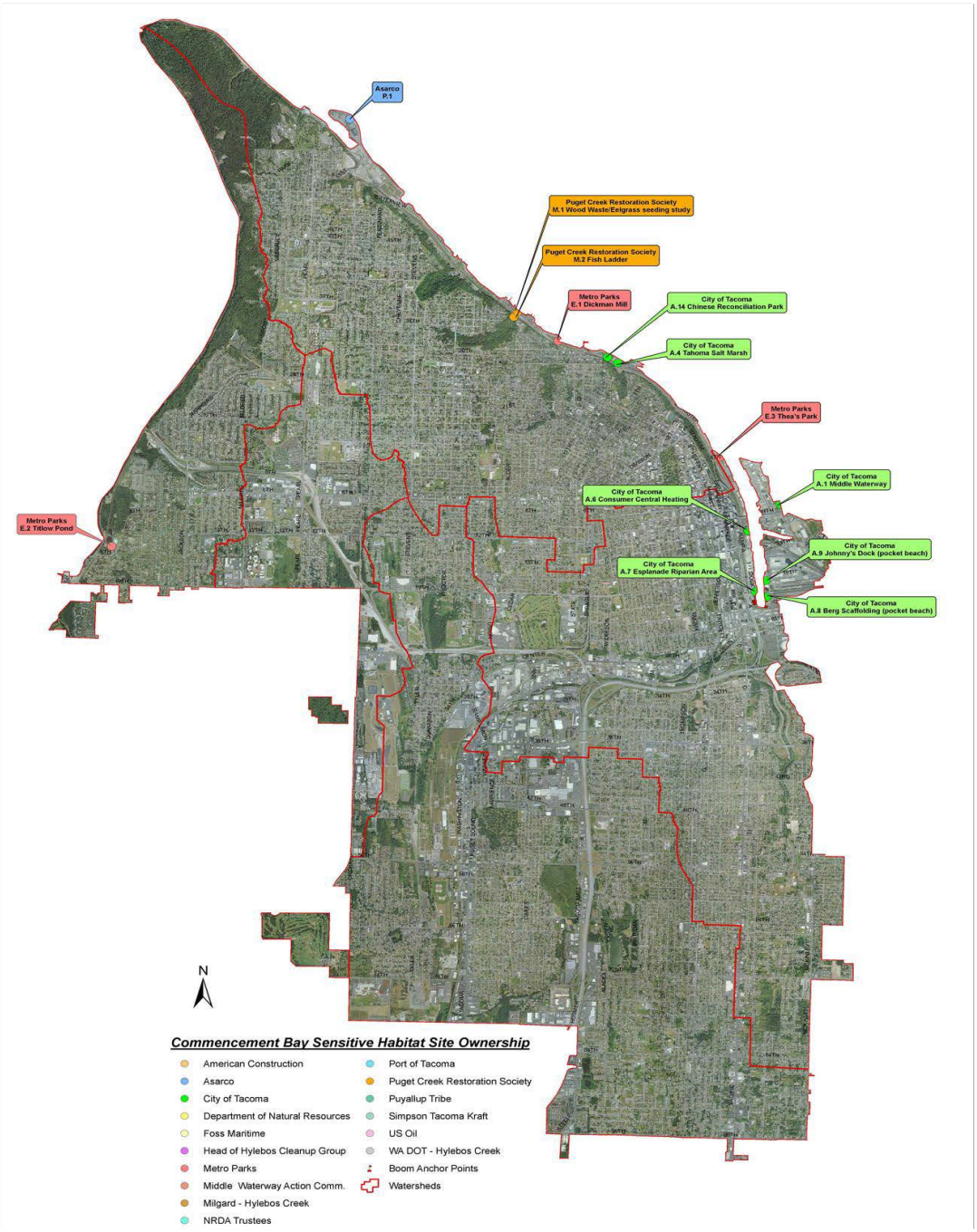


Figure P - 3: NRDA Areas and Sensitive Habitat Areas (West Tacoma Area)

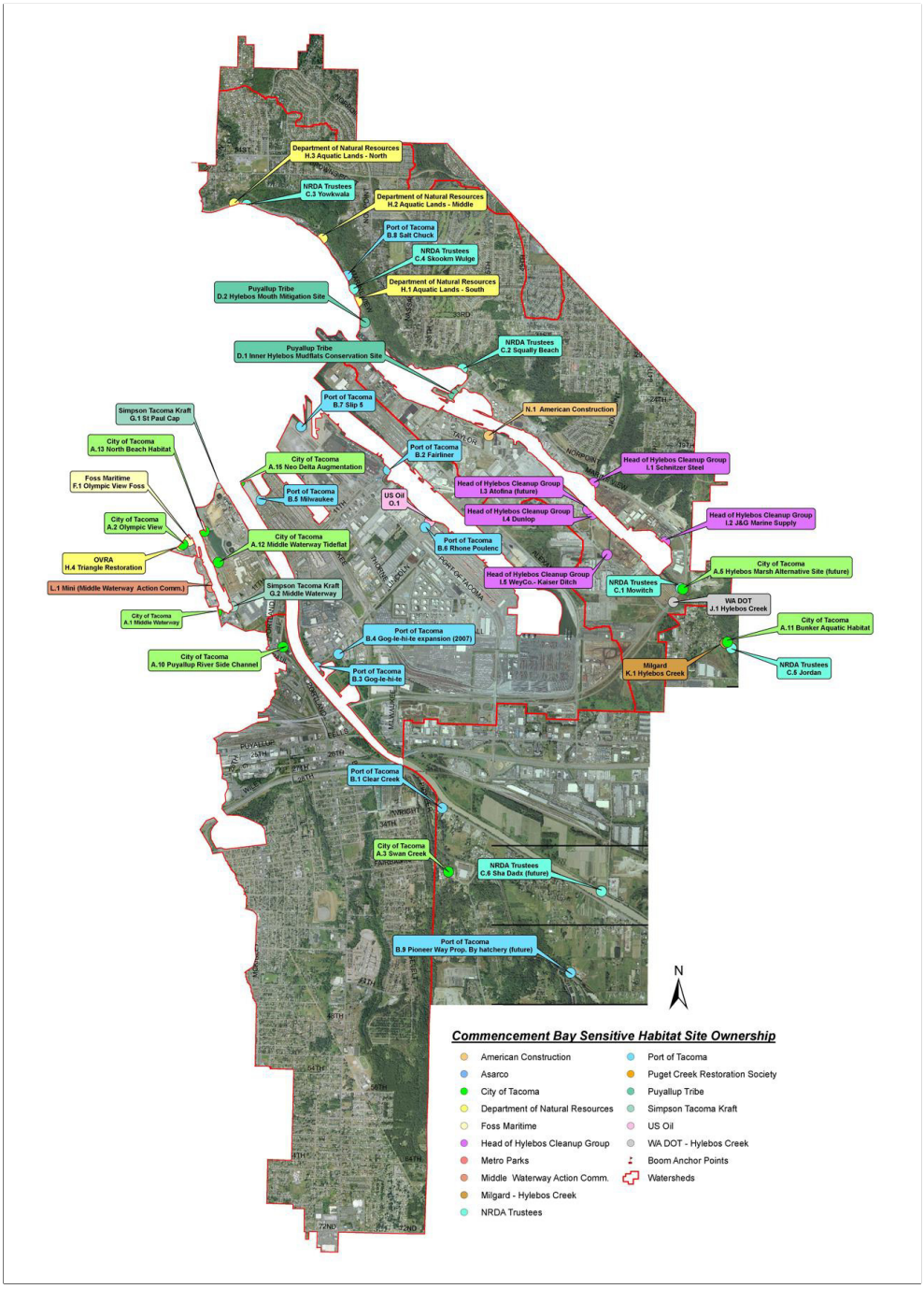


Figure P - 4: NRDA Areas and Sensitive Habitat Areas (East Tacoma Area)

Manual Applicability

All new development and redevelopment projects within the City of Tacoma, including work both on private property and within the public Right-of-Way, intending to use the Presumptive Approach shall meet the requirements and technical standards of this manual unless specifically exempted by this manual or the Director of Environmental Services or other delegated authority. The requirements of this Manual apply to direct and indirect discharges to the City of Tacoma Municipal Separate Stormwater System and all receiving waterbodies (including groundwater) per Tacoma Municipal Code Chapter 12.

All projects, whether or not they meet the thresholds for complying with Minimum Requirements, shall:

- Comply with all Federal, State and local requirements and the City of Tacoma Municipal Code.
- During construction, prevent erosion and discharge of sediment and other pollutants into receiving waters. Volume 3 - Construction Site Stormwater Best Management Practices contains BMPs that can be used during construction to help prevent erosion and discharge of sediment.
- Use all known available, and reasonable Source Control BMPs. Volume 6 - Source Control Best Management Practices contains Source Control BMPs.
- Size new stormwater conveyance systems per Volume 5 - Stormwater Conveyance Design and Protection of the SWMM.
- Analyze, if necessary, existing conveyance systems as required in Volume 5 - Stormwater Conveyance Design and Protection of the SWMM.
- Inspect and maintain all portions of their stormwater system. See Volume 4 - Best Management Practices Library for inspection and maintenance information related to stormwater features.

This manual can also be helpful in identifying retrofit options. Compliance with the technical standards is encouraged in retrofit situations.

This manual also contains stormwater requirements that may not be specifically considered a new development or redevelopment project.

NPDES Phase I Permit

The Environmental Protection Agency (EPA), created the Clean Water Act to help eliminate the discharge of untreated wastewater into receiving waters thereby helping to ensure those waters are safe for swimming and fishing.

The Clean Water Act made it unlawful to discharge any pollutant from a point source into navigable waters without obtaining a Permit. The NPDES (National Pollutant Discharge Elimination System) Program controls those discharges.

In 1987, the Clean Water Act was amended to include stormwater discharges from MS4s (Municipal Separate Stormwater Systems).

In 1990, Phase I regulations went into effect to allow discharges from MS4s.

In 1995, the Washington State Department of Ecology issued the first NPDES Phase I Municipal Stormwater Permit authorizing jurisdictions to discharge stormwater into receiving waterbodies.

The City of Tacoma is a Phase I Permittee. This means that the City is required to obtain an NPDES Phase I Permit from the Washington State Department of Ecology in order to lawfully discharge stormwater into receiving waters. The Phase I Permit contains the regulations that the City must follow in order to discharge stormwater into receiving waters.

Relationship to Phase I Permit

The most recent National Pollutant Discharge Elimination System (NPDES) Phase I Municipal Stormwater Permit (NPDES Permit) became effective August 1, 2024. Section S5.C.5 of the NPDES Permit requires municipalities to "include a program to prevent and control the impacts of runoff from new development, redevelopment, and construction activities." This manual is designed to be equivalent to Ecology's 2024 Stormwater Management Manual for Western Washington in order to meet the NPDES Permit requirement. The Manual has been adopted by City Council Ordinance. The Manual is effective on July 1, 2026.

There are two approaches that a project proponent may use to document the technical basis for their stormwater BMP designs: the Presumptive Approach and the Demonstrative Approach. Both approaches are based on using best available science and result from existing Federal and State laws that require stormwater treatment systems to be properly designed, constructed, maintained, and operated to:

1. Prevent pollution of state waters and protect water quality, including compliance with State Water Quality Standards.
2. Satisfy State requirements for All Know Available and Reasonable methods of prevention, control and Treatment (AKART) to prevent and control pollution of waters of the State.
3. Satisfy the Federal technology-based treatment requirements under 40 CFR 125.3.

The Presumptive Approach

Project proponents that choose to follow the design standards for BMPs contained in this manual are presumed to have satisfied State and Federal Requirement and do not need to provide additional technical justification beyond what is required in a Stormwater Site Plan.

The Demonstrative Approach

Using the Demonstrative Approach, project proponents do not have to follow the design standards within this Manual. The project proponent must demonstrate that the project will not adversely impact water quality by collecting and providing appropriate supporting data to show that the alternative approach is protective of water quality and satisfies State and Federal water quality laws. The timeline and expectations for providing technical justification of stormwater management practices will depend on the complexity of the individual project and the nature of the receiving environment. The Demonstrative Approach will require monitoring, data collection, and analysis to substantiate the use of an alternate BMP or design.

Manual Corrections and Updates

Minor revisions to the manual may occur on an ongoing basis. It is the applicant's responsibility to verify the requirements when developing stormwater mitigation plans. As needs are identified, additional policies shall be developed and posted to the City website at: tacoma.gov/stormwatermanual

Related Regulations, Programs, and Documents

Department of Ecology's Stormwater Management Manual

This manual was modeled after the Stormwater Management Manual for Western Washington, published by the Department of Ecology in July 2024. Ecology's stormwater manual was originally developed in response to a directive of the Puget Sound Water Quality Management Plan (PSWQA 1987 et seq.). The Puget Sound Water Quality Authority (since replaced by the Puget Sound Partnership) recognized the need for overall guidance for stormwater quality improvement. It incorporated requirements in its plan to implement a cohesive, integrated stormwater management approach through the development and implementation of programs by local jurisdictions, and the development of rules, permits and guidance by Ecology.

The Puget Sound Water Quality Management Plan included a stormwater element (SW-2.1) requiring Ecology to develop a stormwater technical manual for use by local jurisdictions. Ecology's original stormwater manual (the Stormwater Management Manual for the Puget Sound Basin, published in 1992) was developed to meet this requirement.

This Manual is designed to be equivalent to Ecology's 2024 SWMMWW.

Federal, State and Local Regulatory Requirements

The applicant is responsible for identifying and complying with all applicable federal, state, and local regulatory requirements. Projects may have site specific requirements if they are part of a Superfund or cleanup site.

The Office of Regulatory Assistance website is a useful tool for determining additional permitting requirements that may apply to a project: www.ora.wa.gov

The City of Tacoma Permitting website (tacomapermits.org) is a good tool for determining additional regulations that may be posed by other City of Tacoma Departments.

The Washington State Department of Ecology Toxics Cleanup Program website provides information on Washington State cleanup sites: https://ecology.wa.gov/About-us/Get-to-know-us/Our-Programs/Toxics-Cleanup

The EPA Washington Cleanup Site website can be used to determine if a project is located in or discharges to a Superfund Site: https://www.epa.gov/superfund/search-superfund-sites-where-you-live

Other Stormwater Permits

There are sites in the City of Tacoma covered under separate Industrial Stormwater General Permits, Construction Stormwater General Permits, Sand and Gravel General Permits, or separate State issued Discharge Permits. Development at these sites may be required to comply with the Minimum Requirements and design standards in this manual. The City of Tacoma reserves the right to determine which requirements apply to a given project.

Certain projects are exempt from obtaining permits from local jurisdictions. These sites may still be required to comply with the Minimum Requirements and design standards in this manual. Projects exempt from permitting may require stormwater mitigation review and approval from the City of Tacoma before discharging stormwater to the City of Tacoma Municipal Separate Storm Sewer System (MS4).

Within the City of Tacoma limits, the Port of Tacoma, Metropolitan Park District of Tacoma, and Tacoma Community College are Secondary Permittees. Each permittee is responsible for the MS4 they own or operate. The City of Tacoma will review all projects within the City of Tacoma.

Underground Injection Control (UIC) Program

The Washington State Department of Ecology manages the UIC Program which regulates UIC wells. This manual contains several BMPs designed to infiltrate stormwater. These BMPs may be considered UIC wells and therefore must comply with all UIC program requirements. Some examples of UIC wells are drywells, infiltration facilities containing perforated pipe that distributes the water, and underground structures that temporarily store water in the subsurface before infiltration. See Volume 1, Chapter 2 - Underground Injection Control (UIC) Program Guidelines for additional information about UIC wells. Visit https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Underground-injection-control-program and see the 2024 Washington State Department of Ecology Stormwater Management Manual for Western Washington - Volume 1, Chapter 4 - UIC Program Guidelines for additional information.

VOLUME

1

Minimum Requirements and Additional Protective Measures

How to Use this Volume

Use this volume to determine the Minimum Requirements that apply to the project. The Minimum Requirements are the required actions that must occur to ensure compliance with the City of Tacoma Phase I Permit.

Chapter 1 Minimum Requirements and Additional Protective Measures

This Chapter identifies the Minimum Requirements for stormwater management applicable to new development and redevelopment project sites. These requirements are codified in Chapter 12 of the Tacoma Municipal Code (TMC). New development and redevelopment projects also may be subject to other City code requirements, depending on the nature and location of the project.

The City of Tacoma Municipal Code can be found at:

tacoma.gov/government/departments/city-clerks-office/tacoma-municipal-code/

The Minimum Requirements are:

1. Preparation of Stormwater Site Plans
2. Construction Stormwater Pollution Prevention
3. Source Control of Pollution
4. Preserving Drainage Patterns and Outfalls
5. Onsite Stormwater Management
6. Stormwater Treatment
7. Flow Control
8. Wetlands Protection
9. Operation and Maintenance

The City also has one Additional Protective Measure that may apply to a given project:

Infrastructure Protection

Depending on the type and size of the proposed project, different combinations of the Minimum Requirements and Protective Measure apply.

Section 1.3 - Description of Minimum Requirements, provides guidance on applicability of the Minimum Requirements.

1.1 Exemptions

The purpose of this section is to identify activities whose resulting surfaces would be considered exempt from the Minimum Requirements even though those surfaces, per the definition in the Glossary, would be considered replaced hard surfaces or land disturbed.

Unless otherwise indicated in the exemption, the surfaces that result from the activities described in this section are exempt from the Minimum Requirements. Exempt surfaces do not need to be included when evaluating which Minimum Requirements apply to a project.

The following list defines how these exemptions can be used:

- A project may have different types of exempt activities. If the project includes only exempt activities, then the whole project is exempt.
- If the exempt activity is part of, directly related to, or caused by a new development or redevelopment project, it is not considered an exempt activity. It is considered part of the new development or redevelopment project.

- If an exempt activity requires making an ADA update per the federal Americans with Disabilities Act requirements, the ADA update is considered part of the exempt activity, and the exemption applies to the surfaces affected by the ADA update. This exemption does not extend to additional work, such as extending a sidewalk beyond what is necessary for the ADA update.

All projects are encouraged to implement and maintain Best Management Practices to minimize erosion and control sediment during and after construction activities to help ensure protection of receiving waterbodies.

1.1.1 Forest Practices, Commercial Agriculture, Oil and Gas Field Activities or Operations

- Forest practices regulated under Title 222 WAC, except for Class IV-General forest practices that are conversions from timberland to other uses, are exempt from the Minimum Requirements.
- Commercial agriculture practices involving working the land for production are generally exempt. However, the conversion from timberland to agriculture, and the construction of impervious surfaces are not exempt.
- Construction of drilling sites, waste management pits, and access roads, as well as construction of transportation and treatment infrastructure such as pipelines, natural gas treatment plants, natural gas pipeline compressor stations, and crude oil pumping stations are exempt.

1.1.2 Pavement Maintenance

Pavement maintenance activities only include targeted pavement repairs or maintenance. The limits of the exempt surfaces include only the area that must be disturbed to repair or maintain the pavement.

Pavement maintenance activities do not:

- Change the characteristic of the roadway (ex. changing a four-way intersection to a roundabout).
- Increase the traffic capacity of a roadway or parking area (including restriping to add lanes or parking spaces).
- Expand the area of coverage (i.e. add new hard surfaces).

The following pavement maintenance practices are exempt from all Minimum Requirements:

- Pothole patching, square cut patching, or other targeted preservation work
- Overlaying (including grinding and overlaying as long as the top of base course is not exposed) existing asphalt or concrete pavement. Examples of overlay materials include bituminous surface treatment, chip seal, asphalt, and concrete.
    - Overlaying permeable or pervious pavements with traditional (non-permeable) asphalt or concrete is not considered pavement maintenance – those overlain surfaces are considered new impervious surfaces and stormwater mitigation provided by that overlain permeable surface shall be replaced.
- Shoulder grading
- Reshaping/regrading to address drainage issues (including adding curb/gutter and/or wedge curb)

- Crack Sealing

The following are not pavement maintenance activities and are not exempt. The practices are subject to the Minimum Requirements that are triggered when the thresholds are met or exceeded. The extent to which the manual applies is explained for each circumstance.

The following surfaces are considered replaced hard surfaces:

- Removing and intentionally replacing pavement to top of base course or lower, or repairing the pavement base (except for pothole or square cut patching).

The following surfaces are considered new hard surfaces:

- Extending the pavement edge; or
- Paving graveled shoulders; or
- Upgrading from dirt to: gravel, bituminous surface treatment, asphalt, concrete, or permeable pavement; or
- Upgrading from gravel to: bituminous surface treatment, asphalt, concrete, or permeable pavement; or
- Upgrading from a bituminous surface treatment to: asphalt, concrete, or permeable pavement.

Parking lot and road surfacing requirements are regulated through the Tacoma Municipal Code – Title 2 (Buildings), Title 10 (Public Works), Title 13 (Land Use Regulatory Code) and the City of Tacoma Right-of-Way Design Manual. No special considerations will be given to “temporary” pavement surfaces (e.g., parking lots, roads) as the impacts resulting from the proposed hard surface must be mitigated as part of construction.

1.1.3 Utility Activities Projects

Underground utility activities include installing, maintaining and/or upgrading an underground utility. The limits of the exempt surfaces include only the area disturbed by the trench work necessary for the underground utility work (including any over-excavating necessary for the utility trench).

Above ground utilities include installing, maintaining and/or upgrading an above ground utility. The limits of the exempt surfaces include only the area necessary to be disturbed for the installation, maintenance, and/or upgrade. An example of an above ground utility activity would be the removal and replacement of power poles.

In order for a utility activity to be exempt, it cannot be part of, directly related to, or caused by a new development or redevelopment project.

Utility activities must replace the ground surfaces with in-kind material or materials with similar runoff characteristics.

Utility activities are only subject to Minimum Requirement #2, Construction Stormwater Pollution Prevention.

1.1.4 Minor Land Disturbing Activities

The following minor land disturbing activities are only subject to Minimum Requirement #2; unless located within a critical area governed by the City’s Critical Areas Preservation Ordinance. The location of some Critical Areas can be found on tacomaMAP (tMap) - the City's public GIS data viewer.

- Excavation for wells
- Subsurface exploratory excavations for completing Soils Reports
- Removal of hazardous trees;
- Removal of trees or other vegetation which cause sight distance obstructions at intersections (sight distance obstructions are determined by the City of Tacoma Traffic Engineering Section);
- Minor clearing, grading, and excavation associated with individual cemetery graves;
- Land clearing associated with routine maintenance by public utility agencies, as long as appropriate vegetation management practices are followed as described in the Best Management Practices of the Regional Road Maintenance Endangered Species Act Program Guidelines located at http://www.wsdot.wa.gov/maintenance/roadside/esa.htm
- Vegetation maintenance associated with road right-of-ways.
- Stormwater facility maintenance (ex. swale regrading and replanting, wetpond sediment removal and replanting, etc.)

1.1.5 Emergencies

Emergency projects which, if not performed immediately would substantially endanger life or property, are exempt only to the extent necessary to meet the emergency. Emergency activities may include but are not limited to: sandbagging, diking, ditching, filling or similar work during or after periods of extreme weather. Permits authorizing the emergency work may be required after completion of the emergency project.

1.2 Applicability of the Minimum Requirements and Additional Protective Measures

Not all of the Minimum Requirements apply to every new development or redevelopment project. The applicability varies depending on the type and size of the project. This section identifies thresholds that determine the applicability of the Minimum Requirements to different projects. The thresholds shall be determined using the proposed improvements for the entire project site.

Plat or short plat approval shall identify all stormwater BMPs that are required for each lot.

For projects that are implemented in incremental stages or phases as part of a common plan of development or sale, the complete project scope at full build-out must be used when determining which Minimum Requirements apply.

The Minimum Requirements shall be based on the first receiving waterbody along the discharge route. For determining which Minimum Requirements apply to a project, it shall be assumed that stormwater leaves the site. The City of Tacoma reserves the right to make the final determination of the applicability of the Minimum Requirements.

The threshold for determining which Minimum Requirements apply to a project are based upon the area of new hard surfaces, replaced hard surfaces, converted vegetation areas, land disturbed. These areas are considered to be the target surfaces. The target surfaces are those that must comply with the Minimum Requirements. Surfaces that are not the target surfaces are not required to comply with the Minimum Requirements though stormwater BMPs shall be sized to consider all surfaces discharging to them which may include non-target surfaces.

An Operation and Maintenance Manual may be required even if Minimum Requirements do not apply if the proposal includes permanent structural best management practices.

1.2.1 Vesting

The Minimum Requirements contained in this SWMM shall apply to:

- All complete applications submitted on or after July 1, 2026.
- All complete applications submitted prior to July 1, 2021 that have not started construction by July 1, 2026.
- All complete applications submitted prior to July 1, 2026 that have not started construction by July 1, 2031.

Applicants that submit complete applications but do not start construction by the timeframes above must resubmit complete applications and comply with the Minimum Requirements in effect at the time of resubmittal.

See https://www.tacomapermits.org/permitting-library for a list of required items needed for a complete application. A complete application, at a minimum, includes the complete project description, site plan, and if applicable, SEPA checklist.

In this context, "started construction' means the site work associated with, and directly related to the approved project is at a stage where rough grading is complete or utilities are installed. For rough grading to be considered complete, elevations are within 1 foot of final design elevation. Clearing the project site does not constitute "started construction".

1.2.2 Change of Site Function/Usage

The City of Tacoma may require Minimum Requirements be applied to projects where the project scope causes a change in how the site is used (for example, the site was a building but the building was razed and now it is a parking lot) that may affect downstream receiving waterbodies. The City of Tacoma reserves the right to make the final determination of requirements that apply in these situations.

This section applies to all projects that may affect downstream receiving waterbodies regardless of whether that project is a new development or redevelopment project that meets the thresholds for application of the Minimum Requirements of the SWMM. Projects surfaces do not have to be target surfaces to trigger compliance with this section of the SWMM.

The following are examples of a project that causes a change in the use that may affect downstream receiving waterbodies:

- When the project causes an increase in pollution generating surfaces discharging from a project site or
- Causes the type of pollutants discharging from a project site to change, AND
- The total increase in those pollution generating surfaces is 5,000 square feet or more in a threshold discharge area.

The City will make the final determination as to which surfaces Section 1.2.2 applies. Section 1.2.2 can apply to both onsite and offsite surfaces

1.2.3 New Development Project Thresholds

All new development shall be required to comply with Minimum Requirement #2. Where permanent stormwater facilities are provided, an Operation and Maintenance Manual per Minimum Requirement #9 may be required even if the thresholds below are not met.

Minimum Requirement #1-#5 apply to the new and replaced hard surfaces and land disturbed when the project:

- Results in 2,000 square feet, or more, of new plus replaced hard surface area, or
- Has land disturbing activity of 7,000 square feet or more.

In addition to applying Minimum Requirements #1-5 to the new and replaced hard surfaces and land disturbed as described above, Minimum Requirements #1 through #9 apply to the new and replaced hard surfaces and the converted vegetation areas when the project:

- Results in 5,000 square feet, or more, of new plus replaced hard surface area, or
- Converts ¾ acres, or more, of vegetation to lawn or landscaped areas, or
- Converts 2.5 acres, or more, of native vegetation to pasture.

1.2.4 Redevelopment

Redevelopment is development on a site that is already substantially developed (i.e. has 35% or more existing hard surface coverage).

To encourage redevelopment projects, replaced surfaces aren't required to be brought up to new stormwater standards unless the monetary or space thresholds noted in this section are exceeded.

All redevelopment shall be required to comply with Minimum Requirement #2. Where permanent stormwater facilities are provided, an Operation and Maintenance Manual per Minimum Requirement #9 may be required even if the thresholds below are not met.

1.2.4.1 Redevelopment – Applicability of Minimum Requirement #1-5 for New and Replaced Hard Surfaces and Land Disturbed

Minimum Requirements #1-5 apply to the new and replaced hard surfaces and the land disturbed when the project:

- Results in 2,000 square feet, or more, of new plus replaced hard surface area, or
- Has land disturbing activity of 7,000 square feet or more.

1.2.4.2 Redevelopment – Applicability of Minimum Requirements #1-9 for New Hard Surfaces and Converted Vegetation Areas

In addition to applying Minimum Requirements #1-5 to the new and replaced hard surfaces and land disturbed per Section 1.2.4.1, Minimum Requirements #1-9 apply to the new hard surfaces and converted vegetation areas when the project:

- Adds 5,000 square feet, or more, of new hard surfaces, or
- Converts ¾ acres, or more, of vegetation to lawn or landscaped areas, or
- Converts 2.5 acres, or more, of native vegetation to pasture.

1.2.4.3 Redevelopment – Applicability of Minimum Requirement #1-9 for New Hard Surfaces, Replaced Hard Surfaces, and Converted Vegetation Areas

In addition to applying Minimum Requirements #1-5 to the new and replaced hard surfaces and land disturbed per Section 1.2.4.1 and in addition to applying Minimum Requirement #1-9 to the new hard surfaces and converted vegetation areas per Section 1.2.4.2, Minimum Requirements #1-9 apply to the new hard surfaces and replaced hard surfaces and converted vegetation areas depending upon if the redevelopment is multi-family/commercial/industrial, another project type, or if the project is a road-related project as described below.

For multi-family, commercial, or industrial projects, if either of the two thresholds below are crossed:

- Threshold 1:
  - The total of new plus replaced hard surfaces is 5,000 square feet or more, and
  - The valuation of the proposed improvements*, including interior improvements, exceeds 50% of the assessed value** of the existing Project Site improvements.
- Threshold 2:
  - The total of new plus replaced hard surfaces is 5,000 square feet or more, and
  - The new plus replaced hard surfaces total 50% or more of the existing hard surfaces within the Site.

For all other projects (not multi-family, commercial or industrial)***:

- The total of new plus replaced hard surfaces is 5,000 square feet or more, and
- The valuation of the proposed improvements*, including interior improvements, exceeds 50% of the assessed value** of the existing Site improvements.

For road-related projects:

- The total of new plus replaced hard surfaces is 5,000 square feet or more, and
- The total of new plus replaced hard surfaces is 50% or more of the existing hard surfaces within the Site.

*The valuation of the proposed improvements shall be based upon construction cost estimates for the project and must include all site improvements in addition to building improvements. Site improvements may include driveways, parking lots, sport courts, swimming pools, or any other item proposed. The International Code Council building valuation data can be used to help estimate the proposed cost. The City of Tacoma will make the final determination of valuation based upon available information.

**Assessed values can be found on the Pierce County Assessor's website. The City of Tacoma will make the final determination of assessed value based upon available information.

***Other projects include all other projects such as residential (but not multi-family residential), school projects, and parks projects. The City of Tacoma will make the final determination of what constitutes as other projects in the context of Minimum Requirement determination.

1.2.5 Equivalent Areas

The City may allow the Minimum Requirements to be applied to equivalent areas (flow and pollution characteristics). The City of Tacoma shall approve the use of equivalent areas.

The equivalent area facility must discharge to the same outfall or to a discharge location upstream in the receiving water as the project site that transferred the benefit to it. The City also offers an In-Lieu of Payment Option that allows certain projects to pay the City in-lieu of providing

a facility on their project site. See tacoma.gov/stormwatermanual for additional information about the Regional Stormwater Facilities Program.

Installation of a stormwater facility that will be maintained by the City (ex. a facility placed in ROW to treat roadway stormwater) to provide equivalent area mitigation for an onsite area will not be allowed.

1.2.6 Use of Existing Stormwater BMPs

If a new development or redevelopment project is occurring on a surface that is already mitigated by a stormwater BMP and that surface is a targeted surface that requires a stormwater BMP for the new development or redevelopment project, the design must determine if the existing BMP meets current standards.

- If the existing BMP meets current standards, then it may continue to be used to mitigate for the current project target surfaces, so long as it is not part of an area transfer
    - If the existing BMP was installed as part of an area transfer, the existing BMP must be of sufficient size for the existing area transfer and any surfaces that discharge to that facility and must meet all current standards or new BMPs must be installed to handle the surfaces from that original area transfer or the new target surfaces (and any surfaces that may also discharge to that facility).
- If the existing BMP does not meet current standards, it must be adjusted to meet current standards or new BMP(s) must be installed as part of the project.

1.2.7 Flowcharts

The flowcharts in Figure 1-1: New Development Flowchart to Figure 1-3: Road-Related Redevelopment Flowchart are intended as guidance for determining Minimum Requirements. The figures do not provide a complete analysis of each Minimum Requirement. The applicant must review Section 1.2.3 - New Development, Section 1.2.4 - Redevelopment and the text of each Minimum Requirement to determine the stormwater requirements for their project. The written text shall take precedence over the flowcharts.

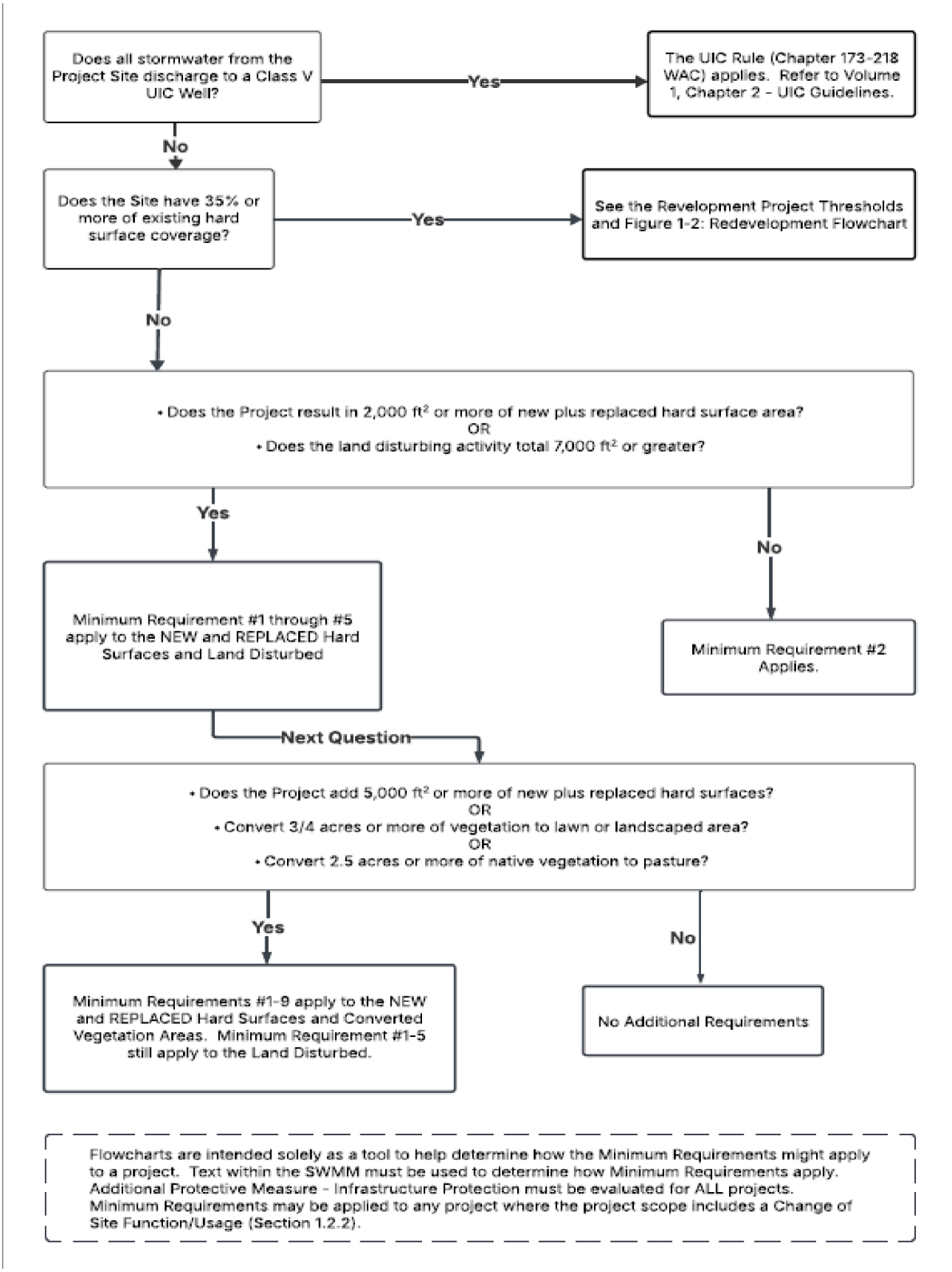


Figure 1 - 1: New Development Flowchart

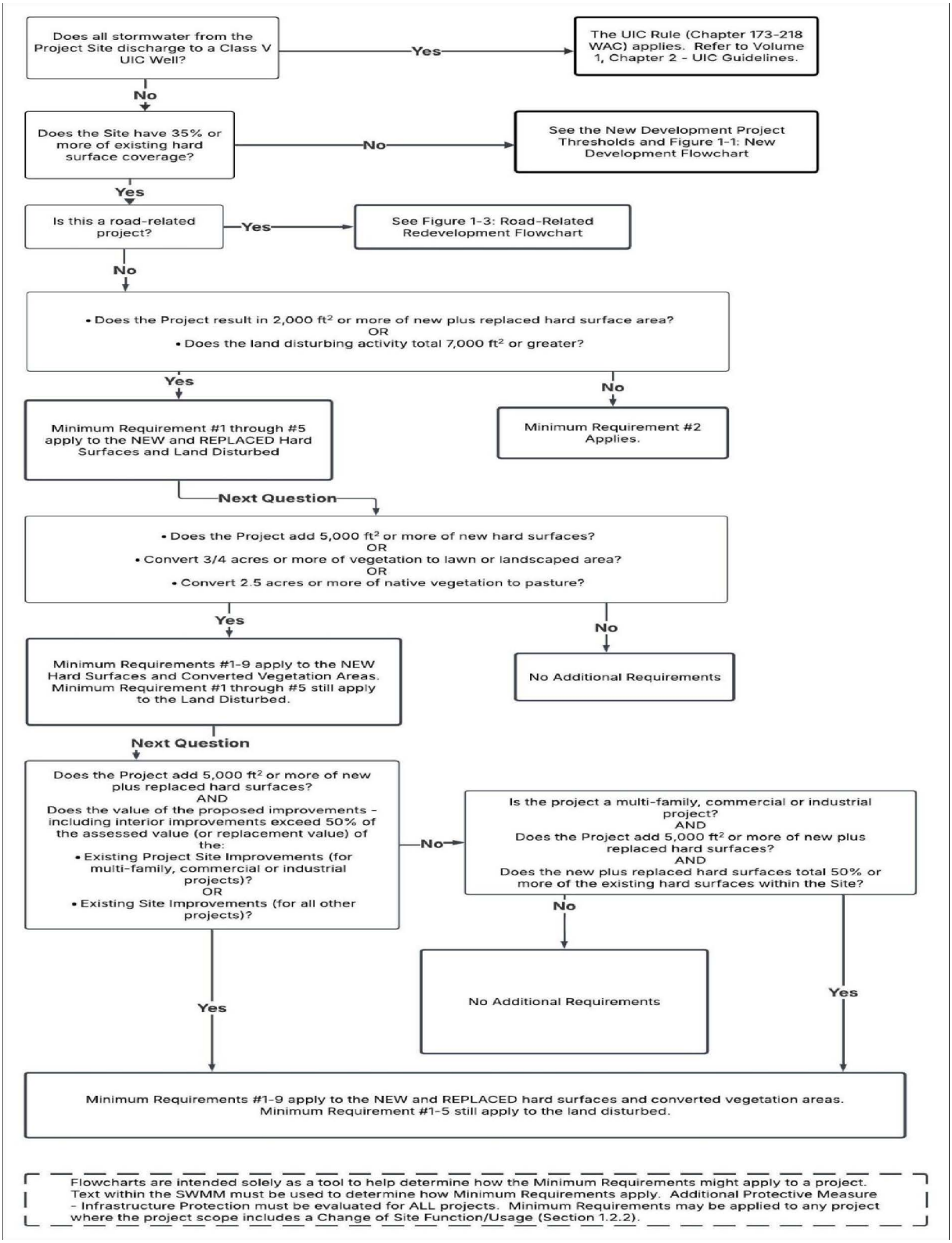


Figure 1 - 2: Redevelopment Flowchart

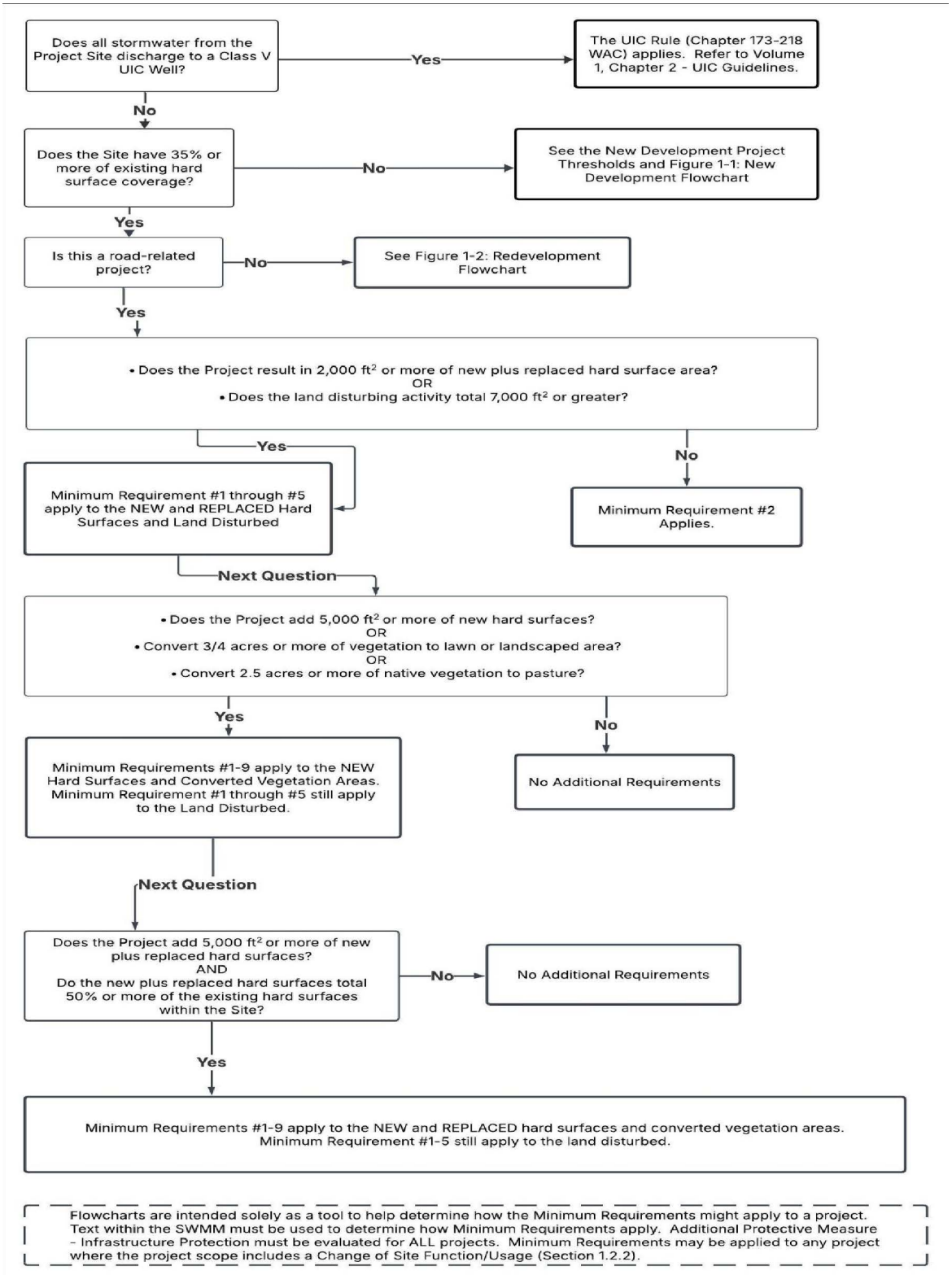


Figure 1 - 3: Road-Related Redevelopment Flowchart

1.3 Description of Minimum Requirements

This section describes the Minimum Requirements for stormwater management for new development and redevelopment projects. Consult Applicability of the Minimum Requirements and Additional Protective Measures to determine which requirements apply to any given project.

Minimum Requirements #1-#5 and #9 do not have separate threshold discharge area (TDA) thresholds and must be applied to the entire project if they are applicable to the project. Minimum Requirements #6, #7, and #8 have TDA Thresholds that describe when and/or what type(s) of BMP(s) must be constructed within each TDA, if applicable to the project.

It is possible for a project to require Minimum Requirements #6, #7, and #8 per the Project Thresholds but not require construction of BMPs in individual TDAs to comply with Minimum Requirements #6, #7, and/or #8. By documenting that the TDA Threshold have not been triggered for that TDA, the project proponent is in compliance with that Minimum Requirement for that TDA.

1.3.1 Minimum Requirement #1: Preparation of Stormwater Site Plans

All projects meeting the Project Thresholds in Applicability of the Minimum Requirements shall prepare a Stormwater Site Plan for City of Tacoma review. Stormwater Site Plans shall use site-appropriate development principles to retain native vegetation and minimize impervious surfaces to the extent feasible. Stormwater Site Plans shall be prepared in accordance with Volume 2 - Documentation.

1.3.1.1 Objective

The intent of a Stormwater Site Plan is to describe the existing conditions of the site and present how stormwater will be managed for the proposed conditions.

1.3.2 Minimum Requirement #2: Construction Stormwater Pollution Prevention

All new development and redevelopment projects are responsible for preventing erosion and discharge of sediment and other pollutants into receiving waters.

Projects that meet or exceed the thresholds in Applicability of the Minimum Requirements and Additional Protective Measures must prepare a Construction Stormwater Pollution Prevention Plan (SWPPP).

Projects below the thresholds in Applicability of the Minimum Requirements and Additional Protective Measures are not required to prepare a Construction SWPPP but must consider the 13 Elements of a SWPPP and develop controls for all SWPPP Elements that pertain to the project.

The Construction SWPPP shall include all information as required in Volume 2 - Documentation.

The Construction SWPPP shall be implemented beginning with initial land disturbance and continuing until final project site stabilization. Sediment and erosion control BMPs shall be consistent with those in Volume 3 of this manual.

1.3.2.1 The 13 Elements of Construction Stormwater Pollution Prevention

The 13 Elements are:

- Element #1: Preserve Vegetation and Mark Clearing Limits
- Element #2: Establish Construction Access
- Element #3: Control Flow Rates
- Element #4: Install Sediment Controls
- Element #5: Stabilize Soils
- Element #6: Protect Slopes
- Element #7: Protect Stormwater System Inlets
- Element #8: Stabilize Channels and Outlets
- Element #9: Control Pollutants
- Element #10: Control Dewatering
- Element #11: Maintain BMPs
- Element #12: Manage the Project
- Element #13: Protect Permanent Stormwater BMPs

Element #1: Preserve Vegetation and Mark Clearing Limits

- Before beginning any land disturbing activities, including clearing and grading, clearly mark all clearing limits, sensitive areas and their buffers, and trees that are to be preserved within the construction area to prevent damage and offsite impacts. Mark clearing limits both in the field and on the plans.
- Retain the duff layer, native topsoil, and natural vegetation in an undisturbed state to the maximum degree practicable. If it is not practicable to retain the duff layer in place, stockpile it onsite, cover it to prevent erosion, and replace it immediately upon completion of the ground-disturbing activities.

- Plastic, metal, fabric fence, or other physical barriers may be used to mark the clearing limits.
- Suggested BMPs (Refer to Volume 3):
  - BMP C101: Preserving Natural Vegetation
  - BMP C102: Buffer Zone
  - BMP C103: High Visibility Fence
  - BMP C233: Silt Fence

Element #2: Establish Construction Access

- Limit construction vehicle ingress and egress to one route, if possible.
- Stabilize access points with a pad of quarry spalls, crushed rock, or other equivalent BMPs to minimize tracking of sediment.
- Locate wheel wash or tire baths onsite if other measures fail to control sediment from leaving the site.
- No tracking of sediment offsite is allowed. If sediment is tracked offsite, offsite areas (including roadways) shall be thoroughly and immediately cleaned by shoveling or pickup sweeping. Transport sediment to a controlled sediment disposal area.
- Keep streets clean at ALL times. Clean tracked sediment immediately.
- Washing of sediment to the stormwater system is not allowed.
- Suggested BMPs (Refer to Volume 3):
  - BMP C105: Stabilized Construction Entrance/Exit
  - BMP C106: Wheel Wash
  - BMP C107: Construction Road/Parking Area Stabilization

Element #3: Control Flow Rates

- Protect downstream properties, receiving waters, and conveyance systems from erosion and other damage due to increases in the velocity and peak volumetric flowrate of stormwater from the project site. A quantitative downstream analysis may be required to ensure no damage to the downstream conveyance system will occur during construction. See Additional Protective Measure - Infrastructure Protection.
- Where necessary, construct flow control facilities as one of the first steps in grading. Flow control facilities shall be functional prior to construction of site improvements (e.g. impervious surfaces). It may be necessary to install temporary flow control facilities to meet flow control requirements during construction.
- Control structures designed for permanent flow control BMPs are not appropriate for use during construction without modification. If used during construction, modify the control structure to allow for long-term storage of runoff and enable sediments to settle. Verify that the flow control BMP is sized appropriately for this purpose. Restore flow control BMPs to their original design dimensions, remove sediment, and install a final control structure at completion of the project.
- Velocity of water leaving the site shall not exceed 3 feet/second if the discharge is to a stream or ditch.

- Permanent infiltration facilities shall not be used for flow control during construction unless lined with an impervious liner or other liner type that ensures no sedimentation. The bottom of the facility shall be scarified to ensure any compaction that occurred during construction is mitigated.
- Suggested BMPs (Refer to Volume 3):
  - BMP C240: Sediment Trap
  - BMP C241: Temporary Sediment Pond
  - BMP C203: Water Bars
  - BMP C207: Check Dams
  - BMP C209: Outlet Protection
  - BMP C235: Wattles
  - BMP C253: Portable Sediment Tank

Element #4: Install Sediment Controls

- Design, install, and maintain effective erosion controls and sediment control to minimize the discharge of pollutants.
- Minimize sediment discharges from the site. The design, installation and maintenance of erosion and sediment controls must address factors such as the amount, frequency, intensity and duration of precipitation, the nature of resulting stormwater, and soil characteristics, including the range of soil particle sizes expected to be present on the site.
- Prior to leaving a construction site or prior to discharge to an infiltration facility, stormwater from disturbed areas shall pass through a sediment removal BMP.
- Construct sediment control BMPs as one of the first steps in grading. These BMPs shall be functional before other land disturbing activities take place.
- Locate BMPs in a manner to avoid interference with the movement of juvenile salmonids attempting to enter off-channel areas or conveyance channels.
- Provide and maintain natural buffers around surface waters, direct stormwater to vegetated areas to increase sediment removal and maximize infiltration, where feasible.
- Seed and mulch earthen structures such as dams, dikes, and diversions according to the timing indicated in Element #5.
- Design outlet structures to withdraw impounded stormwater from the surface to avoid discharging sediment that is still suspended lower in the water column. If installing a floating pump structure, include a stopper to prevent the pump basket from hitting the bottom of the pond.
- Full stabilization includes concrete or asphalt paving; quarry spalls used as ditch lining; or the use of rolled erosion products, a bonded fiber matrix product, or vegetative cover in a manner that will fully prevent soil erosion.
- Suggested BMPs (Refer to Volume 3):
  - BMP C231: Brush Barrier
  - BMP C232: Gravel Filter Berm
  - BMP C233: Silt Fence

- BMP C234: Vegetated Strip
- BMP C235: Wattles
- BMP C240: Sediment Trap
- BMP C241: Temporary Sediment Pond
- BMP C250: Construction Stormwater Chemical Treatment
- BMP C251: Construction Stormwater Filtration
- Emerging technologies exist that can be used for sediment control. The applicant can utilize any BMP that has been approved by Ecology via the Construction Technical Assessment Protocol Ecology program.

Element #5: Stabilize Soils

- Stabilize exposed and unworked soils by application of effective BMPs that prevent erosion.
- From October 1 through April 30, no soils shall remain exposed and unworked for more than 2 days. From May 1 to September 30, no soils shall remain exposed and unworked for more than 7 days. This stabilization requirement applies to all soils onsite, whether at final grade or not.
- Stabilize soils at the end of the shift, before a holiday or weekend, if needed, based on the weather forecast.
- Select appropriate soil stabilization measures for the time of year, site conditions, estimated duration of use, and the potential water quality impacts that stabilization agents may have on downstream waters or groundwater.
- Stabilize soil stockpiles from erosion, protect stockpiles with sediment trapping measures, and where possible, locate piles away from stormwater system inlets, waterways, and conveyance channels.
- Control stormwater volume and velocity within the site to minimize soil erosion.
- Control stormwater discharges, including peak volumetric flowrates and total stormwater volume, to minimize erosion at outlets and to minimize downstream channel and stream bank erosion.
- Minimize the amount of soil exposed during construction activity.
- Minimize the disturbance of steep slopes.
- Minimize soil compaction and, unless infeasible, preserve topsoil.
- Ensure the gravel base used for stabilization is clean and does not contain fines or sediment.
- Suggested BMPs: (Refer to Volume 3)
  - BMP C120: Temporary and Permanent Seeding
  - BMP C121: Mulching
  - BMP C122: Nets and Blankets
  - BMP C123: Plastic Covering
  - BMP C124: Sodding

- BMP C125: Compost
- BMP C126: Topsoiling
- BMP C127: Polyacrylamide for Soil Erosion Protection
- BMP C130: Surface Roughening
- BMP C131: Gradient Terraces
- BMP C140: Dust Control

Element #6: Protect Slopes

- Design and construct cut-and-fill slopes in a manner to minimize erosion. Applicable practices include, but are not limited to, reducing continuous length of slope with terracing and diversions, reducing slope steepness, and roughening slope surfaces (for example, track walking).
- Divert offsite stormwater (sometimes called run-on) or groundwater away from slopes and disturbed areas with interceptor dikes and/or swales. Manage offsite stormwater separately from stormwater generated on the site.
- At the top of the slopes, collect stormwater in pipe slope drains or protected channels to prevent erosion. Size temporary pipe slope drains to convey either:
  - The peak volumetric flowrate calculated using a 10-minute time step from a Type 1A, 10-year, 24-hour frequency storm using a single event model, or
  - The 10-year return period flowrate, indicated by an Ecology-approved continuous simulation model, using a 15-minute time step.

  Use the existing land cover condition for predicting flowrates from tributary areas outside the project limits. For tributary areas on the project site, use the temporary or permanent project land cover condition, whichever will produce the highest flowrate. If using, a continuous simulation model, model bare soils as lawn areas.
- Provide temporary or permanent conveyance to remove groundwater seepage from the slope surface of exposed soil areas.
- Place excavated material on the uphill side of trenches, consistent with safety and space considerations.
- Place check dams at regular intervals within channels that are cut down a slope.
- Stabilize soils on slopes, as specified in Element #5.
- Suggested BMPs (Refer to Volume 3):
  - BMP C120: Temporary and Permanent Seeding
  - BMP C121: Mulching
  - BMP C122: Nets and Blankets
  - BMP C123: Plastic Covering
  - BMP C124: Sodding
  - BMP C130: Surface Roughening
  - BMP C131: Gradient Terraces

- BMP C200: Interceptor Dike and Swale
- BMP C201: Grass-Lined Channels
- BMP C203: Water Bars
- BMP C204: Pipe Slope Drains
- BMP C205: Subsurface Drains
- BMP C206: Level Spreader
- BMP C207: Check Dams
- BMP C208: Triangular Silt Dike (Geotextile-Encased Check Dam)

Element #7: Protect Stormwater System Inlets

- Protect all stormwater system inlets that are operable during construction so that stormwater does not enter the conveyance system without first being filtered or treated to remove sediment.
- Clean or remove and replace inlet protection devices when sediment has filled 1/3 of the available storage (unless a different standard is specified by the product manufacturer).
- Keep all approach roads clean. Do not allow sediment to enter the stormwater system.
- Inspect inlets weekly at a minimum and daily during storm events.
- Suggested BMPs (Refer to Volume 3):
  - BMP C220: Stormwater System Inlet Protection

Element #8: Stabilize Channels and Outlets

- Design, construct, and stabilize all temporary onsite conveyance channels to prevent erosion from either:
  - The peak volumetric flowrate calculated using a 10-minute time step from a Type 1A, 10-year, 24-hour frequency storm using a single event model, or
  - The 10-year return period flowrate, indicated by an Ecology-approved continuous simulation model, using a 15-minute time step.

  Use the existing land cover condition for predicting flowrates from tributary areas outside the project limits. For tributary areas on the project site, use the temporary or permanent project land cover condition, whichever will produce the highest flowrate. If using a continuous simulation model, model bare soils as lawn areas.

- Provide stabilization, including armoring material, adequate to prevent erosion of outlets, adjacent stream banks, slopes, and downstream reaches at the outlets of all conveyance systems.
- Suggested BMPs (Refer to Volume 3):
  - BMP C122: Nets and Blankets
  - BMP C202: Rip Rap Channel Lining
  - BMP C207: Check Dams
  - BMP C209: Outlet Protection

Element #9: Control Pollutants

- Design, install, implement and maintain effective pollution prevention measures to minimize the discharge of pollutants.
- All discharges to the City of Tacoma wastewater system require City approval. Some discharges to the City of Tacoma stormwater system require City approval. The approval may include a separate Special Approved Discharge (SAD) permit. Visit tacoma.gov/government/departments/environmental-services/wastewater/wastewater-permits-and-manuals/ for additional information about SAD permits.
- Handle and dispose of all pollutants, including waste materials and demolition debris that occur on site in a manner that does not cause contamination of stormwater.
- Provide cover, containment, and protection from vandalism for all chemicals, liquid products, petroleum products, and other materials that have the potential to pose a threat to human health and the environment. Provide secondary containment for tanks holding pollutants including onsite fueling tanks. Secondary containment means placing tanks or containers within an impervious structure capable of containing 110% of the volume contained in the largest tank within the containment structure. Double-walled tanks do not require additional secondary containment.
- Conduct maintenance, fueling, and repair of heavy equipment and vehicles using spill prevention and control measures. Clean contaminated surfaces immediately following any spill incident.
- Conduct oil changes, hydraulic system drain down, solvent and degreasing cleaning operations, fuel tank drain down and removal, and other activities, which may result in discharge or spillage of pollutants to the ground or into stormwater using spill prevention measures, such as drip pans.
- Discharge wheel wash or tire bath wastewater to a separate onsite treatment system that prevents discharge to surface water. Alternatively, discharge wheel wash or tire bath wastewater to the wastewater system (only allowed with SAD Permit approval).
- Apply fertilizers and pesticides in a manner and at application rates that will not result in loss of chemicals to stormwater. Follow manufacturers' recommendations for application rates and procedures.
- Use BMPs to prevent or treat contamination of stormwater by pH modifying sources. These sources include, but are not limited to, recycled concrete stockpiles, bulk cement, cement kiln dust, fly ash, new concrete washing and curing waters, waste streams generated from concrete grinding and sawing, exposed aggregate processes, dewatering concrete vaults, and concrete pumping and mixer washout waters.
- Adjust the pH of stormwater if necessary to prevent violations of water quality standards.
- Manage concrete washout appropriately.
    - Washout concrete truck drums or concrete handling equipment in onsite or offsite designated concrete washout areas only.
    - Do not washout concrete truck drums or concrete handling equipment to streets, the stormwater system, receiving waterbodies, or the ground.
        - Washout of small concrete handling equipment may be disposed of in a formed areas awaiting concrete where it will not contaminate stormwater and surface water or groundwater.

- Do not use upland land applications for discharging wastewater from concrete washout areas.
- Do not dump excess concrete onsite, except in designated concrete washout areas.
- Do not washout anything contaminated with concrete into areas where infiltration BMPs are proposed.
- Concrete spillage or concrete discharge directly to groundwater or surface waters of the State is prohibited.

- Written approval from the Department of Ecology is required prior to using chemical treatment other than CO_2, dry ice, or food grade vinegar to adjust pH.
- Clean contaminated surfaces immediately following any discharge or spill incident.
- Uncontaminated water from water-only based shaft drilling for construction of building, road, and bridge foundations may be infiltrated provided the wastewater is managed in a way that prohibits discharge to surface waters. Prior to infiltration, water from water-only based shaft drilling that comes into contact with curing concrete must be neutralized until pH is in the range of 6.5 to 8.5.
- Suggested BMPs (Refer to Volume 3):
  - BMP C151: Concrete Handling
  - BMP C152: Sawcutting and Surfacing Pollution Prevention
  - BMP C153: Material Delivery, Storage and Containment
  - BMP C154: Concrete Washout Area
  - BMP C250: Construction Stormwater Chemical Treatment
  - BMP C251: Construction Stormwater Filtration
  - BMP C252: Treating and Disposing of High pH Water
  - Source Control BMPs from Volume 6, as appropriate.

Element #10: Control Dewatering

- Dewatering discharges to the City of Tacoma stormwater conveyance system or the City of Tacoma wastewater system may require City approval through a Special Approved Discharge (SAD) Permit. See tacoma.gov/government/departments/environmental-services/wastewater/wastewater-permits-and-manuals/ for more information on the SAD Permit Process.
- Discharge foundation, vault, and trench dewatering water that has similar characteristics to site stormwater into a controlled conveyance system prior to discharge to a sediment trap or sediment pond. Stabilize channels as specified in Element #8.
- Clean, non-turbid dewatering water, such as well-point groundwater, can be discharged to systems tributary to state surface waters, as specified in Element #8, provided the dewatering flow does not cause erosion or flooding of receiving waters. Do not route clean dewatering water through TESC BMPs.
- Handle highly turbid or contaminated dewatering water separately from stormwater at the site.
- Other disposal options, depending on site constraints, may include:

  - Infiltration
  - Transport offsite in vehicle, such as a vacuum flush truck, for legal disposal in a manner that does not pollute state waters
  - Ecology approved onsite chemical treatment or other suitable treatment technologies
  - Use of a sedimentation bag that discharges to a ditch or swale for small volumes of localized dewatering
- Suggested BMPs (Refer to Volume 3):
  - BMP C203: Water Bars
  - BMP C236: Vegetative Filtration
  - BMP C250: Construction Stormwater Chemical Treatment
  - BMP C251: Construction Stormwater Filtration

Element #11: Maintain BMPs

- Maintain and repair as needed all temporary and permanent erosion and sediment control BMPs to assure continued performance of their intended function. Conduct maintenance and repairs in accordance with BMP specifications.
- Remove temporary erosion and sediment control BMPs within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized onsite. Permanently stabilize disturbed soil resulting from removal of BMPs or vegetation.
- Suggested BMPs (Refer to Volume 3):
  - BMP C150: Materials On Hand
  - BMP C160: Erosion and Sediment Control Lead

Element #12: Manage the Project

- ***Phasing of Construction*** – Phase development projects in order to prevent soil erosion and the transport of sediment from the project site during construction, unless the Erosion and Sediment Control Lead can demonstrate that construction phasing is infeasible. Revegetation of exposed areas and maintenance of that vegetation shall be an integral part of the clearing activities for any phase.
- ***Seasonal Work Limitations*** – From October 1 through April 30, clearing, grading, and other soil disturbing activities shall only be permitted if shown to the satisfaction of the City that silt-laden stormwater will be prevented from leaving the site through a combination of the following:
  - Site conditions including existing vegetative coverage, slope, soil type, and proximity to receiving waters;
  - Limitations on activities and the extent of disturbed areas; and
  - Proposed erosion and sediment control measures.

  Based on the information provided and local weather conditions, the City may expand or restrict the seasonal limitation onsite disturbance. The following activities are exempt from the seasonal clearing and grading limitations:

- Routine maintenance and necessary repair of erosion and sediment control BMPs
- Routine maintenance of public facilities or existing utility structures that do not expose the soil or result in the removal of the vegetative cover to soil
- Activities where there is one hundred percent infiltration of stormwater within the site in approved and installed erosion and sediment control facilities

- ***Inspection and Monitoring***

a. Inspect, maintain, and repair all BMPs as needed to assure continued performance of their intended function. Projects regulated under the Construction Stormwater General Permit (CSWGP) must conduct site inspections and monitoring in accordance with Special Condition S4 of the CSWGP.

b. Projects that disturb one or more acres must have site inspections conducted by a Certified Erosion and Sediment Control Lead (CESCL) or Certified Professional in Erosion and Sediment Control (CPESC).

c. Projects disturbing less than one acre must have an Erosion Sediment Control Lead (ESC) conduct inspections. The ESC Lead does not have to have CESCL or CPESC certification.

d. The CESCL, CPESC, or ESC Lead shall be identified in the SWPPP and shall be onsite or on-call at all times.

e. The CESCL, CPESC, or ESC Lead must examine stormwater visually for the presence of suspended sediment, turbidity, discoloration, and oil sheen and evaluate the effectiveness of BMPs to determine if it is necessary to install, maintain, or repair BMPs.

f. The CESCL, CPESC, or ESC Lead must inspect all areas disturbed by construction activities, all BMPs, and all locations where stormwater leaves the site at least once every calendar week and within 24 hours of any discharge from the site. (Individual discharge events that last more than one day do not require daily inspections). The CESCL, CPESC, or ESC Lead may reduce the inspection frequency for temporary stabilized, inactive sites to once every calendar month.

g. Construction site operators must correct any problems identified by the CESCL, CPESC, or ESC Lead by:

   - Reviewing the SWPPP for compliance with the 13 construction SWPPP elements and making appropriate revisions within 7 days of the inspection.
   - Fully implementing and maintaining appropriate source control and/or treatment BMPs as soon as possible but correcting the problem within 10 days.
   - Documenting BMP implementation and maintenance in the site log book. (Required for sites larger than 1 acre but recommended for all sites).

   Sampling and analysis of the stormwater discharges from a construction site may be necessary on a case-by-case basis to ensure compliance with standards. Ecology or the City will establish these monitoring and associated reporting requirements.

- ***Responsible Party*** – For all projects, a 24-hour responsible party shall be listed in the SWPPP, along with that person's telephone number and email address.
- ***Maintenance of the Construction SWPPP*** – Keep the Construction SWPPP onsite or within reasonable access to the site. Modify the SWPPP whenever there is a change in the design, construction, operation, or maintenance at the construction site that has, or could have, a significant effect on the discharge of pollutants to waters of the state.

  Modify the SWPPP if, during inspections or investigations conducted by the owner/ operator, City staff, or by local or state officials, it is determined that the SWPPP is ineffective in eliminating or significantly minimizing pollutants in stormwater discharges from the site. Modify the SWPPP as necessary to include additional or modified BMPs designed to correct problems identified. Complete revisions to the SWPPP within seven (7) days following the inspection. City of Tacoma Environment Services (review staff or inspector) may require that a modification to the SWPPP go through additional City review.
- Suggested BMPs (Refer to Volume 3):
  - BMP C150: Materials On Hand
  - BMP C160: Erosion and Sediment Control Lead
  - BMP C162: Scheduling

Element #13: Protect Permanent Stormwater BMPs

- Protect all permanent stormwater BMPs from sedimentation through installation and maintenance of erosion and sediment control BMPs on portions of the site that drain into the BMPs. Restore all BMPs to their fully functioning condition if they accumulate sediment during construction. Sediment impacting Best Management Practices shall be removed before system start-up. Restoring the BMP shall include removal of all sediment and full replacement of treatment media.
- Prevent compacting infiltration facilities by excluding construction equipment and foot traffic.
- Keep all heavy equipment off native soils under infiltration BMPs that have been excavated to final grade to retain the infiltration rate of the soils.
- Protect lawn and landscaped areas from compaction due to construction equipment and material stockpiles.
- Do not allow muddy construction equipment on the base material of permeable pavement or on the permeable pavement section.
- Do not allow sediment laden runoff onto permeable pavements or base materials of permeable pavements.
- Permeable pavements fouled with sediment or that can no longer pass an initial infiltration test must be cleaned prior to final acceptance.
- Suggested BMPs (Refer to Volume 3):
  - BMP C102: Buffer Zone
  - BMP C103: High Visibility Fence
  - BMP C200: Interceptor Dike and Swale
  - BMP C201: Grass-Lined Channels

- BMP C207: Check Dams
- BMP C208: Triangular Silt Dike (Geotextile-Encased Check Dam)
- BMP C231: Brush Barrier
- BMP C232: Gravel Filter Berm
- BMP C233: Silt Fence
- BMP C234: Vegetated Strip
- BMP C235: Wattles

1.3.2.2 Objective

The intent of Stormwater Pollution Prevention is to control erosion and prevent sediment and other pollutants from leaving the site during the construction phase of a project and to have fully functional stormwater facilities and BMPs for the developed site upon completion of construction.

1.3.3 Minimum Requirement #3: Source Control

Following construction, all new and redevelopment projects meeting the Project Thresholds in Volume 1, Section 1.2 - Applicability of the Minimum Requirements shall apply all know, available, and reasonable Source Control BMPs. Source Control BMPs shall be selected, designed, and maintained according to Volume 6 of this manual. Structural and operational BMPs shall be identified in the stormwater site plan report and structural BMPs shall be shown on construction plans submitted for City review.

Note, per Tacoma Municipal Code Chapter 12, source control BMPs shall be implemented by all property owners, residents, businesses, and public entities engaged in pollution generating activities even if there is no new development or redevelopment occurring. Minimum Requirement #3 helps to ensure that new development and redevelopment consider those source control measures during project design.

1.3.3.1 Objective

The intent of source control BMPs is to prevent stormwater from coming in contact with pollutants. They are a cost-effective means of reducing pollutants in stormwater, and, therefore, should be a first consideration in all projects.

1.3.4 Minimum Requirement #4: Preserving Drainage Patterns and Outfalls

For all new and redevelopment projects meeting the Project Thresholds in Volume 1, Section 1.2 - Applicability of the Minimum Requirements, the natural and/or existing condition drainage patterns shall be maintained and discharges from the project site shall occur at the natural and/or existing discharge location to the maximum extent practicable. Natural drainage patterns must always be maintained where natural drainage patterns exist. Note: Compliance with other Minimum Requirements may create a scenario with no discharge due to the use of stormwater management facilities that fully infiltrate - this Minimum Requirement is not meant to require stormwater discharges from a site.

Stormwater shall discharge to the same receiving waterbody in the existing and final condition.

All end of pipe discharges shall have energy dissipation BMPs designed per A400: End of Pipe Discharge Protection.

Stormwater shall not cause adverse impacts to downgradient properties or to the receiving waters. To accomplish this the City will allow discharges as follows:

- Stormwater that has not been concentrated and that has not increased in volume or flowrate as a result of the project, may discharge onto neighboring private parcels, into the City Right-of-Way or other City owned parcels, or into neighboring jurisdictions Right-of-Way without additional constraints.
- Concentrated stormwater and/or stormwater that has increased in volume or flowrate may be discharged onto neighboring private properties or neighboring jurisdiction Right-of-Way provided consultation with the neighboring private property owner and/or neighboring jurisdiction has taken place. Proof of consultation shall be provided to the City. See Volume 2 - Documentation for additional information. Discharges shall follow the guidance below:
    - If the 100-year return period flowrate, as determined by an Ecology approved continuous simulation model and a 15-minute timestep, is less than or equal to 0.3 cfs under existing conditions and will remain less than or equal to 0.3 cfs under developed conditions, the stormwater may be discharged onto a rock pad or similar system that serves to disperse flows. The rock pad shall be designed per A400: End of Pipe Discharge Protection. The design shall demonstrate that there is no adverse impact to the downhill properties or stormwater system.
    - If the 100-year return period flowrate, as determined by an Ecology approved continuous simulation model using a 15-minute timestep, is less than or equal to 0.75 cfs under existing conditions and will remain less than or equal to 0.75 cfs under developed conditions, the stormwater may be discharged through a dispersal trench or similar system designed to disperse flow. The dispersal system shall be designed per A400: End of Pipe Discharge Protection. The design shall demonstrate that there is no adverse impact to the downhill properties or stormwater system.
    - If the 100-year return period flowrate, as determined by an Ecology approved continuous simulation model using a 15-minute timestep, is greater 0.75 cfs under existing conditions and will remain greater than 0.75 cfs under developed conditions, or if a significant adverse impact to downgradient properties or stormwater systems is likely (due to soil conditions or steep slopes, etc.), a formal piped or ditched conveyance system must be provided to convey the stormwater across the

downstream property to an acceptable discharge location. The conveyance system shall be designed per Volume 5 - Stormwater Conveyance Design and Protection.

- Concentrated stormwater and/or stormwater that has increased in volume or flowrate may be discharged to the City of Tacoma stormwater system provided sufficient capacity is available within that system and with approval from the City of Tacoma. See Additional Protective Measure - Infrastructure Protection to determine if an analysis of the downstream system is required for the project. The City of Tacoma stormwater system may need to be extended to serve the site - see Volume 5 - Stormwater Conveyance Design and Protection for additional information.
- For all discharge scenarios, setback requirements for stormwater facilities must be maintained as required and applicable for a given stormwater facility.
- The City of Tacoma reserves the right to make the final determination as to what discharge scenario will be allowed for a given project.

1.3.4.1 Objective

- The intent of Minimum Requirement #4 is to preserve and utilize natural and existing stormwater and surface water systems to the fullest extent practicable by ensuring stormwater is generally following similar drainage patterns before and after project completion because natural and existing stormwater systems provide many benefits including preventing erosion at and downstream of the discharge location.

1.3.5 Minimum Requirement #5: Onsite Stormwater Management

All new development and redevelopment projects meeting the Project Thresholds in Volume 1, Section 1.2 - Applicability of the Minimum Requirements shall apply Stormwater Management BMPs in accordance with the following thresholds, standards, and lists to infiltrate, disperse, and retain stormwater onsite to the extent feasible without causing flooding or erosion impacts.

1.3.5.1 Compliance Options by Project Type

All projects that require compliance with Minimum Requirement #5 (per the Project Thresholds in Volume 1, Section 1.2 - Applicability of the Minimum Requirements) must employ Stormwater Management BMPs as detailed below. The compliance options for the project depend on the amount of improvements proposed, the location of the project, and whether or not the project is Flow Control Exempt.

Each project must use a single compliance option (either List Approach or the LID Performance Standard and BMP L613: Post Construction Soil Quality and Depth). Use of both compliance options on a single project is not allowed.

1.3.5.1.1 Projects that Trigger Only Minimum Requirements #1 - 5 - Not Flow Control Exempt

Projects triggering only Minimum Requirements #1 through #5, except Flow Control Exempt Projects shall either:

a. Use BMPs from List #1, Table 1 - 1: The List Approach for MR #5 Compliance, for all surfaces within each Surface Type in List #1 AND retain or transplant trees per BMP L615: Trees when tree retention and/or planting are required by TMC 13.06.090.B and where feasible; OR

b. Use any Flow Control BMPs to achieve the LID Performance Standard AND apply BMP L613: Post-Construction Soil Quality and Depth AND retain or transplant trees per BMP L615: Trees when tree retention and/or planting are required by TMC 13.06.090.B and where feasible.

1.3.5.1.2 Projects that Trigger Minimum Requirements #1 - #9 - Not Flow Control Exempt

Projects triggering Minimum Requirements #1 through #9, except Flow Control Exempt Projects, shall either:

a. Use BMPs from List #2, Table 1 - 1: The List Approach for MR #5 Compliance, for all surfaces within each Surface Type in List #2 AND retain or transplant trees per BMP L615: Trees where feasible when tree retention and/or planting are required by TMC 13.06.090.B and; OR

b. Use any Flow Control BMPs to achieve the LID Performance Standard AND apply BMP L613: Post-Construction Soil Quality and Depth AND retain or transplant trees per BMP L615: Trees when tree retention and/or planting are required by TMC 13.06.090.B and where feasible.

1.3.5.1.3 Flow Control Exempt Projects

Flow Control Exempt Projects (triggering Minimum Requirement #1 - #5 Only or Minimum Requirements #1 - #9) shall either:

a. Use BMPs from List #3, Table 1 - 1: The List Approach for MR #5 Compliance, for all surfaces within each Surface Type in List #3 AND retain or transplant trees per BMP

L615: Trees when tree retention and/or planting are required by TMC 13.06.090.B and where feasible; OR

b. Use any Flow Control BMPs to achieve the LID Performance Standard AND apply BMP L613: Post-Construction Soil Quality and Depth AND retain or transplant trees per BMP L615: Trees when tree retention and/or planting are required by TMC 13.06.090.B and where feasible.

- If a project has multiple threshold discharge areas (TDAs), all TDAs must be Flow Control Exempt to use the options listed above.

1.3.5.2 Compliance Methods

1.3.5.2.1 Low Impact Development (LID) Performance Standard

The LID Performance Standard allows for the use of any BMPs sited throughout the project site that when modeled meet the LID Performance Standard. The LID Performance Standard allows for a more flexible site design. The LID Performance Standard requires modeling by a Washington State Licensed Professional Engineer. The modeling outputs shall be included in the Stormwater Site Plan Report. See Volume 2 - Documentation for additional information on what is required for modeling outputs.

Utilize one or a combination of Flow Control BMPs to meet the flow reduction modeling standards below. Rain Gardens cannot be used to achieve the LID Performance Standard though Bioretention may be used provided it is designed to provide flow control.

Using an Ecology approved continuous simulation model (assuming a 15-minute timestep) for design, stormwater discharges shall match developed discharge durations to predeveloped discharge durations for the range of predeveloped discharge rates from 8% of the 2-year return period flowrate to 50% of the 2-year return period flowrate. Projects required to comply with Minimum Requirement #7 must match developed discharge durations to predeveloped discharge durations for the range of predeveloped discharge rates from 8% of the 2-year return period flowrate up to the full 50-year return period flowrate.

The predeveloped condition to be matched shall be a forested land cover condition unless:

- Reasonable historic information is provided that indicates the site was prairie prior to settlement.
  - Note: an applicant may submit this historical information as part of the Stormwater Site Plan Report for any given project.

  In this case, the predeveloped condition to be matched can be modeled as pasture.

  In order to determine if an area was historically a prairie it is necessary to provide documentation that includes information such as historical records and maps; geologic information such as a soils report verifying soil types are consistent with a prairie; vegetation surveys; etc.

- The project is located within an area which has been verified to have 40% Total Impervious Area as of 1985 (the drainage area of the immediate stream and all subsequent downstream basins have had at least 40% total impervious area (TIA) since 1985). Figure 1 - 4: 40% Total Impervious Area as of 1985 depicts those areas meeting the criteria. The City of Tacoma tMap also has a layer showing these areas.
  - Note: only the approved map determines these areas. Additionally areas cannot be added on a case by case basis.

In this case, the predeveloped condition to be matched can be the existing land cover condition.

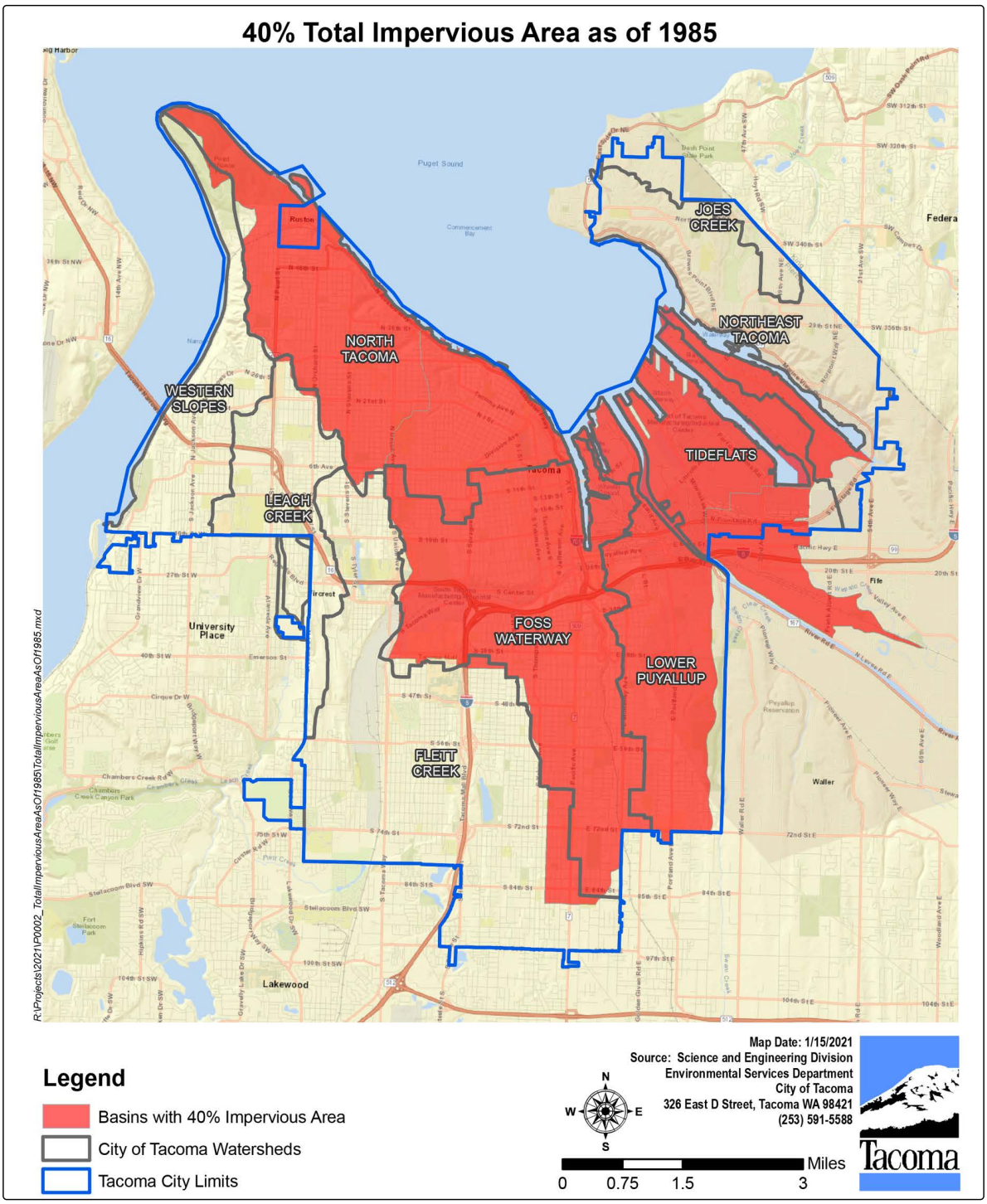


Figure 1 - 4: 40% Total Impervious Area as of 1985

1.3.5.2.2 The List Approach

The List Approach requires evaluating the BMPs in Table 1 - 1: The List Approach for MR #5 Compliance. For all surfaces within each Surface Type, evaluate the feasibility of the BMPs in the order listed, and use the first BMP that is feasible. Additionally, for all projects required to comply with Minimum Requirement #5 - projects shall retain or transplant trees per BMP L615: Trees when tree retention and/or planting are required by TMC 13.06.090.B. Additionally, for all projects required to comply with Minimum Requirement #5 - projects shall retain or transplant trees per BMP L615: Trees. The "or" indicates that either BMP may be used to satisfy the requirement though all BMPs must be evaluated for feasibility.

The project proponent must document why a BMP is considered infeasible. If a BMP is feasible and used for all surfaces within that Surface Type, no other BMP from the list is required for those surface areas within that Surface Type. The infeasibility analysis shall be included in the Stormwater Site Plan. See Volume 2 - Documentation for additional information.

Feasibility shall be determined by evaluation against:

1. Design criteria, limitations, and infeasibility criteria identified for each BMP in this manual; AND
2. Competing Needs Criteria as listed below:
    - Requirements of the following federal or state laws, rules, and standards:
        - Historic Preservation Laws and Archaeology Laws as listed at https://dahp.wa.gov/project-review/preservation-laws
        - Federal Superfund or Washington State Model Toxics Control Act
        - Federal Aviation Administration requirements for airports
        - American with Disabilities Act
    - When found to be in conflict with special zoning district design criteria adopted and being implemented pursuant to a community planning process.
    - Public health and safety standards (ex. active zone of a skate park, bike park, or sport court where permeable pavement violates safety standards).
    - Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.
    - City of Tacoma Land Use Regulatory Codes that provides protection of tree species or other critical areas.

Table 1 - 1: The List Approach for MR #5 Compliance

List #1 For MR #1 - #5 Only Projects That Are Not Flow Control Exempt	List #2 For MR #1- #9 Projects That Are Not Flow Control Exempt	List #3 Flow Control Exempt Projects
Surface Type: Lawn and Landscaped Areas		
BMP L613: Post-Construction Soil Quality and Depth	BMP L613: Post-Construction Soil Quality and Depth	BMP L613: Post-Construction Soil Quality and Depth
Surface Type: Roofs		
1. BMP L614: Full Dispersion, or BMP L602: Downspout Full Infiltration	1. BMP L614: Full Dispersion, or BMP L602: Downspout Full Infiltration	1. BMP L602: Downspout Full Infiltration
2. BMP L601: Rain Gardens, or BMP L630: Bioretention	2. BMP L630: Bioretention	2. BMP L603: Downspout Dispersion
3. BMP L603: Downspout Dispersion	3. BMP L603: Downspout Dispersion	3. BMP L604: Perforated Stub-Out Connections
4. BMP L604: Perforated Stub-Out Connections	4. BMP L604: Perforated Stub-Out Connections	

Table 1 - 1: The List Approach for MR #5 Compliance

List #1 For MR #1 - #5 Only Projects That Are Not Flow Control Exempt	List #2 For MR #1- #9 Projects That Are Not Flow Control Exempt	List #3 Flow Control Exempt Projects
Surface Type: Other Hard Surfaces		
1. BMP L614: Full Dispersion	1. BMP L614: Full Dispersion	1. BMP L612: Sheet Flow Dispersion, or BMP L611: Concentrated Flow Dispersion or BMP L616: Channelized Flow Dispersion
2. BMP L633: Permeable Pavements, or BMP T1050: Compost-Amended Vegetated Filter Strip (CAVFS), or BMP L601: Rain Gardens, or BMP L630: Bioretention, or BMP 750: Ballasted Sidewalks	2. BMP L633: Permeable Pavements, or BMP T1050: Compost-Amended Vegetated Filter Strip (CAVFS); or BMP 750: Ballasted Sidewalks	
3. BMP L612: Sheet Flow Dispersion, or BMP L611: Concentrated Flow Dispersion or BMP L616: Channelized Flow Dispersion	3. BMP L630: Bioretention	
	4. BMP L612: Sheet Flow Dispersion, or BMP L611: Concentrated Flow Dispersion or BMP L616: Channelized Flow Dispersion	

Notes:
1. Size Bioretention and Rain Gardens used in the List Approach to have a minimum horizontal projected surface area below the overflow which is at least 5% of the area draining to it.
2. It is not a requirement to pave surfaces to meet the intent of using Permeable Pavement. If pavement is proposed, it must be permeable to the extent feasible unless BMP L614: Full Dispersion is employed.
3. Where there is an "or" statement in a box, the "or" indicates that either BMP may be used to satisfy the requirement though all BMPs must be evaluated for infeasibility. BMPs must be evaluated in the numbered order.
4. Compost Amended Vegetated Filter Strips may only be used for sidewalks, walkways, and trails and shall follow the criteria within BMP T1050: Compost-Amended Vegetated Filter Strip (CAVFS) specific to compliance with Minimum Requirement #5: Onsite Stormwater Management. Evaluation of other hard surfaces is still required.
5. BMP 750: Ballasted Sidewalks may only be used for sidewalks, walkways, and trails. Evaluation of other hard surfaces is still required.

Where onsite management is not feasible or cannot be used to fully contain stormwater onsite, connections to the City system may be allowed if they meet criteria in Volume 5 - Chapter 2 - Collect and Convey - Connections to the City of Tacoma System.

Supplement Guidance for the List Approach

If a BMP is considered infeasible for a surface in a location on the project site, but is feasible for a surface in another location, the designer must apply the feasible BMP to the surfaces where it is feasible and consider the next BMP in the List for the surface where it is considered infeasible.

The City will consider where it is appropriate to require different BMPs for similar surfaces. The City would not, for example, expect a residential patio to be partially paved with BMP L633: Permeable Pavement and partially paved with an impervious surface directed to BMP L630: Bioretention (because permeable pavement was only feasible for half of the patio). The City would however expect, for example, a plat with branched roads that, one branch be paved with BMP L633: Permeable Pavement and one branch utilize BMP L630: Bioretention (this example assumes Full Dispersion is not feasible for either branch, permeable pavement is feasible for one branch and bioretention is feasible for one branch).

1.3.5.3 Objective

To use stormwater management practices on individual properties to reduce the amount of disruption to the natural hydrologic characteristics of the site.

1.3.6 Minimum Requirement #6: Stormwater Treatment

All new development and redevelopment projects meeting the Project Thresholds in Volume 1, Section 1.2 - Applicability of the Minimum Requirements shall employ Stormwater Treatment BMPs in accordance with the following thresholds, standards, and requirements to remove pollutants from stormwater.

1.3.6.1 Thresholds

Each TDA within a project that triggers Minimum Requirement #6 must be reviewed to determine if Stormwater Treatment BMPs are required for the TDA.

It is possible for a project that triggers Minimum Requirement #6 to not need stormwater treatment BMPs in one or more individual TDA. If a TDA does not trigger the stormwater treatment thresholds below, the applicant must document why stormwater treatment BMPs are not needed within a given TDA.

When assessing a project against the following thresholds, only consider those surfaces that are subject to this Minimum Requirement as determined in Applicability of the Minimum Requirements.

The following require construction of stormwater treatment facilities:

- TDAs in which the total of pollution-generating hard surface (PGHS) is 5,000 square feet or more in a threshold discharge area of the project, or
- TDAs in which the total of pollution-generating pervious surfaces (PGPS) - not including permeable pavements - is three-quarters (¾) of an acre or more in a threshold discharge area, and from which there will be a surface discharge in a natural or artificial conveyance system from the TDA.

Projects that infiltrate stormwater in the South Tacoma Groundwater Protection District have additional and/or different thresholds and requirements for stormwater treatment. See the South Tacoma Groundwater Protection District Infiltration Policy available at https://www.tpchd.org/healthy-places/waste-management/business-pollution-prevention/south-tacoma-groundwater-protection-district for additional information.

1.3.6.2 Treatment Type Requirements

The type of stormwater treatment required is based upon the project scope and receiving waterbody. Below are the requirements for which treatment type applies to a project. Note, more than one treatment type may be required for a project. Stormwater treatment types determined to be applicable to the project TDA(s) must be provided. Projects required to provide oil control must also provide phosphorus, metals, and/or basic treatment (as applicable). Figure 1 - 5: Stormwater Treatment Flowchart below can be used as a tool to help determine which type of treatment is required for the project.

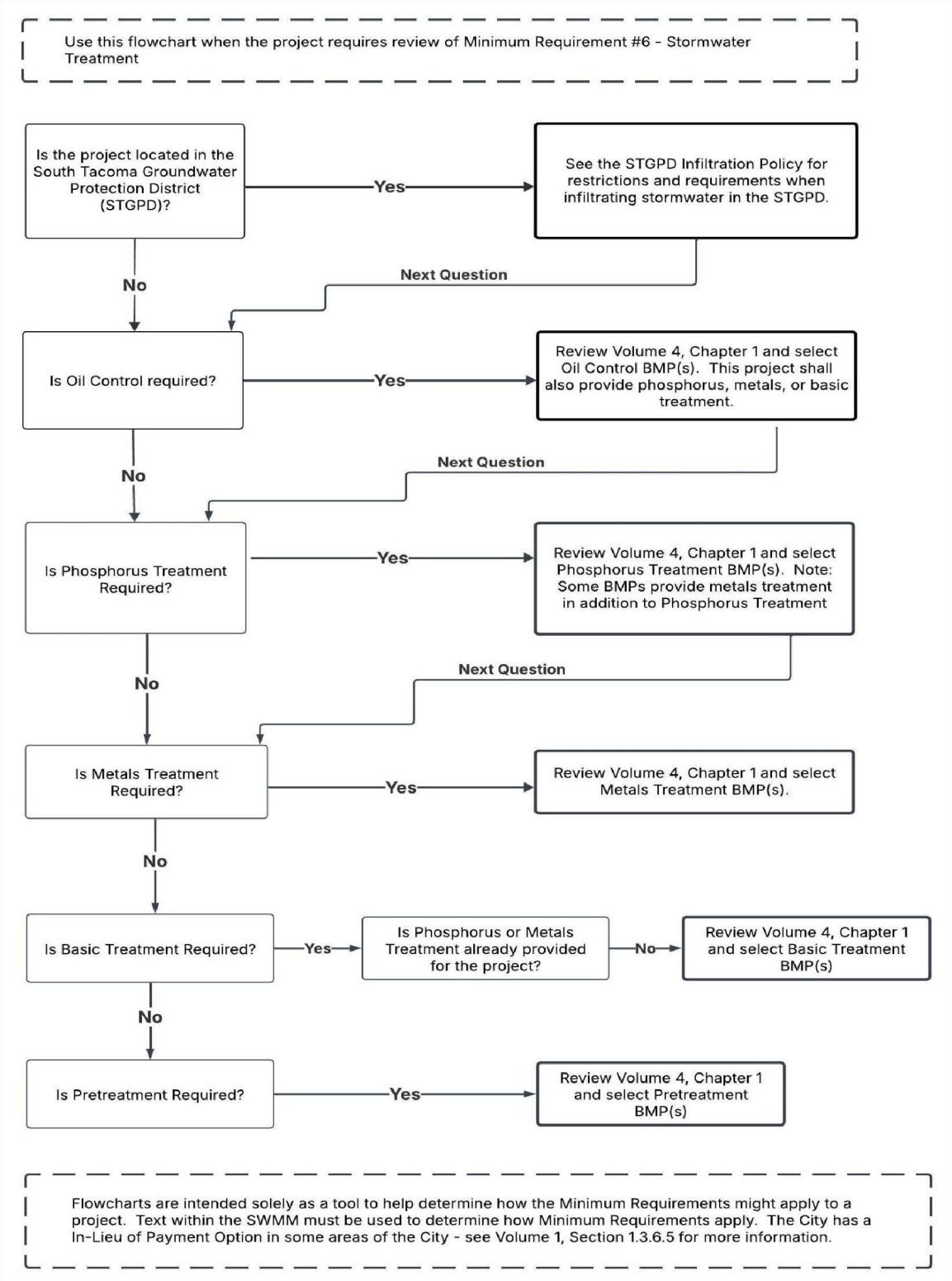


Figure 1 - 5: Stormwater Treatment Flowchart

1.3.6.2.1 Oil Control

Oil Control BMPs are required for areas within a project site that generate high concentrations of oil due to high traffic turnover or the frequent transfer of oil. Areas that require oil control include:

- Areas of commercial or industrial sites subject to an expected average daily traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area, or 300 total trip ends per day.
- Areas of commercial or industrial sites subject to petroleum storage and transfer in excess of 1,500 gallons per year, not including routinely delivered heating oil.
- Areas of commercial or industrial sites subject to parking, storage, or maintenance of 25 or more vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.).
- A road intersection with a measured ADT count of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use improvements.

Traffic count shall be based upon the prepared traffic study if one was required for the project. If a traffic study was not required, the traffic county can be estimated using information from the most recent Trip Generation Manual.

The following are some examples of areas that typically require oil control: industrial machinery and equipment maintenance areas, log storage and sorting yards, fueling stations, vehicle maintenance and repair areas, and heavy equipment storage areas.

1.3.6.2.2 Phosphorus Treatment

Phosphorus Treatment BMPs are required for projects (or portions of projects) within watersheds that have been determined by the local jurisdiction (e.g. through a lake management plan), Ecology (e.g. through a TMDL waste load allocation), or the USEPA to be sensitive to phosphorus and are being managed to control phosphorus. The following are examples of sources that the local jurisdiction can use for determining whether a water body is sensitive to phosphorus:

- Those waterbodies reported under section 303(d) of the Clean Water Act, where designated uses are not supported due to phosphorous or other water quality criteria related to excessive phosphorus. This information can be viewed on Ecology's Water Quality Atlas at the following web address: https://apps.ecology.wa.gov/waterqualityatlas/wqa/map
- Those listed in Washington State's Nonpoint Source Assessment required under section 319(a) of the Clean Water Act due to nutrients.
- A locally adopted plan that contains requirements, recommendations, or policies indicating that a particular receiving water is sensitive to phosphorus.

Currently within the City of Tacoma limits, phosphorus treatment is required for discharges to Wapato Lake when thresholds for Minimum Requirement #6 are met.

1.3.6.2.3 Metals Treatment

Metals treatment is required for the types of project sites listed below that:

a. Discharge directly to fresh waters designated for aquatic life use or that have an existing aquatic life use; or

b. Discharge to conveyance systems that are tributary to fresh waters designated for aquatic life use or that have an existing aquatic life use; or

c. Infiltrate stormwater within ¼ mile of fresh waters designated for aquatic life use or that have an existing aquatic life use.

The types of project sites are:

- Sites subject to industrial activities,
- Commercial project sites,
- Multi-family project sites,
- Roads with an ADT of 7,500 or greater (inside Urban Growth Areas - this includes the Entire City of Tacoma Limits),
- Roads with an ADT of 15,000 or greater (outside Urban Growth Areas),
- Light rail elevated and non-elevated guideways/tracks,
- Other project sites that are anticipated to generate a high pollutant load including:
  - Parking areas as follows:
    - Commercial or industrial areas: all on-street parking areas,
    - Areas other than commercial or industrial areas: on-street parking areas on streets with an expected ADT of 7,500 or greater,
    - Parking areas with an expected trip end count of equal to or greater than 40 vehicles per 1,000 square feet of gross building area,
    - Parking areas with equal to or greater than 100 expected trip ends per day.
  - Fueling stations
  - Transit center bus stops

The following areas of the above-listed project sites do not require Metals Treatment BMPs:

- Areas that discharge directly or indirectly through a municipal separate storm sewer system to a water listed in Appendix III-A: Basic Treatment Receiving Waters of the 2024 Washington State Department of Ecology Stormwater Management Manual for Western Washington (within the City of Tacoma limits this is the Puyallup River and All Salt Waterbodies such as Commencement Bay and the Puget Sound); or
- Landscaped areas of industrial, commercial, and/or multi-family project sites that do not involve any other pollution-generating sources (ex. industrial activities, customer parking, storage of erodible or leachable materials, wastes, or chemicals); or
- Parking lots of industrial and commercial project sites dedicated solely to parking employee's private vehicles that do not involve any other pollution-generating sources (ex. industrial activities, customer parking, storage of erodible or leachable materials, wastes, or chemicals).

For threshold discharge areas within a project site with a mix of land use types, metals treatment is required when the runoff from the areas subject to metals treatment comprise 50% or more of

the total runoff from the threshold discharge area. If the area subject to metals treatment is less than 50% of the total runoff from the threshold discharge area, only basic treatment is required.

1.3.6.2.4 Basic Treatment

Areas that provide phosphorus treatment or metals treatment do not have to provide additional basic treatment. Phosphorus and metals treatment best management practices provide basic treatment.

Basic treatment is required for all areas within a project site that meet the stormwater treatment thresholds but are not required to provide metals treatment and/or phosphorus treatment.

1.3.6.2.5 Pretreatment

Pretreatment best management practices are required:

- When utilizing the following BMPs:
  - BMP T808: Basic Sand Filter
  - BMP T809: Large Sand Filter
  - BMP T810: Sand Filter Vault
  - BMP 700: Infiltration - Basins, Trenches, and Drywells
- Where the basic, phosphorus, or metals stormwater treatment BMP or the receiving waterbody may be adversely impacted by non-targeted pollutants or may be overwhelmed by a heavy load of targeted pollutants.

1.3.6.3 Treatment Facility Selection, Design, and Maintenance

Stormwater treatment facilities shall be:

- Selected in accordance with the Treatment Type requirements above;
- Designed in accordance with criteria in Volume 4; and
- Maintained in accordance with the maintenance standards in Volume 4.

1.3.6.4 Additional Requirements

- The thresholds above apply to both a project's onsite and offsite improvements. Once the project is required to meet this Minimum Requirement, all affected pollution generating surfaces are required to provide treatment. No net or average is permitted between non-pollution generating surfaces and pollution generating.
- Direct and indirect discharge of untreated stormwater from pollution-generating hard surfaces to groundwater is prohibited, except as allowed by dispersion and infiltration through Onsite Stormwater Management BMPs or Infiltration Stormwater Treatment BMPs where the native soils meet the Soil Physical and Chemical Suitability for Treatment (Volume 4, Section 10.1.4.1.3). Certain projects in the South Tacoma Groundwater Protection District require stormwater treatment regardless of project size. See the South Tacoma Groundwater Protection District Infiltration Policy available at tacoma.gov/stormwatermanual

1.3.6.5 In-Lieu of Payment Option

In lieu of constructing stormwater treatment facilities, if available for the project, applicants may pay a fee to the City of Tacoma. The payment will offset construction of City owned and maintained regional stormwater facilities. In order to participate, the program must have capacity available and projects must meet certain eligibility requirements. The "Regional Stormwater

Facilities Program" document available at tacoma.gov/stormwatermanual contains the program requirements, fees, and project feasibility criteria.

1.3.6.6 Objective

The purpose of stormwater treatment is to reduce pollutant loads and concentrations in stormwater using physical, biological, and chemical removal mechanisms so that beneficial uses of receiving waters are maintained and, where applicable, restored.

1.3.7 Minimum Requirement #7: Flow Control

1.3.7.1 Flow Control Applicability

All new development and redevelopment projects meeting the Project Thresholds in Volume 1, Section 1.2 - Applicability of the Minimum Requirements shall provide flow control to reduce the impacts of stormwater from hard surfaces and land cover conversions. The applicability and type of flow control that may be required is based upon discharge location and project impacts.

Each TDA within a project that triggers Minimum Requirement #7 must be reviewed to determine if Flow Control BMPs are required for the TDA.

It is possible for a project that triggers Minimum Requirement #7 to not need flow control BMPs in one or more individual TDA. If a TDA does not trigger the flow control thresholds below, the applicant must document why flow control BMPs are not needed within a given TDA.

When assessing a project against flow control thresholds, only consider those surfaces that are subject to this Minimum Requirement as determined in Applicability of the Minimum Requirements and Additional Protective Measures.

The City of Tacoma reserves the right to make the determination that the flow control standards be applied to any project based upon known downstream erosion issues or potential erosion issues.

When Minimum Requirement #8 is also required, an attempt must be made to meet both Minimum Requirements. If it is not possible to meet both requirements, then the requirement to maintain the hydroperiod of the wetland (meeting Minimum Requirement #8) becomes the overriding concern and documentation must be provided detailing why both requirements could not be met.

1.3.7.2 Flow Control Exempt Threshold Discharge Areas

Flow Control is not required for Flow Control Exempt Threshold Discharge Areas.

1.3.7.3 Flow Control Thresholds

Threshold Discharge Areas (TDAs) that are not Flow Control Exempt TDAs within a project that meet or exceed any of the following thresholds shall provide Flow Control Mitigation.

- Threshold Discharge Areas (TDAs) that have a total of 10,000 square feet or more of effective impervious surface, or
- TDAs that convert ¾ acres or more of vegetation to lawn or landscaped area and from which there is a surface discharge in natural or artificial conveyance systems from the TDA, or
- TDAs that convert 2.5 acres or more of native vegetation to pasture and from which there is a surface discharge in natural or artificial conveyance systems from the TDA, or
- TDAs that, through a combination of effective hard surfaces and converted vegetation areas, cause a 0.15 cfs or greater increase in the 100-year return period flowrate as estimated using an approved continuous simulation model with 15 minute timesteps. Comparison shall be between existing and proposed project site land cover conditions. The proposed site land cover conditions shall not be mitigated land cover conditions.

Figure 1 - 6: Flow Control Flowchart can be used as a tool to help determine when flow control is required.

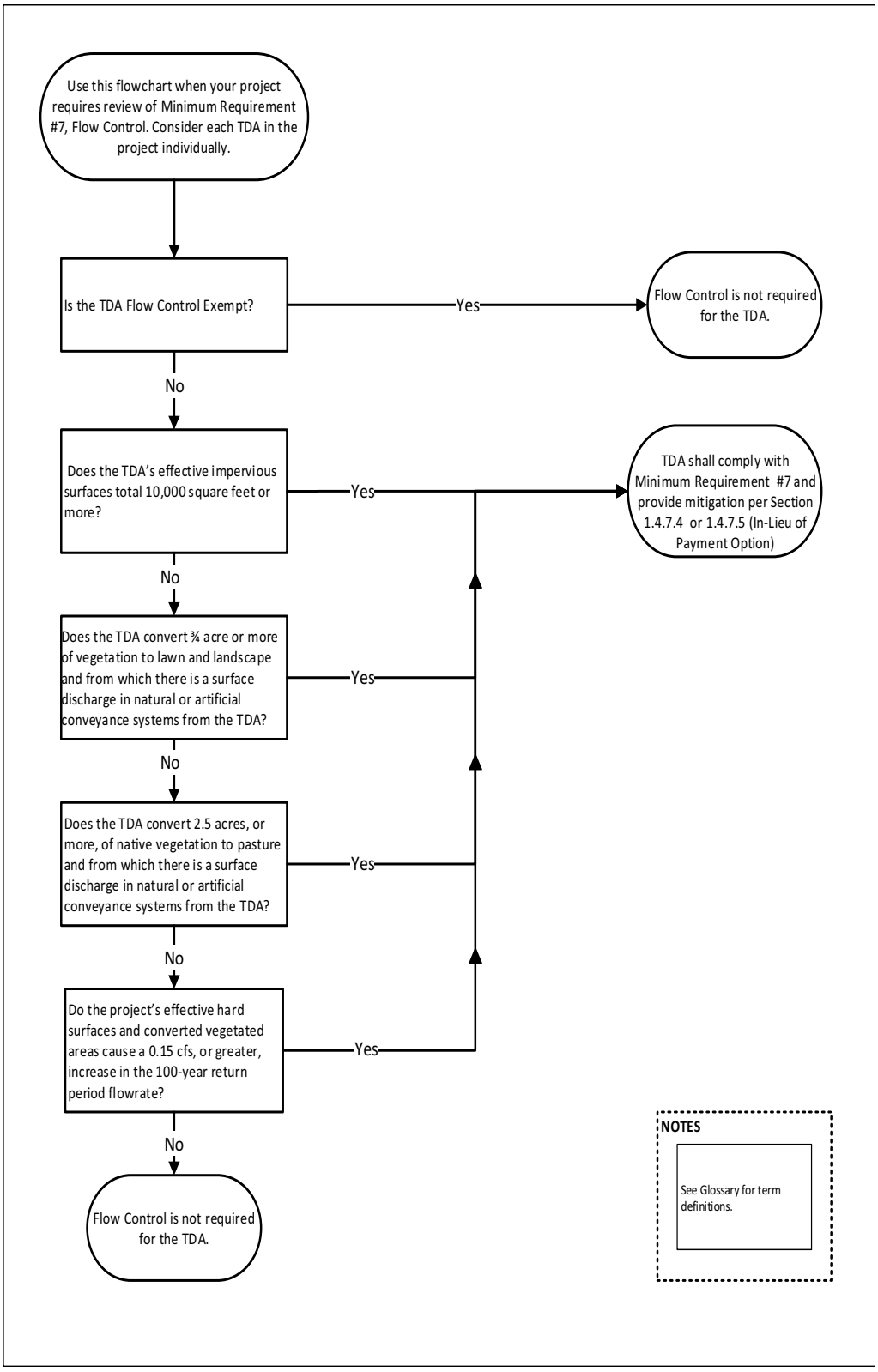


Figure 1 - 6: Flow Control Flowchart

1.3.7.4 Flow Control Mitigation

Using an Ecology approved continuous simulation model for design, assuming 15-minute timesteps, stormwater discharges shall match developed discharge durations to predeveloped discharge durations for the range of predeveloped discharge rates from 50% of the 2-year return period flowrate up to the full 50-year return period flowrate. The predeveloped condition to be matched shall be a forested land cover condition (Flow Control - Forested Condition Mitigation) unless:

- Reasonable historic information is provided that indicates the site was prairie prior to settlement.
    - Note: an applicant may submit this historical information as part of the Stormwater Site Plan Report for any given project.

  In this case, the predeveloped condition to be matched can be modeled as pasture (Flow Control - Pasture Conditions Mitigation)

- The project is located within an area which has been verified to have 40% Total Impervious Area as of 1985 (the drainage area of the immediate stream and all subsequent downstream basins have had at least 40% total impervious area (TIA) since 1985). Figure 1 - 4: 40% Total Impervious Area as of 1985 depicts those areas meeting the criteria. The City of Tacoma tMap also has a layer showing these areas.
    - Note: only the approved map determines these areas. Additionally areas cannot be added on a case by case basis.

  In this case, the predeveloped condition to be matched can be the existing land cover condition (Flow Control - Existing Conditions Mitigation).

1.3.7.5 In-Lieu of Payment Option

n lieu of constructing flow control facilities, if available for the project, applicants may pay a fee to the City of Tacoma. The payment will offset construction of City owned and maintained regional stormwater facilities. In order to participate, the program must have capacity available and projects must meet certain eligibility requirements. The “Regional Stormwater Facilities Program” document available at tacoma.gov/stormwatermanual contains the program requirements, fees, and project feasibility criteria.

1.3.7.6 Flow Control Facility Selection, Design, and Maintenance

Flow control facilities shall be:

- Selected in accordance with guidance in Volume 4;
- Designed in accordance with criteria in Volume 4; and
- Maintained in accordance with the maintenance standards in Volume 4.

1.3.7.7 Objective

The purpose of the flow control – requirement is to prevent increases in natural stream channel erosion rates. The standard intends to maintain the total amount of time that a receiving stream exceeds an erosion causing threshold based upon historic rainfall and natural land cover conditions. That threshold is assumed to be 50% of the 2-year return period flowrate. Maintaining the naturally occurring erosion rates within streams is vital, though by itself insufficient, to protect fish habitat and production.

1.3.8 Minimum Requirement #8: Wetlands Protection

Wetlands are regulated by the City of Tacoma through this requirement and the Ctritical Areas Preservation Ordinance (CAPO), Tacoma Municipal Code 13.11. For more information about wetlands, wetland permits and development close to wetlands, please see https://www.tacomapermits.org/critical-area-permitting. Note, compliance with CAPO may require additional or different mitigation and/or may require modeling/mitigation per this section even if MR#8 is not triggered.

1.3.8.1 Applicability

When assessing a project against the following thresholds, only consider those surfaces that are subject to this Minimum Requirement as determined in Applicability of the Minimum Requirements.

Stormwater discharges to wetlands may require a Critical Area Verification, Minor Development Permit, and/or Development Permit as detailed under the City's Critical Areas Preservation Ordinance (TMC 13.11).

The requirements below are in addition to requirements given in TMC 13.11 and apply only to projects whose stormwater discharges into a wetland, either directly or indirectly through a conveyance system.

When Minimum Requirement #7 is also required, an attempt must be made to meet both Minimum Requirements. If it is not possible to meet both requirements, then the requirement to maintain the hydroperiod of the wetland (meeting Minimum Requirement #8) becomes the overriding concern and documentation must be provided detailing why both requirements could not be met.

1.3.8.2 Thresholds and Requirements

TDAs within projects that meet the thresholds for Minimum Requirement #8 and discharge stormwater directly or indirectly to a wetland must provide Wetlands Protection. See Figure 1 - 7: Determining Required Wetland Protection Levels to determine which Level of Wetland Protection applies to a project. Stormwater BMPs shall not be built within a wetland or buffer except for necessary conveyance systems as approved by City of Tacoma on a case by case basis.

1.3.8.2.1 Wetlands Protection Thresholds

The Level of Wetlands Protection is based upon:

- The Wetland Category into which the TDA discharges,
- Whether or not the TDA triggered Minimum Requirement #7: Flow Control,
- Whether or not the wetland is a depressional or impounded wetland,
- Whether or not the project proponent has legal access to the wetland,
- The wetland habitat score,
- Whether or not the wetland provides habitat for rare, endangered, threatened, and/or sensitive species, and
- Whether or not there is a presence of a breeding population of native amphibians.

1.3.8.2.2 Determining Required Levels of Protection

Use Figure 1 - 7: Determining Required Wetland Protection Levels to determine the required level of protection specific to the project.

The Levels of Protection are:

- General Protection
  - General Protection includes general practices that benefit wetlands of all types.
- Protection from Pollutants
  - Protection from Pollutants includes measures to protect the wetland from pollutants in stormwater runoff.
- Wetland Hydroperiod Protection
  - Wetland Hydroperiod Protection includes measures to avoid excessive hydrologic alteration of existing wetlands from development. There are two methods within Wetland Hydroperiod Protection:
    - Method 1: Monitoring and Wetland Stage: This method requires data collection specific to the wetland, as well as continuous simulation modeling to demonstrate that the proposed project will not negatively alter the wetland hydrology.
    - Method 2: Site Discharge Modeling: This method requires continuous simulation modeling of the runoff from the TDA to demonstrate that the changes in total discharge volume to the wetland will remain similar to the predevelopment condition.

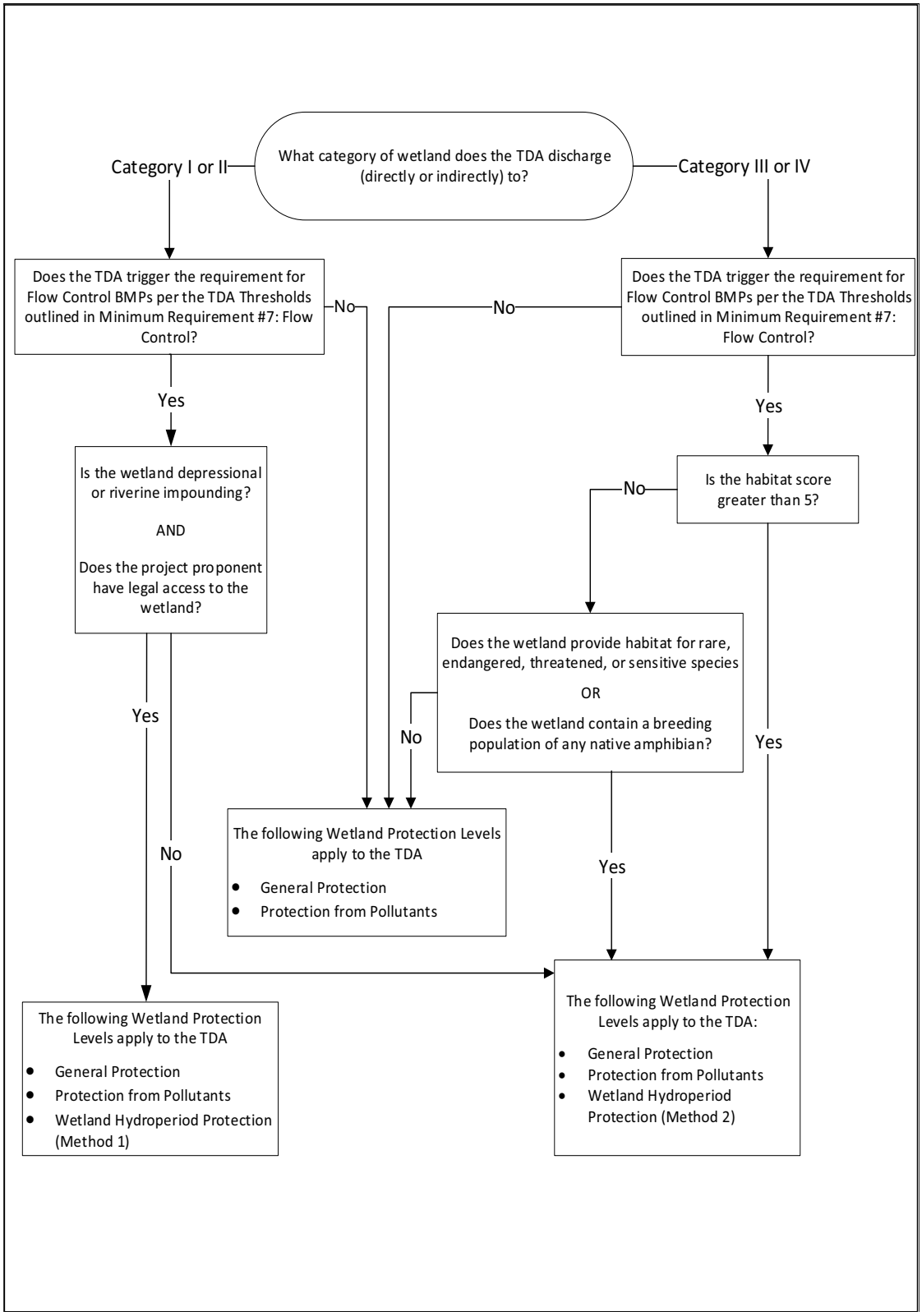


Figure 1 - 7: Determining Required Wetland Protection Levels

1.3.8.2.3 Minimum Requirement #8 Information Needs

In order to determine the level of protection required for a project and assess the impacts and risks to the wetlands the following information is needed.

Some of the information below is obtained from the Wetland Delineation Report. Wetland delineation reports must be prepared by a Wetland Specialist (as defined by TMC 13.01.110).

1. Wetland Category, Wetland Type, Habitat Score

   This information must be obtained following Ecology's Wetland Rating System for Western Washington: 2014 Update (Hruby, 2014). See https://ecology.wa.gov/water-shorelines/wetlands/tools-resources/rating-systems for more information. This information can be found in a Wetland Delineation Report.

2. Presence of rare, endangered, threatened, or sensitive species

   This information is often found in a Wetland Delineation Report.

3. Presence of breeding populations of native amphibian species

   This information is not typically found in a Wetland Delineation Report and must be based on site specific information obtained during specific times of the year or based upon assumptions as allowed in Section 1.3.8.3.3 – Wetland Hydroperiod Protection.

4. Whether or not the TDA threshold for Minimum Requirement #7 are triggered.

5. Whether or not the project proponent has legal access to the wetland.

6. Size boundary and characteristics of the:

   a. Proposed project,

   b. Wetland contributing drainage area, and

   c. Wetland and its buffer

7. Modeling outputs from an Ecology approved continuous simulation model, if Wetland Hydroperiod Protection Modeling is required.

8. Wetland field monitoring data as required to show compliance with Wetland Hydroperiod Protection – Method 2

For compliance with stormwater regulations only, when a separate CAPO permit is not required and the project does not have an obvious direct hydrologic connection to the wetland, the City will allow the applicant to make assumptions to determine the level of protection required for a project. An example of this would be where the project has an indirect piped connection to a City mapped known wetland that is 1 mile away. In these instances, the most conservative assumptions must be made if the information is not already available in recent reports.

1.3.8.3 Levels of Protection

1.3.8.3.1 General Protection

All wetlands (Categories I, II, III and IV) must receive the following general protection:

- Consult regulations issued under federal and state laws that regulate the discharge of pollutants to surface waters, including the Construction Stormwater General NPDES Permit.
- Maintain the wetland buffer required by local and/or state regulations.
- Retain areas of native vegetation connecting the wetland and its buffer with nearby wetlands and other contiguous areas of native vegetation. It is recommended to retain all vegetation connecting wetlands and buffers. If the vegetation is an invasive species or non-desirable, non-native species, it is further recommended to enhance with native vegetation.
- Avoid compaction of soil and introduction of invasive plant or animal species in the wetland and its buffer.
- Take measures to avoid general physical impacts (e.g., littering and vegetation destruction). Examples are protecting existing buffer zones; discouraging access - especially by vehicles, planting outside the wetland, and encouragement of stewardship and signage by landowners.
- Any stormwater management practices, such as Stormwater Treatment or Flow Control BMP implementation, must be done outside of the wetland buffer boundary, except as allowed by the conditions of a Wetland Development Permit. See tacomapermits.org for additional information of Wetland Development Permits.
- Discharge from a BMP or project site should be dispersed using a method to diffuse the flow before entering the wetland buffer.
- Consider fences to restrict human access, but make sure fences do not interfere with wildlife movement. Fences should be used when wildlife passage is not a major issue and the potential for intrusive impacts is high. When wildlife movement and intrusion are both issues, the circumstances will have to be weighed to make a decision about fencing. Check with the local and/or state agencies to determine if fencing would be allowed.

1.3.8.3.2 Protection from Pollutants

All wetlands (Categories I, II, III and IV) must receive the following protection from pollutants:

- Provide Construction Stormwater BMPs per Volume 3 - Construction Site Stormwater Best Management Practices to prevent sediment and other pollutants from entering the wetland.
- Provide Source Control BMPs per Volume 6.
- Provide On-Site Stormwater Management and use site appropriate development principles, which include LID principles, as much as practicable for the site, per Volume 4 - Best Management Practices Library and Volume 2 - Documentation. Site-appropriate development principles and practices will help meet other wetland hydroperiod protection criteria and provide additional habitat.
- Provide Stormwater Treatment BMPs per Volume 4 to treat stormwater prior to entering the wetland and its buffer.

  Note: If the thresholds for Minimum Requirement #6: Stormwater Treatment are not met for a TDA, then it is not required to provide Stormwater Treatment BMPs for that TDA to comply with Wetlands Protection.

If the wetland is a special characteristic wetland (such as mature or old growth forest wetlands, bogs, estuarine wetlands, wetlands of high conservation value, coastal lagoons, and interdunal wetlands), implement Stormwater Treatment BMPs with the most advanced ability to control

nutrient loads. Consider using Stormwater Treatment BMPs with infiltration and active biological filtration.

1.3.8.3.3 Wetland Hydroperiod Protection

Protection of many wetland functions and values depends on maintaining the existing wetland's hydroperiod. Changes in a wetland's hydroperiod can create environments which are preferential for invasive species thereby causing injury to the native species. Changes in wetland hydroperiod can also lead to localized flooding which can impact surrounding properties. This means maintaining the annual fluctuations in water depth and its timing as closely as possible. See Figure 1-7 - Determining Required Wetland Protection Level to determine if Wetland Hydroperiod Protection is required.The Wetland Hydroperiod Protection is separated into two methods (Methods 1 and 2) that are dependent on the wetland category, and whether the project proponent has legal access to the wetland. Method 1 can be used for any project. If Method 2 is triggered, Method 1 can still be used as a compliance option.

Method 1 requires a minimum one year of monitoring followed by continuous simulation modeling of the wetland stage (called Method 1) or conservative assumptions to be made about a wetland. Method 1 shall be applied to the wetlands listed below.

- Category I or II depressional or riverine impounding (including special characteristics Category I or II) wetlands that the project proponent owns, or the project proponent has legal access to – for purposes of conducting monitoring in the wetland.

Method 1 takes into account wetland specific information and field data, therefore, it allows more detailed evaluation of effects of stormwater on wetland functions. In cases where the project proponent neither owns nor has legal access to the Category I or II wetlands receiving stormwater from a proposed project, Method 2 can be used.

Method 2 uses a site discharge volume model to evaluate hydrologic changes in a wetland, with no additional wetland monitoring requirement. Method 2 shall be applied to the wetlands listed below.

- Category I or II wetlands that the project proponent doesn't have legal access to conduct monitoring in the wetland,
- Category I or II riverine, slope or lake-fringe wetlands,
- Category III and IV wetlands with habitat score greater than 5,
- Category III or IV interdunal special characteristic wetlands,
- Category III and IV wetlands that provide habitat for rare, threatened, endangered or sensitive species,
- Category III and IV wetlands that contain a breeding population of any native amphibian species.
    - If the wetland has permanent or seasonal ponding or inundation, assume that it has a breeding population of native amphibians.
    - For seasonal ponding, if the wetland has surface ponding after May 1 of a normal water year or drier, assume that it has a breeding population of native amphibians.
    - See the Wetland Rating System for guidance on identifying field indicators.
    - Recent aerial images of surface water in the wetland during normal water year or drier year can also indicate presence of permanent or seasonal ponding.

1.3.8.3.3.1 Method 1: 1-Year Wetland Monitoring and Wetland Stage Modeling

Method 1 criteria and analysis is based on the presumption that a wetland has limited water level fluctuation and water holding capacity. The risk to the wetland will be minimal if the frequency and duration of water level fluctuation (WLF) in the wetland and the WLF timing post project remain as similar to pre-project levels as possible. Therefore, the criteria sets limits on the frequency and duration of stage excursions (greater WLF than the pre-project level), as well as on overall WLF after development. The criteria were developed based on studies in Wetlands and Urbanization, Implications for the Future (Azous and Horner, 1997).

One water year of field monitoring will characterize the existing WLF and water holding capacity of the wetland, and it will be used to calculate the allowable WLF by the proposed development.

A hydrologic assessment to measure or estimate elements of the hydroperiod under pre-project and post-project conditions should be performed with the aid of a qualified scientist or wetland specialist.

Criteria for Method 1

The project proponent must meet the following six Method 1 criteria in order to comply with the Wetland Hydroperiod Protection requirements.

Criteria 1. Mean Monthly WLF Limit

- If the pre-project (monitored) mean monthly WLF for a given calendar month is less than 15cm (0.49ft, 5.91inch), the post-project mean WLF of the wetland for that calendar month may increase to no more than 20 cm (0.66ft, 7.87inch).
- If the pre-project (monitored) mean monthly WLF for a given calendar month is greater than or equal to 15 cm (0.49ft, 5.91inch), the post-project mean monthly WLF of the wetland for that calendar month may increase by up to, but no more than, 5 cm (0.16ft, 1.97inch).
- Without one year of monitoring data, assume the pre-project mean monthly WLF for any month is greater than or equal to 15 cm (0.49ft, 5.91inch), and the post-project mean monthly WLF of the wetland for that calendar month may increase by up to, but no more than, 5 cm (0.16ft, 1.97inch).

Criteria 2. Mean Annual WLF Limit

- If the pre-project (monitored) mean annual WLF is less than 15cm (0.49ft), the post-project mean annual WLF of the wetland may increase to no more than 20 cm (0.66ft, 7.87inch).
- If the pre-project (monitored) mean annual WLF is greater than or equal to 15 cm (0.49ft, 5.91inch), the post-project mean annual WLF of the wetland may increase by up to, but no more than, 5 cm (0.16ft, 1.97inch)
- Without one year of monitoring data, assume the pre-project mean annual WLF is greater than or equal to 15 cm (0.49ft, 5.91inch), and the post-project mean annual WLF of the wetland may increase by up to, but no more than, 5 cm (0.16ft, 1.97inch)

Criteria 3. Frequency of Stage Excursions

- The frequency of stage excursions of 15 cm (0.49ft, 5.91inch) above or below the pre-project stage must not exceed an annual average of six.

Criteria 4. Durations of Stage Excursions

- The duration of stage excursions of 15 cm (0.49ft, 5.91inch) above or below the pre-project stage must not exceed 3 days per excursion.

  AND

  - For a Wetland that Provides Habitat for Native Amphibians: The stage excursions above or below the pre-project stage must not exceed 8 cm (0.26ft, 3.15inch) for more than 1 day in any 30-day period between January 1 and May 31. The hydroperiod limits characterize wetlands inhabited by breeding native amphibians and apply to breeding zones during the period of January 1 through May 31. If these limits are exceeded, then amphibian breeding success is likely to decline.

    OR

  - For a Peat Wetland: The duration of stage excursions in the post-project scenario cannot be above the pre-project stage for more than 1 day in any year, and applies to all zones over the entire year. If this limit is exceeded, then characteristic bog or fen wetland vegetation is likely to decline.

Criteria 5. Total Dry Period Change

- The total dry period (when pools dry down to the soil surface everywhere in the wetland) must not increase or decrease by more than two weeks in any year between the pre-project and post-project scenarios.

Criteria 6. Perennial to Ephemeral or Seasonal Avoidance

- Alterations to watershed and wetland hydrology that may cause perennial wetlands to become ephemeral or seasonal post-project must be avoided.
- If modeled wetland stage indicates that the wetland is perennial, the dry period at the post-project scenario should not exceed 1 day in any year.

Additional guidance, as well as an excel template to assist with the calculations to verify compliance with Method 1 is provided in Wetland Hydroperiod Data Collection and Evaluation Procedures.

Wetland Hydroperiod Data Collection and Evaluation Procedures for Method 1

Field Monitoring and Data Collection

Field monitoring data of the wetland must be collected to determine the existing pre-project hydroperiod, which will then be compared to model outputs to verify compliance with the Hydroperiod Protection Criteria. Without one year of hydroperiod monitoring, the minimum allowable WLF change can be used (see Criteria for Method 1 in Wetland Hydroperiod Protection and Steps to Verify Compliance with the Method 1 Hydroperiod Protection Criteria below).

An Ecology approved continuous simulation model will be needed for data analysis. Relevant historic monitoring information can also inform the pre-project condition of the wetland. The following lists describe the minimum required wetland specific information in order to implement the Method 1 Wetland Hydroperiod Protection guidance.

1. Contour Data or Water Storage Capacity

Bathymetry, or wetland contours, is indicative of the water storage capacity of the wetland that will be used in the model simulation.

If possible, the bathymetry of the wetland should be surveyed. LIDAR data or GIS analysis may also be used to provide approximate wetland contours.

In the absence of bathymetry data, approximate the bathymetry using the permanent ponding area and assume that the storage will occur on top of that area. This resulting storage area will be lower than the actual area, providing a more protective model.

2. Hydroperiod Monitoring

Collect at least one year of water levels (instantaneous water stage and crest stage) using a crest stage gage or continuous water level loggers in the wetland. Water levels should be collected at least monthly over a year.

Average base stage = (Instantaneous stage at the beginning of interval + Instantaneous stage at the end of interval)/2

3. Flow Monitoring

The goal of this monitoring is to construct a relationship in the model to simulate how flows will be released from the wetland for each given stage. A simplified monitoring approach may be appropriate for a simple wetland flow regime. For instance, where a well-defined outlet controls the outflows from a wetland, instantaneous monitoring of the outflow for the typical range of flows may be sufficient. In this simple case, a velocity and cross-section and stage monitoring at the outlet can be sufficient to create the relationship for the model. These measurements may be performed in conjunction with the hydroperiod monitoring described above. Additional field visits timed with precipitation or dry periods may be necessary to ensure that the outflow relationship covers the range of modeled flows.

Ecology acknowledges that it can be challenging to determine the location(s) of flows to and from wetlands. In some cases, there will be a clear channel that is the source of the inflows and outflows, while in others, the water may disperse over a wide area. An alternative would be to gather nearly continuous (every 15 minute) rainfall data along with wetland stage data (hydroperiod monitoring) and adjust the storage and discharge rate within the model using these data. If the flow data or estimation in the model are not available, assume there is no surface outflow for the wetland (closed depression).

Chapter 8 of Wetlands and Urbanization, Implications for the Future (Azous and Horner, 1997) indicates that a complete wetland water balance includes precipitation, evapotranspiration, surface inflow, surface outflow, groundwater exchange, and change in wetland storage using a tipping-bucket gage and continuous flow measurements. The wetland assessment as part of this Method 1 needs to consider the more protective approach to develop that relationship. A scientist (e.g. wetland scientist or hydrologist) may determine that the groundwater flow is a significant characteristic of the outflow of the system. In this case the project proponent may need to determine the groundwater regime of the system.

Model Construction and Simulation for Method 1

The project proponent should develop a stage-storage-discharge (SSD) table that represents the volume of water that ponds in the wetland and the flowrate of water that discharges from the wetland at a given stage.

An Ecology approved continuous simulation model using 15-minute timesteps shall be utilized for wetland hydroperiod modeling for the pre-project and post-project simulation as described below.

Having a reliable SSD table that represents the wetland is essential to evaluate the effects of development in the model. Wetland bathymetry and contour data by field measurement or using equations to represent the volume-area-depth relations of wetlands and wetland flow monitoring data are critical to develop the SSD table for the wetland.

In the absence of actual wetland flow monitoring data, it may be possible to develop a SSD table for the wetland by combining the model simulated flows with the field data obtained on the wetland WLF (hydroperiod monitoring) data. This would require an iterative modeling process. The modeling iterations would involve manually changing the discharge rates in the SSD table until the resulting simulated WLF approach WLF from the field monitoring data. The project proponent or modeler shall provide the details of how this was estimated in its hydrologic assessment report.

With an SSD table, the following are necessary for the model simulation to evaluate the discharge of development in the model and determine compliance with the Method 1 Wetland Hydroperiod Protection criteria.

- Pre-project condition land uses and associated acreage for the entire contributing area that drains to the wetland.
- Post-project condition land uses and associated acreage for the entire contributing area that drains to the wetland.
- Percentage of developing project area compared to total acreage of contributing area that drains to the wetland.

Pre-Project Simulation

1. Identify existing impervious and pervious surfaces that discharge to the wetland and use the model elements to represent the land use and associated acreage for all hydrologically contributing areas to the wetland.
2. Add the wetland buffer using the lateral flow soil basin, or include it as part of the contributing area land use.
3. Connect the runoff from the contributing basin(s) including interflow and groundwater to the SSD table that represents the wetland.
4. Set the outflow of the wetland as the Point of Compliance (POC).

Post-Project Simulation

1. Identify anticipated impervious and pervious surfaces that discharge to the wetland and use the model elements to represent the land use and associated acreage for all hydrologically contributing areas to the wetland.
2. Identify any Flow Control BMPs in the contributing area draining to the wetland and use the appropriate model elements to represent these facilities.

3. Add the wetland buffer using the lateral flow soil basin, or include it as part of the contributing area land use.

4. Connect the runoff from the contributing basin(s) (including the buffer) including interflow and groundwater to the same SSD table that was used in the pre-project scenario.

5. Connect flows from any Flow Control BMP elements through the downstream element(s) to SSD table that represents the wetland.

6. Connect any infiltration from Flow Control BMP elements to groundwater of SSD table (if applicable).

7. Set the outflow of the wetland as the POC.

The order of the steps above depends on the type of elements and their intended function and could change to be more representative of the contributing flow pathways to the wetland.

Once the model simulations are done for post and pre-project scenarios, export the SSD table stage data for the full period of record: daily, monthly and yearly average, and Max and Min stage.

These model outputs, together with monitored WLF, are to be used to verify compliance with the Method 1 Hydroperiod Protection Criteria in Wetland Hydroperiod Protection.

Steps to Verify Compliance with the Method 1 Hydroperiod Protection Criteria

An excel template has been developed by the Washington State Department of Ecology to assist with the calculation steps. The template can be downloaded from the interactive online version of the Washington State Department of Ecology Stormwater Management for Western Washington.

1) Calculate the Existing WLF of Wetland using Monitored Water Levels

Using the measurements of crest and instantaneous stage during a series of time intervals over a year, calculate water level fluctuation (WLF) between measurements.

Calculate mean annual and mean monthly WLF as the arithmetic averages of a year and each month for which data are available.

Water level fluctuation (WLF) = Crest stage - Average base stage

2) Estimate the WLF by Continuous Simulation of Stages in the Model

Using modeled daily, monthly and yearly stages (average, max and min) for the full period of record, calculate daily, monthly or annual WLF as follows:

WLF = Max stage - average stage

3) Calculate Allowable WLF change

Allowable WLF change by the proposed project is determined by two factors: Monitored WLF of the wetland, and the size of the proposed project relative to the wetland's contributing basin area.

Allowable WLF change for the proposed project is calculated as follows:

- If monitored WLF is less than 15 cm (0.49 ft, 5.91 inch),

- Allowable WLF change for the wetland (A) = 20 cm (0.66 ft, 7.87 inch) – monitored WLF
- Allowable WLF change for the proposed project = A / percentage of development by proposed project in the contributing basin area.

- If monitored WLF for a given calendar month is greater than or equal to 15 cm (0.49 ft, 5.91 inch),
  - Allowable WLF of the wetland (A) for that calendar month may increase by up to, but no more than, 5 cm (0.1 6ft, 1.97 inch).
  - Allowable WLF change for the proposed project = 5 cm / percentage of development by proposed project in the contributing basin area.

For example, if the project develops 10 acres of a 100 acre basin (10%), the project can cause no more than 10% of total allowable WLF change in the wetland. If the total allowable WLF change for the wetland is 10 cm (0.32 ft, 3.94 inch), the allowable WLF change for the proposed site is 1.0 cm (0.032 ft, 0.394 inch).

4) Verify Compliance with the Criteria

Compare each modeled daily, monthly or annual WLF with the calculated allowable WLF (factored by percentage of development by proposed project in the contributing basin area). If any of the modeled WLF difference between pre-project and post-project scenarios exceeds the calculated allowable WLF change for the proposed project, it means the proposed project does not comply with Method 1 Wetland Hydroperiod Protection.

For criteria about durations and frequencies, assess individual modeled stage outputs to verify compliance.

1.3.8.3.3.2 Method 2: Site Discharge Modeling

An alternative way to predict the risk to the wetland hydroperiod from stormwater discharges is to assess the changes in total volume of flows into a wetland that result from the development project. The size of the wetland and its capacity are not known or needed to utilize Method 2. The risk to wetland functions will be assumed to increase as the total discharge volumes from the site into the wetland diverge from the pre-project conditions. The risk will be decreased if the divergence is smaller.

As stormwater generated at the project site passes through the wetland buffer, total discharge volumes from the site to the wetland are to be calculated at the outflow of the wetland buffer. The existing or required length and area of wetland buffer per local and/or state regulations around the wetland should be included as an element in the model under both pre-project (existing) and post-project scenarios.

Criteria for Method 2

The project proponent must ensure they are meeting both of the following Method 2 criteria in order to comply with Wetland Hydroperiod Protection.

Criteria 1. Mean Daily Total Discharge Volumes from the Site

Total volume of water into a wetland on daily basis should not be more than 20% higher or lower than the pre-project volumes. Calculate the average of the total discharge volumes from the site for each day over the period of precipitation record in the approved model for pre- and post-

project scenarios. There will be 365 (366 for a leap year) average daily values for the pre-project scenario and 365 (366 for a leap year) for the post-project. No day can exceed 20% change in volume.

Criteria 2. Mean Monthly Total Discharge Volumes from the Site

Total volume of water into a wetland on a monthly basis should not be more than:

- 20% higher or lower than the pre-project volumes for the months of October, November, and December.
- 15% higher or lower than the pre-project volumes for all remaining months (January through September)

Calculate the average of the monthly total discharge volumes from the site for each calendar month over the period of precipitation record in the approved model for pre- and post-project scenarios.

The guidance for implementing Method 2 and assessing the criteria above in the respective model is provided in Wetland Hydroperiod Data Collection and Evaluation Procedure for Method 2.

Summer Months Allowable Exception for Criteria 2:

The exception for summer months (July, August, and September) may be an option for projects that are not able to meet the monthly basis criteria above. To utilize this exception, additional information about the wetland is necessary. It is important to note that this information may not be available, as it goes beyond what is required to complete the standard Method 2 analysis. If that is the case, then the exception will not be an option for the project being analyzed.

If the only months that fail the monthly basis criteria above are July, August, and/or September, then complete the following for the failing month(s):

1. Obtain information about the wetland size consistent with what is described in the Contour Data or Water Storage Capacity section of I-C.5 Wetland Hydroperiod Protection Data Collection, Evaluation Procedures, and Strategies
2. Determine the size of the entire contributing basin to the wetland.
3. Determine the size of the pre-project area that has been contributing to the wetland.
4. Calculate the ratio of the project area to the contributing basin area and multiply by the 15 cm Mean Monthly WLF Limit. The calculated value represents the Mean Monthly WLF limit for the project being analyzed.
5. Using the information about the wetland size and the monthly volume changes for the months that failed criteria 2, calculate the WLF for each specific month.
6. Compare the two values. If the limit is not surpassed by the monthly change, then the month passes. If it does not pass, then the month still fails.
7. Repeat these steps for all months that failed the original criteria 2 analysis.

Wetland Hydroperiod Data Collection and Evaluation Procedure for Method 2

Model Construction and Simulation for Method 2

When modeling, include the wetland buffer downstream of the project area as the final element in both the pre-project and post-project scenarios. In the model, also include any flow control BMPs. The point of compliance (POC) should be assigned to capture the total (surface, interflow, and groundwater) volume leaving the wetland buffer for both the pre-project and the post-project scenarios.

An Ecology approved continuous simulation model using 15-minute timesteps shall be utilized for wetland hydroperiod modeling for the pre-project and post-project simulation as described below.

Pre-project simulation

1. Identify existing impervious and pervious surfaces that discharge to the wetland and use the model elements to represent these land areas. Note: this is meant to be the project area only not the entire area contributing to the wetland.
2. Identify the wetland buffer area and use the lateral flow soil basin to represent the wetland buffer.
3. Connect the model elements to the wetland buffer ensuring that impervious land areas are connected to surface flows and that for any other model elements all flows (surface, interflow, and groundwater) are connected.
4. Set the wetland buffer element as the most downstream element.
5. Set the POC at the outflow of the wetland buffer element including surface runoff, interflow, and groundwater.

Post-project simulation

1. Identify anticipated post-project impervious and pervious surfaces that discharge to the wetland and use the model elements to represent these land areas.
2. Identify any Flow Control BMPs and use the appropriate the model elements to represent these facilities.
3. Identify the wetland buffer area and use the lateral flow soil basin to represent the wetland buffer.
4. Connect the model elements to the wetland buffer ensuring that impervious land areas are connected to surface flows and that for any other model elements all flows (surface, interflow, and groundwater) are connected.
5. Connect any Flow Control BMP elements to the wetland buffer ensuring that surface flows are connected to surface water and any infiltration is connected to groundwater.
6. Set the wetland buffer element as the most downstream element.
7. Set the POC at the outflow of the wetland buffer element including surface runoff, interflow, and groundwater.

Once the model simulations are done for post and pre-project scenarios, verify compliance with the Method 2 Hydroperiod Protection Criteria.

1.3.8.3.3.3 Strategies to meet the Wetland Hydroperiod Protection Criteria

Consider the following strategies to minimize impacts on the wetland hydroperiod and to meet the Wetland Hydroperiod Protection Criteria. The list is in order of preference:

- Increasing the retention of natural pervious cover.
- Reducing the level of development.
- Reducing the total amount of impervious surfaces.
- Increasing infiltration using Onsite Stormwater Management BMPs and site appropriate development principles which include LID principles.
- Increasing or maintaining larger wetland buffer zones.
- Increasing infiltration and/or storage capacity of Flow Control BMPs.

1.3.8.4 Stormwater Treatment and Flow Control Facility Placement

Stormwater treatment and flow control facilities shall not be constructed within a wetland or its buffer unless approved as part of a City of Tacoma Critical Area Verification, Minor Development Permit, and/or Development Permit. If selective runoff bypass is proposed to maintain the hydroperiod, the hydraulic analysis shall consider the impacts of the bypassed flow. Bypassed flow shall comply with Minimum Requirement #6: Stormwater Treatment and Minimum Requirement #7: Flow Control as applicable.

1.3.8.5 Objective

Wetlands are extremely important natural resources which provide multiple stormwater benefits, including groundwater recharge, flood control, and stream channel erosion protection. They are easily impacted by development unless careful planning and management are conducted. Wetlands can be severely degraded by stormwater discharges from urban development due to pollutants in the runoff and also due to disruption of natural hydrologic functioning of the wetland system. Changes in water levels and the frequency and duration of inundations are of particular concern. This requirement ensures wetlands are protected.

1.3.9 Minimum Requirement #9: Operation and Maintenance

An Operation and Maintenance (O&M) Manual shall be provided for all proposed permanent stormwater BMPs at the time construction plans are submitted for review.

The Operation and Maintenance Manual shall be a stand-alone document that includes:

- A narrative description of the proposed stormwater system,
- A description of each permanent stormwater BMP including,:
  - BMP number and name
  - what it does,
  - how it works, and
  - manufacturer information, as applicable.
- A site plan with the locations of all permanent stormwater BMPs clearly marked,
- Detail drawings of the proposed permanent facilities including overall dimensions and locations of inflow, bypass, and discharge,
- The name and phone number for the person(s) responsible for maintenance,
- A description of where the Operation and Maintenance Manual will be kept,
- A description of all maintenance tasks and the frequency of each task for each component of the stormwater system,
  - The maintenance tasks and frequencies must meet the standards provided in Volume 4.
- A sample maintenance activity log indicating emergency and routine actions to be taken for each component of the stormwater system.
- It is recommended to include a cost estimate for maintenance of each component of the stormwater system.

For privately maintained facilities, a copy of the O&M Manual shall be retained onsite or within reasonable access to the site, be made available for review by City staff, and shall be transferred with the property to the new owner.

A covenant and easement agreement is required for all proposed private stormwater facilities to ensure proper maintenance and access. The document shall be recorded on title.

For public facilities, a copy of the O&M manual shall be retained by the appropriate department.

For all facilities (public and private), a log of maintenance activities outlining all inspections and routine or corrective actions completed shall be kept onsite or electronically and be available for inspection by the City.

An applicant does not have to submit an Operation and Maintenance Manual for stormwater BMPs that will be maintained by the City of Tacoma. City of Tacoma staff develop the documents internally and copies are retained internally.

1.3.9.1 Objective

To ensure that stormwater control facilities are adequately maintained and operated properly. Projects are required to plan for and perform appropriate preventative maintenance and performance checks at regular intervals.

1.4 Additional Protective Measure - Infrastructure Protection

1.4.1 Objectives

Additional Protective Measure – Infrastructure Protection Measure – Infrastructure Protection is intended to ensure the existing downstream private and public stormwater systems can handle increases in the amount stormwater that will enter those systems. New stormwater systems shall be designed per Volume 5, Section 3.4 – Full Backwater Analysis.

1.4.2 Thresholds

All projects that increase the amount of stormwater to the existing downstream stormwater conveyance system shall review this section to see if analyses or mitigation are required for the project.

1.4.3 Quantitative Analysis

Projects that impact the downstream system by increasing the amount of stormwater to the downstream private or public stormwater system may be required to complete a quantitative downstream analysis of the downstream system to ensure the system is appropriately sized before a connection to the system will be allowed. The type of analysis required shall be based upon the project impacts as described in Table 1 - 2: Quantitative Analysis Determination below. The City of Tacoma may require different or additional analyses than those represented in Table 1 - 2: Quantitative Analysis Determination based upon project impacts such as conversions from pervious surfaces to hard surfaces, use of underdrained facilities, and/or lined facilities or known issues with the existing stormwater system.

Table 1 - 2: Quantitative Analysis Determination

*Increase in Surface Area and/or Increase in Surface Area Converted from Pervious to Impervious Contributing to Downstream System	Smallest Pipe Size within ¼ mile downstream of the site**	Required Analysis
< 5,000 SF	Any size	None
≥ 5,000 SF and < 10,000 SF	≥ 12" φ	Pipe Analysis not Required. Inlet and Gutter Capacity Analysis required (as applicable).
≥ 5,000 SF and < 10,000 SF	< 12" φ	Single Segment Capacity Analysis and Inlet and Gutter Capacity Analyses (as applicable).
≥ 10,000 SF	≥ 12" φ	Single Segment Capacity Analysis and Inlet and Gutter Capacity Analyses (as applicable).
≥ 10,000 SF	< 12" φ	Full Backwater Analysis and Inlet and Gutter Capacity Analyses.
Any Size	Connecting to a City-owned and identified trunk main	Pipe Analyses Not Required but Inlet and Gutter Capacity Analysis Required if increase in surface area and/or increase in surface area converted from pervious to impervious contributing to downstream system is 5,000 SF or greater and a connection to the curb is made.

* Comparison shall be made between existing land cover conditions and proposed land cover conditions. See Volume 5 for additional information about the required analyses. See Volume 5 for additional information about the required analyses. Inlet and Gutter Capacity Analysis, if required based on impact, is only required for projects proposing through curb discharges.

**The applicant shall determine the smallest pipe 1/4 mile from the discharge location or where the discharge will occur into the downstream system. 1/4 mile is not as the crow flies but as the water flows within the pipe system.

The City of Tacoma may require analysis of the downstream system if discharge occurs from a pumped system to ensure the pump system is not creating any downstream capacity or erosion issues.

1.4.4 Mitigation – Infrastructure Protection

Projects that discharge stormwater directly or indirectly to any of the following may have to provide mitigation for Infrastructure Protection:

The City will issue Executive Directives that define areas with known capacity problems (the second and third bullets below) and associated mitigation criteria. These can be viewed at tacoma.gov/stormwatermanual under Policy Documents.

- To a conveyance system without capacity to convey the fully developed design event as determined through a full backwater quantitative analysis and/or Inlet and Gutter Capacity Analysis, or
- To a capacity problem downstream of the project as determined by the City of Tacoma, or

- To any other problem, such as downstream stabilization issues, as determined by the City of Tacoma.

The City will issue Executive Directives that define areas with known capacity problems and associated mitigation criteria. These can be viewed at www.tacoma.gov/stormwatermanual under Policy Documents.

The type of mitigation is dependent upon the City of Tacoma review of the project impacts. Mitigation may include upsizing the existing stormwater conveyance system, installing additional catch basins, onsite stormwater detention or other mitigation measures as determined appropriate by the City of Tacoma.

1.4.5 Objective

To identify and evaluate offsite water quantity, erosion, slope stability, and impacts to receiving waterbodies that may be caused or aggravated by a proposed project, and to determine measures for preventing impacts and for not aggravating existing issues.

1.5 Exceptions, Adjustments, and Modifications

1.5.1 Exceptions to the Minimum Requirements

Exceptions to the Minimum Requirements may be requested, in writing, in accordance with TMC 12.08D.160. Public notice of application for an exception, decision and written findings that document the determination to grant an exception will be published in accordance with TMC 12.08D.160.

Exceptions must meet the following criteria:

- Application of the Minimum Requirement(s) would impose a severe and unexpected economic hardship; and
- The exception will not increase risk to the public health and welfare, nor be injurious to other properties in the vicinity and/or downstream, and to the quality of waters of the state; and
- The exception is the least possible exception that could be granted to comply with the intent of the Minimum Requirements.

Applications for an exception from the Minimum Requirements of TMC 12.08D.160 must be made in writing and include the following information:

- The current (pre-project) use of the site; and
- How application of the Minimum Requirement(s) restricts the proposed use of the site compared to the restrictions that existed prior to the adoption of the Minimum Requirements; and
- The possible remaining uses of the site if the exception were not granted; and
- The uses of the site that would have been allowed prior to the adoption of the Minimum Requirements; and
- A comparison of the estimated amount and percentage of value loss as a result of the Minimum Requirements versus the estimated amount and percentage of value loss as a result of requirements that existed prior to adoption of the Minimum Requirements; and
- The feasibility for the owner to alter the project to apply the Minimum Requirements.

The decision to grant an exception is within the sole discretion of the City of Tacoma, and an exception will only be approved to the extent it is necessary. New or additional requirements may be imposed on the project to offset or mitigate harm that may be caused by approving the exception. The applicant may be required to submit a report, plans, and/or analysis prepared by a Washington State Licensed Professional Engineer along with the request. The Washington State Department of Transportation Highway Runoff Manual, Chapter 2, Appendix A, presents methods that may be useful for evaluating economic hardship and human health criteria. The approval of an exception shall not be construed to be an approval of any violation of any other provisions of the City's Municipal Code, or of any other valid law of any governmental entity having jurisdiction.

1.5.2 Adjustments to Minimum Requirements

Adjustments to the Minimum Requirements may be requested, in writing, to allow a reduction or modification of a requirement or to permit an alternative requirement. The applicant shall submit all requests to the City of Tacoma. Request for Adjustment shall be included within the Stormwater Site Plan and shall include documentation (including referencing the two bullets below) that outlines how:

- The adjustment provides substantially equivalent environmental protection; and
- Based on Sound Engineering Practices, the objectives of safety, function, environmental protection and facility maintenance are met.

Adjustments may be used to alter the performance standards of one or more Minimum Requirements. Adjustments may not be used to alter the design criteria of the BMPs used to comply with the MRs. If a project proponent wants to alter the design criteria of a BMPs, they must use the Demonstrative Approach.

The decision to grant an adjustment is within the sole discretion of the City of Tacoma and an adjustment will only be approved to the extent it is necessary. New or additional requirements may be imposed on the project to offset or mitigate harm that may be caused by approving the adjustment. The applicant may be required to submit a report, plans, and/or analysis prepared by a Washington State Licensed Professional Engineer along with the request. The approval of an adjustment shall not be construed to be an approval of any violation of any other provisions of the City's Municipal Code, or of any other valid law of any governmental entity having jurisdiction.

1.5.3 Modifications

Modifications to design standards and other requirements in this manual may be requested in writing to the City of Tacoma. Requests for modifications shall be made within the Stormwater Site Plan. The modification request must describe why the requirement in the manual cannot be met and why it will not likely affect downstream properties, stormwater system function and operation, the quality of waters of the state, the facility function, and the health and welfare of the public.

Modifications that alter a Minimum Requirement must be made under the Adjustment or Exception process.

The City of Tacoma reserves the right to make the final determination of whether to approve or deny the modification and inform the applicant.

Chapter 2 Underground Injection Control (UIC) Guidelines

2.1 Introduction to UIC Wells

Underground Injection Control (UIC) wells are structures built to discharge fluids from the ground surface into the subsurface.

A UIC is one of the following:

1. A bored, drilled or driven shaft, or dug hole whose depth is greater than the largest surface dimension;
2. An improved sinkhole (a naturally occurring karst depression or natural crevice that has been modified for the purpose of directing fluids to the subsurface); or
3. A subsurface fluid distribution system (an assemblage of perforated pipes, drain holes, or other similar mechanisms intended to distribute fluids below the surface of the ground

Any of the following may be considered UIC Wells depending on the depth and means of distributing water:

- BMP L602 – Downspout Full Infiltration
- BMP L604 – Perforated Stub-Out Connections
- BMP 720 – Infiltration Trenches
- BMP 730 – Drywells
- BMP 740 – Infiltration Swales
- BMP L630 – Bioretention
- Commercially Manufactured Infiltration Devices (ex. Stormtech Chambers)
- Drain Fields
- French Drains

The Underground Injection Control (UIC) program is administered by the Washington State Department of Ecology. See https://ecology.wa.gov/regulations-permits/guidance-technical-assistance/underground-injection-control-program for additional information. If the well is located on tribal land, the program is administered by the Environmental Protection Agency, Region 10 – see https://www.epa.gov/uic/underground-injection-control-region-10-ak-id-or-and-wa for information on the EPA process. See the 2024 Washington State Department of Ecology Stormwater Management Manual for Western Washington - Volume 1, Chapter 4 - UIC Program Guidelines for additional information.

Because UICs are often used to manage stormwater, guidance for UIC is included within the SWMM. City staff will review infiltration facilities for compliance with the SWMM while also referring to the UIC guidelines. Applicants shall utilize the specific design criteria within each BMP in addition to guidance within this chapter when proposing UIC wells. Where design criteria conflict, the stricter design criteria shall govern. The City has attempted to include items specific to UIC wells within each BMP that could be considered a UIC but ultimately, it is up the applicant to ensure all requirements are met.

The Washington State Department of Ecology (Ecology) requires certain UIC wells, including both new and existing wells that are not already registered, to be registered and will also review the wells as part of their process which requires wells to be either rule-authorized or covered by a state waste discharge permit. See https://ecology.wa.gov/regulations-permits/guidance-technical-assistance/underground-injection-control-program for more information on the registration process. Note, this process is separate from the City of Tacoma process.

The City will require proof of UIC registration (email stating UIC is registered from Ecology) or proof from Ecology that the UIC will be allowed (an email from Ecology UIC coordinator is sufficient) before City of Tacoma permit approval when UIC wells are proposed. The City attempts to not approve Permits containing items that may otherwise not be approved by other agencies.

2.2 Meeting the Nonendangerment Standard

Ecology, as part of their process, determines if a new UIC well is either rule-authorized or needs a state waste discharge permit based on whether the UIC well meets the nonendangerment standard. Applicants may use either the Presumptive Approach for UIC Wells or the Demonstrative Approach for UIC Wells to meet the nonendangerment standards. Those wells that cannot meet the nonendagerement standard will not be allowed to be installed.

As part of the Ecology process, existing UIC Wells must complete a UIC well assessment to determine if they meet the nonendangerment standard. If they do not meet the nonendangerment standard, they must be decommissioned or retrofitted to meet the nonendangerment standard. See the 2024 Washington State Department of Ecology Stormwater Management Manual for Western Washington - Volume 1, Chapter 4 - UIC Program Guidelines for additional information.

2.3 The Presumptive Approach for UIC Wells

The presumptive approach is met by the use of source control BMPs, treatment BMPs (see Section 2.10 – Determining Stormwater Treatment Requirements for UIC Wells below), site suitability criteria (see criteria within each BMP in addition to Section 2.5 – Siting and Design of New UIC Wells below), and design standards within this SWMM.

2.4 The Demonstrative Approach for UIC Well

The demonstrative approach must show, with UIC well-specific emphasis, how the proposed Stormwater Treatment BMPs will be protective of the groundwater quality and meet the nonendangerment standard. The UIC registration application submittal plans, technical reports, maps and diagrams, and analysis narratives must be sufficiently detailed to validate how the selected BMPs will currently, and into the future, provide for groundwater protection and help the UIC well comply with the nonendangerment standard (WAC 173-218-080).

New UIC wells must meet the demonstrative approach to meet the nonendangerment standard if the presumptive approach is not completely followed, or if for any reason a project proponent chooses not to directly apply all of the requirements of this manual (or an equivalent manual).

The documentation for the demonstrative approach is a site-specific analysis that demonstrates that the proposed discharge will comply with groundwater quality standards.

To be eligible for rule-authorization using the demonstrative approach, the following topic areas must be addressed and documented with the UIC well registration:

- Site-specific analysis of pollutant loading, including a risk assessment of downgradient and adjacent drinking water sources
- Site-specific analysis of the treatment capacity of the vadose zone, if used for treatment
- BMP selection process used
- Pollutant removal expected from the selected BMPs
- Technical basis supporting the performance claims for the selected BMPs
- Assessment of how the selected BMPs will comply with state groundwater quality standards and satisfy state all known, available, and reasonable methods of prevention, control, and treatment (AKART) requirements

2.5 Siting and Design of New UIC Wells

2.5.1 Siting Requirements for Rule-Authorization of New UIC Wells

In addition to complying with the Site Suitability Criteria contained in Volume 4, Chapter 3, Section 3.1 and Depth to Bedrock, Water Table, or Impermeable Layer in Volume 4, Chapter 10, Section 10.1.4.1.4 the following apply to all UIC Wells.

2.5.1.1 Restrictions on Siting IC Wells

- Prohibited areas: UIC wells may not receive stormwater from the following activities and conditions. See WAC 173-218-040(5)(b) for list of other prohibited UIC wells.
  - Vehicle maintenance, repair, and service
  - Commercial or fleet vehicle washing
  - Airport/airplane deicing
  - Storage of treated lumber
  - Storage or handling of hazardous materials
  - Generation, storage, transfer, treatment, or disposal of hazardous wastes
  - Handling of radioactive materials
  - Solid waste handling facilities, including compost and biosolid facilities, except for those that recycle only glass, paper, plastic, or cardboard
  - Concrete recycling facilities that generate, store, or handle crushed concrete
  - Asphalt recycling facilities that generate, store, or handle crushed asphalt
  - Fire fighting training facilities
  - Industrial areas where mechanical maintenance activities occur
  - Industrial or commercial areas that have outdoor processing, handling, or storage of raw solid materials or finished products unless the facility has specific management plans for proper storage and spill prevention, control, and containment appropriate to the types of materials handled at the facility (see Volume 6 for information on stormwater pollution prevention plans and source control)
  - Contaminated sites when the stormwater would increase the mobility of the contaminants at the site. For example, a drywell could not be used upgradient of or

over the contaminant plume at a leaking underground storage tank site. The stormwater could increase the movement of the contaminants.

- Process water from the production area of an animal feeding operation.
- Land use, activity, or infiltration determined to be a significant contributor of pollutants to waters of the State or a site release of hazardous substances from historical or current activities resulting in contamination of soil, groundwater, surface water, if the groundwater is in direct communication with surface water, or sediment, which is prohibited under the Model Toxics Control Act (Chapter 173-340 WAC) and Sediment Management Standards (Chapter 173-204 WAC).

Because of the potential to contaminate groundwater, a UIC well must be individually authorized under a waste discharge permit to receive stormwater from any areas subject to the activities listed above. Ecology does not consider conventional stormwater treatment to be protective of groundwater in these situations. Stormwater from areas subject to the activities listed above must be handled on-site with a closed-loop system or discharged to the sanitary sewer, if allowed by the local jurisdiction.

Stormwater from portions of a site that do not come into contact with the prohibited activities are allowed to discharge to the UIC well following the presumptive approach.

Soil contamination: Owners/operators may not site UIC wells where there are soil contaminants that could be transported to groundwater unless the site soil and groundwater is remediated and has been documented to comply with applicable state and federal cleanup standards prior to construction.

2.5.1.2 Siting UIC Wells Near Drinking Water Wells

Because a UIC well could be a potential source of contamination, it must be sited ≥ 100 feet from a drinking water well, outside of the sanitary control area of a public drinking water system, and ≥ 200 feet from a spring used for drinking water supplies. The design must consider the distance between the UIC well and a drinking water well based on the direction and rate of groundwater flow, and the vulnerability of the drinking water supply well to potential contamination, which is influenced by the following documented factors:

- Depth/distance from the bottom of the UIC well to the drinking water well screened interval(s), and
- Presence or lack of confining layer(s) between the bottom of the UIC well and the aquifer interval(s) used as the water supply, and
- Characteristics of the geologic material between the bottom of the UIC well and the aquifer.

2.5.1.3 Groundwater Protection Areas

At a minimum, basic treatment to remove solids prior to discharge to the UIC well is required for UIC wells located:

- In a wellhead protection area where the drinking water well is categorized with a high-susceptibility rating by the Washington State Department of Health, and/or
- Where a confining layer is not present between the base of the UIC well and the top of the aquifer used as a drinking water source, except when a UIC well receives insignificant and or low pollutant load from stormwater (see Table 1-6: Pollutant Loading Classifications for Solids, Metals, and Oil in Stormwater Runoff Directed to UIC Wells).

Requirements of the South Tacoma Groundwater Protection District apply to all UIC wells located within the South Tacoma Groundwater Protection District. To locate the wellhead protection areas and the associated water districts in each county, see the Washington State Department of Health (DOH) Source Water Assessment Program maps at the following web address: https://fortress.wa.gov/doh/swap/Design and Construction Requirements for Rule Authorization of New UIC Wells

2.5.2 Design and Construction Requirements for Rule-Authorization of New UIC Wells

In order to be rule-authorized under the presumptive approach, UIC wells must be designed and installed in accordance with this manual or an equivalent manual adopted at the time of construction. The following subsections include additional requirements for design and construction of UIC wells.

2.5.2.1 Prevention of Clogging During Construction

In order to prevent clogging, UIC wells must be protected from sediment in runoff generated during construction. See Volume 3 for construction BMPs to prevent other pollutants from entering the UIC well during the construction phase of a project.

2.5.2.2 Stormwater Infiltration Rate/Drawdown Time

In most cases, UIC wells are designed to completely drain ponded runoff within 48 to 72 hours after flow to the UIC well has stopped. If the UIC well is designed to meet a stormwater treatment requirement, the design infiltration rate must be sufficient to accommodate the water quality design flow rate.

2.5.2.3 Vertical Separation for Rule-Authorization Using the Presumptive Approach

WAC 173-218-090 requires that new Class V UIC wells used for stormwater management must not directly discharge into groundwater. A 5-foot separation between the bottom of the well and the top of the groundwater is required, unless a demonstrative approach confirms that a separation of 3 feet will meet the nonendangerment standard.

The required depth to groundwater/vertical separation between the base of the UIC well and the top of the groundwater table for rule-authorization using the presumptive approach depends on the treatment capacity of the unsaturated zone. Section 2.10 Determining Stormwater Treatment Requirements for UIC Wells below and Section 2.11 Classification of Vadose Zone Treatment Capacity for UIC Wells below provide a method for determining the treatment requirements based on the treatment capacity of the vadose zone and the pollutant loading classification of the stormwater runoff directed to the UIC wells.

The minimum vertical separation is 5 feet between the base of a UIC well and the highest elevation between the seasonal high groundwater table, bedrock, hardpan, or other low-permeability layer.

Vertical Separation When 5-Foot Minimum Separation Cannot Be Met

If the vertical separation required for the presumptive approach cannot be met:

- Rule-authorization can be obtained using the demonstrative approach (see Section 2.4 The Demonstrative Approach for UIC Wells above), or
- A reduction in separation to as little as 3 feet can be considered under the presumptive approach provided:

- The treatment requirements are otherwise met (see Section 2.10 Determining Stormwater Treatment Requirements for UIC Wells below and Section 2.11 Classification of Vadose Zone Treatment Capacity for UIC Wells below), and:
- The groundwater mounding analysis, the volumetric water holding capacity of the zone receiving the water, and the design of the overflow and/or bypass structures are evaluated by the design professional and deemed adequate to prevent overtopping and to meet the site suitability criteria specified in this section.

2.6 Operation and Maintenance of UIC Wells

The UIC rule requires that wells are operated and maintained to protect groundwater quality. Maintenance of UIC wells prevents clogging and contamination from materials that collect in the well over time. The following required preventive maintenance activities will help maintain UIC function:

- Treatment for solids removal or a catch basin with a down-turned elbow upstream of discharge to the UIC well to promote the long-term infiltration capacity and reduce the need for maintaining the UIC wells, as well as reduce the long-term accumulation of contaminants in the vadose zone
- Frequent inspections and regular maintenance to improve the long-term performance of UIC wells
- Periodic removal of debris and sediment from the drywell to reduce or eliminate the buildup of materials that could inhibit infiltration
- Checking for structural damage and repair as needed

See Volume 4 – Appendix C: Operation and Maintenance for recommended maintenance criteria and inspection frequencies.

2.7 Source Control and Stormwater Treatment Requirements for UIC Wells

The UIC rule bases source control and stormwater treatment requirements on the types and quantities of pollutants expected from the proposed land use contributing stormwater to the UIC well.

The rule presumes a UIC well meets the nonendangerment standard and is rule-authorized if the designer follows the guidelines in this section based on the following:

- Application of source control BMPs to control loading of pollutants that are difficult to remove from stormwater by filtration, settlement, or other treatment technologies, and
- Appropriate treatment of stormwater to remove pollutants, which may be achieved by either or both:
  - Application of treatment to remove pollutants before discharging stormwater into the UIC well
  - Availability of appropriate vadose zone treatment capacity to remove the solid phase of pollutants in stormwater by filtration and adsorption (see Section 2.10 Determining Stormwater Treatment Requirements for UIC Wells below and Section 2.11 Classification of Vadose Zone Treatment Capacity for UIC Wells below)

2.7.1 Source Control

Source control is necessary to protect groundwater from pathogens, pesticides, nitrates, road salts and other anti-icing and deicing chemicals, fuel additives, and many other pollutants in urban runoff, as well as accidental spills.

The operational and structural source control BMPs that are also required to meet the nonendangerment standard for various land uses are described in Volume 6. Targeted education and outreach may also be a necessary source control measure.

Source control BMPs can significantly reduce clogging and pollutants, especially solids, and must be used at all project sites. Protect UIC wells during the construction phase to prevent sediment from entering the UIC well. Implement the BMPs in Volume 3. Where there are no existing stormwater treatment BMPs to practically address a pollutant issue and where filtration by the vadose zone cannot provide adequate removal of pollutants, owners are required to use source control BMPs to meet the nonendangerment standard. Otherwise, the discharge to the UIC well is prohibited (WAC 173-218-090(1)(c)(i)(D)). See Section 2.5 – Siting and Design of New UIC Wells above for prohibited discharges.

Wherever practicable, reduce the exposure of stormwater to these contaminants by one or more of the following:

- Careful attention to the product label application rates
- Targeted product use to avoid contamination of stormwater
- Careful management of the storage and use of products
- Separation of areas where products are used from contributing areas that discharges to a UIC well
- Spill response planning

2.7.2 Stormwater Treatment

The BMPs chosen for the site must remove or reduce the target pollutants to levels that will comply with State groundwater quality standards when the discharge reaches the groundwater table or first comes into contact with an aquifer (see Chapter 173-200 WAC). Each BMP is designed to reduce or eliminate certain pollutants. See other sections in Volume 5 for specific Stormwater Treatment BMP design criteria.

Removing solids from stormwater runoff before it is discharged to a UIC well helps preserve infiltration rates over the long term. UIC wells used for flow control are required to have solids removed prior to discharge. Treatment for solids removal must be designed, constructed, operated and maintained in accordance with this manual or an equivalent manual.

Designers may alternatively use the demonstrative approach (Section 2.4 – The Demonstrative Approach above) should they wish to install a BMP that is not included in this manual.

Some pollutants may require additional treatment beyond that provided by the approved BMPs described in other sections in Volume 5. The text below discusses these pollutants.

Bacteria

Fecal coliform bacteria and other pathogens in stormwater come from many sources. Examples are manure fertilizers, pet waste, and animal feeding operations.

Stormwater treatment BMPs are unreliable in removing fecal coliform bacteria and other pathogens from runoff. Because of this, UIC wells shall not receive direct stormwater discharges

from areas or sites that generate high loadings of fecal coliform bacteria, such as animal feeding operations.

Alternatively, runoff from sites generating high loadings of bacteria and pathogens may be:

- Discharged to the sanitary sewer, if allowed by the local jurisdiction; or
- Used for crop irrigation, as long as other applicable requirements are met; or
- Directed to a bioretention or biofiltration BMP after the nutrient loading is addressed; or
- Diverted through stormwater treatment wetlands (BMP T1130: Stormwater Treatment Wetlands) prior to discharge to a UIC well.

Municipal UIC well owners must implement appropriate source control, targeted education and outreach, and illicit discharge detection and elimination programs in areas served by their UIC wells to prevent pet wastes from contaminating stormwater and to control other sources of pathogens.

UIC wells in the vicinity of land application areas (i.e., along adjacent roadways) must be protected by appropriate buffers and berms to prevent manure-contaminated runoff from entering the UIC well. Best practices for setbacks, nutrient loading, and timing of application must also be implemented.

Private UIC well owners must ensure that their UIC wells are appropriately protected from sources of bacterial contamination.

Soluble Pollutants, Pesticides, Fertilizer, and Nutrients

Many soluble pollutants that are commonly found in stormwater (including pesticides, fertilizers, road salts, and other chemical pollutants) are very difficult to remove from stormwater. Source controls applicable to the land use and activities at the site are required to reduce the contamination of stormwater from these chemicals.

Areas such as parks, playgrounds, golf courses, public ball fields, cemeteries, and urban landscape typically use pesticides and fertilizers for landscape management. Examples of other activities that generate high nutrient loads include commercial composting, commercial animal handling areas, nurseries, and land application areas.

Pesticides include a host of chemicals with varying chemical fate and transport characteristics. Some pesticides travel to groundwater more readily because they are more water soluble and less likely to “stick” or sorb to soil particles. These pesticides need treatment by a biological treatment method, such as a biofiltration swale or constructed wetland. UIC wells that receive stormwater with pesticides that use one of these biological treatment methods are rule-authorized when they are registered, providing this technical guidance is followed.

If UIC owners wish to use a different treatment method for pesticides, they may apply to the department for rule-authorization using the demonstrative approach outlined in Section 2.4 – The Demonstrative Approach above. Nonbiological treatment systems are ineffective at removing these pollutants from stormwater. Instead, stormwater from these types of landscaped areas should be directed to bioretention, biofiltration, or constructed wetland BMPs prior to discharge to UIC wells. Stormwater with fertilizer or nutrients may be used to irrigate crops and/or landscaped areas in accordance with other applicable requirements.

Ecology encourages use of the following practices:

- Limited use of applied chemicals

- Site design to minimize runoff from the landscaped surface
- Development of a pesticide management plan

UIC wells in the vicinity of land application areas (i.e. along adjacent roadways) must be protected by appropriate buffers and berms to prevent manure-contaminated runoff from entering the UIC well. Best practices for setbacks, nutrient loading, and timing of application must also be implemented.

Industrial Activities with Requirements to Monitor for Nitrate, Nitrite, Ammonia, or Phosphorus

The U.S. EPA lists industrial activities that have monitoring requirements for nitrate, nitrite, ammonia, or phosphorus. Sites where nitrate, nitrite, ammonia, or phosphorus come into contact with stormwater must be directed to one of the following:

- Bioretention or biofiltration BMPs
- Constructed wetlands prior to discharge
- Wastewater system, only as allowed by Environmental Services

Facilities may complete a no exposure certification as part of Ecology's UIC well registration process for exemption from these requirements. In order to qualify, no outdoor processing, handling, or storage of raw solid materials or finished products may take place at the facility. Industrial facilities that qualify for no-exposure certification may use the tables in Section 2.11 Classification of Vadose Zone Treatment Capacity for UIC Wells below to determine treatment requirements.

Commercial Site Roofs With Ventilation for Commercial Indoor Pollutants

Roof runoff from commercial businesses with ventilation systems specifically designed to remove commercial indoor pollutants must be evaluated on a case-by-case basis to identify the pollutants of concern and the appropriate treatment requirements.

In general, this runoff may be classified as a "medium" pollutant loading source (see Section 2.11 Classification of Vadose Zone Treatment Capacity for UIC Wells below), and the requirements of this section may be applied to discharges from these areas to UIC wells.

Commercial Site Outdoor Handling or Storage

Treatment for solids removal (basic treatment) is required at commercial sites with outdoor handling or storage of raw solid materials. Examples include gravel, sands, logs, salts, and compost.

Industrial Site Roofs

Roof runoff from industrial facilities must be evaluated on a case-by-case basis and should be treated according to the other Best Management Practice requirements for the facility.

Industrial Sites Outdoor Handling or Storage

Owners at industrial sites where outdoor processing, handling, or storage of raw solid materials or finished products, including outdoor loading areas for these materials or products, takes place must provide solids removal (basic treatment). These are sites defined by the U.S. EPA (40 CFR 122.26(b)(14)).

2.8 Spill and Illicit Discharges to UIC Wells

Appropriate spill control, prevention, and response measures for various land uses are described in Volume 6. The spill control requirements in Volume 6 apply to all stormwater discharges to UIC wells. Any spills that pose a threat to groundwater quality should be reported to Ecology. Petroleum spills that enter a UIC well must be reported to Ecology. Report a spill immediately to both:

- 1-800-258-5990 (Washington Emergency Management Division)
- 1-800-424-8802 (National Response Center)

There are no penalties for reporting a spill unnecessarily. but there may be significant penalties for not reporting one.

2.9 Deep UIC Wells

2.9.1 General Guidance for Deep UIC Wells

UIC wells that extend below an upper confining layer and discharge into the underlying vadose zone are designated by Ecology as deep UIC wells. This includes drywells where drilling extends through a surficial till layer into the vadose zone below.

Ecology recommends that project proponents explore alternative approaches to stormwater management before deciding to use a deep UIC well. Projects using deep UIC wells must provide the following:

- A hydrogeologic study, performed by a Washington State Licensed Hydrogeologist, that details the following, to determine if contamination could occur:
  - Consideration of potential changes to the aquifer.
  - Infiltration testing to determine mounding affects.
  - Identification of the direction and rate of groundwater flow.
  - Evaluation of the treatment capacity of the vadose zone (see Section 2.10 Determining Stormwater Treatment Requirements for UIC Wells and Section 2.11 Classification of Vadose Zone Treatment Capacity for UIC Wells below).
  - Determination as to whether the proposed deep UIC well is located within a groundwater protection area (GWPA) such as a wellhead protection area.
  - If a deep UIC well is located within a GWPA, assessment of the vulnerability of the drinking water supply source as follows:
    - Evaluate whether the introduction of stormwater will affect the quality of the groundwater at the water supply well.
    - Describe the following hydrogeologic factors that may influence the vulnerability of a groundwater supply source:

      •Depth of the drinking water well screened interval in relation to the deep UIC well infiltration depth, and

      •Presence or lack of a confining layer between the land surface and the aquifer interval, and

•Type of material between the land surface and the aquifer, and between the bottom of the deep UIC well and the aquifer.

- Documentation of notification and summary of discussion with downgradient and adjacent drinking water well owners
- An operation and maintenance manual for the deep UIC wells and treatment structures that includes a schedule for their implementation.
- A list of source control BMPs that will be implemented to minimize solids entering the deep UIC well.
- Description of any additional special stormwater treatment needs and site operation requirements.
- A minimum of basic treatment for all discharges to drywells to remove suspended sediments, and to prevent sediment entering the well structure and vadose zone.
- A minimum 15-foot separation between the base of the drywell and the surface of the seasonal high groundwater table.
- Stabilization of the site prior to the drywells going on-line to prevent sediment entering the drywells.
- A landscape management plan.
- Sealing of any impermeable layers that are penetrated during drilling, to prevent aquifer interconnection if a perched aquifer or other saturated stratum is penetrated.
- A surface seal for final completion of a deep drywell

Ecology recommends hiring a Washington licensed well driller for construction of deep UICs. However, most UIC wells are not regulated by the Well Construction Act.

2.9.2 Deep UIC Wells within Sensitive Groundwater Areas

Groundwater protection areas are by or close by a surrounding community and non-transient noncommunity water system, that uses groundwater as a source of drinking water (40 C.F.R. 144.87) and other sensitive groundwater areas critical to protecting underground sources of drinking water from contamination; such as sole source aquifers, highly productive aquifers supplying private wells, critical aquifer recharge areas and/or other state and local areas determined by state and local governments. Deep UIC wells that extend below an upper confining layer and discharge into the underlying vadose zone may require greater protection from potential pollution sources considered to be a high threat to groundwater (WAC 173-218-030) due to the absence of a confining layer between the UIC well and drinking water supplies.

2.9.3 Requirements for Deep UIC Wells in Wellhead Protection Areas

Within wellhead protection areas (WHPAs), enhanced measures and procedures are necessary to protect groundwater supplies by limiting or prohibiting certain activities. Each WHPA is divided into wellhead protection zones (WHPZs) which may be characterized as a minimum distance or as a groundwater time of travel (TOT).

Prior to submitting an application to Ecology, the proponent for deep UIC well(s) must notify downgradient and adjacent drinking water well owner(s), water purveyor(s), and water district(s) (Owners) of the proposal to install a deep UIC well within the drinking water WHPA. The notification must include the proposed well depth, land use information, and any proposed treatment of the fluids to the UIC well. Documentation of notification and a summary of

discussion between the proponent and the Owner(s) must be included in the application for review by Ecology. UIC applications for deep UIC wells are not considered complete until such notification and summary are submitted.

2.9.4 Deep UIC Well Rule Authorizations Within WHPZs

Table 1-3: Prohibitions and Additional Conditions for Facilities and Activities Within the Area(s) Draining to a Deep UIC Well below describes where deep UIC wells are prohibited or where additional conditions are required for rule-authorization. Depending on which WHPZ the facility or activity is located in, some UIC wells may be prohibited or may be required to meet one or more additional conditions (a, b, c, d, and e, as listed in the table).

In addition to the facilities and activities listed in Table 1-3: Prohibitions and Additional Conditions for Facilities and Activities Within the Area(s) Draining to a Deep UIC Well below, other land use, activity, or infiltration determined to be a significant contributor to pollution may also be prohibited or require further conditions for rule-authorization.

2.9.4.1 Sanitary Control Areas

All UIC wells, including deep UIC wells, are prohibited within the sanitary control area (100 feet from the wellhead). These areas are vulnerable to spills and other human activities and are critical to the protection and quality of drinking water wells and the groundwater within this WHPZ. Therefore, the most effective protective measure is a moratorium on stormwater injection activities within this zone.

2.9.4.2 Six-Month Time of Travel WHPZ

Within the six-month TOT WHPZs, only stormwater from residential roofs are appropriate for non-restricted stormwater discharge to the subsurface. In some circumstances, Ecology may consider conditionally approved discharges to deep UIC wells for parks and some commercial roofs.

2.9.4.3 One-Year Time of Travel WHPZ

Allowed activities in the area that drains to a deep UIC well located within the one-year TOT WHPZ include those allowed in the six-month TOT WHPZ in addition to conditionally-approved residential driveways and small light-use parking lots.

2.9.4.4 Five-Year Time of Travel WHPZ

The five-year TOT WHPZ, with its larger volume and potential for longer residency times, can provide greater treatment opportunities for stormwater moving through soils. These natural treatment conditions, in conjunction with enhanced filtration technologies, provide greater treatment efficiencies for a wider variety of stormwater disposal activities. In addition to all the allowed activities identified in the six-month TOT WHPZ, UIC registrations for commercial roofs susceptible to industrial emissions may be considered for conditional rule-authorization.

2.9.4.5 Ten-Year Time of Travel WHPZ

Within the ten-year TOT WHPZ, all allowed activities in the five-year TOT WHPZ may be rule-authorized. Additionally, commercial roof runoff and residential driveways may be rule authorized through the presumptive approach without conditional approval. Stormwater injections from parking lots that meet the definition of "high-use site" may be considered in the WHPZ when they are conditionally rule-authorized. Stormwater from non-commercial airports, automobile refueling stations, and industrial roof runoff may be conditionally rule-authorized when paired with an individual state waste discharge permit.

Table 1 - 3: Prohibitions and Additional Conditions for Facilities and Activities Within the Area(s) Draining to a Deep UIC Well

Type of Activity Draining to the Deep UIC Well	UIC well location within 100 feet	UIC well location within 6-month time of travel	UIC well location within 1-year time of travel	UIC well location within 5-year time of travel	UIC well location within 10-year time of travel
Multi-unit residential roof runoff	Prohibited	a	a	a	a
Commercial/ Municipal roof runoff (no emissions)	Prohibited	a, b	a, b, d	a, b, d	a, b, d
Commercial/ Municipal roof runoff (with emissions)	Prohibited	Prohibited	Prohibited	a, b, c, d	a, b, c, d
Residential driveways	Prohibited	Prohibited	a, b	a, b	a, b
Vegetated areas (parks, school fields, etc.)	Prohibited	a, b, c, d	a, b, c, d	a, b, c, d	a, b, c, d
Parking lots	Prohibited	Prohibited	a, b, c, d	a, b, c, d	a, b, c, d
Parking lots that meet the definition of "high-use site"	Prohibited	Prohibited	Prohibited	Prohibited	a, b, c, d
Non-commercial airports (FBO - On fuel pad only-No mobile fueling)	Prohibited	Prohibited	Prohibited	Prohibited	a, b, c, d, e

Type of Activity Draining to the Deep UIC Well	UIC well location within 100 feet	UIC well location within 6-month time of travel	UIC well location within 1-year time of travel	UIC well location within 5-year time of travel	UIC well location within 10-year time of travel
Automotive refueling stations (only stormwater separated from fuel pad)	Prohibited	Prohibited	Prohibited	Prohibited	a, b, c, d, e
Industrial roof runoff	Prohibited	Prohibited	Prohibited	Prohibited	a, b, c, d, e
Fire fighting training facilities	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited
Train terminals and train yards	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited
Recycling facilities	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited
Treated Lumber Manufacturing Facilities	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited
Fuel refinery	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited
Fuel depot	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited
Vehicle maintenance, repair and service	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited
Commercial or fleet vehicle washing	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited
Airport de-icing activities	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited
Storage of treated lumber	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited

Type of Activity Draining to the Deep UIC Well	UIC well location within 100 feet	UIC well location within 6-month time of travel	UIC well location within 1-year time of travel	UIC well location within 5-year time of travel	UIC well location within 10-year time of travel
Storage or handling of hazardous materials	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited
Generation, storage, transfer, treatment, disposal of hazardous wastes	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited
Handling of radioactive materials	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited
Solid waste handling facilities	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited
Concrete recycling facilities	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited
Asphalt recycling facilities	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited
Contaminated sites	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited
Concentrated Animal Feeding Operation (CAFO)	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited

Type of Activity Draining to the Deep UIC Well	UIC well location within 100 feet	UIC well location within 6-month time of travel	UIC well location within 1-year time of travel	UIC well location within 5-year time of travel	UIC well location within 10-year time of travel
Notes: a. Hydrogeologic Study b. Site-specific analysis that demonstrates the proposed discharge will comply with groundwater quality standards c. Stormwater Pollution Prevention Plan d. Integrated landscape management plan e. Must apply for, and be issued, a state waste discharge permit					

2.10 Determining Stormwater Treatment Requirements for UIC Wells

For all stormwater discharges to UIC wells, some form of treatment is required. Treatment may be provided by the vadose zone or by structural treatment BMPs, and depends on the geologic conditions, the land use, and activities at the project site.

The tables in Section 2.11 – Classification of Vadose Zone Treatment Capacity for UIC Wells identify Ecology's presumption about the extent to which the vadose zone provides sufficient treatment for a given pollutant loading classification and whether additional treatment is necessary to meet the groundwater quality standards for these pollutants.

Depending on conditions, treatment may be as simple as a catch basin with a downturned elbow, or as complex as an oil and water separator followed by basic and/or metals removal. See Table 1-7: Treatment Type Required for UIC Wells Based on Pollutant Loading Classification and Vadose Zone Treatment Layer Capacity for treatment requirements as a function of pollutant loading classification and vadose zone treatment capacity.

2.10.1 Exceptions Based on Site-Specific or Local Studies

Exceptions to the tables in Section 2.11 - Classification of Vadose Zone Treatment Capacity for UIC Wells may be made under any of the following circumstances:

- More detailed site-specific data are gathered by the project proponent and project is approved by the City.
- The required thicknesses of the vadose zone treatment layer listed in Table 1-5: Vadose Zone Treatment Capacity may be as little as 3 feet for a high-capacity treatment matrix and 6 feet for a medium-capacity treatment matrix when all of the following requirements are met:
  - The UIC well is regulated under a local stormwater management program that satisfies the requirements in Section 2.2 - Meeting the Nonendangerment Standard, and the City approves the change in minimum thicknesses.
  - The pollutant loadings are insignificant or low.

- Reliable on-site information is available. Designers may use borehole logs within 0.25 miles of the proposed UIC well if geologic conditions are consistent.
- Site-specific, long-term water level data history justifies the minimal separation from the groundwater table in cases where the 3 feet of high-capacity treatment matrix provides the entire separation between the bottom of the structure and the seasonal high groundwater table.
- Potential mounding of infiltrating stormwater above the groundwater table is likely. Additional separation or treatment may be required.

2.10.2 Vadose Zone Treatment Capacity

In general, the vadose zone may provide adequate filtration, adsorption, and other pollutant reduction capacity to meet the nonendangerment standard for solids, metals, oil, grease, and PAHs. Designers may use the tables in Section 2.11 - Classification of Vadose Zone Treatment Capacity for UIC Wells to evaluate the use of the vadose zone for treatment and to determine treatment requirements to reduce concentrations of these pollutants prior to discharge to the UIC well.

Studies of stormwater pollutant concentrations in water through and below infiltration systems show mixed results in the effectiveness of vadose zone filtration in protecting groundwater quality (USEPA, 1999), (Pitt et al., 1999), (Mason et al., 1999), and (Appleyard, 1993).

Designers can eliminate many of the problems documented in these studies by proper siting, design, maintenance, and use of the UIC well. Additional actions to offset problems are enhanced source control, spill prevention and response plans, and additional treatment prior to discharge to the UIC well, or prohibition of the discharge.

Studies of subsurface infiltration systems also indicate that filtered and adsorbed pollutants accumulate in the vadose zone at depths of less than a few feet below the UIC well at concentrations that may require soil cleanup activities upon decommissioning of a UIC well (Mikkelsen et al., 1996a), (Mikkelsen et al., 1996b), and (Appleyard, 1993).

Because contaminated soil removal and disposal costs can be considerable, project proponents may wish to consider including pretreatment BMPs to remove solids from stormwater runoff and avoid potential cleanup requirements following long-term use of the UIC well.

Note, projects located in the South Tacoma Groundwater Protection District must follow the treatment requirements of the South Tacoma Groundwater Protection District Infiltration Policy. If the policy memo conflicts with UIC Guidance, the more stringent requirement shall apply.

2.11 Classifications of Vadose Zone Treatment Capacity for UIC Wells

The treatment capacity of the vadose zone is classified as high, medium, low, or none. Ecology bases these classifications on minimum thickness and the characteristics of the geologic materials that make up the proposed treatment layer.

The tables include several different ways of describing the geologic materials: grain-size distribution, sand-to-fines ratio, well log lithology, geologic names, and infiltration rate. Table 1.4: Examples of Geologic Material Description provides examples of language that may be used in the other tables.

Table 1 - 4 Examples of Geological Material Descriptions

Geological Material Description Method	Example
Grain size characteristics	Materials with median grain size < 0.125 mm
Sand-to-fines ratio	Having a sand to silt/clay ratio of < 1:1 and sand plus gravel < 50%
Well log lithology	Sandy or silty clay Silt Clayey or sandy silt Sandy loam or loamy sand Silt/clay with interbedded sand
Geologic name	This category includes geologic terms that indicate provenance, including till, hardpan, caliche, and loess
Infiltration rate	Infiltration rate of ≥ 12 in/hr

The ability of geologic materials to filter or adsorb pollutants such as solids, oils, and metals is related to grain size, the amount of organic matter, and the presence of clays, among other factors. Native organic matter improves adsorption and filtration (Ingloria et al., 1997) but is rarely found at depths below UIC wells.

Geologic materials classified as having a high treatment capacity are fine-grained with a greater capacity to filter discharges. These materials also tend to remove pollutants by chemical reactions such as cation exchange capacity (CEC) and sorption. High-capacity treatment layers must total a minimum of 5 feet between the bottom of the UIC well and the seasonal high groundwater table to provide an adequate level of treatment (see Figure 1-8: Schematic Vadose Zone Treatment Layer Example).

Geologic materials classified as having a medium treatment capacity provide moderate to high filtration and have minor or no chemically reactive characteristics. Medium-capacity treatment layers must total a minimum of 10 feet to provide an adequate level of treatment.

Geologic materials that have a low treatment capacity provide some minimal filtration. Although the sand and gravel mixtures in this category may provide some filtration when the UIC well is initially installed, preferential flow paths develop that contribute to relatively rapid reduction in treatment capacity. Low-capacity treatment layers must total a minimum of 25 feet between the bottom of the UIC well and the seasonal high groundwater table to provide an adequate level of treatment.

Geologic materials that are classified as having no treatment capacity do not provide filtration to remove pollutants. Since this type of material does not have treatment capacity, basic treatment of stormwater (Removal of Solids) is always required prior to discharge to the UIC well, except for sites that are classified as having an insignificant pollutant load in Table 1-6: Pollutant Loading Classifications for Solids, Metals, and Oil in Stormwater Runoff Directed to UIC Wells.

Note, projects located in the South Tacoma Groundwater Protection District must follow the treatment requirements of the South Tacoma Groundwater Protection District Infiltration Policy. If the policy memo conflicts with UIC Guidance, the more stringent requirement shall apply.

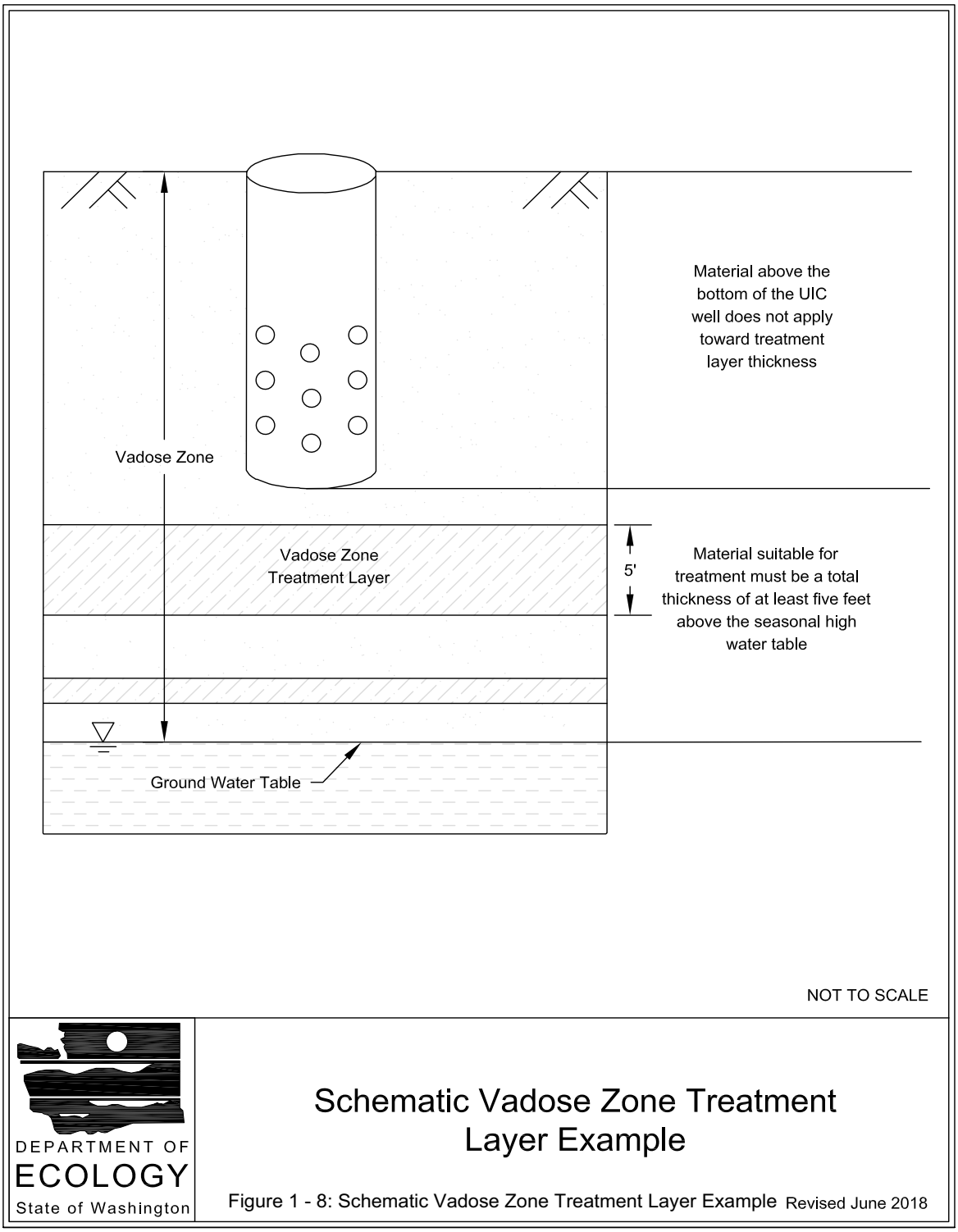


Figure 1 - 8: Schematic Vadose Zone Treatment Layer Example

2.11.1 Classification of Vadose Zone Treatment Capacity

Site exploration or information from the site or, a site nearby, is required to obtain sufficient data to classify the treatment capacity of the vadose zone materials using Table 1-7: Treatment Type Required for UIC Wells Based on Pollutant Loading Classification and Vadose Zone Treatment Layer Capacity. A soils report is required to classify the treatment capacity of the vadose zone.

The treatment capacity classifications in Table 1-5: Vadose Zone Treatment Capacity apply to the vadose zone between the bottom of the UIC well and the top of the highest known seasonal groundwater table. Designers should use Table 1-5: Vadose Zone Treatment Capacity to assist in the determination of treatment requirements when using Table 1-7: Treatment Type Required for UIC Wells Based on Pollutant Loading Classification and Vadose Zone Treatment Layer Capacity.

If vadose zone conditions are unknown, use “none” for treatment capacity. If thicknesses are less than the listed minimums, use “none” for treatment capacity or consider using the demonstrative approach (see 2.4 - The Demonstrative Approach for UIC Wells). Separation between the bottom of the UIC well and the top of the groundwater table is still required, see WAC 173-218-090(1)(b).

2.11.1.1 Depth to Groudwater

The minimum required separation between the bottom of the UIC well and the highest seasonal groundwater table depends on the characteristics of the vadose zone, the potential for mounding of infiltrating stormwater above the groundwater table, and the degree of certainty of available data as to the seasonal high groundwater table elevation.

Knowledge of the seasonal high groundwater table is especially important for siting UIC wells in areas with seasonal high groundwater table less than 15 feet below the bottom of the UIC well.

Significant mounding of infiltrating stormwater can occur above the groundwater table (Appleyard, 1993) and UIC wells must not discharge stormwater directly into groundwater at any time. This applies even if the groundwater level is rising in response to the UIC discharge.

In most cases, one depth to water measurement, such as water level data associated with a single borehole log, is not sufficient to determine the depth/elevation of the seasonal high groundwater table. This is especially true if drilling was conducted outside of the period of seasonal high groundwater levels or following a period of lower than normal precipitation. Seasonal high groundwater tables generally occur during late winter through mid-spring in most of Washington State. In heavily irrigated areas, the seasonal high groundwater table elevation may occur in late summer. The elevation of the seasonal high groundwater table is best determined through installation and periodic monitoring of one or more groundwater monitoring wells at the infiltration BMP location.

Table 1 -5: Vadose Zone Treatment Capacity

Vadose Zone Treatment Layer Capacity Classification	Required Minimum Thickness of Vadose Zone Treatment Layer	Description of Vadose Zone Layer[c,d]
HIGH	5 Feet	Meets all of the following characteristics: • Materials with median grain size < 0.125 mm • Having a sand to silt/clay ratio of < 1:1 and sand plus gravel < 50% • Materials with CEC of ≥ 5 milliequivalents CEC/100 g dry soils, and a minimum of 1% organic content, ≥ 18-inch minimum thickness • Typical geotechnical descriptive words for appropriate soils: ◦ Lean, fat, or elastic clay ◦ Sandy or silty clay ◦ Silt ◦ Clayey or sandy silt ◦ Sandy loam or loamy sand ◦ Silt/clay with interbedded sand ◦ Well-compacted, poorly sorted materials *This category generally includes till, hardpan, caliche, and loess.*

Vadose Zone Treatment Layer Capacity Classification	Required Minimum Thickness of Vadose Zone Treatment Layer	Description of Vadose Zone Layer[c,d]
MEDIUM	10 Feet	Meets all of the following characteristics: • Materials with average grain size 0.125 to 4 mm • Having a sand to silt/clay ratio from 1:1 and 9:1 and percent sand > percent gravel • Field-tested saturated hydraulic conductivity between 2.4 in/hr and 6 in/hr at the bottom elevation of the proposed BMP • Materials between 2 and 5 milliequivalents CEC/100 g dry soils, and a minimum of 0.5% to 1% organic content, • Typical geotechnical descriptive words for appropriate soils: ◦ Fine, medium, or coarse sand ◦ Sand with interbedded clay and/or silt ◦ Poorly compacted, poorly sorted materials *This category includes some alluvium and outwash deposits.*

Vadose Zone Treatment Layer Capacity Classification	Required Minimum Thickness of Vadose Zone Treatment Layer	Description of Vadose Zone Layer[c,d]
LOW	25 Feet	Meets all of the following characteristics: • Materials with median grain size > 4 mm to 64 mm • Having a sand to silt/clay ratio > 9:1 and percent sand less than percent gravel • Field-tested saturated hydraulic conductivity between 6 in/hr and 12 in/hr at the bottom elevation of the proposed BMP • Materials with CEC of ≤ 2 milliequivalents CEC/100 g dry soils and a minimum of < 0.5% organic content • Typical geotechnical descriptive words for appropriate soils: ◦ Poorly sorted, silty, or muddy gravel ◦ Sandy gravel, gravelly sand, or sand and gravel *This category includes some alluvium and outwash deposits.*

Vadose Zone Treatment Layer Capacity Classification	Required Minimum Thickness of Vadose Zone Treatment Layer	Description of Vadose Zone Layer[c,d]
None	Not Applicable	Meets all of the following characteristics: • Vadose zone conditions are unknown; or • Vadose zone conditions are known and are characterized in any of the following ways: ◦ Sedimentary materials with median grain size > 64 mm ◦ Total fines < 5% ◦ Field-tested saturated hydraulic conductivity > 12 in/hr at the bottom elevation of the proposed BMP ◦ Materials with no measurable CEC or organic content ◦ Typical geotechnical descriptive words for appropriate soils: • Well-sorted or clean gravel • Boulders and/or cobbles • Fracture rock *This category generally includes vadose zones with conditions that are unknown or vadose zones that are known to be composed of fractured basalt, other fractured bedrock, and cavernous limestone.*

Vadose Zone Treatment Layer Capacity Classification	Required Minimum Thickness of Vadose Zone Treatment Layer	Description of Vadose Zone Layer[c,d]

Notes:

a. This table is applicable to designers intending to use the presumptive approach to identify the necessary level of stormwater treatment prior to discharge to a UIC well. Designers for industrial sites with no outdoor processing, storage, or handling of raw or finished products may also use these tables.

b. This table is not applicable to stormwater from industrial activities, outdoor processing, storage, or handling of raw or finished products; or areas where stormwater runoff comes into contact with leachate or other prohibited discharges.

c. If vadose zone conditions are unknown or if the vadose zone thicknesses are less than those listed, use “none” for the treatment capacity.

d. Separation between the bottom of the UIC well and the top of the groundwater table is required, see WAC 173-218-090(1)(b).

Table 1 - 6: Pollutant Loading Classifications for Solids, Metals, and Oil in Stormwater Runoff Directed to UIC Wells

Pollutant Loading Classification	Area Contributing Runoff to the UIC Well
Insigificant	• Impervious surfaces not subject to motorized vehicle traffic or application of sand or deicing chemicals • Unmaintained open space
Low	• Parking areas with < 40 total trip ends per 1,000 square feet (sf) of gross building area or < 100 total trip ends (if you exceed either threshold, move to the Medium Classification) • Other land uses with similar traffic/ use characteristics (e.g., most residential parking and employee-only parking areas for small office parks or other commercial buildings) • Roads with ADT as follows: ◦ Fully controlled and partially controlled limited access highways with ADT <15,000 ◦ Other roads with ADT < 7,500 vehicles
Medium	• Parking areas with between 40 and 100 trip ends per 1,000 sf of gross building area or between 100 and 300 total trip ends (if you exceed either threshold, move to the High Classification) • Primary access points for high-density residential apartments • Intersections controlled by traffic signals that do not meet the definition of a high-density intersection (see the Glossary) • Transit center bus stops • Roads with ADT as follows: ◦ Fully controlled and partially controlled limited access highways with ADT between 15,000 and 30,000 vehicles ◦ Other roads with ADT between 7,500 and 30,000 vehicles

Pollutant Loading Classification	Area Contributing Runoff to the UIC Well
High	• High-use sites ◦ Includes roads with ADT > 30,000 vehicles • On-street parking areas of municipal streets in commercial and industrial areas • Highway rest areas Other land uses with similar traffic/use characteristics (e.g., commercial buildings with a frequent turnover of visitors, such as grocery stores, shopping malls, restaurants, drive-through services, etc.)
Notes: a. This table is applicable to designers intending to use the presumptive approach to identify the necessary level of treatment upstream of a UIC well. Designers for industrial sites with no outdoor processing, storage, or handling of raw or finished products may also use these tables. b. This table is not applicable to stormwater from industrial activities, outdoor processing, storage, or handling of raw or finished products; or areas where stormwater runoff comes into contact with leachate or other prohibited discharges.	

Use the treatment capacity classification from Table 1-5: Vadose Zone Treatment Capacity and the pollutant loading classification from Table 1-6: Pollutant Loading Classifications for Solids, Metals, and Oil in Stormwater Runoff Directed to UIC Wells to determine the appropriate level of treatment for solids, oil, and metals in Table 1-7: Treatment Type Required for UIC Wells Based on Pollutant Loading Classification and Vadose Zone Treatment Layer Capacity.

Note, projects located in the South Tacoma Groundwater Protection District must follow the treatment requirements of the South Tacoma Groundwater Protection District Infiltration Policy. If the policy memo conflicts with UIC Guidance, the more stringent requirement shall apply.

Designers may use UIC wells to provide flow control of excess stormwater for flows greater than the water quality design storm where pollutant concentrations that reach groundwater will meet Washington State groundwater quality standards; or where stormwater is adequately treated prior to discharge.

Table 1 - 7: Treatment Type Required for UIC Wells Based on Pollutant Loading Classification and Vadose Zone Treament Layer Capacity

Pollutant Loading Classification	Vadose Zone Treatment Layer Capacity			
	High	Medium	Low	None
Insignificant	Two-stage drywell[a]	Two-stage drywell[a]	Two-stage drywell[a]	Two-stage drywell[a]
Low	Two-stage drywell[a]	Pretreatment[b]	Pretreatment[b]	Remove solids[c]
Medium	Pretreatment[b]	Remove solids[c]	Remove solids[c]	Remove solids[c]
High	Remove oil[d]	Remove oil[d]	Remove oil and solids[c,d]	Remove oil and solids[c,d]

Notes:

a. A two-stage drywell has a catch basin or other presettling device that traps small quantities of oils and solids. Regularly inspect and maintain the catch basin or other presettling device.

b. Pretreatment removes solids, but at a level less than basic treatment. Ecology's definition for pretreatment is 50% removal. See the definition for pretreatment in the Glossary.

c. Treatment to remove solids means basic treatment. See the definition of basic treatment in the Glossary. Removal of solids removes a large portion of the total metals in most stormwater runoff. Any special treatment requirements in this chapter still apply. Owners may use appropriate source control BMPs for low-pollutant-loading sites, in lieu of structural treatment BMPs

d. Treatment to remove oil is to be accomplished by applying one of the oil control BMPs identified in this manual. See BMP T11.10: API (Baffle type) Separator and BMP T11.11: Coalescing Plate (CP) Separator

   - At high-density intersections and at commercial or industrial sites subject to an expected average daily traffic (ADT) count of 100 vehicles/1,000 sf gross building area, sufficient quantities of oil may be generated to justify operation of a separator BMP.
   - At other high-use sites, project proponents may select a basic treatment BMP that also provides adsorptive capacity, such as a biofiltration swale, a filter, or other adsorptive technology, in lieu of a separator BMP. A catch basin with a turned down elbow is not adequate for oil control in this case.
   - For roads in eastern Washington with ADT >30K, basic treatment with sorptive characteristics (i.e., swale or sand filter) is required, and suffices for the oil treatment requirement.
   - The requirement to apply a basic treatment BMP with adsorptive characteristics also applies to commercial parking and to streets with ADT > 7,500.

VOLUME

2

Documentation - Stormwater Site Plan (SSP), Construction Stormwater Pollution Prevention Plan (SWPPP) & Other Required Documents

Chapter 1 Documentation Overview

1.1 Documentation Requirements

- Project proponents shall document how stormwater mitigation measures were chosen for a project.
- Projects that trigger Minimum Requirement #1: Preparation of Stormwater Site Plans and Minimum Requirement #2: Construction Stormwater Pollution Prevention shall submit a Stormwater Site Plan (Report and Plan Set) and a Construction Stormwater Pollution Prevention Plan (Report and Plan Set) to the City for review and approval.
    - The Stormwater Site Plan Report Template and Construction Stormwater Pollution Prevention Plan Report Template shall be used. Templates are available at tacoma.gov/stormwatermanual
        - Projects that only trigger Minimum Requirements #1 - #5 may use the Stormwater Site Plan Short Form Template and Construction Stormwater Pollution Prevention Plan Short Form Template.
    - The documentation shall include all components described in this volume as applicable to the project.
- Projects not triggering Minimum Requirements may still be required to submit certain documentation to the City in order to obtain permits. The requirements will be based upon the scope of work. It is recommended to follow the requirements of this volume for all projects that involve site development and need stormwater mitigation.

1.2 Stormwater Site Plan Overview

- Minimum Requirement #1: Preparation of Stormwater Site Plans requires new development and redevelopment projects that trigger the thresholds (see Applicability of the Minimum Requirements) prepare a Stormwater Site Plan.
- A Stormwater Site Plan (SSP) is a comprehensive report and drawing set containing all the technical information, calculations, and analyses necessary to evaluate projects for compliance with the stormwater requirements.
- The Stormwater Site Plan Report describes the existing conditions of the site and project site, the proposed conditions of the site and project site, and how stormwater will be managed in the final condition.
- The Stormwater Site Plan Drawings, sometimes called Civil Plan Set of the Site Plan, are a series of drawings that visually show what is described in the Stormwater Site Plan Report. The drawings are the basis for constructing the proposed project site improvements.

1.3 Construction Stormwater Pollution Prevention Plan Overview

- Minimum Requirement #2: Construction Stormwater Pollution Prevention requires new development and redevelopment projects that trigger the thresholds to prepare a Construction Stormwater Pollution Prevention Plan.
- A Construction Stormwater Pollution Prevention Plan is a comprehensive report and drawing set containing all the technical information and analysis necessary to protect receiving waters from construction stormwater.

- The Construction Stormwater Pollution Prevention Plan describes the existing conditions of the site and how stormwater will be managed during construction.
- The Construction Stormwater Pollution Prevention Plan Drawings, typically part of the Civil Plan Set or Site Plan, are a series of drawings that visually show what is described in the Construction Stormwater Pollution Prevention Plan. The drawings are the basis for installing temporary Best Management Practices for use during construction.

Chapter 2 Who Can Prepare an SSP and/or SWPPP?

- State law (Chapter 18.43) requires engineering work be performed by or under direct supervision of a Washington State Licensed Professional Engineer. Reports and drawings that include engineering work shall be certified and sealed as required by state law prior to review by the City though any project many include engineering work.
    - Generally, projects that trigger Minimum Requirement #6: Stormwater Treatment, Minimum Requirement #7: Flow Control, Minimum Requirement #8: Wetlands Protection, and Additional Protective Measure - Infrastructure Protection and/or those that utilize the LID Performance Standard for Minimum Requirement #5: Onsite Stormwater Management compliance involve the practice of engineering though any project may involve engineering work.
- Certain components of the SSP and SWPPP may require preparation by other types of professionals such as a Washington State Licensed Professional Geologist, a Certified Professional Soil Scientist, a Washington State Licensed Onsite Wastewater Treatment System Designer, a Certified Erosion and Sediment Control Lead, a Washington State Licensed Land Surveyor, and/or a Washington State Licensed Landscape Architect. Many BMPs describe the type of professional needed to complete certain specific reports. It is ultimately up the project proponent to ensure the correct professional is completing the work. If the appropriate professional did not complete the work, the City will request work is completed again by the required professional.

Chapter 3 Resources for Stormwater Site Plan Development

The following is a list of potential resources to help develop the Stormwater Site Plan. This list is not comprehensive:

- tacoma.gov/stormwatermanual contains additional policies related to stormwater management that may not be contained in the SWMM
- tacoma.gov/stormwatermanual contains templates, checklists, and sizing calculators.
- tacomapermits.org provides information on how to submit plans to the City of Tacoma and includes resources and Tip Sheets related to the permitting process including specific submittal requirements
- tacomaMAP - tmap.cityoftacoma.org is the City's public GIS data viewer that can be used to find information about a parcel, utility information, and land use information.
- https://fortress.wa.gov/doh/swap/ contains a helpful tool that can be used to help locate groundwater wells.
- https://www.tpchd.org/healthy-homes/septic-systems can be used to help locate existing septic systems.
- https://www.co.pierce.wa.us/359/Recording - This Pierce County site contains recorded maps and documents associated with parcels.
- https://ecology.wa.gov/Spills-Cleanup/Contamination-cleanup/Underground-storage-tanks contains information about underground storage tanks
- https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Stormwater-general-permits/Construction-stormwater-permit contains information about the Construction Stormwater General Permit
- https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies contains information about the Asarco Smelter Plume

Chapter 4 Components of the Stormwater Site Plan

Below are the typical required components of a Stormwater Site Plan Report. Because each project is unique, all components may not apply to every project and additional items may be requested by the City of Tacoma in order to fully understand the project. Where calculations are required, complete calculations must be provided including a description of all assumptions made and complete modeling reports.The applicant must know which Minimum Requirements and design standards apply to their project to know which components of a Stormwater Site Plan are applicable. Applicants shall use the City of Tacoma Stormwater Site Plan Report Template available at tacoma.gov/stormwatermanual. Use of the template aids in a consistent and timely review.

4.1 Title Pages

- Ensure the Title describes the project and uses the word Stormwater Site Plan (ex: Yellow Submarine Development Stormwater Site Plan)
- Include contact information for the individual or team members completing the Stormwater Site Plan:
  - Name
  - Company Name
  - Telephone Number
  - Email Address
- Washington State Licensed Professional Engineer certification and seal (per RCW 18.43)
- Date of Preparation
- Project Location including address and parcel number(s)
- City of Tacoma Permit Number(s) associated with Stormwater Site Plan

4.2 Table of Contents

- Include a table of contents to aid in development and review.

4.3 List of Figures

- Include a list of figures to aid in development and review.

4.4 Numbering

- Provide page numbers, table numbers, and figure numbers.

4.5 Project Information

- Include the following:
  - Contact information for the property owner, applicant, and individual or team members completing the Stormwater Site Plan:
    - Name
    - Address

    - Telephone Number
    - Email Address
- City of Tacoma Permit Number
- Associated City of Tacoma Permit Numbers
- Any other associated permits such as NPDES Industrial, Sand and Gravel, or individual permits relevant to the site.
- City of Tacoma Stormwater Management Manual used for SSP Development.
    - If other than current manual describe vesting.

4.6 Project Overview

- Provide a brief description of the proposed project.

4.7 Existing Site and Project Site Conditions

- Describe the existing site and project site conditions. Description may be a combination of written words and figures or drawings. Conditions must be based upon site-specific investigations.
- Describe the following:
    - Existing Site and Project Site Use
    - Stormwater Runoff Patterns (natural and artificial)
    - Points where stormwater enters and exits the site and project site
    - Locations of sensitive and critical areas (including groundwater protection areas, wetlands and their buffers, steep slopes, floodplains, geologic hazard areas, streams, creeks, ravines, springs, etc) on the site and within 500 feet of the project site
    - Structures
    - Fuel tanks (above and below ground)
    - Groundwater wells on the site and within 100 feet of the site
    - Septic systems on the site and within 100 feet of the site
    - Superfund areas on the site and within 100 feet of the site
    - Flood Hazard Areas on the site and within 100 feet of the site
    - All receiving waters downstream from the site
    - Public and private easements
- Provide an existing conditions map(s) that shows the following:
    - Outline and Square Footage of Hard Surface Areas
    - Outline and Square Footage of Vegetation Areas
    - Outline and Square Footage of Native Vegetation Areas
    - Outline and Square Footage of Pasture Areas
    - Outline and Square Footage of Lawn/Landscaped Areas

- Outline of Threshold Discharge Areas

Each area should have a separate color or shading to clearly distinguish one area from another.

- Provide a map showing the downstream flowpath from the site to the Puget Sound - include all receiving waterbodies along flowpath. Assume that stormwater does not infiltrate along flowpath and will ultimately reach the Puget Sound. Include a map for each TDA or if each flowpath can be clearly distinguished, one map will suffice. Clearly show the ¼ mile point for determining TDA.
- Include any additional information necessary to fully describe the existing project site conditions and surroundings.

4.8 Proposed Site and Project Site Conditions

- Describe the proposed site and project site conditions. Description may be a combination of written words and figures or drawings.
- Describe the following:
  - Proposed site and project site use
  - Stormwater Runoff Patterns (natural and artificial)
  - Points where stormwater enters and exits the site and project site.
  - Improvements such as buildings, sidewalks, parking lots, etc.
  - Fuel tanks (above and below ground)
  - Groundwater wells on the site and within 100 feet of the site
  - Septic systems on the site and within 100 feet of the site
  - Proposed public and private easements.
- Provide a proposed conditions map(s) that shows the following:
  - Outline and Square Footage of New Hard Surface Areas
  - Outline and Square Footage of Replaced Hard Surface Areas
  - Outline and Square Footage of New Pollution Generating Hard Surface Areas
  - Outline and Square Footage of Replaced Pollution Generating Hard Surface Areas
  - Outline and Square Footage of Hard Surface Areas to Remain Unaltered
  - Outline and Square Footage of Areas Converted from Vegetation to Lawn/ Landscaped Areas
  - Outline and Square Footage of Areas Converted from Native Vegetation to Pasture
  - Outline and Square Footage of Pollution Generating Pervious Surfaces
  - Outline and Square Footage of Vegetation Areas to Remain Unaltered
  - Outline and Square Footage of Native Vegetation Areas to Remain Unaltered
  - Outline and Square Footage of Pasture Areas to Remain Unaltered
  - Outline and Square Footage of Lawn/Landscaped Areas to Remain Unaltered
  - Outline of Threshold Discharge Areas

Each area should have a separate color or shading to clearly distinguish one area from another.

- Provide a map showing the downstream flowpath from the project site to the Puget Sound - include all receiving waterbodies along flowpath. Assume that stormwater does not infiltrate along flowpath and will ultimately reach the Puget Sound. Include a map for each TDA or if each flowpath can be clearly distinguished, one map will suffice. Clearly show the ¼ mile point for determining TDA.
- Include any additional information necessary to fully describe the proposed project site conditions and surroundings

4.9 Project Thresholds and Minimum Requirement Determination

- Include the Project Threshold Table - available at tacoma.gov/stormwatermanual
- Define all receiving waters downstream from the project site for each Threshold Discharge Area.
- Describe any watershed specific requirements.
- Complete and include applicable flowcharts for determining Minimum Requirements - available at tacoma.gov/stormwatermanual.
- Clearly state which Minimum Requirements apply to the project. Include discussion of Cumulative Impacts as necessary.

4.10 Discussion of Minimum Requirements

4.10.1 Minimum Requirement #1: Preparation of Stormwater Site Plans

- State how this Minimum Requirement is being met.
- Describe how Site Appropriate Development Principles were used to retain native vegetation and minimize impervious surfaces.

4.10.2 Minimum Requirement #2: Construction Stormwater Pollution Prevention

- State that the Construction Stormwater Pollution Prevention Plan is available as a stand-alone document.

4.10.3 Minimum Requirement #3: Source Control

- Describe the types of activities and potential pollutants that are likely to occur on the site.
- Provide a list of all Source Control BMPs from the SWMM that apply to the project. It is not necessary to include the actual BMPs copied and pasted from the SWMM within the SSP.
- Provide the completed Source Control Selection Worksheet available at tacoma.gov/stormwatermanual
- Provide a list of additional source control BMP aside from those in the SWMM that will be used on the site.

4.10.4 Minimum Requirement #4: Preserving Drainage Patterns and Outfalls

- Describe how the natural or existing drainage patterns are maintained.
- If stormwater will be concentrated and/or increased in volume or flowrate:
  - Include modeling assumptions and outputs to determine increases in the 100-year return period flowrate.
  - Provide proof of consultation to allow discharge onto private property.
  - Describe mitigation measures as necessary.
    - Include all calculations and assumptions.

4.10.5 Minimum Requirement #5: Onsite Stormwater Management

- State which approach is being used for compliance: The List Approach or the LID Performance Standard
- If using the List Approach:
  - State the BMPs being used for each surface type. Provide BMP name(s) and number(s)
  - Include the infeasibility checklist for any BMPs deemed infeasible.
    - Include a reference to associated documents used for determining infeasibility such as Soils Report, Survey showing site and project site topography, maps showing distance to property lines, etc.
  - Provide sizing calculations for all BMPs proposed.
- If using the LID Performance Standard
  - State the BMPs being used for compliance. Provide the BMP name(s) and number(s).
  - State that BMP L613: Post-Construction Soil Quality and Depth is being used.
  - Provide sizing calculations for all BMPs proposed.
  - Provide the modeling report showing that with the use of BMPs, the LID Performance Standard is met.

4.10.6 Minimum Requirement #6: Stormwater Treatment

- Describe the reason the project must comply (or is not required to comply) with Minimum Requirement #6: Stormwater Treatment.
  - Describe the requirement for each Threshold Discharge Area.
- Describe treatment type required.
  - If any areas are not being treated that would require treatment provide an explanation as to why.
- State the BMP(s) being used.
  - Provide BMP name(s) and number(s).
  - Provide sizing calculations for all BMPs proposed.

    - If an Emerging Technology is proposed, include the most current Use Level Designation as an attachment/appendix to the SSP Report. If the Use Level Designation requires review by the manufacturer you must provide an email or letter from the manufacturer verifying their review.
- Provide a stormwater treatment basin map clearly showing surfaces requiring treatment and surfaces receiving treatment (facility contributing areas).
    - Outline and Square footage of areas requiring treatment
    - Outline and Square footage of areas receiving treatment
    - Outline and Square footage of areas receiving treatment that is pollution generating
    - Outline and Square footage of areas bypassing treatment
    - Outline and Square footage of areas bypassing treatment that are pollution generating.

4.10.7 Minimum Requirement #7: Flow Control

- Describe the reason the project must comply (or is not required to comply) with Minimum Requirement #7: Flow Control.
    - Describe the requirement for each Threshold Discharge Area.
- Describe flow control type required (ex. Forested, Pasture, or Existing Mitigation).
- State the BMP(s) being used.
    - Provide BMP name(s) and number(s).
    - Provide sizing calculations for all BMPs proposed.
    - Provide modeling report showing the Performance Standards have been met.
- Provide a flow control basin map clearly showing surfaces requiring flow control and surfaces receiving flow control (facility contributing areas).
    - Outline and Square footage of areas requiring flow control
    - Outline and Square footage of areas receiving flow control
    - Outline and Square footage of areas bypassing flow control

4.10.8 Minimum Requirement #8: Wetlands Protection

- Describe the reason the project must comply (or is not required to comply) with Minimum Requirement #8: Wetlands Protection.
    - Describe the requirement for each Threshold Discharge Area.
- Describe Level of Protection Required.
    - Include wetland delineation report as attachment/appendix to SSP Report.
    - Include all wetland hydrology calculations.
        - Provide existing and proposed basin maps that clearly show land use conditions and acreages (or square feet) used in the analysis.
- State the BMP(s) being used for mitigation.
    - Provide sizing calculations for all BMPs proposed.

- If an Emerging Technology is proposed, include the most current Use Level Designation as an attachment/appendix to the SSP Report.
- Provide a stormwater treatment or flow control basin map or both.

4.10.9 Minimum Requirement #9: Operation and Maintenance

The Operation and Maintenance Manual shall be a stand-alone document for the project owner once the project is complete. If the stormwater facilities will be maintained by the City of Tacoma, it is not necessary to include an Operation and Maintenance Manual though a statement must be made in the SSP that the City is responsible for providing the Operation and Maintenance Manual. The City develops its own O&M Manual. The Operation and Maintenance Manual must include:

- A narrative description of the stormwater facilities.
- An 11 x 17 inch site plan, with the locations of the stormwater facilities (including conveyance) prominently noted. This is needed to enable the Operation and Maintenance Manual to be a stand-alone document make this sentence an open bullet under this bullet.
  - Not required for facilities that will be maintained by the City and located in the public right-of-way because the facility plans are uploaded to the City of Tacoma system.
- Detail drawings of the proposed facilities including overall dimensions and locations of inflow, bypass, and discharge.
- The person or organization responsible for maintenance of the onsite storm system, including the phone number and current responsible party.
- Where the Operation and Maintenance Manual is to be kept. Note that it must be made available to the City for inspection. The Operation and Maintenance Manual shall be onsite prior to Certificate of Occupancy.
- A description of each stormwater facility, including what it does and how it works. Include any manufacturer’s documentation and recommendations. For City maintained facilities located in the public right of way, do not include manufacturer's documentation and recommendations as part of the submittal.
- A description of all maintenance tasks and the frequency of each task for each facility. Include any manufacturer’s recommendations. For City maintained facilities located in the Public Right of Way, do not include this with the submittal.
- A sample maintenance activity log indicating emergency and routine actions to be taken.
- It is recommended to include a cost estimate for maintenance of each facility.

4.11 Additional Protective Measure - Infrastructure Protection

Describe the reason the project must comply (or is not required to comply) with Additional Protective Measure - Infrastructure Protection.

Include the complete Single Segment Capacity Analysis, Inlet and Gutter Capacity Analysis, or Full Backwater Analysis (as required by the project thresholds). Include:

- All model assumptions including tailwater assumptions.
- All model outputs as an attachment/appendix to the SSP Report.
- Include a diagram or map showing the pipe segments, inlets, and gutter sections analyzed. Include:
  - Pipe type
  - Slope
  - Inlet type
  - Downstream survey if required by the City of Tacoma.
- Provide existing and proposed basin maps that clearly show land use conditions and acreages (or square feet) used in the analysis.
- Provide analysis results including:
  - Hydraulic gradeline
  - Locations where stormwater overtops the conveyance system.
- Provide proposed mitigation measures.

4.12 Conveyance System Design

- Include the complete Full Backwater Analysis, including:
  - All model assumptions including tailwater assumptions.
  - All model outputs as an attachment/appendix to the SSP Report.
  - Include a diagram or map showing the pipe segments, inlets, and gutter sections analyzed. Include:
    - Pipe type
    - Slope
    - Inlet type
    - Downstream survey if required by the City of Tacoma.
  - Provide existing and proposed basin maps that clearly show land use conditions and acreages (or square feet) used in the analysis.
- Provide analysis results including:
  - Hydraulic gradeline

4.13 Soils Report

- Include the soils report as a separate stand-alone document.
  - Soils report requirements are contained in Volume 4 - Appendix B.

4.14 Wetland Delineation Report

- Include the Wetland Delineation Report as a separate stand-alone document.
- Wetland Delineation Report requirements are contained in Volume 1 - Minimum Requirement #8: Wetlands Protection.

4.15 Modeling Reports

- Include the complete continuous simulation model and/or single event model reports as a separate appendix/attachment to the Stormwater Site Plan Report.

4.16 Emerging Technology Use Level Designations

- Include the Use Level Designation as a separate attachment/appendix to the Stormwater Site Plan Report.

4.17 Relevant Historical Reports

- Include relevant historical reports as separate attachments/appendices to the Stormwater Site Plan Report.

4.18 Access and Easement Documentation

Access and easement documents shall be separate stand-alone documents. Document types include:

- Covenant and Easement Agreement
- Private Easements
- Public Easements

Chapter 5 Components of the Construction Stormwater Pollution Prevention Plan

Below are the required components of a Construction Stormwater Pollution Prevention Plan Report. Many components are identical to information contained in the Stormwater Site Plan, because the SWPPP is a stand-alone document, information shall be included separately on both documents. Because each project is unique, all components may not apply to every project and additional items may be requested by the City of Tacoma in order to fully understand the project. Applicants shall use the City of Tacoma Construction Pollution Prevention Plan Report Template available at tacoma.gov/stormwatermanual. Use of the template aids in a consistent and timely review.

5.1 Title Page(s)

- Ensure the Title describes the project and uses the word Construction Stormwater Pollution Prevention Plan (ex: Yellow Submarine Development Construction Stormwater Pollution Prevention Plan Report)
- Include contact information for the individual or team members completing the Construction Stormwater Pollution Prevention Plan Report:
  - Name
  - Company Name
  - Telephone Number
  - Email Address
- Washington State Licensed Professional Engineer certification and seal (per RCW 18.43)
- Date of Preparation
- Project Location including address and parcel number(s)
- City of Tacoma Permit Number(s) associated with Construction Stormwater Pollution Prevention Plan

5.2 Table of Contents

- Include a table of contents to aid in development and review.

5.3 List of Figures

- Include a list of figures to aid in development and review.

5.4 Numbering

Provide page numbers, table numbers, and figure numbers.

5.5 Project Information

- Include the following:
  - Contact information for the property owner, applicant, and individual or team members completing the Construction Stormwater Pollution Prevention Plan:
    - Name

    - Address
    - Telephone Number
    - Email Address
- City of Tacoma Permit Number
- Associated City of Tacoma Permit Numbers:
- Note if an NPDES Construction Stormwater General Permit is required.
- Any other associated permits such as NPDES Industrial, Sand and Gravel, or individual permits relevant to the site.
- City of Tacoma Stormwater Management Manual used for SWPPP Development.
    - If other than current manual describe vesting.

5.6 Project Overview

- Provide a brief description of the proposed project.

5.7 Existing Site and Project Site Conditions

- Describe the existing site and project site conditions. Description may be a combination of written words and figures or drawings. Conditions must be based upon site-specific investigations.
- Describe the following:
    - Existing Use
    - Stormwater Runoff Patterns (natural and artificial)
    - Points where stormwater enters and exits the project site.
    - Locations of sensitive and critical areas (including groundwater protection areas, wetlands and their buffers, steep slopes, floodplains, geologic hazard areas, streams, creeks, ravines, springs, etc) on the site and within 500 feet of the site
    - Structures
    - Fuel tanks (above and below ground)
    - Groundwater wells on the site and within 100 feet of the site
    - Septic systems on the site and within 100 feet of the site
    - Superfund area on the site and within 100 feet of the site
    - Flood Hazard Areas on the site and within 100 feet of the site
    - All receiving waters downstream from the site.
    - Location of existing public and private easements. Easements may require protection during construction.
    - Description of site soils as related to erodibility.
        - A soils report may be required depending on the project site proposed construction activities, potential for erosion, and proximity to receiving

waterbodies. The soils report may include information below as necessary to appropriately choose and size BMPs:

- Erodibility
- Settleability
- Permeability
- Texture
- Soil Structure

◦ Potential erosion control problem areas

- Include any additional information necessary to fully describe the existing project site conditions and surroundings as related to construction stormwater pollution prevention.

5.8 13 Elements of Construction Stormwater Pollution Prevention

- Describe how each of the Construction Stormwater Pollution Prevention Elements has been addressed.
- Identify the type and location of BMPs used to satisfy each of the required element.
- Provide written justification identifying the reason an element is not applicable to the proposal.
- Provide design calculations (including all assumptions and variables used) for BMPs such as sediment ponds, interceptor swales, and detention that require engineering calculations.

5.9 Construction Schedule

- Provide a proposed construction schedule
- Describe any proposed phasing or sequencing.

5.10 Modeling Report

- Include the complete continuous simulation model and/or single event model reports as a separate appendix/attachment to the Construction Stormwater Pollution Prevention Plan.

Chapter 6 Drawings

6.1 Required Drawings

Project drawings shall be provided and include the following as applicable for the project. The drawings shall be stand-alone documents and shall not be included in the Stormwater Site Plan Report or Construction Stormwater Pollution Prevention Report. See tacomapermits.org for information about required format and minimum standards for drawings. Drawings shall include all information necessary to fully understand existing site and project site conditions and provide enough information to construct the required improvements. Plans shall provide sufficient information such that additional calculations, assumptions, etc. do not have to be made by the contractor. The City will make the final determination is plans are of sufficient quality to ensure the proposed project meet City codes and requirements. Additional information beyond what is shown below may be requested. Below are also items that may be needed in addition to those provided at tacomapermits.org.

- At least one sheet must contain a plan view of the site and entire project site. In the event the project site is sufficiently large that detailed plans on any given sheet do not encompass the entire project site, then the sheet containing the plan view of the entire site must serve as an index to subsequent detailed plan sheets.
- Cross sections shall be provided for roadways, including access roads, and stormwater facilities.
- Identify any onsite or adjacent critical areas, associated buffers (e.g., wetlands, watercourses and natural conveyance channels, water bodies, steep slopes, streams, shorelines etc) significant trees and natural vegetation easements, if any.
- Existing Site Information Including:
    - Existing topography for the project site and extending 50' beyond project boundaries. Existing topography for adjacent rights-of-way for the full width of right-of-way.
        - Contours at a maximum 5' vertical elevation intervals.
        - Engineered designs require field verification of contours (field survey).
        - Depending on the site, a standalone topographic survey sheet may be required.
    - Existing lot boundaries, right of way boundaries, tracts, and easements. Documentation of public and private easements may be required.
    - Existing structures, including all structures within 50 feet of project boundaries, including:
        - All hard surfaces such as roads, parking lots, driveways, patios, buildings, garages, walkways, etc.
        - Existing structures to be removed.
        - Existing storage tanks (above and below ground).
        - Existing oil water separators, grease interceptors or other wastewater pretreatment facilities.
        - Existing wells, wastewater systems, septic tanks and drainfields onsite and/or within 50’ of the project boundaries.
    - Existing site access points.

- Existing stormwater facilities including stormwater treatment facilities, flow control facilities, and onsite stormwater management facilities.
- Existing utilities including:
  - Any franchised utilities located above or below ground.
  - Stormwater systems, which transport stormwater onto, across, or from the site. The ultimate connection to the City of Tacoma system or private outfall must be shown to verify there are no illicit connections.
    - Invert or flow line elevation of existing stormwater system pipes, culverts, and channels.
    - Rim elevations of any existing conveyance structures (catch basins, manholes, etc.)
  - Invert elevations for connections to existing public utilities.
  - Existing wastewater systems, including private side sewers, showing their connections to the main.
  - Clearly label utilities as public or private.

- Proposed site information, including:
  - Finished grade contours for the site showing catch points to existing topography at the limits of grading.
    - Contours at a maximum 5' vertical elevation intervals.
    - Engineered designs require field verification of contours (field survey).
    - Depending on the site, a standalone topographic survey sheet may be required.
  - Contours, spot elevations and flow arrows to clearly indicate how driveways, parking areas and other hard surfaces will be graded.
  - Proposed lot boundaries, right of way boundaries, tracts, and easements. Documentation of public and private easements may be required.
  - Proposed structures including:
    - Proposed storage tanks (above and below ground).
    - Location and details for oil water separators, grease interceptors or other wastewater pre-treatment facilities.
    - Proposed hard surfaces such as roads, parking lots, driveways, patios, buildings, garages, walkways, etc.
- Permanent Stormwater Mitigation Facilities - Both Above and Below Ground (onsite stormwater management, stormwater treatment, flow control)
  - Clearly show with dimensions the location of the stormwater facility.
  - For facilities designed to infiltrate, on profile view clearly show the facility and soil profile to clearly show the infiltration facility is being placed in appropriate soil layer and distance to restrictive layer is appropriate.

- Show all components of the stormwater facility including its connection to the stormwater conveyance system (including connections to the roof drain system and/or footing drains).
- Label facilities with BMP number from SWMM.
- Clearly label as public or private.
- Clearly show setback distances from structures and property lines. For facilities designed to infiltrate, on profile view clearly show the facility and soil profile to clearly show the infiltration facility is being placed in appropriate soil layer and distance to restrictive layer is appropriate.
- Clearly show dimensions for all BMP components - including vegetated flowpaths.
- Provide facility details.
  - Include the appropriate GSI Typical Details or Standard Plans and any other details needed for construction of the facility. Include specifications for all components.
- For BMP L613: Post-Construction Soil Quality and Depth: Clearly hatch or otherwise mark the location(s) where the BMP is being employed. If more than one implementation option is being used, clearly delineate the areas where various options are being used.
  - A single plan set note stating where this BMP will be is not sufficient unless there is an accompanying landscape plans or plan set page that clearly shows final cover conditions and can very clearly be used to determine the locations for implementation.
- Proposed utilities including: Exact line and grade of all proposed utilities at crossings with other utilities.
- Any franchised utilities located above or below ground
- Stormwater conveyance systems, which transport stormwater onto, across, or from the site.
  - Invert or flow line elevation of proposed stormwater pipes, culverts, and channels
  - Rim elevations of any proposed conveyance structures (catch basins, manholes, etc.)
  - Pipe type and pipe specifications.
- Structure details and specifications. Include specifications for connector type.
- Invert elevations for connections to public utilities.
- Proposed wastewater, including private side sewers, showing their connections to the main.
- Clearly label utilities as public or private.
- Where necessary, provide a detail showing there is sufficient space inside structure to make connection.
- Finish floor elevations for all proposed buildings.

- Plan views of stormwater conveyance facilities for which there is no accompanying profile view shall include the following information: pipe sizes, pipe types and materials, lengths of runs, pipe slope and exact locations of pipes or channels, structure identifier (e.g., catch basin/manholenumber), type of structure (e.g., Type 2 CB), exact location of structures (e.g., station and offset, or dimensioning), invert elevations in/out of structures, and top elevations of structures. Notes and/or labels shall be included referencing details, cross-sections, profiles, etc.

- In existing and proposed rights-of-way, stormwater conveyance systems shall be shown in profile view. Profile views shall include:
  - Existing and finish grades.
  - Proposed pipes, channels and structures.
  - Existing underground utilities where such utilities cross proposed stormwater conveyance systems.
  - Profile views shall include the following information: pipe sizes, pipe types and materials, lengths of runs, gradients and exact locations of pipes or channels, structure identifier (e.g. catch basin/manholenumber), type of structure (e.g., Type 2 CB), exact location of structures (e.g. station and offset, or dimensioning), invert elevations in/out of structures, and top elevations of structures. Plan and profile views shown on the same sheet shall be aligned, duplicate information should be avoided for plan and profile views on the same sheet.
- A planting plan (which may be part of the landscape plan) is required.

6.2 Temporary Erosion and Sedimentation Drawings

The Temporary Erosion and Sedimentation Drawings shall include the following information, at a minimum:

- Vicinity map with roads and receiving waters within one mile of the site.
- Erosion and Sediment Control Notes,
- Name, address and 24-hour contact telephone number(s) of the designated emergency contact person. The emergency contact information may be supplied at the pre-construction meeting.
- Name, address, and phone number of the Erosion and Sediment Control Lead (ESC), Certified Erosion and Sediment Control Lead (CESCL), or Certified Professional in Erosion and Sediment Control (CPESC) as applicable.
- Name, address, telephone number, and email address of the parcel(s) owner and the Design Engineer.
- Detailed listing of the construction sequence.
- Detailed listing of the phasing of any erosion and sediment control work.
- Legal description of subject property.
- North arrow.
- Boundaries of existing vegetation, e.g. tree lines, pasture areas, etc.
- Areas of potential erosion problems.
- Onsite or adjacent critical areas.

- Existing and proposed contours.
- Label final grade contours and identify developed condition drainage basins.
- Delineation of areas that are to be cleared and graded.
- Areas where vegetation will be undisturbed.
- All cut and fill slopes indicating top and bottom of slope catch lines.
- Location of stockpiles, haul roads and disposal sites.
- Locations for swales, interceptor trenches, or ditches.
- All temporary and permanent stormwater conveyance pipes, ditches, or cutoff trenches required for erosion and sediment control.
- Provide minimum slope and cover for all temporary pipes or call out pipe inverts.
- Show grades, dimensions, and direction of flow in all ditches, swales, culverts and pipes.
- Details for bypassing offsite run-on around disturbed areas.
- Locations and outlets of any dewatering systems.
- Locations of all existing and proposed channels, swales or stormwater system pipes which either convey offsite stormwater through or route stormwater around the construction area.
- Locations of all ESC facilities with dimensions and details. Clearly show all discharge locations.
- When sedimentation ponds and traps are proposed, at least one cross section detail shall be shown.
- Details and notes for mulching and revegetation, including detailed planting procedures, seed/plant specifications, and plant maintenance specifications.
- Any best management practices used that are not referenced in the SWMM shall be explained and illustrated with detailed drawings.
- Locations of BMPs to be used for the control of pollutants other than sediment, e.g. concrete wash water.
- Water quality sampling locations to be used for monitoring water quality on the construction site, if applicable.
- Description of inspection reporting responsibility, documentation, and filing.

Chapter 7 Documentation Required After Approval

This section includes the specifications and contents required of those plans submitted after the City has approved the permit.

7.1 Revisions

If the designer wishes to make changes or revisions to the originally approved permit submittal documents, the proposed revisions shall be submitted to the City prior to construction of the revisions. The submittals shall include the following:

1. A revised Stormwater Site Plan Report to include the proposed changes.
2. Revised drawings showing all proposed changes.
3. Any other supporting information that explains and supports the reason for the change.

Note: Revisions shall be shown as clouded revisions to approved Drawings and Reports. See tacomapermits.org for the application process for revisions.

7.2 Record Drawing Submittal

All projects, except single family residence, shall submit record drawings (as-builts) to the City when the project is complete. If a single family residence has made substantial changes to design, as-builts shall be submitted to the City. These shall be engineering drawings that accurately represent the project as constructed. Record Drawings shall show the invert and rim elevations to the nearest 0.01 foot for all storm structures. Record drawings shall be received and accepted after facility installation and prior to final inspection and/or closeout. As-built Stormwater Site Plan Reports and/or other reports may be required based upon the extent of the field changes. See the Right-of-Way Permitting general notes for record drawing requirements for right-of-way projects. Drawings shall be submitted as both CAD files and pdf files.

7.3 Engineer's Certification

For all projects, except single family residence, the Engineer of Record shall provide an Engineer's Certification to the City of Tacoma after facility installation and prior to permit final inspection and/or closeout. The Engineer's Certification shall include, as applicable:

1. The permit number.
2. Statements to attest:
    a. That all stormwater facilities have been installed according to the approved permit documents. If stormwater facilities have not been installed in accordance with the approved permit documents, documentation may need to be provided that substantiates the change.
    b. Record drawings have been provided to the City electronically.
    c. The soils at the bottom of facilities designed to infiltrate are as indicated in the plans. The designer or soils professional that classified the soils will need to be onsite during construction to verify the soil types. If engineered soils are used, soil chemical and physical properties from the soil delivered to the site must be provided to the City to verify that the soil used meets the physical and chemical properties required for the given BMP.

The Operations and Maintenance Manual is located onsite.

VOLUME

3

Construction Site Stormwater Best Management Practices

How to Use this Volume

This Volume contains the Best Management Practices that can be used to help ensure compliance with Minimum Requirement #2: Construction Stormwater Pollution Prevention.

Chapter 1 Construction Stormwater Pollution Prevention Best Management Practices (BMPs)

Best Management Practices (BMPs) are defined as schedules of activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices, that when used singly or in combination, prevent or reduce the release of pollutants to waters of Washington State. This chapter contains standards and specifications for temporary BMPs to be used as applicable during the construction phase of a project.

An applicant can elect to utilize experimental BMPs or make modifications to the standards contained within the BMPs with City of Tacoma approval. Experimental and modified BMPs must achieve the same or better performance than the BMPs contained in this chapter.

Ecology has approved products as able to meet the requirements of many BMPs contained within the chapter. Ecology maintains a list of products deemed functionally equivalent at https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies. These products may be used on projects in the City of Tacoma through the City may limit their use on a case by case basis.

Table 3 - 1: Construction Stormwater BMPs by SWPP Element shows how each Construction Stormwater Pollution Prevention BMP in this manual relates to the associated SWPP Element.

Table 3 - 1: Construction Stormwater BMPs by SWPP Element

Construction Stormwater BMP	Construction SWPP Element #												
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13
BMP C101: Preserving Natural Vegetation	X												
BMP C102: Buffer Zone	X												X
BMP C103: High Visibility Fence	X												X
BMP C105: Stabilized Construction Entrance/Exit		X											
BMP C106: Wheel Wash		X											
BMP C107: Construction Road/Parking Area Stabilization		X											
BMP C120: Temporary and Permanent Seeding					X	X							
BMP C121: Mulching					X	X							
BMP C122: Nets and Blankets					X	X		X					
BMP C123: Plastic Covering					X	X							

Table 3 - 1: Construction Stormwater BMPs by SWPP Element

Construction Stormwater BMP	Construction SWPP Element #												
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13
BMP C124: Sodding					X	X							
BMP C125: Compost					X								
BMP C126: Topsoiling					X								
BMP C127: Polyacrylamide for Soil Erosion Protection					X								
BMP C130: Surface Roughening					X	X							
BMP C131: Gradient Terraces					X	X							
BMP C140: Dust Control					X								
BMP C150: Materials On Hand											X	X	
BMP C151: Concrete Handling									X				
BMP C152: Sawcutting and Surfacing Pollution Prevention									X				
BMP C153: Material Delivery, Storage and Containment									X				
BMP C154: Concrete Washout Area									X				
BMP C160: Erosion and Sediment Control Lead											X	X	
BMP C162: Scheduling												X	
BMP C200: Interceptor Dike and Swale						X							X
BMP C201: Grass-Lined Channels						X							X
BMP C202: Rip Rap Channel Lining								X					
BMP C203: Water Bars			X			X				X			
BMP C204: Pipe Slope Drains						X							
BMP C205: Subsurface Drains						X							
BMP C206: Level Spreader						X				X			

Table 3 - 1: Construction Stormwater BMPs by SWPP Element

Construction Stormwater BMP	Construction SWPP Element #												
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13
BMP C207: Check Dams			X			X		X					X
BMP C208: Triangular Silt Dike (Geotextile-Encased Check Dam)						X							X
BMP C209: Outlet Protection			X					X					
BMP C220: Stormwater System Inlet Protection							X						
BMP C231: Brush Barrier				X									X
BMP C232: Gravel Filter Berm				X									
BMP C233: Silt Fence				X									X
BMP C234: Vegetated Strip				X									X
BMP C235: Wattles			X	X									
BMP C236: Vegetative Filtration										X			
BMP C240: Sediment Trap			X	X									
BMP C241: Temporary Sediment Pond			X	X									
BMP C250: Construction Stormwater Chemical Treatment				X					X				

Table 3 - 1: Construction Stormwater BMPs by SWPP Element

Construction Stormwater BMP	Construction SWPP Element #												
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13
BMP C251: Construction Stormwater Filtration				X					X				
BMP C252: Treating and Disposing of High pH Water									X				
BMP C253: Portable Sediment Tank			X	X						X			
BMP C254: Discharge to Wastewater System			X	X						X			
Construction SWPPP Elements: Element #1: Preserve Vegetation and Mark Clearing Limits Element #2: Establish Construction Access Element #3: Control Flow Rates Element #4: Install Sediment Controls Element #5: Stabilize Soils Element #6: Protect Slopes Element #7: Protect Stormwater System Inlets Element #8: Stabilize Channels and Outlets Element #9: Control Pollutants Element #10: Control Dewatering Element #11: Maintain BMPs Element #12: Manage the Project Element #13: Protect Permanent Stormwater BMPs													

Construction Stormwater BMPs associated with onsite work shall be located on the subject parcel to the maximum extent practicable. BMPs shall not discharge stormwater over sidewalks or interfere with the traveled way - both pedestrian and vehicular traffic. Discharge locations shall not cause localized flooding or cause puddling in the right-of-way.

1.1 BMP C101: Preserving Natural Vegetation

1.1.1 Purpose

The purpose of preserving natural vegetation is to reduce erosion wherever practicable. Limiting site disturbance is the single most effective method for reducing erosion. For example, conifers can hold up to about 50 percent of all rain that falls during a storm. Up to 20-30 percent of this rain may never reach the ground but is taken up by the tree or evaporates. Another benefit is that the rain held in the tree can be released slowly to the ground after the storm.

1.1.2 Conditions of Use

Natural vegetation should be preserved on steep slopes, near perennial and intermittent watercourses or swales, in wooded areas, and any other location practicable.

Phase construction to preserve natural vegetation on the project site for as long as possible during construction.

1.1.3 Design and Installation Specifications

Natural vegetation can be preserved in natural clumps or as individual trees, shrubs and vines.

The preservation of individual plants is more difficult because heavy equipment is generally used to remove unwanted vegetation. The points to remember when attempting to save individual plants are:

- Is the plant worth saving? Consider the location, species, size, age, vigor, and the work involved. The City of Tacoma encourages the preservation of native vegetation and trees, where practicable.
- Existing trees to be preserved shall be fenced and protected during construction activities per Tacoma Municipal Code 9.18.030, according to industry standards (ANSI A300 Part 5) and the International Society of Arboriculture's Best Management Practices – Managing Trees During Construction.

Described below are the most common types of injury that occur to trees. The language is adapted from the International Society of Arboriculture's Best Management Practices – Managing Trees from Construction.

- Root cutting or damage which can be caused by excavation equipment, trenching equipment, burial of debris, fill over roots, and alterations made to the water table by grade changes.
- Soil compaction resulting from vehicle, equipment and foot traffic. Compacted soils permit less root growth and biological activity as a result of aeration, higher mechanical resistance to root penetration and slowed water movement.
- Mechanical injury to the tree. Trunks, roots, and tree crowns can be damaged by construction equipment. Injury can affect the ability of the tree or plant to transport water and nutrients, and removes the ability for the plant to protect against pathogens.
- Fill placed near the root collar can facilitate infection and encourage stem-girdling which will affect the long-term longevity of the tree or plant

1.1.4 Maintenance Standards

- Inspect flagged and/or fenced areas regularly to make sure flagging or fencing has not been removed or damaged. If the flagging or fencing has been damaged or visibility reduced, it shall be repaired or replaced immediately and visibility restored.
- If tree roots have been exposed or injured, prune cleanly with an appropriate pruning saw or loppers directly above the damaged roots and recover with native soils.

1.2 BMP C102: Buffer Zone

1.2.1 Purpose

Creation of an undisturbed area or strip of natural vegetation or an established suitable planting that will provide a living filter to reduce soil erosion and stormwater velocities.

1.2.2 Conditions of Use

Buffer zones are used along streams, wetlands and other bodies of water that need protection from erosion and sedimentation. Vegetative buffer zones can be used to protect natural swales and can be incorporated into the natural landscaping of an area.

Do not use critical area buffer zones as sediment treatment areas. Do not disturb critical area buffers.

1.2.3 Design and Installation Specifications

- Preserve natural vegetation or plantings in clumps, blocks, or strips as this is generally the easiest and most successful method. However, single specimen trees and plants should also be preserved.
- Leave all unstable slopes in their natural, undisturbed state.
- Mark clearing limits and keep all equipment and construction debris out of the natural areas. Steel construction fencing is the most effective method of protecting sensitive areas and buffers. Alternatively, wire-backed silt fence on steel posts is marginally effective. Flagging alone is not allowed.
- Keep all excavations and material storage areas outside the dripline of trees and shrubs.
- Do not push debris or extra soil into the buffer zone area because it will cause damage from burying and smothering.
- Vegetative buffer zones for streams, lakes or other waterways shall be established by the City or other state or federal permits or approvals.

1.2.4 Maintenance Standards

- Inspect the area frequently to make sure fencing remains in place and the area remains undisturbed. Fix or replace damaged fencing immediately.

1.3 BMP C103: High Visibility Fence

1.3.1 Purpose

Fencing is intended to:

- Restrict clearing to approved limits.
- Prevent disturbance of sensitive areas, their buffers, and other areas required to be left undisturbed.
- Limit construction traffic to designated construction entrances or roads.
- Protect areas where marking with survey tape or flagging may not provide adequate protection.

1.3.2 Conditions of Use

To establish clearing limits, plastic, fabric, or metal fence may be used:

- At the boundary of sensitive areas, their buffers, and other areas required to be left uncleared.
- As necessary to control vehicle access to and on the site.

1.3.3 Design and Installation Specifications

- High visibility plastic fence shall be composed of a high-density polyethylene material and shall be at least four feet in height. Posts for the fencing shall be steel or wood and placed every 6 feet on center (maximum) or as needed to ensure rigidity. The fencing shall be fastened to the post every six inches with a polyethylene tie. On long continuous lengths of fencing, a tension wire or rope shall be used as a top stringer to prevent sagging between posts. The fence color shall be high visibility orange. The fence tensile strength shall be 360 lbs./ft. using the ASTM D4595 testing method.
- If appropriate, install fabric silt fence in accordance with BMP C233: Silt Fence to act as high visibility fence. Silt fence shall be at least 3 feet high and must be highly visible to meet the requirement of this BMP.
- Design and install metal fences according to the manufacturer's specifications.
- Metal fences shall be at least 3 feet high and must be highly visible.
- Do not wire or staple fences to trees.

1.3.4 Maintenance Standards

- If the fence has been damaged or its visibility reduced, it shall be repaired or replaced immediately and visibility restored.

1.4 BMP C105: Stabilized Construction Entrance/Exit

1.4.1 Purpose

Construction entrances are stabilized to reduce the amount of sediment transported onto paved roads by vehicles or equipment by constructing a stabilized pad of quarry spalls at entrances and exits to construction sites.

1.4.2 Conditions of Use

Construction entrances shall be stabilized wherever traffic will be leaving a construction site and traveling on paved roads or other paved areas within 1,000 feet of the site.

Construction vehicle ingress and egress shall be limited to one route. Additional routes may be allowed for very large projects or linear projects.

For residential construction provide stabilized construction entrances/exits for each residence. Stabilized surfaces shall be of sufficient length/width to provide vehicle access/parking based upon lot size and configuration. See Figure 3 - 1: Stabilized Construction Entrance.

1.4.3 Design and Installation Specifications

- The stabilized construction entrance shall be:
  - A minimum of 15' wide; and a minimum of 100' feet long.

  The length of the entrance may be reduced to the maximum practicable size when the size or configuration of the site does not allow the full lengths.

- Construct stabilized construction entrance with a pad that is:
  - A minimum 12" thick pad of 4" to 8" quarry spalls, or
  - A minimum 4" course of asphalt treated base, or
  - Existing pavement, or
  - A minimum 12" thick pad of permeable ballast meeting the requirements of WSDOT's Standard Specifications for Road, Bridge, and Municipal Construction Section 9-03.9(2).
  - For single-family residence construction, the pad may be clean 1 ½" minimum aggregate placed at least 8" thick.
  - Manufactured alternatives to construction entrance may be used provided they ensure no track-out.
- Do not use crushed concrete, cement or asphalt rubble for the stabilized construction entrance.
- Place a separation geotextile under the spalls to prevent fine sediment from pumping up into the rock pad. The geotextile shall meet WSDOT Standard Specification 9-33.2(1) Table 3-12 Geotextile for Separation or Soil Stabilization or the following standards:
  - Grab Tensile Strength (ASTM D4751) – 200 psi min.
  - Grab Tensile Elongation (ASTM D4632) – 30% max.
  - Mullen Burst Strength (ASTM D3786-80a) – 400 psi min.

- AOS (ASTM D4751) – 20 to 45 (U.S. standard sieve size)

- Consider early installation of the first lift of asphalt or extra concrete in areas that will be paved; this can be used as a stabilized entrance.
- Install fencing (see BMP C103: High Visibility Fence) as necessary to restrict traffic to the construction entrance.
- Whenever possible, construct the entrance on a firm, compacted subgrade. This can substantially increase the effectiveness of the pad and reduce the need for maintenance
- If possible, install the stabilized construction entrance on the uphill side of the site so that stormwater will not pond near the stabilized construction entrance.
- Construction entrance associated with private parcel construction shall be located outside the City Right-of-Way.
- Construction entrance should avoid crossing existing sidewalks if possible. If a construction entrance must cross a sidewalk, the sidewalk must be covered and protected from sediment leaving the site.

1.4.4 Maintenance Standards

- Add quarry spalls or additional permeable ballast if the pad is no longer in accordance with the specifications.
- If the entrance is not preventing sediment from being tracked onto pavement, alternative measures to keep the streets free of sediment shall be used. This may include replacement of the stabilized construction entrance, street sweeping, an increase in the dimensions of the entrance, or the installation of a wheel wash.
- No tracking of sediment onto the roadway is allowed. If sediment is tracked onto the road, immediately clean the road thoroughly by shoveling or pickup sweeping. Transport sediment to a controlled sediment disposal area.
- Perform street sweeping by hand or with a high efficiency sweeper. Do not use a non-high efficiency mechanical sweeper because this creates dust and throws soils into storm systems or conveyance ditches.
- Keep streets clean at ALL times. Clean tracked sediment immediately.
- Street washing of sediment to the stormwater system is not allowed.
- If sediment is discharged to the stormwater system it is the responsibility of the applicant to clean the downstream system.
- Immediately remove any materials that are loosened from the pad and end up on the roadway.
- Install fencing if vehicles are entering or exiting the site at points other than the construction entrance(s).
- Upon project completion and site stabilization, permanently stabilize all construction accesses intended as permanent access for maintenance.

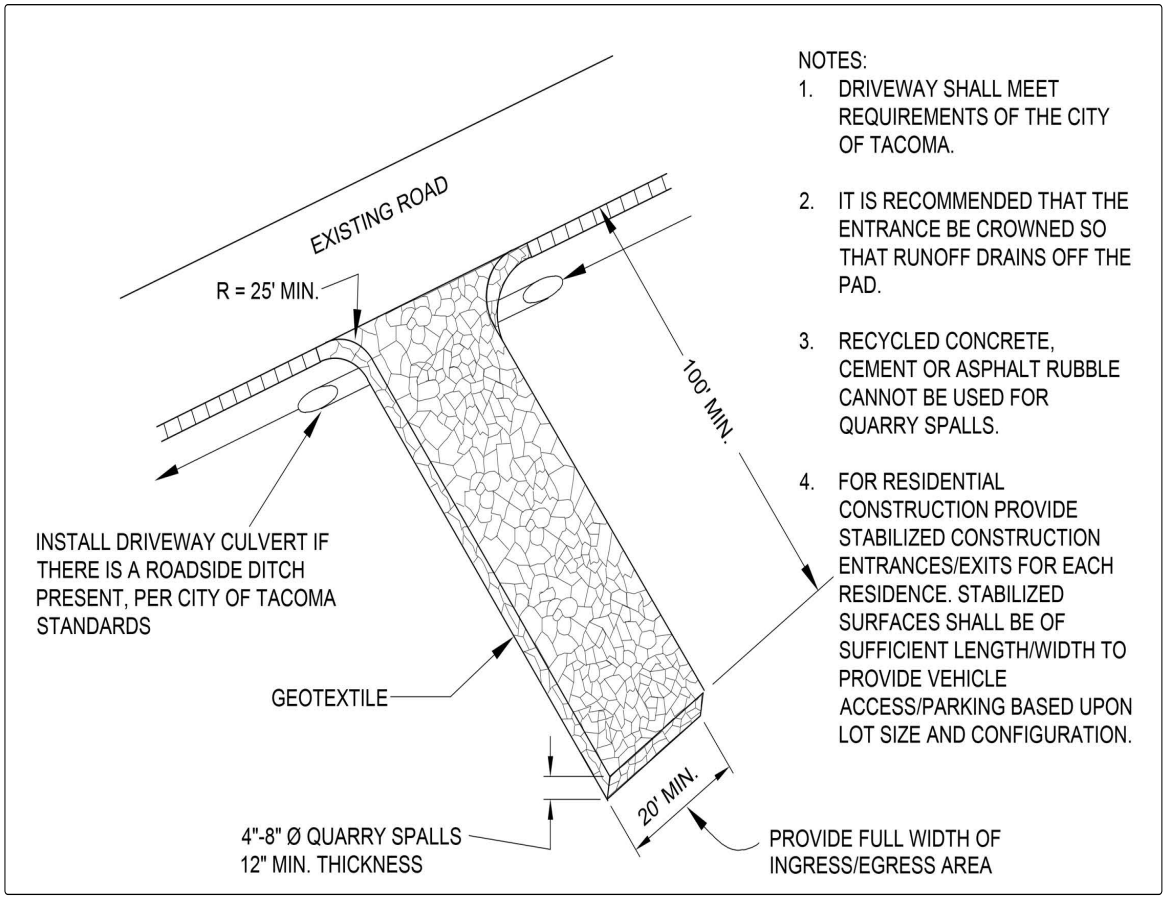


Figure 3 - 1: Stabilized Construction Entrance

1.5 BMP C106: Wheel Wash

1.5.1 Purpose

Wheel washes reduce the amount of sediment transported onto paved roads by washing sediment from the wheels of motor vehicles prior to the motor vehicle leaving the construction site.

1.5.2 Conditions of Use

- Can be used when a stabilized construction entrance (see BMP C105: Stabilized Construction Entrance/Exit) is not preventing sediment from being tracked onto pavement.
- Wheel washing is generally an effective BMP when installed with careful attention to topography. For example, a wheel wash can be detrimental if installed at the top of a slope abutting a right-of-way where the water from the dripping truck can run unimpeded into the street.
- Pressure washing combined with an adequately sized and surfaced pad with direct discharge to a large 10-foot x 10-foot sump can be very effective.
- Discharge wheel wash or tire bath wastewater to a separate onsite treatment system that prevents discharge to surface water or to the wastewater system with a City of Tacoma Special Approved Discharge permit.
- Consider using a closed-loop recirculation system to conserve water.
- Wheel wash or tire bath wastewater shall not include wastewater from concrete washout areas.

1.5.3 Design and Installation Specifications

- A minimum of 6 inches of asphalt treated base (ATB) over crushed base material or 8 inches over a good subgrade is recommended to pave the wheel wash.
- Use a low clearance truck to test the wheel wash before paving. Either a belly dump or lowboy will work well to test clearance.
- Keep the water level from 12 to 14 inches deep to avoid damage to truck hubs and filling the truck tongues with water.
- Figure 3 - 2: Wheel Wash provides a potential detail for a design of a wheel wash. The applicant is not required to construct the wheel wash per this detail.
    - An effective wheel wash will have:
        - A stabilized approach (pavement, permeable ballast, rumble plates) that is clear of exposed soil.
        - An appropriately sized wash deck that allows for at least one complete tire revolution (additional revolutions will be required for more cohesive soil)
        - Multiple angled spray patterns that reach all tires and the vehicle undercarriage
        - High-volume, moderate-pressure spray
        - Reasonably clear rinse water

    - A collection system for overspray and drip out
    - A stabilized egress (pavement, permeable ballast, rumble plates) that is clear of exposed soil.
- Midpoint spray nozzles are only needed in extremely muddy conditions.
- Polymers may be used to promote coagulation and flocculation in a closed-loop system. Polyacrylamide (PAM) added to the wheel wash water at a rate of 0.25 - 0.5 pounds per 1,000 gallons of water increases effectiveness and reduces cleanup time. If PAM is already being used for dust or erosion control and is being applied by a water truck, the same truck can be used to change the wash water.

1.5.4 Maintenance Standards

- The wheel wash should start out the day with fresh water.
- The wash water should be changed as necessary with a minimum of once per day. On large earthwork jobs where more than 10-20 trucks per hour are expected, the wash water will need to be changed more often.
- Wheel wash or tire bath wastewater shall be discharged to a separate onsite treatment system, such as closed-loop recirculation or land application, or to the wastewater system with a City of Tacoma Special Approved Discharge permit.

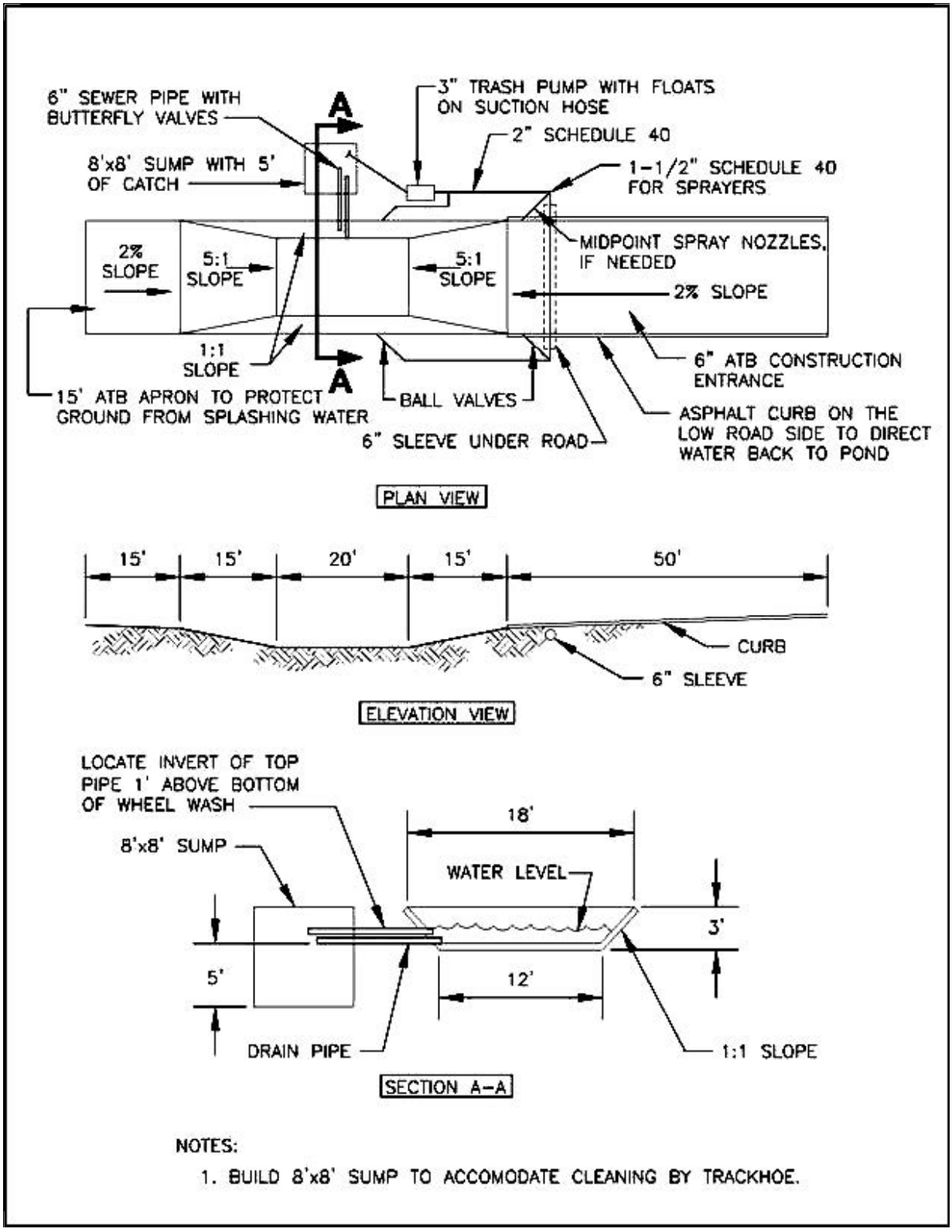


Figure 3 - 2: Wheel Wash

1.6 BMP C107: Construction Road/Parking Area Stabilization

1.6.1 Purpose

Stabilizing subdivision roads, parking areas and other onsite vehicle transportation routes immediately after grading reduces erosion caused by construction traffic or runoff.

1.6.2 Conditions of Use

- Stabilize roads or parking areas wherever they are constructed, whether permanent or temporary, for use by construction traffic.
- Install fencing (see BMP C103: High Visibility Fence), if necessary, to limit the access of vehicles to only those roads and parking areas that are stabilized.

1.6.3 Design and Installation Specifications

- On areas that will receive asphalt as part of the project, install the first lift as soon as possible.
- Use one of the following methods to stabilize the area immediately after grading or utility installation.
  - Pave the road/parking area.
  - Apply 6-inch depth of 2- to 4-inch crushed rock, gravel base, or crushed surfacing base course.
  - Apply a 4-inch course of asphalt treated base (ATB).
  - Apply cement or calcium chloride[1].
  - Apply a 6-inch depth of hog fuel (only if the area will not be used for permanent roads, parking areas or structures).
- Whenever possible, place construction roads and parking areas on a firm, compacted subgrade.
- Temporary road gradients shall not exceed 15 percent. Carefully grade roadways to ensure no water will pond on the roadway surface. Provide conveyance ditches on each side of the roadway in the case of a crowned section, or on one side in the case of a super-elevated section. Direct conveyance ditches to a sediment control BMP.
- Rather than relying on conveyance ditches, it may also be possible to grade the road so that runoff sheet flows into a heavily vegetated area with a well-developed topsoil. Landscaped areas are not adequate. If this area has at least 50 feet of vegetation, then it is generally preferable to use the vegetation to treat runoff, rather than a sediment pond or trap. The 50 feet shall not include wetlands. If runoff is allowed to sheetflow through adjacent vegetated areas, it is vital to design the roadways and parking areas so that no concentrated runoff is created.
- Protect stormwater system inlets to prevent sediment-laden water entering the stormwater system (see BMP C220: Stormwater System Inlet Protection).

1. If cement or cement kiln dust is used for roadbase stabilization, pH monitoring and BMPs are necessary to evaluate and minimize the effects on stormwater.

1.6.4 Maintenance Standards

- Inspect stabilized areas regularly, especially after large storm events.
- Add crushed rock, gravel base, hog fuel, etc. as required to maintain a stable driving surface and to stabilize any eroded areas.
- Following construction, restore all areas to preconstruction condition or better to prevent future erosion.
- No tracking of sediment onto the roadway is allowed. If sediment is tracked onto road, clean the road thoroughly by shoveling or pickup sweeping.

1.7 BMP C120: Temporary and Permanent Seeding

1.7.1 Purpose

Seeding reduces erosion by stabilizing exposed soils. A well-established vegetative cover is one of the most effective methods of reducing erosion.

1.7.2 Conditions of Use

- Seeding may be used throughout the project on disturbed areas that have reached final grade or that will remain unworked.
- Channels that will be vegetated should be installed before major earthwork and hydroseeded with a Bonded Fiber Matrix. The vegetation should be well established (i.e., 75 percent cover) before water is allowed to flow in the ditch. With channels that will have high flows, install erosion control blankets over the hydroseed. If vegetation cannot be established from seed before water is allowed in the ditch, sod should be installed in the bottom of the ditch over hydromulch and blankets.
- Seed detention ponds as required.
- Mulch is required at all times because it protects seeds from heat, moisture loss, and transport due to runoff.

  Mulch can be applied on top of the seed or simultaneously by hydroseeding. See BMP C121: Mulching for specifications.

- All disturbed areas shall be reviewed in late August to early September and all seeding shall be completed by the end of September. Otherwise, vegetation will not establish itself enough to provide more than average protection.
- At final site stabilization, seed and mulch all disturbed areas not otherwise vegetated or stabilized.

1.7.3 Design and Installation Specifications

- Seed during seasons most conducive to plant growth.
  - The optimum seeding windows for western Washington are April 1 through June 30 and September 1 through October 1.
  - Seeding that occurs between July 1 and August 30 will require irrigation until 75 percent grass cover is established.
  - Seeding that occurs between October 1 and March 30 will require a mulch or an erosion control blanket until 75 percent grass cover is established.
- To prevent seed from being washed away, confirm that all required surface water control measures have been installed.
- The seedbed should be firm and rough. All soil should be roughened no matter what the slope. If compaction is required for engineering purposes, track walk slopes before seeding. Backblading or smoothing of slopes greater than 4:1 is not allowed if they are to be seeded.
- New and more effective restoration-based landscape practices rely on deeper incorporation than that provided by a simple single-pass rototilling treatment. Wherever practical, the subgrade should be initially ripped to improve long-term permeability, infiltration, and water inflow qualities. At a minimum for permanent areas, use soil

amendments to achieve organic matter and permeability performance defined in engineered soil/landscape systems. For systems that are deeper than 8 inches, complete the rototilling process in multiple lifts, or prepare the soil system properly and then place it to achieve the specified depth.

- The use of fertilizers is discouraged. Fertilizers should only be used where necessary to ensure growth. Amending soils per BMP L613: Post-Construction Soil Quality and Depth should be considered (and may be required for permanent lawn and landscaped areas) as the first measure for ensuring vegetation growth. If fertilization is necessary, naturally-derived fertilizers should be chosen over chemically-derived fertilizers. Apply fertilizers per manufacturer's direction. Always use slow-release fertilizers.
- Hydroseed applications shall include a minimum of 1,500 pounds per acre of mulch with 3 percent tackifier. See BMP C121: Mulching for specifications.
- On steep slopes, Bonded Fiber Matrix (BFM) or Mechanically Bonded Fiber Matrix (MBFM) products should be used. BFM/MBFM products are applied at a minimum rate of 3,000 pounds per acre of mulch with approximately 10 percent tackifier. Application is made so that a minimum of 95 percent soil coverage is achieved. Numerous products are available commercially and should be installed per manufacturer's instructions. Most products require 24-36 hours to cure before a rainfall and cannot be installed on wet or saturated soils. Generally, these products come in 40-50 pound bags and include all necessary ingredients except for seed and fertilizer.
- BFMs and MBFMs have some advantages over blankets:
    - No surface preparation required;
    - Can be installed via helicopter in remote areas;
    - On slopes steeper than 2.5:1, blanket installers may need to be roped and harnessed for safety;
- In most cases, the shear strength of blankets is not a factor when used on slopes, only when used in channels. BFMs and MBFMs are good alternatives to blankets in most situations where vegetation establishment is the goal.
- When installing seed via hydroseeding operations, only about 1/3 of the seed actually ends up in contact with the soil surface. This reduces the ability to establish a good stand of grass quickly. One way to overcome this is to increase seed quantities by up to 50 percent.
- Vegetation establishment can also be enhanced by dividing the hydromulch operation into two phases:
    - Phase 1- Install all seed and fertilizer with 25-30 percent mulch and tackifier onto soil in the first lift;
    - Phase 2- Install the rest of the mulch and tackifier over the first lift.
- An alternative is to install the mulch, seed, fertilizer, and tackifier in one lift. Then, spread or blow straw over the top of the hydromulch at a rate of about 800-1000 pounds per acre. Hold straw in place with a standard tackifier. Both of these approaches will increase cost moderately but will greatly improve and enhance vegetative establishment. The increased cost may be offset by the reduced need for:
    - Irrigation
    - Reapplication of mulch
    - Repair of failed slope surfaces

  - This technique works with standard hydromulch (1,500 pounds per acre minimum) and BFM/MBFMs (3,000 pounds per acre minimum).

- Provide a healthy topsoil to areas to be permanently landscaped. This will reduce the need for fertilizers, improve overall topsoil quality, provide for better vegetal health and vitality, improve hydrologic characteristics, and reduce the need for irrigation. See the Post-Construction Soil Quality and Depth BMP in Volume 4 for more information. Compost shall meet specification in A900: Compost. City of Tacoma Tagro Potting Soil can be used as an alternative to the compost component. Areas that will be seeded only and not landscaped may need compost or meal-based mulch included in the hydroseed in order to establish vegetation. Replace native topsoil on the disturbed soil surface before application.
- Seed that is installed as a temporary measure may be installed by hand if it will be covered by straw, mulch, or topsoil. Seed that is installed as a permanent measure may be installed by hand on small areas (usually less than 1 acre) that will be covered with mulch, topsoil, or erosion blankets.
- Unless otherwise stated, seed mixes shall be applied at a rate of 120 pounds per acre. This rate may be reduced if soil amendments of slow-release fertilizers are used.
- See Table 3 - 2: Standard Temporary Erosion Control Seed Mix to Table 3 - 8: Native Wet Biofiltration Swale Seed Mix for recommended seed mixes. Seed mixes are also shown in A1000: Vegetation. Seed mix should be chosen based upon location, exposure, soil type, slope, and expected foot traffic. Alternative seed mixes may be used provided justification is provided for their use.
  - Table 3 - 2: Standard Temporary Erosion Control Seed Mix is a standard mix where only temporary vegetative cover is required.

Table 3 - 2: Standard Temporary Erosion Control Seed Mix

Scientific Name	Common Name	Percent By Weight
Festuca rubra var. commutata	Chewings fescue	40
Lolium perenne	perennial rye	40
Agrostis capillaris	colonial bentgrass	10
Trifolium repens	white Dutch clover	10

  - Table 3 - 3: Native Temporary Erosion Control Seed Mix is a mix made from native species that can be used where only temporary vegetative cover is required.

Table 3 - 3: Native Temporary Erosion Control Seed Mix

Scientific Name	Common Name	Percent By Weight
Bromus carinatus	California brome	25
Deschampsia caespitosa	Tufted hairgrass	15
Festuca rubra	native red fescue	20
Hordeum brachyantherum	meadow barley	40

- Table 3 - 4: Landscaping Seed Mix is a mix appropriate as a final vegetative cover for lawn areas.

Table 3 - 4: Landscaping Seed Mix

Scientific Name	Common Name	Percent By Weight
Lolium perenne	perennial rye	70
Festuca rubra var. commutata	Chewings fescue	30

- Table 3 - 5: Low Growing Turf Seed Mix is a mix appropriate for dry situations and requires little maintenance once established.

Table 3 - 5: Low Growing Turf Seed Mix

Scientific Name	Common Name	Percent By Weight
Festuca arundinaceae	dwarf tall fescue	45
Lolium perenne var. barclay	dwarf perennial rye	30
Festuca rubra	red fescue	20
Agrostis capillaris	colonial bentgrass	5

- Table 3 - 6: Native Meadow Seed Mix is a mix recommended for areas that will be maintained infrequently or not at all and where native plant colonization is desirable.

Table 3 - 6: Native Meadow Seed Mix

Scientific Name	Common Name	Percent By Weight
grasses		
Bromus carinatus	California brome	30
Deschampsia caespitosa	tufted hairgrass	10
Elymus glaucus	blue wildrye	10
Festuca roemerii	Roemer's fescue	20
perennials		
Achillea millefolium	yarrow	5
Eriophyllum lanatum	Oregon sunshine	5
Eschscholzia californica	California poppy	3
Lupinus bicolor	bicolor lupine	6
Solidago canadensis	Canada goldenrod	3
annuals		
Clarkia amoena	farewell to spring	5
Gilia capitata	globe gilia	3

◦ Table 3 - 7: Native Basic Biofiltration Swale Seed Mix represents a mix appropriate for intermittently wet areas.

Table 3 - 7: Native Basic Biofiltration Swale Seed Mix

Scientific Name	Common Name	Percent by Weight
Beckmannia syzigachne	American slough grass	5
Danthonia californica	California oat grass	5
Deschampsia caespitosa	tufted hairgrass	15
Elymus glaucus	blue wildrye	30
Glyceria occidentalis	western mannagrass	15
Hordeum brachyantherum	meadow barley	30

◦ Table 3 - 8: Native Wet Biofiltration Swale Seed Mix represents a mix appropriate for wet areas that are not regulated wetlands.

- Apply this mix at a rate of 60 pounds per acre.

Table 3 - 8: Native Wet Biofiltration Swale Seed Mix

Scientific Name	Common Name	Percent by Weight
Beckmannia syzigachne	American slough grass	10
Carex obnupta	slough sledge	40
Carex stipata	beaked sedge	5
Eleocharis palustris	common spikerush	5
Glyceria occidentalis	western mannagrass	20
Juncus patens	spreading rush	15
Scirpus microcarpus	small-fruited bullrush	5

1.7.4 Maintenance Standards

- Reseed any seeded areas that fail to establish at least 75 percent cover after 3 months of active growth following germination during the growing season (100 percent cover for areas that receive sheet or concentrated flows). If reseeding is ineffective, use an alternate method, such as sodding, mulching, or nets/blankets. If winter weather prevents adequate grass growth, this time limit may be relaxed at the discretion of the City.
- After adequate cover is achieved, reseed and protect with mulch any areas that experience erosion. If the erosion problem is stormwater and surface water related, the problem shall be fixed and the eroded area reseeded and protected by mulch.
- Water seeded areas if necessary. Watering shall not cause runoff.

1.8 BMP C121: Mulching

1.8.1 Purpose

The purpose of mulching soils is to provide immediate temporary protection from erosion. Mulch also enhances plant establishment by conserving moisture, holding fertilizer, seed, and topsoil in place, and moderating soil temperatures. Only the most common types are discussed in this section.

1.8.2 Conditions of Use

As a temporary cover measure, mulch should be used:

- On disturbed areas that require cover measures for less than 30 days.
- As a cover for seed.
- During the wet season on slopes steeper than 3H:1V with more than 10 feet of vertical relief.
- Mulch may be applied at any time of the year and must be refreshed periodically.
- Tackifiers shall be plant-based, such as guar or alpha plantago, or chemical-based such as poly-acrylamide or polymers.
- Install mulch or tackifier products per manufacturer's recommendations.

1.8.3 Design and Installation Specifications

- Mulch shall be compost, chipped site vegetation, hydro-mulch, wood-based mulch or wood straw, wood strand mulch, or straw. See Table 3 - 9: Mulch Standards and Guidelines for specifications, application rates, and additional information.
- A minimum of 2” of mulch is required. Increase the mulch thickness until the ground is 95% covered (not visible under the mulch). Thickness may need to increase for disturbed areas in or near sensitive or other areas susceptible to erosion.
- Mulch used within the ordinary high-water mark of surface waters should be selected to minimize potential flotation of organic matter. Compost has a higher specific gravities (densities) than straw, wood, or chipped material.

1.8.4 Maintenance Standards

- The thickness of the cover must be maintained.
- Remulch and/or protect with a net or blanket any areas that experience erosion. If the erosion problem is stormwater and surface water related, then fix the problem and remulch the eroded area.

Table 3 - 9: Mulch Standards and Guidelines

Compost

- Compost shall:
  - Meet the definition for "composted material" per WAC 173-350-100 and comply with standards in WAC 173-350-220, except the feedstock may contain biosolids or manure feedstocks.
  - Be coarse compost meeting the following size gradations (by dry weight) when tested in accordance with the U.S. Composting Council "Test Methods for the Examination of Compost and Composting" (TMECC) Test Method 02.02-B.

Sieve Size	Minimum Percent Passing
3"	100
1"	90
3/4"	70
¼"	40

  - Have no visible water or dust during handling.
  - Have soil organic matter content of 40% to 65%.
  - Have a carbon to nitrogen ratio below 25:1. Carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.
  - Be applied a minimum of 2" thick (~100 tons/acre) though thicker application rates may provide more effective control.
- Do not use near wetlands or phosphorus impaired waterbodies.
- Compost can be later tilled into soils to help meet the requirements of BMP L613: Post-Construction Soil Quality and Depth as required per Minimum Requirement #5.

Compost specifications are also contained in A900: Compost.

Chipped Site Vegetation

- Chipped site vegetation shall:
  - Have an average size of 2-4" with gradations from fine to 6" in length for texture, variation, and interlocking properties.
  - Be applied a minimum of 2" thick.
- Do not apply on slopes greater than 10%.
- Do not use within 200 feet of surface waterbodies.

Using chipped site vegetation is a cost-effective way to dispose of debris associated with clearing and grubbing material. The decomposition of the chipped vegetation may help impart nutrients for grass establishment.

Table 3 - 9: Mulch Standards and Guidelines

Hydro-mulch
• Hydro-mulch shall: ◦ Be applied with seed and tackifier. • May be applied without seed and tackifier if application rate is doubled. ◦ Have no growth inhibiting factors. ◦ Have fibers less than ¾" in length to ensure machinery does not clog. Be applied at 35-45 pounds per 1,000 sf or 1500-2000 pounds per acre with a hydromulcher.
Wood-based Mulch or Wood Straw
• Wood-based mulch or straw mulch shall: ◦ Have no visible water or dust during handling. ◦ Be purchased from a supplier with a Solid Waste Handling Permit or a supplier that is exempt from solid waste regulations. ◦ Be applied 2" thick (~100 tons/acre) • Wood-based mulch or wood straw is often called "hog" or "hogged fuel". The preparation of wood-based mulch typically does not account for weed seed control so the inclusion of weed plants or seeds should be monitored and minimized or prevented during application.
Wood Strand Mulch
• Wood strand mulch shall be: ◦ A blend of loose long, thin wood pieces derived from native conifers or deciduous trees with high length-width ratio. ◦ A minimum of 95% of the wood strand shall have lengths between 2" and 10" with a width and thickness between 1/16" and 3/8". ◦ Free of resin, tannin, or other compounds that are detrimental to plant establishment and growth. ◦ Applied 2" thick. Do not use sawdust or wood shavings.
Straw
• Straw shall be: ◦ Air-dried. ◦ Free from undesirable seed and coarse material. ◦ Applied 2"-3" thick (5 bales per 1000 ft^2 or 2-3 tons per acre) • Thickness may be reduced by half when used with seeding. • Hand-application requires a greater thickness than blown straw to ensure required coverage. ◦ Held in place by crimping, using a tackifier, or covering with netting. Blown straw shall be held in place using a tackifier. • Although straw can be cost-effect, straw can introduce and/or encourage weed species and has no long-term benefits so should only be used when other materials are unavailable. Do not used within the ordinary high-water elevation of surface waters (due to flotation).

1.9 BMP C122: Nets and Blankets

1.9.1 Purpose

Erosion control nets and blankets are intended to prevent erosion and hold seed and mulch in place on steep slopes and in channels so that vegetation can become well established. In addition, some nets and blankets can be used to permanently reinforce turf to protect conveyance ditches during high flows. Nets (commonly called matting) are strands of material woven into an open, but high-tensile strength net (for example, coconut fiber matting). Blankets are strands of material that are not tightly woven, but instead form a layer of interlocking fibers, typically held together by a biodegradable or photodegradable netting (for example, excelsior or straw blankets). They generally have lower tensile strength than nets, but cover the ground more completely. Coir (coconut fiber) fabric comes as both nets and blankets.

1.9.2 Conditions of Use

Erosion control netting and blankets shall be made of natural plant fibers unaltered by synthetic materials.

Erosion control nets and blankets should be used:

- To aid permanent vegetated stabilization of slopes 2H:1V or greater and with more than 10 feet of vertical relief.

For conveyance ditches and swales (highly recommended). The application of appropriate netting or blanket to conveyance ditches and swales can protect bare soil from channelized runoff while vegetation is established. Nets and blankets also can capture a great deal of sediment due to their open, porous structure. Synthetic nets and blankets can be used to permanently stabilize channels and may provide a cost-effective, environmentally preferable alternative to riprap. 100 percent synthetic blankets manufactured for use in conveyance ditches may be easily reused as temporary conveyance ditch liners.

Disadvantages of blankets include:

- Surface preparation required;
- On slopes steeper than 2.5:1, blanket installers may need to be roped and harnessed for safety;

Advantages of blankets include:

- Can be installed without mobilizing special equipment;
- Can be installed by anyone with minimal training;
- Can be installed in stages or phases as the project progresses;
- Seed and fertilizer can be hand-placed by the installers as they progress down the slope;
- Can be installed in any weather;
- There are numerous types of blankets that can be designed with various parameters in mind. Those parameters include: fiber blend, mesh strength, longevity, biodegradability, cost, and availability.

1.9.3 Design and Installation Specifications

- See Figure 3 - 3: Nets and Blankets – Slope Installation, and Figure 3 - 4: Nets and Blankets – Channel Installation, for typical orientation and installation of blankets used in channels and as slope protection.

  Note: These are typical only; all blankets must be installed per manufacturer's installation instructions.

- Installation is critical to the effectiveness of these products. If good ground contact is not achieved, runoff can concentrate under the product, resulting in significant erosion.

Installation of Blankets on Slopes:

- Complete final grade and track walk up and down the slope.
- Slope surface shall be free of rocks, clods, sticks and grass. Nets/blankets shall have good contact with the soil.
- Apply permanent seeding per BMP C120: Temporary and Permanent Seeding or mulching per BMP C121: Mulching before placing net/blanket.
- Dig a small trench, approximately 12 inches wide by 6 inches deep along the top of the slope. Cover with soil to secure.
- Install the leading edge of the blanket into the small trench, backfill the trench with soil and staple approximately every 18 inches. Staples are metal. "U"-shaped, and a minimum of 6 inches long. Longer staples are used in sandy soils. Biodegradable stakes are also available and should be used where applicable.
- Roll the blanket slowly down the slope as the installer walks backwards. The blanket rests against the installer's legs. Staples are installed as the blanket is unrolled. It is critical that the proper staple pattern in used for the blanket being installed. The blanket should not be allowed to roll down the slope on its own as this stretches the blanket, making it impossible to maintain soil contact. In addition, no one should be allowed to walk on the blanket after it is in place.
- If the blanket is not long enough to cover the entire slope length, the trailing edge of the upper blanket should overlap the leading edge of the lower blanket and be stapled. On steeper slopes, this overlap should be installed in a small trench, covered with soil and stapled.
- With the variety of products available, it is impossible to cover all the details of appropriate use and installation. Therefore, it is critical that the design engineer consults the manufacturer's information and that a site visit takes place in order to ensure that the product specified is appropriate.
- Jute matting must be used in conjunction with mulch (BMP C121: Mulching). Excelsior, woven straw blankets, and coir (coconut fiber) blankets may be installed without mulch. There are many other types of erosion control nets and blankets on the market that may be appropriate in certain circumstances.
- In general, most nets (e.g., jute matting) require mulch in order to prevent erosion because they have a fairly open structure. Blankets typically do not require mulch because they usually provide complete protection of the surface.
- Extremely steep, unstable, wet, or rocky slopes are often appropriate candidates for use of synthetic blankets, as are riverbanks, beaches, and other high-energy environments. If synthetic blankets are used, the soil should be hydromulched first.

- 100 percent biodegradable blankets are available for use in sensitive areas. These organic blankets are usually held together with a paper or fiber mesh and stitching which may last up to a year.
- Most netting used with blankets is photodegradable, meaning it will break down under sunlight (not UV stabilized). However, this process can take months or years even under bright sun. Once vegetation is established, sunlight does not reach the mesh. It is not uncommon to find non-degraded netting still in place several years after installation. This can be a problem if maintenance requires the use of mowers or ditch cleaning equipment. In addition, birds and small animals can become trapped in the netting.

1.9.4 Maintenance Standards

- Good contact with the ground must be maintained, and erosion must not occur beneath the net or blanket.
- Repair or staple any areas of the net or blanket that are damaged or not in close contact with the ground.
- If erosion occurs due to poorly controlled stormwater and surface water, fix the problem and protect the eroded area.

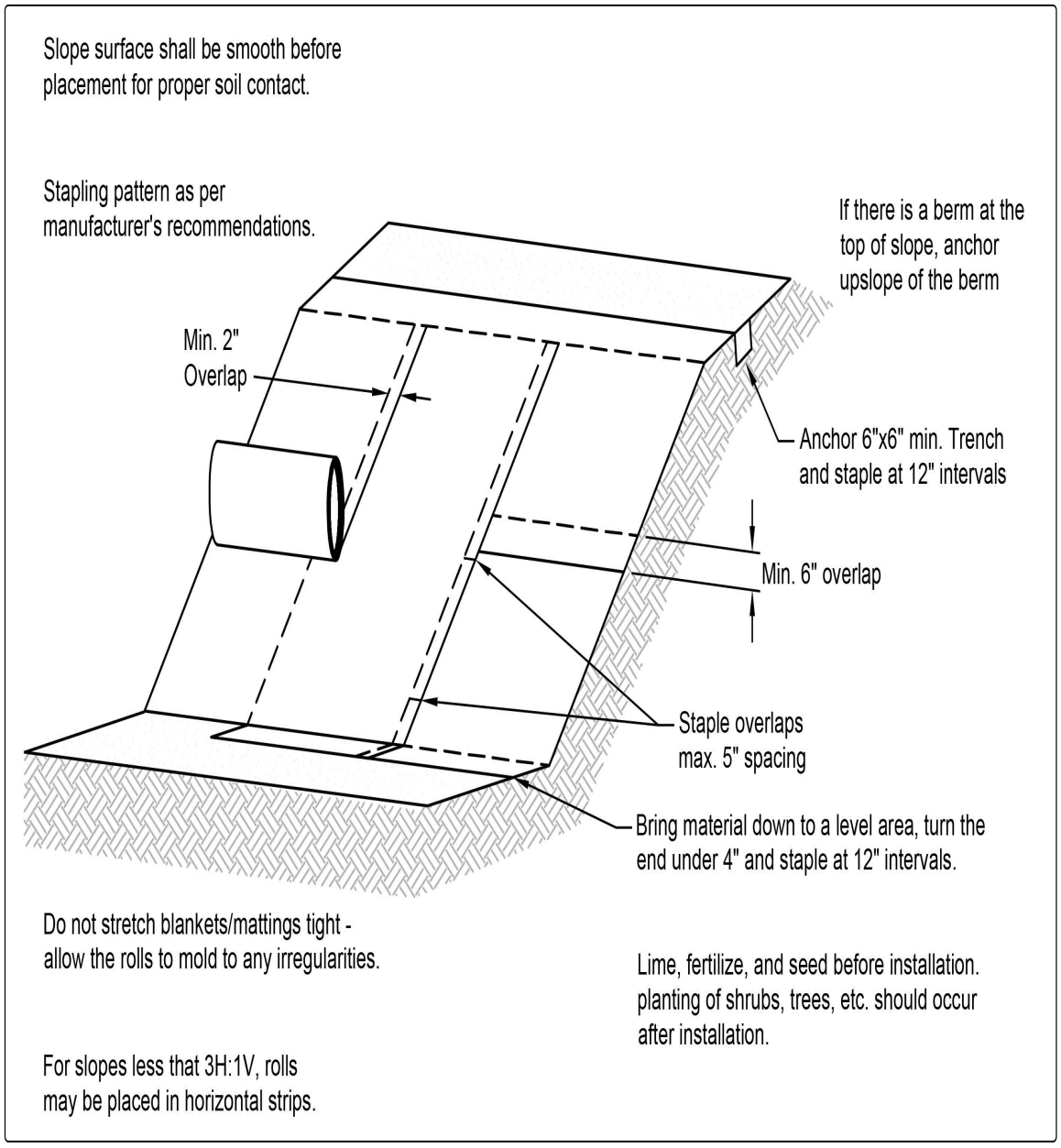


Figure 3 - 3: Nets and Blankets – Slope Installation

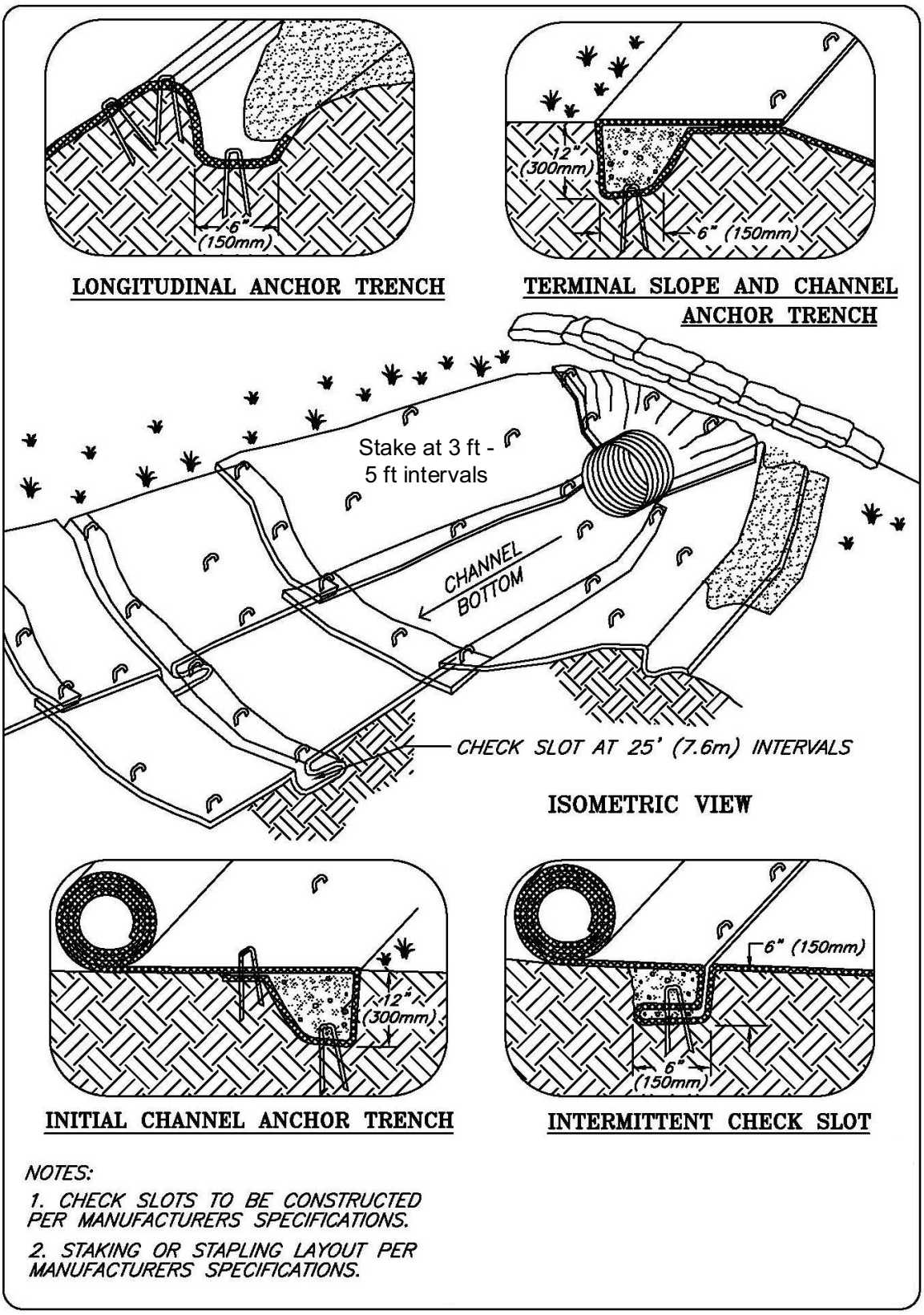


Figure 3 - 4: Nets and Blankets – Channel Installation

1.10 BMP C123: Plastic Covering

1.10.1 Purpose

Plastic covering provides immediate, short-term erosion protection to slopes and disturbed areas.

1.10.2 Conditions of Use

- Plastic covering may be used on disturbed areas that require cover measures for less than 30 days, except as stated below.
- Plastic is particularly useful for protecting cut and fill slopes and stockpiles.
- The relatively rapid breakdown of most polyethylene sheeting makes it unsuitable for long-term (greater than six months) applications.
- Due to rapid runoff caused by plastic covering, this method shall not be used upslope of areas that might be adversely impacted by concentrated runoff. Such areas include steep and/or unstable slopes.
- Whenever plastic is used to protect slopes, water collection measures must be installed at the base of the slope. These measures include plastic-covered berms, channels, and pipes used to convey clean rainwater away from bare soil and disturbed areas. At no time is clean runoff from a plastic covered slope to be mixed with dirty runoff from a project.
- Other uses for plastic include:
  - Temporary ditch liner;
  - Pond liner in temporary sediment pond;
  - Liner for bermed temporary fuel storage area if plastic is not reactive to the type of fuel being stored;
  - Emergency slope protection during heavy rains; and
  - Temporary conveyance used to direct stormwater and surface water.

1.10.3 Design and Installation Specifications

Plastic slope cover must be installed as follows:

- Run plastic up and down slope, not across slope.
- Plastic may be installed perpendicular to a slope if the slope length is less than 10 feet.
- Minimum of 8-inch overlap at seams.
- On long or wide slopes, or slopes subject to wind, all seams should be taped.
- Place plastic into a small (12-inch wide by 6-inch deep) slot trench at the top of the slope and backfill with soil to keep water from flowing underneath.
- Place sand filled burlap or geotextile bags every 3 to 6 feet along seams and pound a wooden stake through each to hold them in place. Alternative options for holding plastic in place exist and may be considered with COT approval.
- Inspect plastic for rips, tears, and open seams regularly and repair immediately. This prevents high velocity runoff from contacting bare soil, which causes extreme erosion;
- Plastic sheeting shall have a minimum thickness of 6 mil.

- If erosion at the toe of a slope is likely, a gravel berm, riprap, or other suitable protection shall be installed at the toe of the slope in order to reduce the velocity of runoff.

1.10.4 Maintenance Standards

- Torn sheets must be replaced and open seams repaired.
- If the plastic begins to deteriorate due to ultraviolet radiation, it must be completely removed and replaced.
- When the plastic is no longer needed, it shall be completely removed.
- Properly dispose of products used to weigh down covering.

1.11 BMP C124: Sodding

1.11.1 Purpose

The purpose of sodding is to establish turf for immediate erosion protection and to stabilize conveyance systems where concentrated overland flow will occur.

1.11.2 Conditions of Use

Sodding may be used in the following areas:

- Disturbed areas that require short-term or long-term cover.
- Disturbed areas that require immediate vegetative cover.
- All waterways that require vegetative lining. Waterways may also be seeded rather than sodded, and protected with a net or blanket.

1.11.3 Design and Installation Specifications

Sod shall be free of weeds, of uniform thickness (approximately 1-inch thick), and shall have a dense root mat for mechanical strength.

The following steps are recommended for sod installation:

- Shape and smooth the surface to final grade in accordance with the approved grading plan. Overexcavate areas as needed to allow room for placing soil amendment and sod.
- Amend 4 inches (minimum) of compost into the top 8 inches of the soil if the organic content of the soil is less than ten percent or the infiltration rate is less than 0.6 inches per hour. Compost used shall:
    - Meet the definition for “composted material” per WAC 173-350-100 and comply with standards in WAC 173-350-220, except the feedstock may contain biosolids or manure feedstocks.
    - Have no visible water or dust during handling.
    - Have soil organic matter content of 40% to 65%.
    - Have a carbon to nitrogen ratio below 25:1. Carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.

      City of Tacoma Tagro Potting Soil can be used as an alternative to the compost component in BMP C124: Sodding.
- Fertilize according to the supplier's recommendations.
- Work lime and fertilizer 1 to 2 inches into the soil, and smooth the surface.
- Lay strips of sod beginning at the lowest area to be sodded and perpendicular to the direction of water flow. Wedge strips securely into place. Square the ends of each strip to provide for a close, tight fit. Stagger joints at least 12 inches. Staple on slopes steeper than 3H:1V. Staple the upstream edge of each sod strip.
- Roll the sodded area and irrigate.
- When sodding is carried out in alternating strips or other patterns, seed the areas between the sod immediately after sodding.

1.11.4 Maintenance Standards

If the grass is unhealthy, the cause shall be determined and appropriate action taken to reestablish a healthy groundcover. If it is impossible to establish a healthy groundcover due to frequent saturation, instability, or some other cause, the sod shall be removed, the area seeded with an appropriate mix, and protected with a net or blanket.

1.12 BMP C125: Compost

1.12.1 Purpose

The purpose of compost is to help establish vegetation and filter stormwater thus removing fine sediment and other contaminants. Compost can be used alone as a compost blanket, as a berm, or inside a sock.

1.12.2 Conditions of Use

- Do not use if stormwater will discharge to a nutrient sensitive waterbody.
- Do not use as a stormwater system inlet protection measure.

1.12.3 Design and Installation Specifications

- Compost shall:
  - Meet the definition for “composted material” per WAC 173-350-100 and comply with standards in WAC 173-350-220, except the feedstock may contain biosolids or manure feedstocks.
  - Be coarse compost meeting the following size gradations (by dry weight) when tested in accordance with the U.S. Composting Council “Test Methods for the Examination of Compost and Composting” (TMECC) Test Method 02.02-B.

Sieve Size	Minimum Percent Passing
3”	100
1”	90
3/4”	70
¼”	40

  - Have no visible water or dust during handling.
  - Have soil organic matter content of 40% to 65%.
  - Have a carbon to nitrogen ratio below 25:1. Carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.
- Do not use near wetlands or phosphorus impaired waterbodies.
- Compost can be later tilled into soils to help meet the requirements of BMP L613: Post-Construction Soil Quality and Depth as required per Minimum Requirement #5.

City of Tacoma TAGRO Potting Soil can be used as an alternative to the compost component in BMP C125: Compost.

Compost specifications are also contained in A900: Compost.

Compost Blankets

Compost blankets are simply compost blanketed over an area.

- Place compost 3” thick.
- Compost can be blown onto slopes up to 2:1 or spread by hand on shallower slopes.
- Compost can be mixed with a seed mix to ensure rapid vegetation.

- Compost does not need to be removed after construction phase unless required by the Erosion and Sediment Control Lead.

Compost Berms

Compost berms are a perimeter sediment control that can be used instead of silt fence.

- Do not use compost berms on steep slopes.
- Berm width shall be a minimum of 2 feet.
- Berm height shall be a minimum of 12 inches.
- Berm width shall be twice the berm height.

Compost can be blown in place or placed by front-end loader.

Compost should be spread over proposed landscaped section when construction is complete to aid in revegetation.

Compost Socks

Compost socks are similar to straw wattles.

- Sock material that is biodegradable will last up to 6 months and can be used for soil amendment after 6 months.
- Sock material that is non-biodegradable must be removed after construction is complete.
- Place socks perpendicular to flow.
- Walk socks in place to ensure good soil contact.
- Install wooden stakes every 12” on steep slopes or every 24” on shallow slopes

1.12.4 Maintenance Standards

Compost Blankets

- Inspect compost regularly.
- Ensure a 3” thick blanket.

Compost Berms

- Inspect compost berm regularly.
- Ensure vehicular traffic does not cross berm and track compost offsite. If this occurs, sweep compost immediately.

Compost Socks

- Do not allow erosion or concentrated runoff under or around the barrier.
- Inspect the socks after each rainfall and repair any socks that tear or are not abutting the ground.

1.13 BMP C126: Topsoiling

1.13.1 Purpose

To provide a suitable growth medium for final site stabilization with vegetation. While not a permanent cover practice in itself, topsoiling is an integral component of providing permanent cover in those areas where there is an unsuitable soil surface for plant growth. Native soils and disturbed soils that have been organically amended not only retain much more stormwater, but they also serve as effective biofilters for urban pollutants and, by supporting more vigorous plant growth, reduce the amount of water, fertilizer, and pesticides needed to support installed landscapes. Topsoil does not include any subsoils, only the material from the top several inches, including organic debris.

Use this BMP in conjunction with other BMPs such as seeding, mulching, or sodding. This BMP is functionally equivalent to BMP L613: Post-Construction Soil Quality and Depth which is required per Minimum Requirement #5: Onsite Stormwater Management for disturbed areas that will be developed as lawn or landscaped areas at the completed project.

1.13.2 Conditions of Use

- Permanent landscaped areas shall contain healthy topsoil that reduces the need for fertilizers, improves overall topsoil quality, provides for better vegetal health and vitality, improves hydrologic characteristics, and reduces the need for irrigation.
- Leave native soils and the duff layer undisturbed to the maximum extent practicable.
- To the maximum extent practical, native soils disturbed during clearing and grading shall be restored to a condition equal to or better than the original site condition's moisture-holding capacity. Use onsite native topsoil, incorporate amendments into onsite soil, or import blended topsoil to meet this requirement.
- Topsoiling is a required procedure when establishing vegetation on shallow soils, and soils of critically low pH (high acid) levels.
- Stripping of the existing, properly functioning soil system and vegetation for the purpose of topsoiling during construction is not acceptable. If an existing soil system is functioning properly, it shall be preserved in its undisturbed and uncompacted condition.
- Depending on where the topsoil comes from, or what vegetation was onsite before disturbance, invasive plant seeds may be included and could cause problems for establishing native plants, landscaped areas, or grasses.
- Topsoil from the site will contain mycorrhizal bacteria that are necessary for healthy root growth and nutrient transfer. These native mycorrhizae are acclimated to the site and will provide optimum conditions for establishing grasses. Commercially available mycorrhizae products should be used when topsoil is brought in from offsite.

1.13.3 Design and Installation Specifications

If topsoiling is to be done, the following items should be considered:

- Topsoil shall have:
  - A minimum depth of 8-inches. Scarify subsoils below the topsoil layer at least 4-inches with some incorporation of the upper material to avoid stratified layers, where feasible. Ripping or restructuring the subgrade may also provide additional benefits regarding the overall infiltration and interflow dynamics of the soil system.

- A minimum organic content of 10% dry weight in planting beds, and 5% organic matter content in turf areas. Incorporate organic amendments to a minimum 8-inch except where tree roots or other natural features limit the depth of incorporation.
- A pH between 6.0 and 8.0 or matching the pH of the undisturbed soil.

- To obtain a topsoil meeting the above specifications return native topsoil to the site, import topsoil of sufficient organic content, and/or incorporate organic amendments:
  - To meet the organic content requirements, the compost shall:
    - Meet the definition for “composted material” per WAC 173-350-100 and comply with standards in WAC 173-350-220, except the feedstock may contain biosolids or manure feedstocks.
    - Have no visible water or dust during handling.
    - Have soil organic matter content of 40% to 65%.
    - Have a carbon to nitrogen ratio below 25:1. Carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.

      City of Tacoma TAGRO Topsoil Mix can be used as an alternative to the compost component in BMP C125: Compost.
  - For till soils use a mixture of approximately two parts soil to one part compost. This equates to 4 inches of compost mixed to a depth of 12 inches in till soils. Increasing the concentration of compost beyond this level can have negative effects on vegetal health, while decreasing the concentrations can reduce the benefits of amended soils.
- Mulch planting beds with 2” of organic material.
- If blended topsoil is imported, fines should be limited to 25 percent passing through a 200 sieve.
- The final composition and construction of the soil system will result in a natural selection or favoring of certain plant species over time. For example, recent practices have shown that incorporation of topsoil may favor grasses, while layering with mildly acidic, high-carbon amendments may favor more woody vegetation.
- Locate the topsoil stockpile so it meets specifications and does not interfere with work on the site. It may be possible to locate more than one pile in proximity to areas where topsoil will be used.
- Allow sufficient time in scheduling for topsoil to be spread prior to seeding, sodding, or planting.
- Do not place topsoil while in a frozen or muddy condition, when the subgrade is excessively wet, or when conditions exist that may otherwise be detrimental to proper grading or proposed sodding or seeding.
- Care must be taken not to apply topsoil over subsoil if the two soils have contrasting textures. Sandy topsoil over clayey subsoil is a particularly poor combination, as water creeps along the junction between the soil layers and causes the topsoil to slough.
- If topsoil and subsoil are not properly bonded, water will not infiltrate the soil profile evenly and it will be difficult to establish vegetation. The best method to prevent a lack of bonding is to work the topsoil into the layer below for a depth of at least 6 inches.

- Field exploration of the site shall be made to determine if there is surface soil of sufficient quantity and quality to justify stripping. Topsoil shall be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, clay loam). Areas of natural groundwater recharge should be avoided.
- Confine stripping to the immediate construction area. A 4- to 6- inch stripping depth is common, but depth may vary depending on the particular soil. Place all surface runoff control structures in place prior to stripping.

Stockpile topsoil in the following manner:

- Side slopes of the stockpile shall not exceed 2:1.
- Surround all topsoil stockpiles between October 1 and April 30 with an interceptor dike with gravel outlet and silt fence. Between May 1 and September 30, install an interceptor dike with gravel outlet and silt fence if the stockpile will remain in place for a longer period of time than active construction grading.
- Complete erosion control seeding or covering with clear plastic or other mulching materials of stockpiles within 2 days (October 1 through April 30) or 7 days (May 1 through September 30) of the formation of the stockpile. Do not cover native topsoil stockpiles with plastic.
- Topsoil shall not be placed while in a frozen or muddy condition, when the subgrade is excessively wet, or when conditions exist that may otherwise be detrimental to proper grading or proposed sodding or seeding.
- Maintain previously established grades on the areas to be topsoiled according to the approved plan.
- When native topsoil is to be stockpiled and reused, the following should apply to ensure that the mycorrhizal bacterial, earthworms, and other beneficial organisms will not be destroyed:
  - Topsoil is to be re-installed within 4 to 6 weeks;
  - Topsoil is not to become saturated with water;
  - Plastic cover is not allowed.

1.13.4 Maintenance Standards

- Inspect stockpiles regularly, especially after large storm events. Stabilize any areas that have eroded.
- Establish soil quality and depth toward the end of the construction. Once established, protect from compaction and erosion.
- Plant and mulch soil after installation.
- Leave plant debris or its equivalent on the soil surface to replenish organic matter.
- Reduce and adjust, where possible, the use of irrigation, fertilizers, herbicides and pesticides, rather than continuing to implement formerly established practices.

1.14 BMP C127: Polyacrylamide for Soil Erosion Protection

1.14.1 Purpose

Polyacrylamide (PAM) is used on construction sites to prevent soil erosion.

Applying PAM to bare soil in advance of a rain event significantly reduces erosion and controls sediment in two ways. PAM helps maintain soil structure, which increases the ability to infiltrate.

1.14.2 Conditions of Use

Do not apply PAM directly to water or allow it to enter a waterbody. In areas that drain to a sediment pond, PAM can be applied to bare soil under the following conditions:

- During rough grading operations.
- In staging areas.
- In balanced cut and fill earthwork.
- On haul roads prior to placement of crushed rock surfacing.
- On compacted soil roadbase.
- At stockpiles.
- After final grade and before paving or final seeding and planting.
- At pit sites.
- At sites having a winter shut down. In the case of winter shut down, or where soil will remain unworked for several months, PAM should be used together with mulch.

1.14.3 Design and Installation Specifications

PAM may be applied in dissolved form with water, or it may be applied in dry, granular or powdered form. The preferred application method is the dissolved form.

PAM is to be applied at a maximum rate of 2/3 pound PAM per 1,000 gallons water (80 mg/L) per 1 acre of bare soil. Higher concentrations of PAM do not provide any additional effectiveness.

The Preferred Method:

- Pre-measure the area where PAM is to be applied and calculate the amount of product and water necessary to provide coverage at the specified application rate (2/3 pound PAM per 1,000 gallons per acre).
- PAM is water soluble, but dissolves very slowly. Dissolve pre-measured dry granular PAM with a known quantity of clean water in a bucket several hours or overnight. Mechanical mixing will help dissolve the PAM. Always add PAM to water - not water to PAM.
- Pre-fill the water truck about 1/8 full with water. The water does not have to be potable, but it must have relatively low turbidity – in the range of 20 NTU or less.
- Add PAM and water mixture to the truck.
- Completely fill the water truck to specified volume.
- Spray PAM and water mixture onto dry soil until the soil surface is uniformly and completely wetted.

An Alternate Method:

PAM may also be applied as a powder at the rate of 5 pounds per acre. This must be applied on a day that is dry. For areas less than 5 to 10 acres, a hand-held “organ grinder” fertilizer spreader set to the smallest setting will work. Tractor-mounted spreaders will work for larger areas.

Benefits and Limitations:

The following benefits and limitations should be considered:

- PAM shall be used in conjunction with other BMPs and not in place of other BMPs.
- Do not use PAM on a slope that flows directly into a stream or wetland or any other waterbody.
- PAM has little to no effect on sandy soils with little clay content.
- Do not add PAM to water discharging from site.
- The total number of sediment control BMPs used shall be maximized to achieve the greatest amount of settlement of sediment prior to discharging from the site.
- On all sites, use silt fences to limit the discharges of sediment from the site.
- Cover and protect all areas not being actively worked from rainfall. PAM shall not be the only cover BMP used.
- PAM can be applied to wet soil, but dry soil is preferred due to less sediment loss.
- PAM will work when applied to saturated soil but is not as effective as applications to dry or damp soil.
- Keep the granular PAM supply out of the sun. Granular PAM loses its effectiveness in three months after exposure to sunlight and air.
- Proper application and re-application plans are necessary to ensure total effectiveness of PAM usage.
- PAM, combined with water, is very slippery and can be a safety hazard. Care must be taken to prevent spills of PAM powder onto paved surfaces. During an application of PAM, prevent over-spray from reaching pavement, as pavement will become slippery. If PAM powder gets on skin or clothing, wipe it off with a rough towel rather than washing with water, which makes cleanup messier and take longer.
- Some PAMs are more toxic and carcinogenic than others. Only the most environmentally safe PAM products should be used.
- The specific PAM copolymer formulation must be anionic. **Cationic PAM shall not be used in any application because of known aquatic toxicity problems.** Only the highest drinking water grade PAM, certified for compliance with ANSI/NSF Standard 60 for drinking water treatment, will be used for soil applications. PAM use shall be reviewed and approved by the City. The Washington State Department of Transportation (WDSDOT) has listed approved PAM products on its web page: https://wsdot.wa.gov/Business/MaterialsLab/QPL.htm
- PAM designated for these uses should be "water soluble", "linear", or "non-crosslinked". Cross-linked or water absorbent PAM, polymerized in highly acidic (pH<2) conditions, are used to maintain soil moisture content.
- The PAM anionic charge density may vary from 2 to 30 percent; a value of 18 percent is typical. Studies conducted by the United States Department of Agriculture (USDA)/ARS

demonstrated that soil stabilization was optimized by using very high molecular weight (12-15 mg/mole), highly anionic (>20% hydrolysis) PAM.

- PAM tackifiers are available and being used in place of guar and alpha plantago. Typically, PAM tackifiers should be used at a rate of no more than 0.5 to 1 pounds per 1,000 gallons of water in a hydromulch machine. Some tackifier product instructions say to use at a rate of 3 to 5 pounds per acre, which can be too much. In addition, pump problems can occur at higher rates due to increased viscosity.

1.14.4 Maintenance Standards

- PAM may be reapplied on actively worked areas after a 48-hour period.
- Reapplication is not required unless PAM treated soil is disturbed or turbidity levels show the need for an additional application. If PAM treated soil is left undisturbed, a reapplication may be necessary after two months. When PAM is applied first to bare soil and then covered with straw, a reapplication may not be necessary for several months.
- Loss of sediment and PAM may be a basis for penalties per RCW 90.48.080.

1.15 BMP C130: Surface Roughening

1.15.1 Purpose

Surface roughening aids in the establishment of vegetative cover, reduces runoff velocity, increases infiltration, and provides for sediment trapping through the provision of a rough soil surface. Horizontal depressions are created by operating a tiller or other suitable equipment on the contour or by leaving slopes in a roughened condition by not fine grading them.

1.15.2 Conditions for Use

- All slopes steeper than 3H:1V and greater than 5 vertical feet require surface roughening.
- Areas with grades steeper than 3H:1V should be roughened to a depth of 2 to 4 inches prior to seeding.
- Areas that will not be stabilized immediately may be roughened to reduce runoff velocity until seeding takes place.
- Slopes with a stable rock face do not require roughening.
- Slopes where mowing is planned should not be excessively roughened.

1.15.3 Design and Installation Specifications

- There are different methods for achieving a roughened soil surface on a slope, and the selection of an appropriate method depends upon the type of slope. Roughening methods include stair-step grading, grooving, contour furrows, and tracking. See Figure 3 - 5: Surface Roughening by Tracking and Contour Furrows for tracking and contour furrows. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether the slope is formed by cutting or filling.
- Disturbed areas that will not require mowing may be stair-step graded, grooved, or left rough after filling.
- Stair-step grading is particularly appropriate in soils containing large amounts of soft rock. Each "step" catches material that sloughs from above, and provides a level site where vegetation can become established. Stairs should be wide enough to work with standard earth moving equipment. Stair steps must be on contour or gullies will form on the slope.
- Areas that will be mowed (these areas should have slopes less steep than 3:1) may have small furrows left by disking, harrowing, raking, or seed-planting machinery operated on the contour.
- Graded areas with slopes greater than 3:1 but less than 2:1 should be roughened before seeding. This can be accomplished in a variety of ways, including "track walking," or driving a crawler tractor up and down the slope, leaving a pattern of cleat imprints parallel to slope contours.
- Tracking is done by operating equipment up and down the slope to leave horizontal depressions in the soil.

1.15.4 Maintenance Standards

- Areas that are graded in this manner should be seeded as quickly as possible.
- Regular inspections should be made of the area. If rills appear, they should be re-graded and re-seeded immediately.

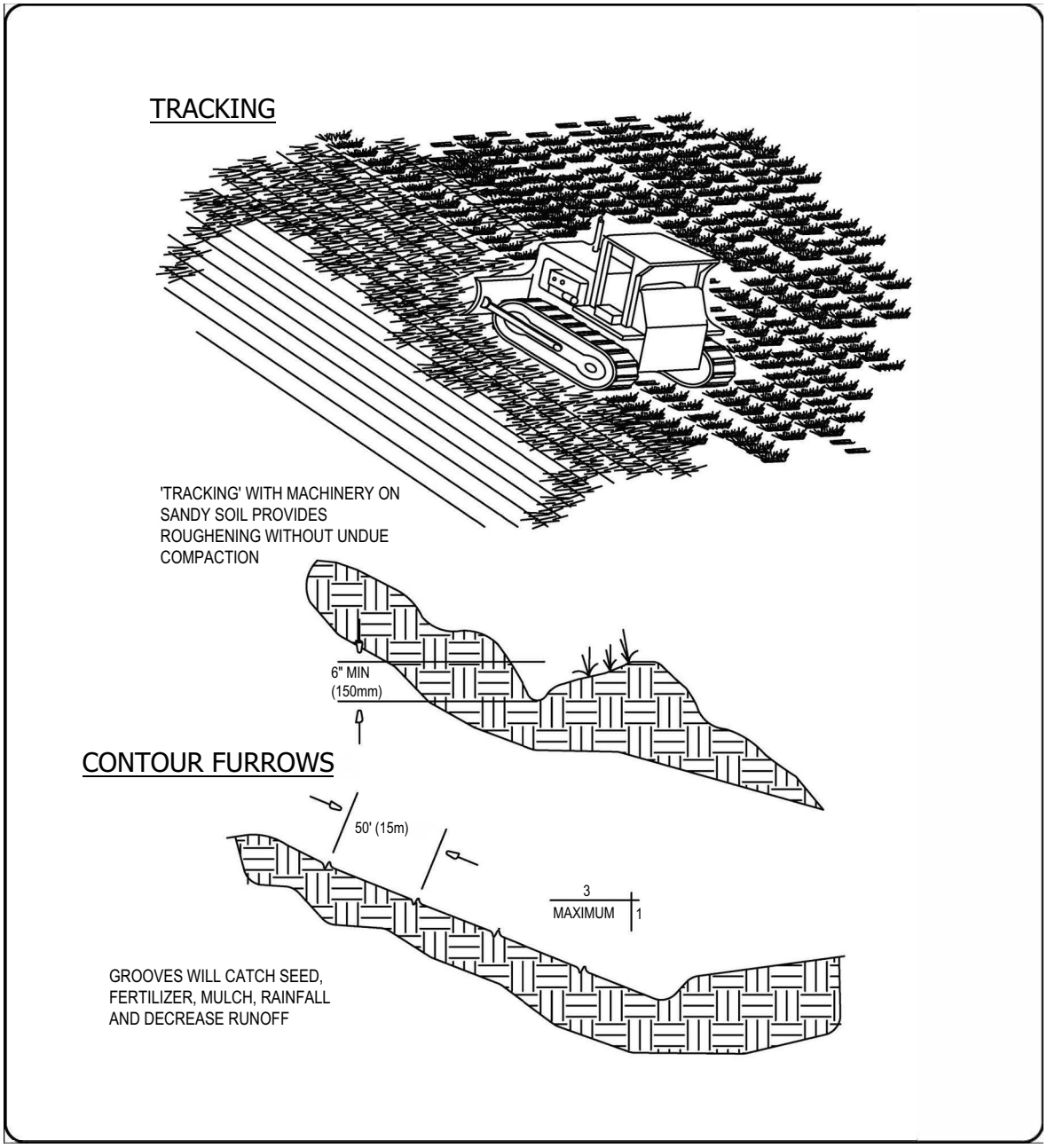


Figure 3 - 5: Surface Roughening by Tracking and Contour Furrows

1.16 BMP C131: Gradient Terraces

1.16.1 Purpose

Gradient terraces reduce erosion damage by intercepting surface runoff and conveying it to a stable outlet at a non-erosive velocity.

1.16.2 Conditions of Use

Gradient terraces normally are limited to denuded land having a water erosion problem. They should not be constructed on deep sands or on soils that are too stony, steep, or shallow to permit practical and economical installation and maintenance. Gradient terraces may be used only where suitable outlets are or will be made available. See Figure 3 - 6: Gradient Terraces for gradient terraces.

1.16.3 Design and Installation Specifications

The maximum vertical spacing of gradient terraces should be determined by the following method:

$$VI = (0.8)s + y$$

Where:

VI = vertical interval in feet

s = land rise per 100 feet, expressed in feet

y = a soil and cover variable with values from 1.0 to 4.0

Values of “y” are influenced by soil erodibility and cover practices. The lower values are applicable to erosive soils where little to no residue is left on the surface. The higher value is applicable only to erosion-resistant soils where a large amount of residue (1½ tons of straw/acre equivalent) is on the surface.

- The minimum constructed cross-section should meet the design dimensions.
- The top of the constructed ridge should not be lower at any point than the design elevation plus the specified overfill for settlement. The opening at the outlet end of the terrace should have a cross section equal to that specified for the terrace channel.
- Channel grades may be either uniform or variable with a maximum grade of 0.6 feet per 100 feet length. For short distances, terrace grades may be increased to improve alignment. The channel velocity should not exceed that which is non-erosive for the soil type with the planned treatment.
- All gradient terraces should have adequate outlets. Such an outlet may be a grassed waterway, vegetated area, or tile outlet. In all cases, the outlet must convey runoff from the terrace or terrace system to a point where the outflow will not cause damage. Vegetative cover should be used in the outlet channel.
- The design elevation of the water surface of the terrace should not be lower than the design elevation of the water surface in the outlet at their junction, when both are operating at design flow.

- Vertical spacing determined by the above methods may be increased as much as 0.5 feet or 10 percent, whichever is greater, to provide better alignment or location, avoid obstacles, adjust for equipment size, or reach a satisfactory outlet.
- The contributing area above the top should not exceed the area that would be drained by a terrace with normal spacing.
- The terrace should have enough capacity to handle the peak volumetric flowrate expected from a Type 1A, 2-year, 24-hour frequency storm without overtopping.
- The terrace cross-section should be proportioned to fit the land slope. The ridge height should include a reasonable settlement factor. The ridge should have a minimum top width of 3 feet at the design height. The minimum cross-sectional area of the terrace channel should be 8 square feet for land slopes of 5 percent or less, 7 square feet for slopes from 5 to 8 percent, and 6 square feet for slopes steeper than 8 percent. The terrace can be constructed wide enough to be maintained using a small cat.

1.16.4 Maintenance Standards

Maintenance should be performed as needed. Terraces should be inspected regularly, at least once a year, and after large storm events.

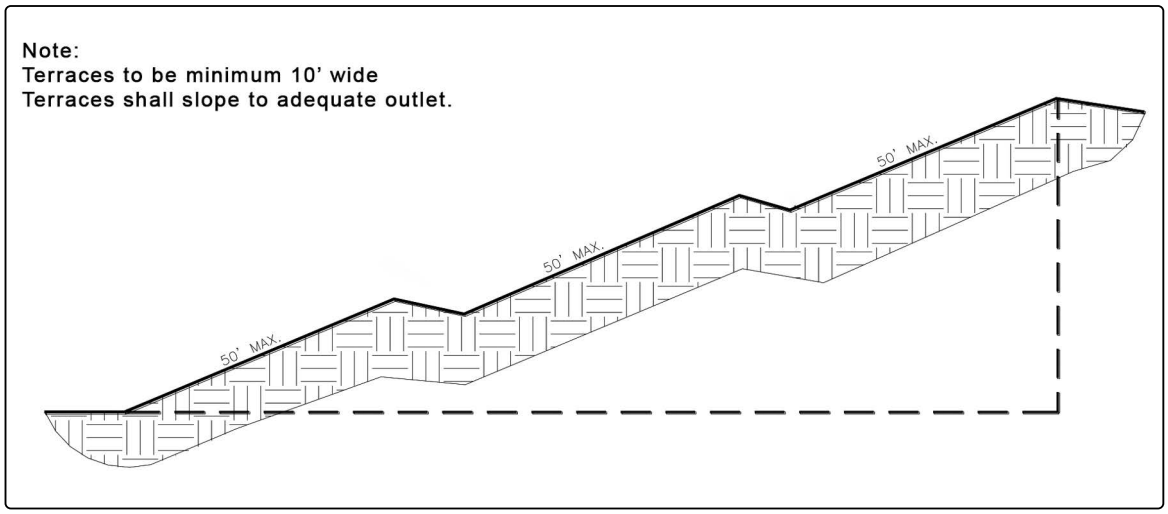


Figure 3 - 6: Gradient Terraces

1.17 BMP C140: Dust Control

1.17.1 Purpose

Dust control prevents wind transport of dust from disturbed soil surfaces.

1.17.2 Conditions of Use

Use dust control practices in areas (including roadways) subject to surface and air movement of dust where onsite and offsite impacts to streets, the stormwater system, or receiving waterbodies are likely.

1.17.3 Design and Installation Specifications

- Vegetate or mulch areas that will not receive vehicle traffic. In areas where planting, mulching, or paving is impractical, apply gravel or landscaping rock.
- Limit dust generation by clearing only to those areas where immediate activity will take place, leaving the remaining area(s) in the original condition, if stable. Maintain the original ground cover as long as practical.
- Construct natural or artificial windbreaks or windscreens. These may be designed as enclosures for small dust sources.
- Sprinkle the site with water until surface is wet. Repeat as needed. To prevent carryout of mud onto street, refer to Stabilized Construction Entrance (BMP C105: Stabilized Construction Entrance/Exit).
- Irrigation water can be used for dust control. Install irrigation systems as a first step on sites where dust control is a concern.
- Spray exposed soil areas with a dust palliative, following the manufacturer's instructions and cautions regarding handling and application. Used oil is prohibited from use as a dust suppressant.
- PAM (BMP C127: Polyacrylamide for Soil Erosion Protection) added to water at a rate of 2/3 pounds per 1,000 gallons of water per acre and applied from a water truck is more effective than water alone. This is due to the increased infiltration of water into the soil and reduced evaporation. In addition, small soil particles are bonded together and are not as easily transported by wind. Adding PAM may actually reduce the quantity of water needed for dust control. There are concerns with the proper use of PAM, refer to BMP C127: Polyacrylamide for Soil Erosion Protection for more information on PAM application. PAM use requires COT approval.
- Lower speed limits. High vehicle speed increases the amount of dust stirred up from unpaved roads and lots.
- Upgrade the road surface strength by improving particle size, shape, and mineral types that make up the surface and base materials.
- Add surface gravel to reduce the source of dust emission. Limit the amount of fine particles to 10 to 20 percent.
- Use geotextile fabrics to increase the strength of new roads or roads undergoing reconstruction.
- Encourage the use of alternate, paved routes, if available.
- Restrict use of paved roadways by tracked vehicles and heavy trucks to prevent damage to road surfaces and bases.

- Apply chemical dust suppressants using the admix method, blending the product with the top few inches of surface material. Suppressants may also be applied as surface treatments.
- Pave unpaved permanent roads and other trafficked areas.
- Use vacuum street sweepers.
- Remove mud and other dirt promptly so it does not dry and then turn into dust.
- Limit dust generating work on windy days.
- Contact the Puget Sound Clean Air Agency for guidance and training on other dust control measures. Compliance with the Puget Sound Clean Air Agency's recommendations/requirements constitutes compliance with this BMP.

1.17.4 Maintenance Standards

Evaluate the potential for dust generation frequently during dry periods. Complete the actions outlined above as needed to limit the dust.

Any dust which leaves the site must be cleaned immediately.

1.18 BMP C150: Materials On Hand

1.18.1 Purpose

Quantities of erosion prevention and sediment control materials should be kept on the project site at all times to be used for regular maintenance and emergency situations such as unexpected heavy summer rains. Having these materials onsite reduces the time needed to implement BMPs when inspections indicate that existing BMPs are not meeting the Construction SWPPP requirements.

1.18.2 Conditions of Use

Construction projects of any size or type can benefit from having materials on hand. A small commercial development project could have a roll of plastic and some gravel available for immediate protection of bare soil and temporary berm construction. A large earthwork project, such as highway construction, might have several tons of straw, several rolls of plastic, flexible pipe, sandbags, geotextile fabric, and steel “T” posts.

- Materials are stockpiled and readily available before any site clearing, grubbing, or earthwork begins. A large contractor or developer could keep a stockpile of materials that are available to be used on several projects.
- If storage space at the project site is at a premium, the contractor could maintain the materials at a location less than one hour from the site.

1.18.3 Design and Installation Specifications

Depending on project type, size, complexity, and length, materials and quantities will vary. Table 3 - 10: Materials on Hand, provides a good minimum that will cover numerous situations.

Table 3 - 10: Materials on Hand

Material	Measure	Quantity
Clear Plastic, 6 mil	100 foot roll	1-2
Drain Pipe, 6 or 8 inch diameter	25 foot section	4-6
Sandbags, filled	each	25-50
Quarry Spalls	ton	2-4
Washed Gravel	cubic yard	2-4
Geotextile Fabric	100 foot roll	1-2
Catch Basin Inserts	each	2-4
Steel “T” Posts	each	12-24

1.18.4 Maintenance Standards

- All materials with the exception of the quarry spalls, steel “T” posts, and gravel should be kept covered and out of both sun and rain.
- Re-stock materials used as needed.

1.19 BMP C151: Concrete Handling

1.19.1 Purpose

Concrete work can generate process water and slurry that contain fine particles and high pH, both of which can violate water quality standards in the receiving water. Concrete spillage or concrete discharge to waters of the State is prohibited. Use this BMP to minimize and eliminate concrete, concrete process water, and concrete slurry from entering waters of the State.

1.19.2 Conditions of Use

Utilize these management practices any time concrete is used.

Concrete construction projects include, but are not limited to, the following:

- Curbs
- Sidewalks
- Roads
- Bridges
- Foundations
- Floors
- Runways

Disposal options for concrete, in order of preference are:

1. Offsite disposal
2. Concrete washout areas
3. De minimus washout to formed areas awaiting concrete

1.19.3 Design and Installation Specifications

- Wash concrete truck drums at an approved offsite location or in designated concrete washout areas only.
    - Return unused concrete remaining in the truck and pump to the originating batch plant for recycling. Do not dump excess concrete onsite, except in designated concrete washout areas as allowed in BMP C154: Concrete Washout Area.
- Do not wash out concrete trucks onto the ground (including formed areas awaiting concrete), or into the stormwater conveyance system, open ditches, streets, or streams.
- Wash small concrete handling equipment (e.g. hand tools, screeds, shovels, rakes, floats, trowels, and wheelbarrows) into designated concrete washout areas or into formed areas awaiting concrete pour.
- At no time shall concrete be washed off into the footprint of an area where an infiltration feature will be installed.
- Wash equipment difficult to move, such as concrete paving machines, in areas that do not directly drain to natural or constructed stormwater conveyance or potential infiltration areas.

- Do not allow washwater from areas, such as concrete aggregate driveways, to discharge directly (without detention or treatment) to natural or constructed stormwater conveyances.
- Contain washwater and leftover product in a lined container when no designated concrete washout areas (or formed areas, allowed as described above) are available. Dispose of contained concrete and concrete washwater (process water) properly. Always use forms or solid barriers for concrete pours within 15-feet of surface waters.
- Refer to BMP C252: Treating and Disposing of High pH Water and BMP C253: Portable Sediment Tank for pH adjustment requirements.
- Refer to the Construction Stormwater General Permit for pH monitoring requirements if the project involves one of the following activities:
  - Significant concrete work (as defined in the Construction Stormwatwer General Permit).
  - The use of engineered soils amended with (but not limited to) Portland cement-treated base, cement kiln dust or fly ash.
  - Discharging stormwater to segments of water bodies on the 303(d) list (Category 5) for high pH.

1.19.4 Maintenance Standards

Containers shall be checked for holes in the liner daily during concrete pours and repaired the same day.

1.20 BMP C152: Sawcutting and Surfacing Pollution Prevention

1.20.1 Purpose

Sawcutting and surfacing operations generate slurry and process water that contains fine particles and have a high pH (concrete cutting), both of which can violate water quality standards in the receiving water. This BMP is intended to minimize and eliminate process water and slurry from entering waters of the State

1.20.2 Conditions of Use

Anytime sawcutting or surfacing operations take place, use these management practices. Sawcutting and surfacing operations include, but are not limited to, the following:

- Sawing
- Coring
- Grinding
- Roughening
- Hydro-demolition
- Bridge and road surfacing

1.20.3 Design and Installation Specifications

- Vacuum slurry and cuttings during cutting and surfacing operations.
- Do not leave slurry and cuttings on permanent concrete or asphalt pavement overnight.
- Do not allow slurry and cuttings to enter any natural or constructed conveyance system.
- Dispose of collected slurry and cuttings in a manner that does not violate groundwater or surface water quality standards.
- Do not allow process water that is generated during hydro-demolition, surface roughening, or similar operations to enter any natural or constructed conveyance system. Dispose of process water in a manner that does not violate groundwater or surface water quality standards.
- Handle and dispose of cleaning waste material and demolition debris in a manner that does not cause contamination of water. If the area is swept with a pick-up sweeper, haul the material out of the area to an appropriate disposal site.

1.20.4 Maintenance Standards

Continually monitor operations to determine whether slurry, cuttings, or process water could enter waters of the state. If inspections show that a violation of water quality standards could occur, stop operations and immediately implement preventive measures such as berms, barriers, secondary containment, and vacuum trucks.

1.21 BMP C153: Material Delivery, Storage and Containment

1.21.1 Purpose

Prevent, reduce, or eliminate the discharge of pollutants from material delivery and storage to the stormwater system or watercourses by minimizing the storage of hazardous materials onsite, storing materials in a designated area, and installing secondary containment.

1.21.2 Conditions of Use

These procedures are suitable for use at all construction sites with delivery and storage of the following materials:

- Petroleum products such as fuel, oil, and grease
- Soil stabilizers and binders (e.g. Polyacrylamide)
- Fertilizers, pesticides, and herbicides
- Detergents
- Asphalt and concrete compounds
- Hazardous chemicals such as acids, lime, adhesives, paints, solvents, and curing compounds
- Any other material that may be detrimental if released to the environment

1.21.3 Design and Installation Specifications

The following steps should be taken to minimize risk:

- Locate temporary storage area away from vehicular traffic, near the construction entrance(s), and away from conveyance systems and receiving waterbodies.
- Supply Material Safety Data Sheets (MSDS) for all materials stored. Keep chemicals in their original labeled containers.
- Surrounding materials with earth berms is an option for temporary secondary containment.
- Minimize hazardous material storage onsite.
- Handle hazardous materials as infrequently as possible.
- During the wet weather season (October 1 through April 30), consider storing materials in a covered area.
- Store materials in secondary containment, such as an earthen dike, a horse trough, or a children’s wading pool for non-reactive materials such as detergents, oil, grease, and paints. “Bus boy” trays or concrete mixing trays may be used as secondary containment for small amounts of material.
- Do not store chemicals, drums, or bagged materials directly on the ground. Place these items on a pallet and, when possible, in secondary containment.
- If drums cannot be stored under a roof, domed plastic covers are inexpensive and snap to the top of drums, preventing water from collecting.

1.21.4 Material Storage Areas and Secondary Containment Practices:

- Store liquids, petroleum products, and substances listed in 40 CFR Parts 110, 117, or 302 in approved containers and drums and do not overfill the containers or drums. Store containers and drums in temporary secondary containment facilities.
- Temporary secondary containment facilities shall provide for a spill containment volume able to contain precipitation from a 25 year, 24 hour storm event plus 10% of the total enclosed container volume of all containers, or 110% of the capacity of the largest container within its boundary, whichever is greater.
- Secondary containment facilities shall be impervious to the materials stored therein for a minimum contact time of 72 hours.
- Secondary containment facilities shall be maintained free of accumulated rainwater and spills. In the event of spills or leaks, collect accumulated rainwater and spills and place into drums. Handle these liquids as hazardous waste unless testing determines them to be non-hazardous. Dispose of all wastes properly.
- Provide sufficient separation between stored containers to allow for spill cleanup and emergency response access.
- During the wet weather season (October 1 through April 30), cover each secondary containment facility during non-working days.
- Secondary containment facilities shall be covered at all times, except when in active use.
- Keep material storage areas clean, organized, and equipped with an ample supply of appropriate spill clean-up material.
- The spill kit should include, at a minimum:
    - 1 water resistant nylon bag
    - 3 oil absorbent socks (3-inches by 4-feet)
    - 2 oil absorbent socks (3-inches by 10-feet)
    - 12 oil absorbent pads (17-inches by 19-inches)
    - 1 pair splash resistant goggles
    - 3 pairs nitrile gloves
    - 10 disposable bags with ties
    - Instructions

1.21.5 Maintenance Standards

Any stormwater within the material storage area shall be pumped or otherwise discharged after each rain event. Before pumping, the stormwater must be evaluated to determine if it must go to treatment or can be discharged without treatment. If stormwater is contaminated, direct the discharge to appropriate treatment.

Restock spill kit materials as needed.

1.22 BMP C154: Concrete Washout Area

1.22.1 Purpose

Prevent or reduce the discharge of pollutants to stormwater from concrete waste by conducting washout offsite, or performing onsite washout in a designated area to prevent pollutants from entering surface waters or groundwater.

1.22.2 Conditions of Use

Use concrete washout best management practices on construction projects where:

- It is not possible to dispose of all concrete wastewater and washout offsite (ready mix plant, etc.)
- Concrete truck drums are washed onsite.
- Concrete is used as a construction material.

At no time shall concrete be washed off into the footprint of an area where an infiltration feature will be installed.

Note: Auxiliary concrete truck components (e.g. chutes and hoses) and small concrete handling equipment (e.g. hand tools, screeds, shovels, rakes, floats, trowels, and wheelbarrows) may be washed into formed areas awaiting concrete pour.

1.22.3 Design and Installation Specifications

Implementation

- Perform washout of concrete truck drums at an approved offsite location or in designated concrete washout areas only.
- Do not wash out concrete trucks onto the ground, or into the stormwater conveyance system, open ditches, streets, or streams.
- Do not allow excess concrete to be dumped onsite, except in designated concrete washout areas.
- Wash equipment difficult to move, such as concrete paving machines, in areas that do not directly discharge to natural or constructed stormwater conveyance or potential infiltration areas.
- Concrete washout areas may be prefabricated concrete washout containers, or self-installed structures (above-grade or below-grade).
- Prefabricated containers are most resistant to damage and protect against spills and leaks. Companies may offer delivery service and provide regular maintenance and disposal of solid and liquid waste.
- If self-installed concrete washout areas are used, below-grade structures are preferred over above-grade structures because they are less prone to spills and leaks.
- Self-installed above-grade structures should only be used if excavation is not practical.
- Identify concrete washout area on the TESC plan.

- Concrete washout areas shall be constructed and maintained in sufficient quantity and size to contain all liquid and concrete waste generated by washout operations.

Education

- Discuss the concrete management techniques described in this BMP with the ready-mix concrete supplier before any deliveries are made.
- Educate employees and subcontractors on the concrete waste management techniques described in this BMP.
- Arrange for the contractor's superintendent or Erosion and Sediment Control Lead (BMP C160: Erosion and Sediment Control Lead) to oversee and enforce concrete waste management procedures.
- Install a sign adjacent to each temporary concrete washout facility to inform concrete equipment operators to utilize the proper facilities.

Contracts

Incorporate requirements for concrete waste management into concrete supplier and subcontractor agreements.

Location and Placement Considerations:

- Locate washout area or temporary concrete washout facilities at least 50 feet from sensitive areas such as stormwater system inlets, open conveyance ditches, or waterbodies, including wetlands.
- Allow convenient access for concrete trucks, preferably near the area where the concrete is being poured.
- If trucks need to leave a paved area to access washout, prevent track-out with a pad of rock or quarry spalls (BMP C105: Stabilized Construction Entrance/Exit). These areas should be far enough away from other construction traffic to reduce the likelihood of accidental damage and spills.
- The washout area volume installed should depend on the expected demand for storage capacity.
- On large sites with extensive concrete work, washouts may be placed in multiple locations for ease of use by concrete truck drivers.

Concrete Truck Washout Procedures

- Washout concrete truck drums in designated concrete washout areas only.
- Concrete washout from concrete pumper bins can be washed into concrete pumper trucks and discharged into designated concrete washout areas or properly disposed of offsite.

Concrete Washout Area Installation

- Install concrete washout areas prior to starting concrete work.
- Construct concrete washout areas of sufficient quantity and volume to contain all liquid and concrete waste generated by washout operations. It is recommended that the minimum length and width be 10 feet.

- Plastic lining should be a minimum of 10-mil polyethylene sheeting and free of holes, tears, or other defects that compromise impermeability.
- Lath and flagging should be commercial grade.
- Install liner seams per manufacturer's recommendations.
- Prepare soil base free of rocks or other debris that may cause tears of holes in plastic lining.

1.22.4 Inspection and Maintenance

- Inspect and verify that concrete washout BMPs are in place prior to the commencement of concrete work.
- Once concrete wastes are washed into designated washout areas and allowed to harden, the concrete should be broken up, removed, and disposed of per applicable solid waste regulations. Dispose of hardened concrete on a regular basis.
- During periods of concrete work, inspect daily to verify continued performance.
  - Check overall condition and performance.
  - Check remaining capacity (% full).
  - If using self-installed washout facilities, verify plastic liners are intact and sidewalls are not damaged.
  - If using prefabricated containers, check for leaks.
- Maintain washout facilities to provide adequate holding capacity with a minimum freeboard of 12 inches.
- Washout facilities must be cleaned, or new facilities must be constructed and ready for use once the washout is 75% full.
- If the washout is nearing capacity, vacuum and dispose of the waste material in an approved manner.
  - Do not discharge liquid or slurry to streets, the stormwater system, receiving waterbodies, or the ground.
  - Do not use wastewater system without obtaining a City of Tacoma Special Approved Discharge permit. Visit https://tacoma.gov/government/departments/environmental-services/wastewater/wastewater-permits-and-manuals/ for additional information.
  - Place a secure, non-collapsing, non-water collecting cover over the concrete washout facility prior to predicted wet weather to prevent accumulation and overflow of precipitation.
  - Remove and dispose of hardened concrete and return the structure to a functional condition. Concrete may be reused onsite or hauled away for disposal or recycling.
- When you remove materials from the self-installed concrete washout, build a new structure; or, if the previous structure is still intact, inspect for signs of weakening or damage, and make any necessary repairs. Re-line the structure with new plastic after each cleaning.

1.22.5 Removal of Temporary Concrete Washout Facilities

- When temporary concrete washout facilities are no longer required for the work, remove and properly dispose of the hardened concrete, slurries and liquids.

- Remove materials used to construct temporary concrete washout facilities from the site of the work and dispose of or recycle it.
- Holes, depressions or other ground disturbance caused by the removal of the temporary concrete washout facilities shall be backfilled, repaired, and stabilized to prevent erosion.

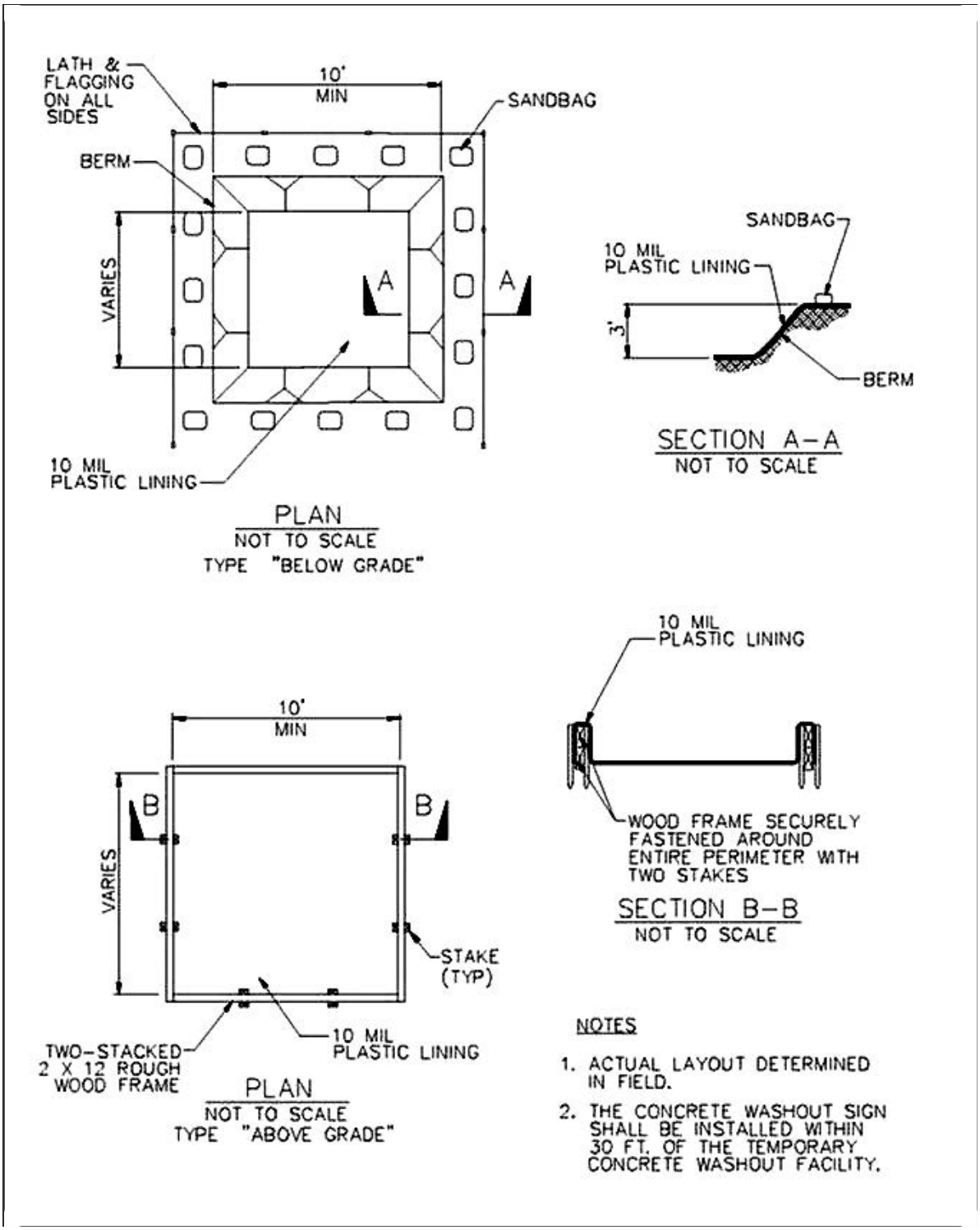


Figure 3 - 7: Temporary Concrete Washout Facility

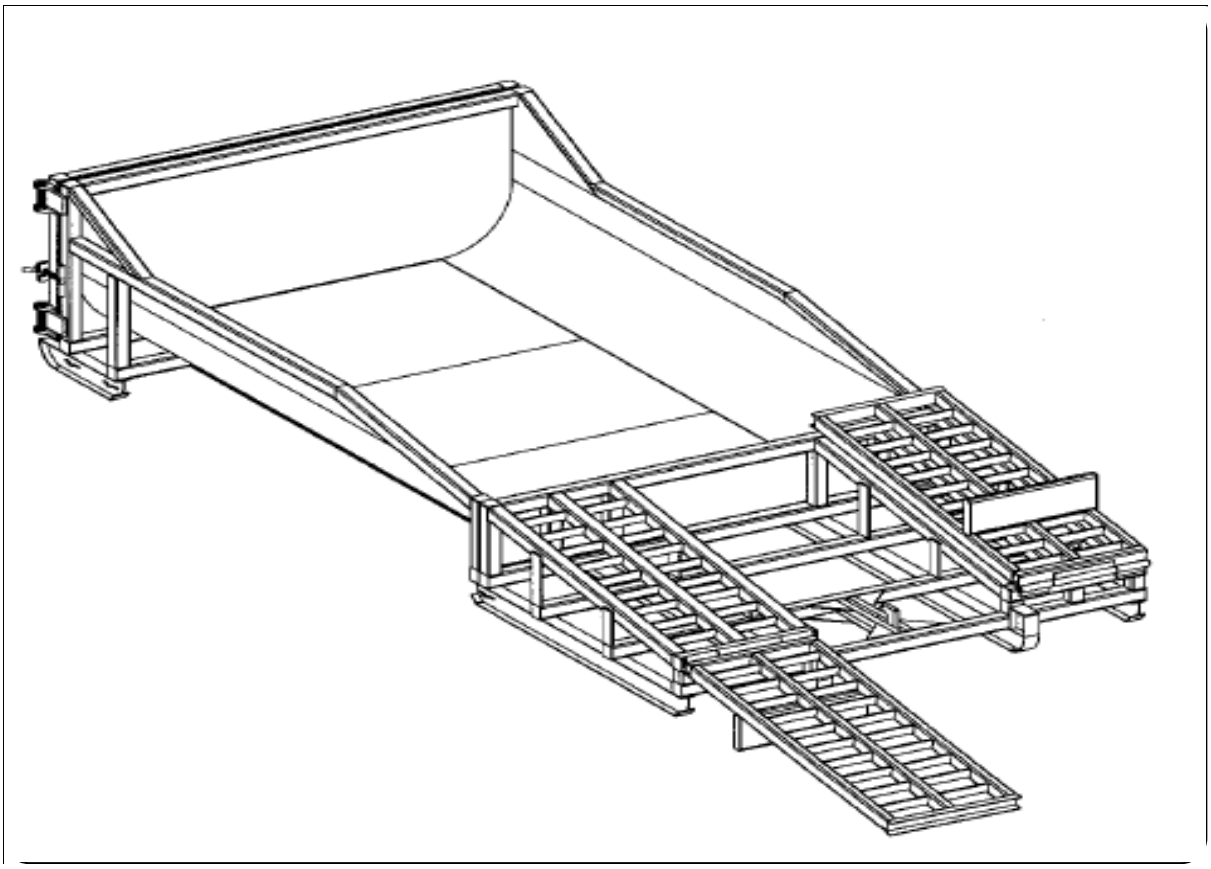


Figure 3 - 8: Prefabricated Concrete Washout Container with Ramp

1.23 BMP C160: Erosion and Sediment Control Lead

1.23.1 Purpose

The project proponent must designate at least one person as the responsible representative in charge of erosion and sediment control (ESC) and water quality protection. The designated person shall be the erosion and sediment control (ESC) lead, who is responsible for ensuring compliance with all local, state, and federal erosion and sediment control and water quality requirements.

1.23.2 Conditions of Use

- An erosion and sediment control contact is required for all projects.
- A certified erosion and sediment control lead (CESCL) or certified professional in erosion and sediment control (CPESC) is required on projects that include, but are not limited to:
  - Construction activity that disturbs one acre of land or more.
- Projects disturbing less than one acre must have an Erosion Sediment Control Lead (ESC) conduct inspections. The ESC Lead does not have to have CESCL or CPESC certification.
- The CESCL, CPESC, or ESC Lead shall be identified in the SWPPP and shall be onsite or on-call at all times.
- The CESCL, CPESC, or ESC Lead must be knowledgeable in the principles and practices of erosion and sediment control and have the skills to assess:
  - Site conditions and construction activities that could impact the quality of stormwater.
  - Effectiveness of erosion and sediment control measures used to control the quality of stormwater discharges.

1.23.3 Specifications

- The CESCL lead shall:
  - Have a current certified erosion and sediment control lead (CESCL) certificate proving attendance in an erosion and sediment control training course that meets the minimum ESC training and certification requirements established by Ecology.
- For additional information concerning the Certified Professional in Erosion and Sediment Control program please go to https://envirocertintl.org/cpesc/.
- The ESC lead shall have authority to act on behalf of the contractor or developer and shall be available, on call, 24 hours per day throughout the period of construction.
- The Construction SWPPP shall include the name, telephone number, email, and address of the designated ESC lead.
- An ESC lead may provide inspection and compliance services for multiple construction projects in the same geographic region.
- Duties and responsibilities of the ESC lead shall include, but are not limited to, the following:
  - Inspecting all areas disturbed by construction activities, all BMPs and all locations where runoff leaves the site at least once every calendar week and within 24 hours of

any discharge from the site. The ESC lead may reduce the inspection frequency for temporary stabilized, inactive sites to monthly.

- Examining stormwater visually for the presence of suspended sediment, turbidity, discoloration, and oil sheen.
- Evaluating the effectiveness of BMPs.
- Maintaining a permit file onsite at all times which includes the SWPPP and any associated permits and plans.
- Directing BMP installation, inspection, maintenance, modification, and removal.
- Updating all project drawings and the Construction SWPPP with changes made.
- Keeping daily logs and inspection reports. Inspection reports should include:
  - Inspection date/time.
  - Weather information, general conditions during inspection, and approximate amount of precipitation since the last inspection.
  - A summary or list of all BMPs implemented, including observations of all erosion/sediment control structures or practices. The following shall be noted:
    - Locations of BMPs inspected,
    - Locations of BMPs that need maintenance,
    - Locations of BMPs that failed to operate as designed or intended, and
    - Locations where additional or different BMPs are required.
  - Visual monitoring results, including a description of discharged stormwater. The presence of suspended sediment, turbid water, discoloration, and oil sheen shall be noted, as applicable.
  - Any water quality monitoring performed during inspection.
  - General comments and notes, including a brief description of any BMP repairs, maintenance, or installations made as a result of the inspection.
- Facilitating, participating in, and taking corrective actions resulting from inspections performed by outside agencies or the owner.
- Keeping an inventory of equipment onsite.

1.24 BMP C162: Scheduling

1.24.1 Purpose

Sequencing a construction project can reduce the amount and duration of soil exposed to erosion.

1.24.2 Conditions of Use

The construction sequence schedule is an orderly listing of all major land-disturbing activities together with the necessary erosion and sediment control measures planned for the project. This type of schedule guides the contractor on work to be done before other work is started so serious erosion and sedimentation problems can be avoided.

Following a specified work schedule that coordinates the timing of land-disturbing activities and the installation of control measures is perhaps the most cost-effective way of controlling erosion during construction. The removal of surface ground cover leaves a site vulnerable to accelerated erosion. Construction procedures that limit land clearing, provide timely installation of erosion and sedimentation controls, and restore protective cover quickly can significantly reduce the erosion potential of a site.

1.24.3 Design Considerations

- Minimize construction during rainy periods.
- Schedule projects to disturb only small portions of the site at any one time. Complete grading as soon as possible. Immediately stabilize the disturbed portion before grading the next portion. Practice staged seeding in order to revegetate cut and fill slopes as the work progresses.

1.25 BMP C200: Interceptor Dike and Swale

1.25.1 Purpose

Provide a dike or swale, at the top or base of a disturbed slope or along the perimeter of a disturbed construction area to convey stormwater. Use the dike and/or swale to intercept the runoff from unprotected areas and direct it to areas where erosion can be controlled. This can prevent runoff from entering the work area or sediment-laden runoff from leaving the construction site.

1.25.2 Conditions of Use

Where the runoff from an exposed site or disturbed slope must be conveyed to an erosion control facility that can safely convey the stormwater.

- Locate upslope of a construction site to prevent runoff from entering disturbed area.
- When placed horizontally across a disturbed slope, it reduces the amount and velocity of runoff flowing down the slope.
- Locate downslope to collect runoff from a disturbed area and direct it to a sediment basin.

1.25.3 Design and Installation Specifications

- Stabilize dike and/or swale and channel with temporary or permanent vegetation or other channel protection during construction.
- Steep grades require channel protection and check dams.
- Channel requires a positive grade to allow stormwater and surface water to drain; steeper grades require channel protection and check dams.
- Review construction for areas where overtopping may occur.
- Should be used at the top of new fill before vegetation is established.
- May be used as a permanent diversion channel to carry the runoff.
- Sub-basin tributary area should be one acre or less.
- Design capacity for either:
    - The peak volumetric flowrate calculated using a 10-minute time step from a Type 1A, 10-year, 24-hour frequency storm using a single event model, or
    - The 10-year return period flowrate, indicated by an Ecology-approved continuous simulation model, using a 15-minute time step.

      Design for worst-case land cover conditions.

      For permanent facilities, design capacity per Volume 4.

Interceptor Dikes

Interceptor dikes shall meet the following criteria:

Top Width	2 feet minimum.
Height	1.5 feet minimum on berm.
Side Slope	2:1 or flatter.
Grade	Depends on topography, however, dike system minimum is 0.5% and maximum is 1%
Compaction	Minimum of 90 percent ASTM D698 standard proctor.

Horizontal Spacing of Interceptor Dikes:

Average Slope	**Slope Percent**	**Flowpath Length**
20H:1V or less	3-5%	300 feet
(10 to 20)H:1V	5-10%	200 feet
(4 to 10)H:1V	10-25%	100 feet
(2 to 4)H:1V	25-50%	50 feet

Stabilization depends on velocity and reach.

Slopes <5%	Seed and mulch applied within 5 days of dike construction (see BMP C121: Mulching).
Slopes 5 - 40%	Dependent on runoff velocities and dike materials. Stabilization should be done immediately using either sod or riprap or other measures to avoid erosion. See Volume 5, Section 4.3: Open Channel Specifications for additional guidance on channel protection.

- The upslope side of the dike shall be graded to ensure stormwater and surface water reach the dike outlet. No erosion shall occur at the outlet. Provide energy dissipation measures as necessary. Sediment-laden runoff must be released through a sediment trapping facility.
- Minimize construction traffic over temporary dikes. Use temporary cross culverts for channel crossing.

Interceptor Swales

Interceptor swales shall meet the following criteria:

Bottom Width	2 feet minimum; the bottom shall be level.
Depth	1-foot minimum.
Side Slope	2H:1V or flatter
Grade	Maximum 5 percent, and be graded to ensure stormwater and surface water reach a suitable outlet (such as a sediment pond).
Stabilization	Seed as per BMP C120: Temporary and Permanent Seeding, or BMP C202: Rip Rap Channel Lining, 12 inches thick of riprap pressed into the bank and extending at least 8 inches vertical from the bottom.

1.25.4 Maintenance Standards

- Inspect diversion dikes and interceptor swales once a week and after every rainfall. Immediately remove sediment from the flow area.
- Repair damage caused by construction traffic or other activity before the end of each working day.
- Check outlets and make timely repairs as needed to avoid gully formation. When the area below the temporary diversion dike is permanently stabilized, remove the dike and fill and stabilize the channel to blend with the natural surface.

1.26 BMP C201: Grass-Lined Channels

1.26.1 Purpose

To provide a channel with a vegetative lining for conveyance of runoff. See Figure 3 - 9: Typical Grass-Lined Channels, for typical grass-lined channels.

1.26.2 Conditions of Use

This practice applies to construction sites where concentrated runoff needs to be contained to prevent erosion or flooding.

- Use this BMP when a vegetative lining can provide sufficient stability for the channel cross section and lower velocities of water (normally dependent on grade). This means that the channel slopes are generally less than 5 percent and space is available for a relatively large cross section.
- Typical uses include roadside ditches, channels at property boundaries, outlets for diversions, and other channels and conveyance ditches in low areas.
- Channels that will be vegetated should be installed before major earthwork and hydroseeded with a bonded fiber matrix (BFM). The vegetation should be well established (i.e., 75 percent cover) before water is allowed to flow in the ditch. With channels that will have high flows, erosion control blankets should be installed over the hydroseed. If vegetation cannot be established from seed before water is allowed in the ditch, sod should be installed in the bottom of the ditch in lieu of hydromulch and blankets.

1.26.3 Design and Installation Specifications

- Locate the channel where it can conform to the topography and other features such as roads.
- Locate them to use natural conveyance systems to the greatest extent possible.
- Avoid sharp changes in alignment or bends and changes in grade.
- Do not reshape the landscape to fit the conveyance channel.
- Base the maximum design velocity on soil conditions, type of vegetation, and method of revegetation, but at no times shall velocity exceed 5 feet/second. Size the channel to contain the flowrate calculated by one of the following methods using the worst-case land cover:
  - The peak volumetric flowrate calculated using a 10-minute timestep from a Type 1A, 10-year, 24-hour storm using a single event model, or
  - The 10-year return period flowrate, indicated by an Ecology-approved continuous simulation model, using a 15-minute timestep.
- An **established grass** or vegetated lining is required before the channel can be used to convey stormwater, unless stabilized with nets or blankets.
- If the design velocity of a channel to be vegetated by seeding exceeds 2 ft/sec, a temporary channel liner is required. See Figure 3 - 10: Temporary Channel Liners.
- Remove check dams when the grass has matured sufficiently to protect the ditch or swale unless the slope of the swale is greater than 4 percent. Seed and mulch the area beneath the check dams immediately after dam removal.

- If vegetation is established by sodding, the permissible velocity for established vegetation may be used and no temporary liner is needed.
- Do not subject grass-lined channel to sedimentation from disturbed areas. Use sediment-trapping BMPs upstream of the channel.
- **V-shaped grass channels** generally apply where the quantity of water is small, such as in short reaches along roadsides. The V-shaped cross section is least desirable because it is difficult to stabilize the bottom where velocities may be high.
- **Trapezoidal grass channels** are used where runoff volumes are large and slope is low so that velocities are nonerosive to vegetated linings.

  Note: It is difficult to construct small parabolic shaped channels.
- Subsurface conveyance systems (such as perforated pipe), or riprap channel bottoms, may be necessary on sites that are subject to prolonged wet conditions due to long duration flows or a high water table.
- Provide outlet protection at culvert ends and at channel intersections.
- Grass channels, at a minimum, should carry the peak volumetric flowrate for temporary construction stormwater facilities from the 10-year, 24-hour frequency storm assuming a Type 1A rainfall distribution (3.0-inches) using a 10-minute timestep, and assuming the worst-case land cover condition, without eroding. Where flood hazard exists, increase the capacity according to the potential damage.
- Grassed channel side slopes generally are constructed 3:1 or flatter to aid in the establishment of vegetation and for maintenance.
- Construct channels a minimum of 0.2 foot larger around the periphery to allow for soil bulking during seedbed preparations and sod buildup.

1.26.4 Maintenance Standards

- During the establishment period, check grass-lined channels after every rainfall.
- After grass is established, periodically check the channel; check the channel after every heavy rainfall event. Immediately make repairs.
- It is particularly important to check the channel outlet and all road crossings for bank stability and evidence of piping or scour holes.
- Remove all significant sediment accumulations to maintain the designed carrying capacity. Keep the grass in a healthy, vigorous condition at all times, since it is the primary erosion protection for the channel.

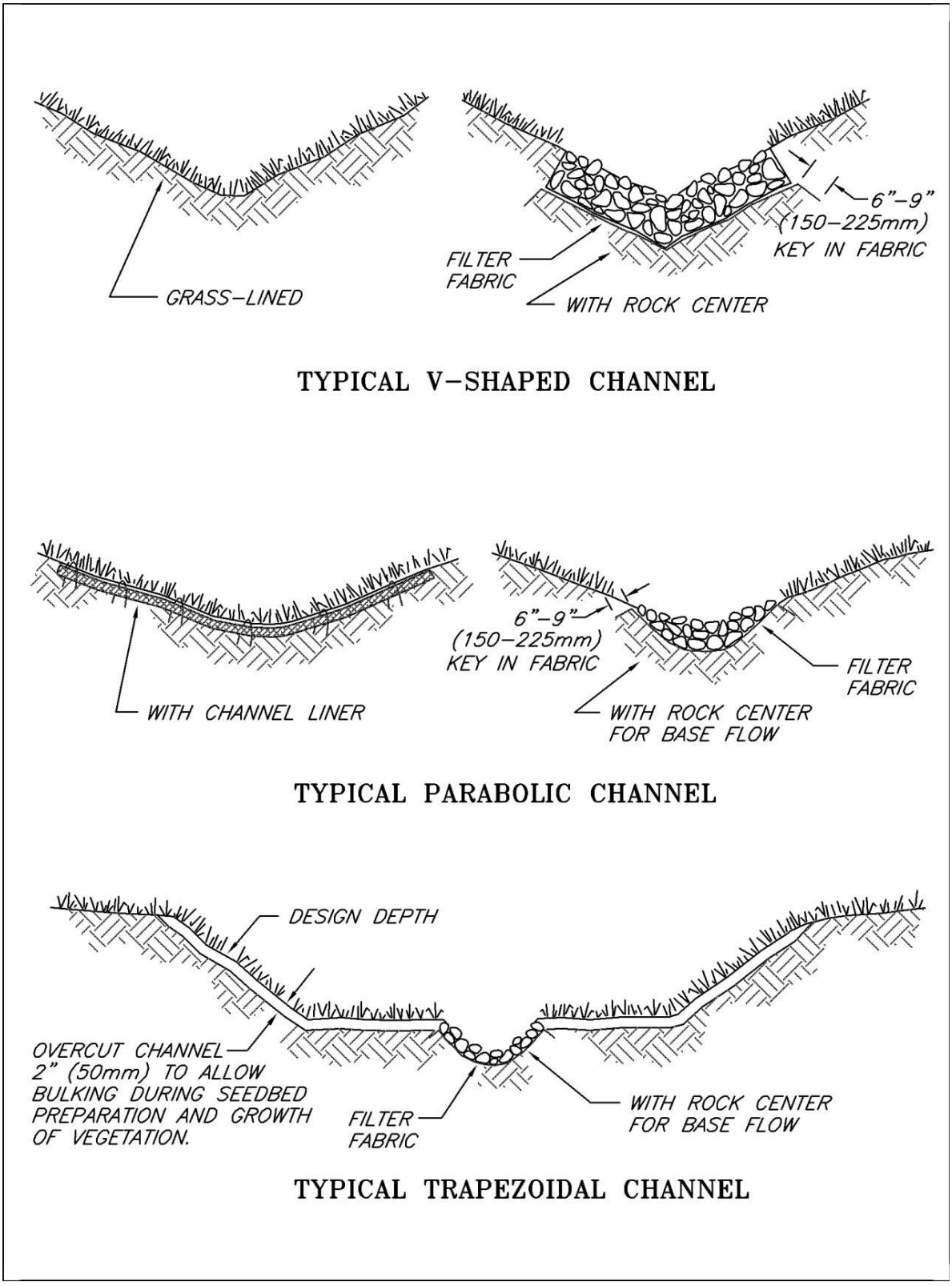


Figure 3 - 9: Typical Grass-Lined Channels

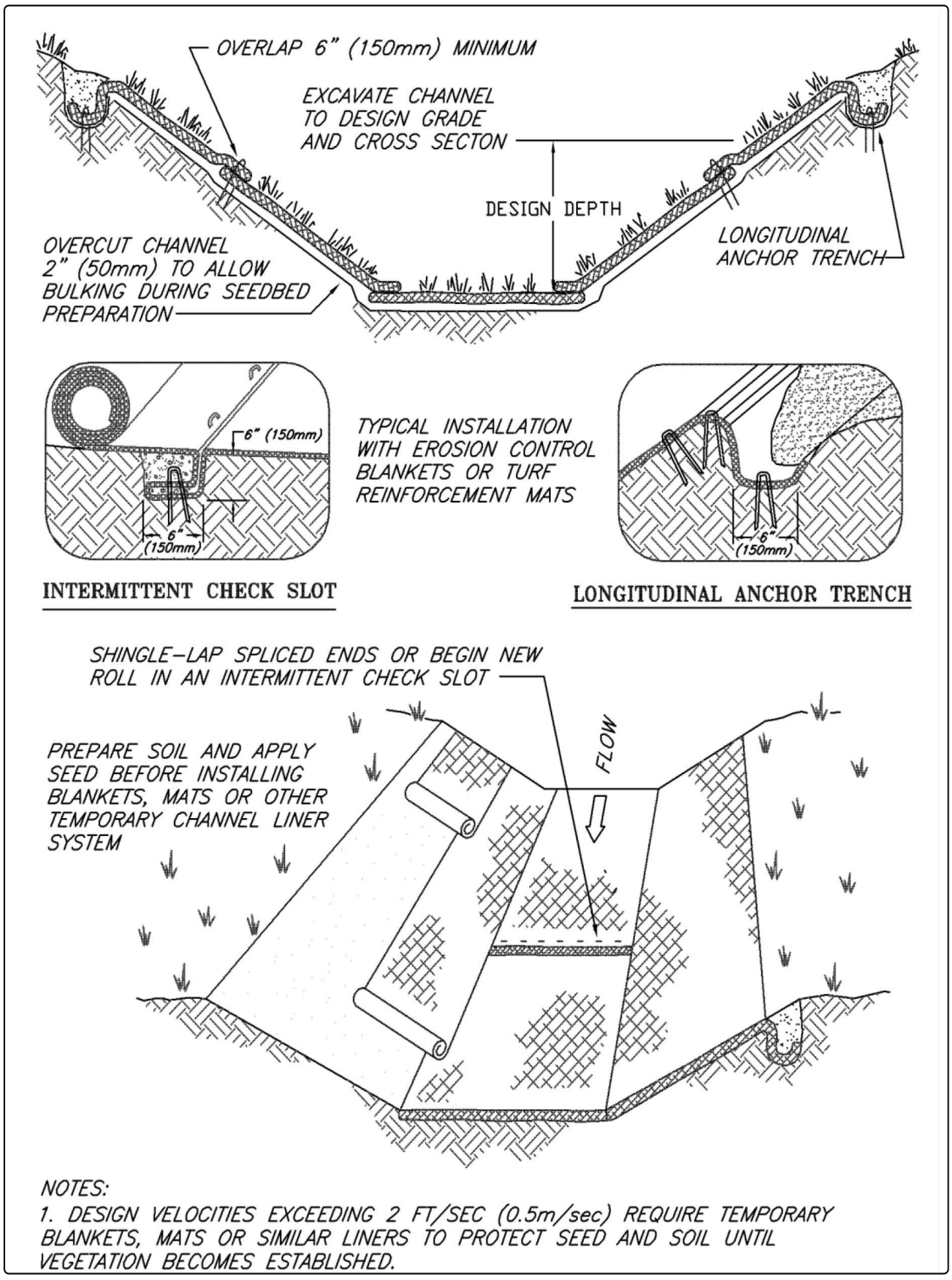


Figure 3 - 10: Temporary Channel Liners

1.27 BMP C202: Rip Rap Channel Lining

1.27.1 Purpose

To protect erodible channels by providing a channel liner using either blankets or riprap.

1.27.2 Conditions of Use

- Use this BMP when natural soils or vegetated stabilized soils in a channel are not adequate to prevent channel erosion.
- Use this BMP when a permanent ditch or pipe system is to be installed and a temporary measure is needed.
- The Federal Highway Administration recommends not using flexible liners whenever the slope exceeds 10 percent or the shear stress exceeds 8 pounds per square foot.

1.27.3 Design and Installation Specifications

- See BMP C122: Nets and Blankets for information on blankets.
- Since riprap is used where erosion potential is high, construction must be sequenced so the riprap is put in place with the minimum possible delay (see Figure 3 - 11: Soil Erosion Protection – Rip Rap Protection).
- Only disturb areas where riprap is to be placed if final preparation and placement of the riprap can immediately follow the initial disturbance. Where riprap is used for outlet protection, place the riprap before or in conjunction with the construction of the pipe or channel so it is in place when the pipe or channel begins to operate.
- The designer, after determining the appropriate riprap size for stabilization, shall consider that size to be a minimum size and then, based on riprap gradations actually available in the area, select the size or sizes that equal or exceed the minimum size. Consider the possibility of damage when selecting a riprap size, especially if there is nearby water or a gully in which to toss the stones. See Volume 5, Section 4.3: Open Channel Specifications for additional channel protection guidance.
- Use field stone or quarry stone of approximately rectangular shape for the riprap. The stone shall be hard and angular and of such quality that it will not disintegrate on exposure to water or weathering and shall be suitable in all respects for the purpose intended.
- Place a lining of engineering filter fabric (geotextile) between the riprap and the underlying soil surface to prevent soil movement into or through the riprap. The geotextile should be keyed in at the top of the bank.
- Do not use filter fabric on slopes steeper than 1-1/2H:1V as slippage may occur. It should be used in conjunction with a layer of coarse aggregate (granular filter blanket) when the riprap to be placed is 12 inches and larger.

1.27.4 Maintenance Standards

- Replace riprap as needed.

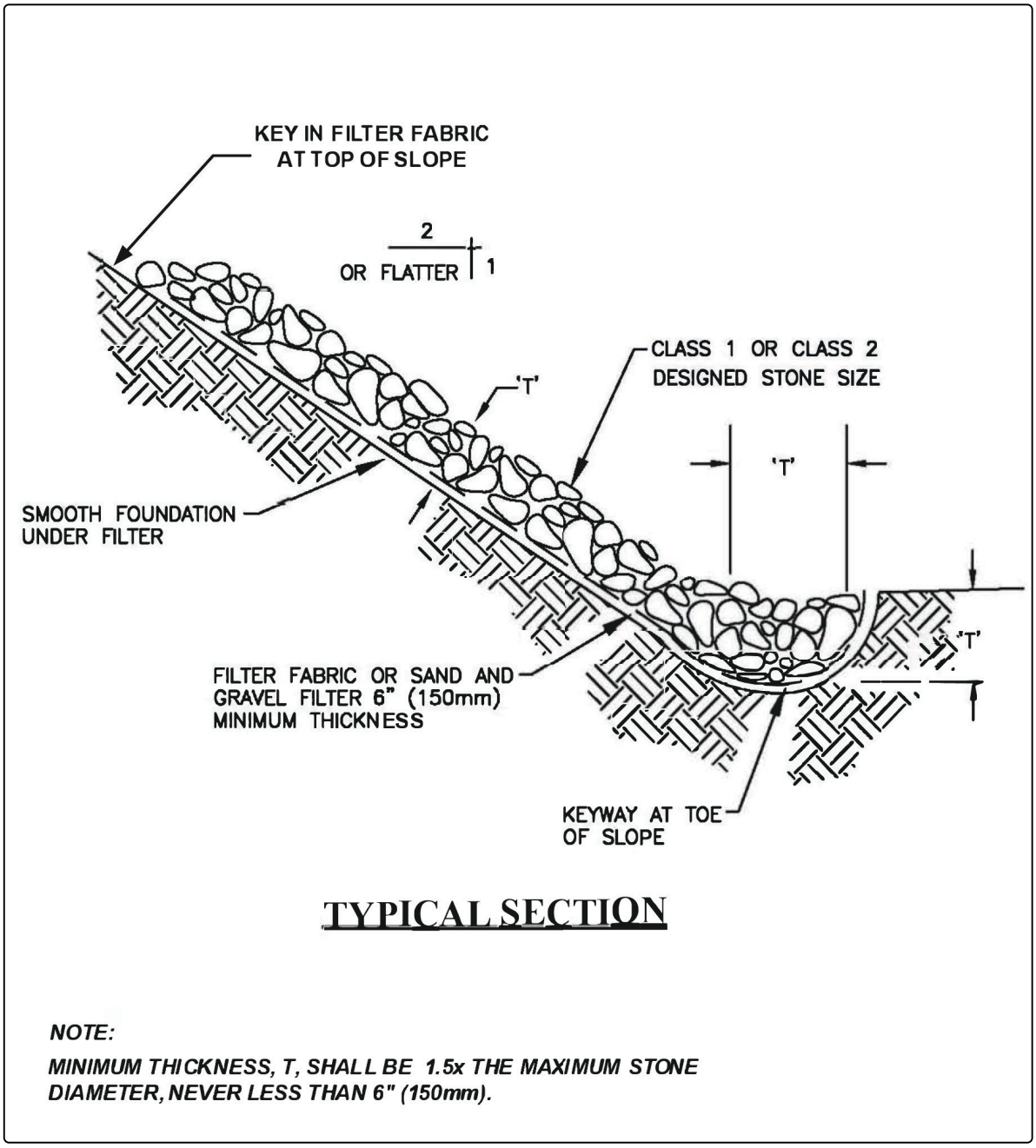


Figure 3 - 11: Soil Erosion Protection – Rip Rap Protection

1.28 BMP C203: Water Bars

1.28.1 Purpose

A water bar is a small ditch or ridge of material is constructed diagonally across a road or right-of-way to divert stormwater runoff from the road surface, wheel tracks, or a shallow road ditch.

1.28.2 Conditions of Use

Clearing right-of-way and construction of access for power lines, pipelines, and other similar installations often require long, narrow right-of-ways over sloping terrain. Disturbance and compaction promotes gully formation in these cleared strips by increasing the volume and velocity of runoff. Gully formation may be especially severe in tire tracks and ruts. To prevent gullying, runoff can often be diverted across the width of the right-of-way to undisturbed areas by using small predesigned diversions.

Give special consideration to each individual outlet area, as well as to the cumulative effect of added diversions. Use gravel to stabilize the diversion where significant vehicular traffic is anticipated.

1.28.3 Design and Installation Specifications

- Height: 8-inches minimum measured from the channel bottom to the top of the ridge.
- Side slope of channel: 2H:1V maximum; 3H:1V or flatter when vehicles will cross.
- Base width of ridge: 6-inches minimum.
- Locate them to use natural grades and conveyance channels and to discharge into well vegetated stable areas.
- Guideline for Spacing:

Slope %	Spacing (ft)
< 5	125
5 - 10	100
10 - 20	75
20 – 35	50
> 35	Use rock lined ditch

- Grade of water bar and angle: Select angle that results in ditch slope of less than 2 percent.
- Install as soon as clearing and grading is complete. Reconstruct when construction is complete on a section when utilities are being installed.
- Compact the ridge when installed.
- Stabilize, seed, and mulch portions that are not subject to traffic. Gravel areas crossed by vehicles.

1.28.4 Maintenance Standards

- Periodically inspect water bars for wear, and after every heavy rainfall inspect for erosion damage.
- Immediately remove sediment from the flow area and repair the dike.

- Check outlet areas and make timely repairs as needed.
- When permanent road conveyance systems are established and the area above the temporary right-of-way diversion is permanently stabilized, remove the dike and fill the channel to blend with the natural ground, and appropriately stabilize the disturbed area.

1.29 BMP C204: Pipe Slope Drains

1.29.1 Purpose

To use a pipe to convey stormwater away from or over bare soil to prevent gullies, channel erosion, and saturation of slide-prone soils.

1.29.2 Conditions of Use

Pipe slope drains can be used when a temporary or permanent stormwater conveyance is needed to move the water down a slope steeper than 10% to avoid erosion (Figure 3 - 12: Pipe Slope Drains).

Pipe slope drains can be:

- Connected to new catch basins and used temporarily until all permanent piping is installed;
- Used to collect water from aquifers exposed on cut slopes and convey it to the base of the slope;
- Used to collect clean runoff from plastic sheeting and direct it away from exposed soil;
- Installed in conjunction with silt fence to collect and convey water to a controlled area;
- Used to divert small seasonal streams away from construction. They have been used successfully on culvert replacement and extension jobs. Large flex pipe can be used on larger streams during culvert removal, repair, or replacement; and,
- Connected to existing roof downspout systems and used to divert water away from work areas during building renovation, demolition, and construction projects.
- Used at bridge ends to collect runoff and convey it to the base of the fill slopes along the bridge approaches.
- Used on road projects to collect runoff from pavement and pipe it away from side slopes.

There are several commercially available collectors that are attached to the pipe inlet and help prevent erosion at the inlet.

1.29.3 Design and Installation Specifications

Size the pipe to convey the flow. The capacity for temporary pipe slope drains shall be sufficient to handle the peak volumetric flowrate from a 10-year, 24-hour frequency storm assuming a Type 1A rainfall distribution (3.0-inches) using a 10-minute timestep and single event model. Alternatively, use the 10-year return period flowrate, indicated by an Ecology approved continuous simulation model assuming a 15 minute timestep. Size temporary pipe slope drains using the worst-case land cover condition.

- Use care in clearing vegetated slopes for installation.
- Re-establish cover immediately on areas disturbed by installation.
- Use temporary pipe slope drains on new cut or fill slopes.
- Use diversion dikes or swales to collect water at the top of the slope.
- Ensure that the entrance area is stable and large enough to direct flow into the pipe.
- Piping of water through the berm at the entrance area is a common failure mode.

- The entrance shall consist of a standard flared end section for culverts 12 inches and larger with a minimum 6-inch metal toe plate to prevent runoff from undercutting the pipe inlet. The slope of the entrance shall be at least 3 percent. Sand bags may also be used at pipe entrances as a temporary measure.
- Thoroughly compact the soil around and under the pipe and entrance section to prevent undercutting.
- Securely connect the flared inlet section to the pipe slope drain and have watertight connecting bands.
- Securely fasten, fuse or have gasketed, watertight fittings for the pipe slope drain sections, and securely anchor them into the soil.
- Install thrust blocks anytime 90 degree bends are utilized. Depending on size of pipe and flow, these can be constructed with sand bags, straw bales staked in place, “T” posts and wire, or ecology blocks.
- Pipe needs to be secured along its full length to prevent movement. This can be done with steel “T” posts and wire. A post is installed on each side of the pipe and the pipe is wired to them. This should be done every 10-20 feet of pipe length, depending on the size of the pipe and quantity of water to be diverted.
- Use interceptor dikes to direct runoff into a pipe slope drain. Ensure the height of the dike is at least 1 foot higher at all points than at the top of the inlet pipe.
- Stabilize the area below the outlet with a riprap apron (see BMP C209: Outlet Protection for the appropriate outlet material). For permanent installations, protect the discharge location using guideance in A400: End of Pipe Discharge Protection.
- If the pipe slope drain is conveying sediment-laden water, direct all flows into the sediment trapping facility.

1.29.4 Maintenance Standards

- Check inlet and outlet points regularly, especially after storms.
- The inlet should be free of undercutting, and no water should be going around the point of entry. If there are problems, the headwall should be reinforced with compacted earth or sand bags.
- The outlet point should be free of erosion and installed with appropriate outlet protection.
- For permanent installations, inspect pipe periodically for vandalism and physical distress such as slides and wind-throw.
- Normally the pipe slope is so steep that clogging is not a problem with smooth wall pipe; however, debris may become lodged in the pipe.

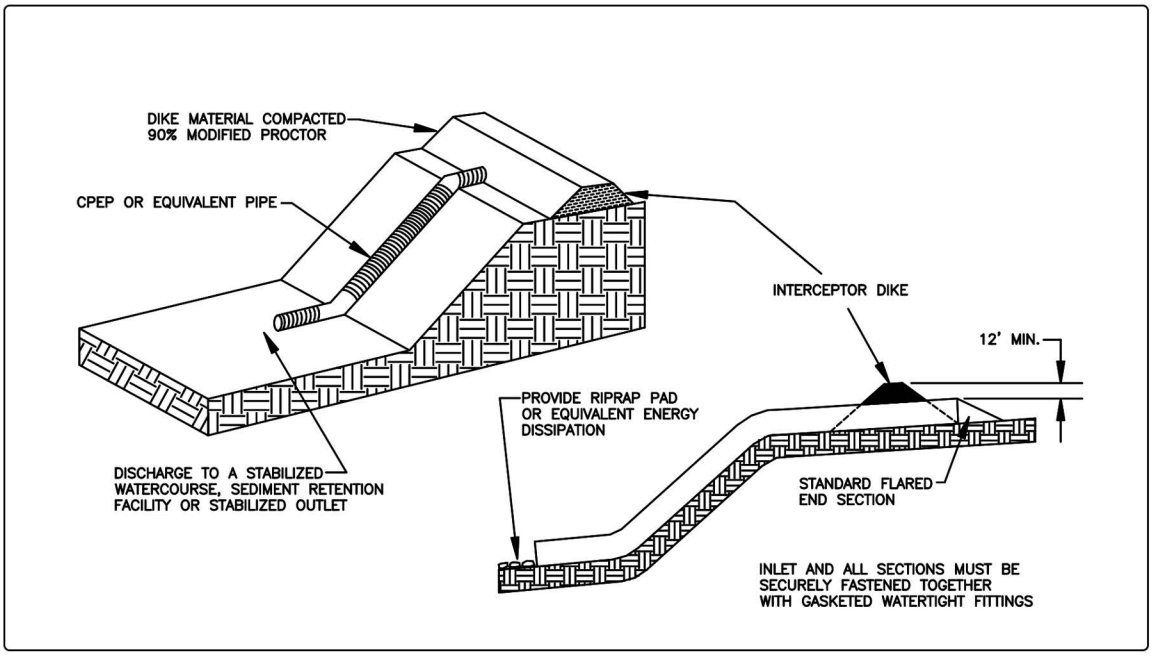


Figure 3 - 12: Pipe Slope Drains

1.30 BMP C205: Subsurface Drains

1.30.1 Purpose

To intercept, collect, and convey groundwater to a satisfactory outlet, using a perforated pipe or conduit below the ground surface. Subsurface drains are also known as “French drains”. The perforated pipe provides a dewatering mechanism to drain excessively wet soils, provide a stable base for construction, improves stability of structures with shallow foundations, or reduces hydrostatic pressure to improve slope stability.

1.30.2 Conditions of Use

Use when excessive water must be removed from the soil. The soil permeability, depth to water table, and impervious layers are all factors which may govern the use of subsurface drains.

1.30.3 Design and Installation Specifications

Relief drains

- Are used either to lower the water table in large, relatively flat areas, improve the growth of vegetation, or to remove surface water.
- Are installed along a slope and drain in the direction of the slope.
- Can be installed in a grid pattern, a herringbone pattern, or a random pattern.

Interceptor drains

- Are used to remove excess groundwater from a slope, stabilize steep slopes, and lower the water table immediately below a slope to prevent the soil from becoming saturated.
- Are installed perpendicular to a slope and drain to the side of the slope.
- Usually consist of a single pipe or series of single pipes instead of a patterned layout.

Depth and spacing considerations for interceptor drains

- The depth of an interceptor drain is determined primarily by the depth to which the water table is to be lowered or the depth to a confining layer. For practical reasons, the maximum depth is usually limited to 6 feet, with a minimum cover of 2 feet to protect the conduit.
- The soil should have depth and sufficient permeability to permit installation of an effective stormwater system at a depth of 2 to 6 feet.

Subsurface Drain Sizing and Placement

- Size subsurface drains to carry the required capacity without pressure flow. The minimum diameter for a subsurface drain is 4 inches.
- The minimum velocity required to prevent silting is 1.4 feet per second. Grade the line to achieve this velocity at a minimum. The maximum allowable velocity using a sand-gravel filter or envelope is 9 feet per second.
- Use filter material and fabric around all subsurface drains for proper bedding and filtration of fine materials. Envelopes and filters should surround the subsurface drain to a minimum of 3-inch thickness.
- Construct the trench on a continuous grade with no reverse grades or low spots.

- Stabilize soft or yielding soils under the subsurface drain with gravel or other suitable material.
- Backfill immediately after placement of the subsurface drain pipe. Do not allow sections of the subsurface drain pipe to remain uncovered overnight or during a rainstorm. Place backfill material in the trench in such a manner that the subsurface drain pipe is not displaced or damaged.
- Do not install permanent subsurface drains near trees as tree roots may clog the lines. Use solid pipe with watertight connections where necessary to pass a subsurface drainage system through a stand of trees.
- The quantity and quality of discharge needs to be accounted for in the receiving stream (additional detention may be required).
- The capacity of a subsurface drain is determined by calculating the maximum rate of groundwater flow to be intercepted. Therefore, it is good practice to make complete subsurface investigations, including hydraulic conductivity of the soil, before designing a subsurface drainage system.

Subsurface Drain Outlets

- Ensure that the outlet of the subsurface drain empties into a channel or other watercourse above the normal water level.
- An adequate outlet for the subsurface drainage system must be available either by gravity or pumping.
- Empty the outlet of the subsurface drain into a sediment trapping BMP through a catch basin. If free of sediment, it can then empty into a receiving channel, swale, or stable vegetated area adequately protected from erosion and undermining.
- Secure an animal guard to the outlet end of the pipe to keep out rodents.
- Use at least 10 feet of corrugated metal, cast iron, or heavy-duty plastic without perforations outlet pipe. Do not use an envelope or filter material around the outlet pipe, and bury at least two-thirds of the pipe length.
- When outlet velocities exceed those allowable for the receiving stream, provide outlet protection.

1.30.4 Maintenance Standards

- Check the subsurface drains periodically to ensure that they are free-flowing and not clogged with sediment or roots.
- Keep the outlet clean and free of debris.
- Keep surface inlets open and free of sediment and other debris.
- Trees located too close to a subsurface drain often clog the system with their roots. If a subsurface drain becomes clogged, relocate the subsurface drain or remove the trees as a last resort. Plan the placement of the subsurface drain to minimize this problem.
- Where subsurface drains are crossed by heavy vehicles, check the line to ensure that it is not crushed and use pipe material that can handle traffic loads.

1.31 BMP C206: Level Spreader

1.31.1 Purpose

To provide a temporary outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope. To convert concentrated runoff to sheet flow and release it onto stabilized areas.

1.31.2 Conditions of Use

- Use when a concentrated flow of water needs to be dispersed over a large area with existing stable vegetation.
- Items to consider are:
  - What is the risk of erosion or damage if the flow may become concentrated?
  - Is an easement required if discharged to adjoining property?
- Use only where the slopes are gentle, the water volume is relatively low, and the soil will adsorb most of the low flow events.

1.31.3 Design and Installation Specifications

- Use above undisturbed areas that are stabilized by existing vegetation.
- Do not allow low points in the level spreader. If the level spreader has any low points, flow will concentrate, create channels and may cause erosion.
- Discharge area below the outlet must be uniform with a slope of less than 20%.
- Construct outlet level in a stable, undisturbed soil profile (not on fill).
- Do not allow the runoff to reconcentrate after release unless intercepted by another downstream measure.
- The grade of the channel for the last 20 feet of the dike or interceptor entering the level spreader shall be less than or equal to 1 percent. The grade of the level spreader shall be 0 percent to ensure uniform spreading of storm runoff.
- A 6-inch high gravel berm placed across the level lip shall consist of washed crushed rock, 2- to 4-inch or 3/4-inch to 1½-inch size.
- Calculate the spreader length by estimating the peak volumetric flowrate expected from a 10-year, 24-hour frequency storm assuming a type 1A rainfall distribution (3.0-inches) using a 10-minute timestep. The length of the spreader shall be a minimum of 15 feet for 0.1 cubic feet per second and shall be 10 feet for each 0.1 cubic feet per second there after to a maximum of 0.5 cubic feet per second per spreader. Use multiple spreaders for higher flows.
- The width of the spreader should be at least 6 feet.
- The depth of the spreader as measured from the lip should be at least 6 inches and it should be uniform across the entire length.
- Level spreaders shall be setback a minimum of 5 feet from the property line unless there is an easement for flow.
- Materials that can be used include sand bags, lumber, logs, concrete, and pipe. To function properly, the material needs to be installed level and on contour. Figure 3 - 13: Cross-Section of a Level Spreader and Figure 3 - 14: Detail of a Level Spreader provide a

cross-section and a detail of a level spreader. A capped perforated pipe can also be used as a spreader.

1.31.4 Maintenance Standards

- The spreader should be inspected after every runoff event to ensure proper function.
- The contractor should avoid the placement of any material on the structure and should prevent construction traffic from crossing over the structure.
- If the spreader is damaged by construction traffic, immediately repair it.

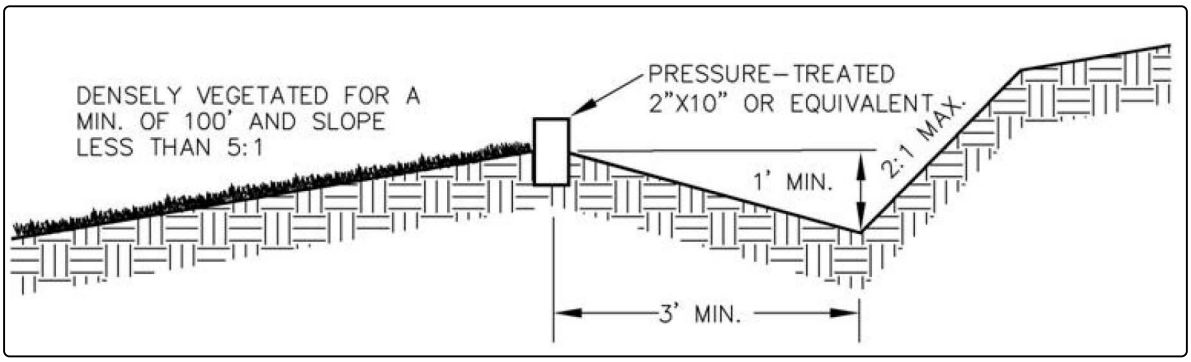


Figure 3 - 13: Cross-Section of a Level Spreader

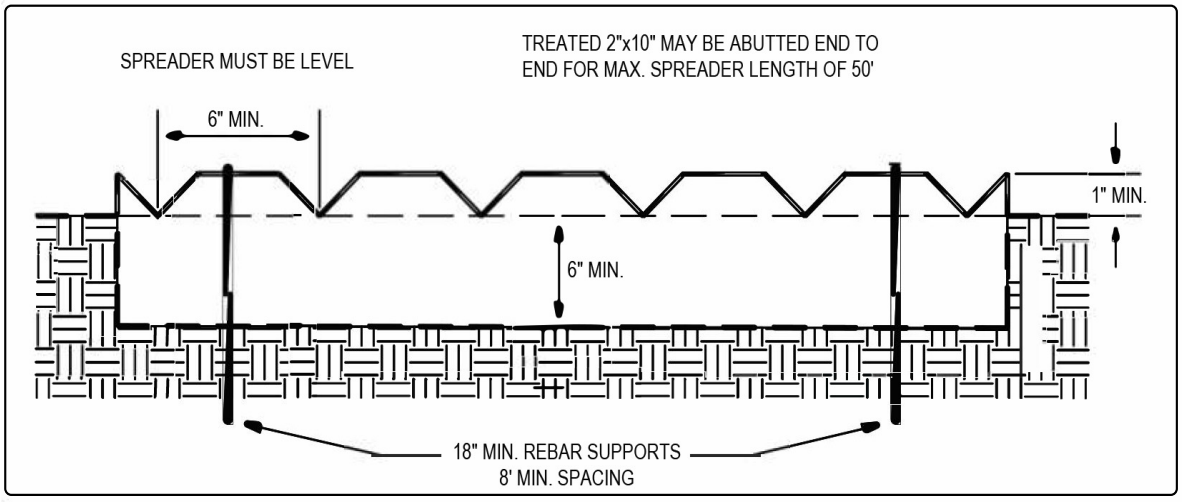


Figure 3 - 14: Detail of a Level Spreader

1.32 BMP C207: Check Dams

1.32.1 Purpose

Construction of small dams across a swale or ditch reduces the velocity of concentrated flow and dissipates energy at the check dam.

1.32.2 Conditions of Use

- Use check dams where temporary channels or permanent channels are not yet vegetated, channel lining is infeasible, and velocity checks are required.
- Do not place check dams in streams unless approved by the State Department of Fish and Wildlife. Do not place check dams in wetlands without approval from the City of Tacoma Planning and Development Services and other appropriate state agencies.
- Do not place check dams below the expected backwater from any salmonid bearing water between September 15 and June 15 to ensure that there is no loss of high flow refuge habitat for overwintering juvenile salmonids and emergent salmonid fry.

1.32.3 Design and Installation Specifications

- Construct rock check dams from appropriately sized rock; rock or pea-gravel filled bags; or other products intended for this purpose. The rock used must be large enough to stay in place given the expected design flow through the channel. The rock must be placed by hand or by mechanical means (no dumping of rock to form dam) to achieve complete coverage of the ditch or swale and to ensure that the center of the dam is lower than the edges.
- Before installing check dams bypass upstream flow away from the work area.
- Whatever material is used, the dam should form a triangle when viewed from the side. This prevents undercutting as water flows over the face of the dam rather than falling directly onto the ditch bottom.
- Check dams in association with sumps work more effectively at slowing flow and retaining sediment than just a check dam alone. A deep sump should be provided immediately upstream of the check dam.
- In some cases, if carefully located and designed, check dams can remain as permanent installations with very minor regrading. They may be left as either spillways, in which case accumulated sediment would be graded and seeded, or as check dams to prevent further sediment from leaving the site.
- Check dams can be constructed of either rock or pea-gravel filled bags. Numerous new products are also available for this purpose. They tend to be re-usable, quick and easy to install, effective, and cost efficient.
- Check dams should be placed perpendicular to the flow of water.
- The maximum spacing between the dams shall be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.
- Keep a maximum height of 2 feet at the center of the dam.
- Keep the center of the check dam at least 12 inches lower than the outer edges at natural ground elevation.
- Keep the side slopes of the check dam at 2H:1V or flatter.

- Key the stone into the ditch banks and extend it beyond the abutments a minimum of 18 inches to avoid washouts from overflow around the dam.
- Use filter fabric foundation under a rock or sand bag check dam. If a blanket ditch liner is used, this is not necessary. A piece of organic or synthetic blanket cut to fit will also work for this purpose.
- In the case of grass-lined ditches and swales, remove all check dams and accumulated sediment when the grass has matured sufficiently to protect the ditch or swale - unless the slope of the swale is greater than 4 percent. Seed and mulch the area beneath the check dams immediately after dam removal.
- Ensure that channel appurtenances, such as culvert entrances below check dams, are not subject to damage or blockage from displaced stones. Figure 3 - 15: Check Dams, depicts a typical rock check dam.

1.32.4 Maintenance Standards

- Monitor check dams for performance and sediment accumulation during and after each runoff producing rainfall. Remove sediment when it reaches one half the sump depth.
- Anticipate submergence and deposition above the check dam and erosion from high flows around the edges of the dam.
- If significant erosion occurs between dams, install a protective riprap liner in that portion of the channel.

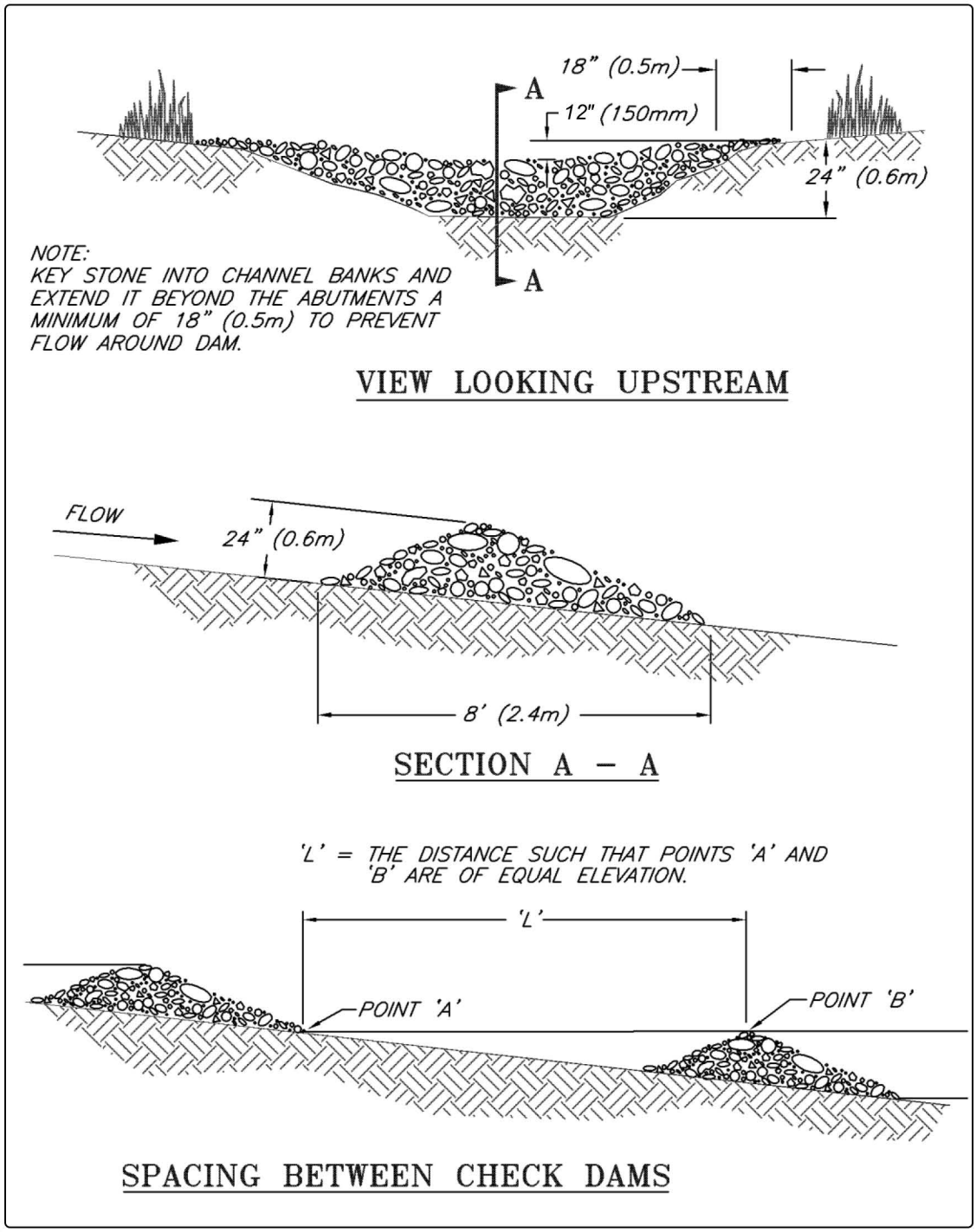


Figure 3 - 15: Check Dams

1.33 BMP C208: Triangular Silt Dike (Geotextile-Encased Check Dam)

1.33.1 Purpose

Triangular silt dikes (TSDs) may be used as check dams, for perimeter protection, for temporary soil stockpile protection, for drop inlet protection, or as a temporary interceptor dike (refer to Figure 3 - 16: Sediment Barrier – Geosynthetic Dike).

1.33.2 Conditions of Use

- TSDs may be used on soil or pavement with adhesive or staples.
- TSDs have been used to build temporary:
  - sediment ponds
  - diversion ditches
  - concrete wash out facilities
  - curbing
  - water bars
  - level spreaders
  - berms

1.33.3 Design and Installation Specifications

- TSDs are made ade of urethane foam sewn into a woven geosynthetic fabric.
- It is triangular, 10 inches to 14 inches high in the center, with a 20-inch to 28-inch base. A 2–foot apron extends beyond both sides of the triangle along its standard section of 7 feet. A sleeve at one end allows attachment of additional sections as needed.
- Install with ends curved up to prevent water from flowing around the ends.
- The fabric flaps and check dam units are attached to the ground with wire staples. Wire staples should be No. 11 gauge wire and should be 200 mm to 300 mm in length.
- When multiple units are installed, the sleeve of fabric at the end of the unit shall overlap the abutting unit and be stapled.

When used as check dams:

- TSDs should be located and installed as soon as construction will allow.
- TSDs should be placed perpendicular to the flow of water.
- The leading edge of the TSD must be secured with rocks, sandbags, or a small key slot and staples.

1.33.4 Maintenance Standards

- Monitor triangular silt dikes for performance and sediment accumulation during and after each runoff producing rainfall. Remove sediment when it reaches one half the height of the dam.
- Anticipate submergence and deposition above the triangular silt dam and erosion from high flows around the edges of the dam. Immediately repair any damage or undercutting of the dam.

- In the case of grass-lined ditches and swales, remove check dams and accumulated sediment when the grass has matured sufficiently to protect the ditch or swale, unless the slope of the swale is greater than 4 percent. Seed and mulch the area beneath the check dams immediately after dam removal.

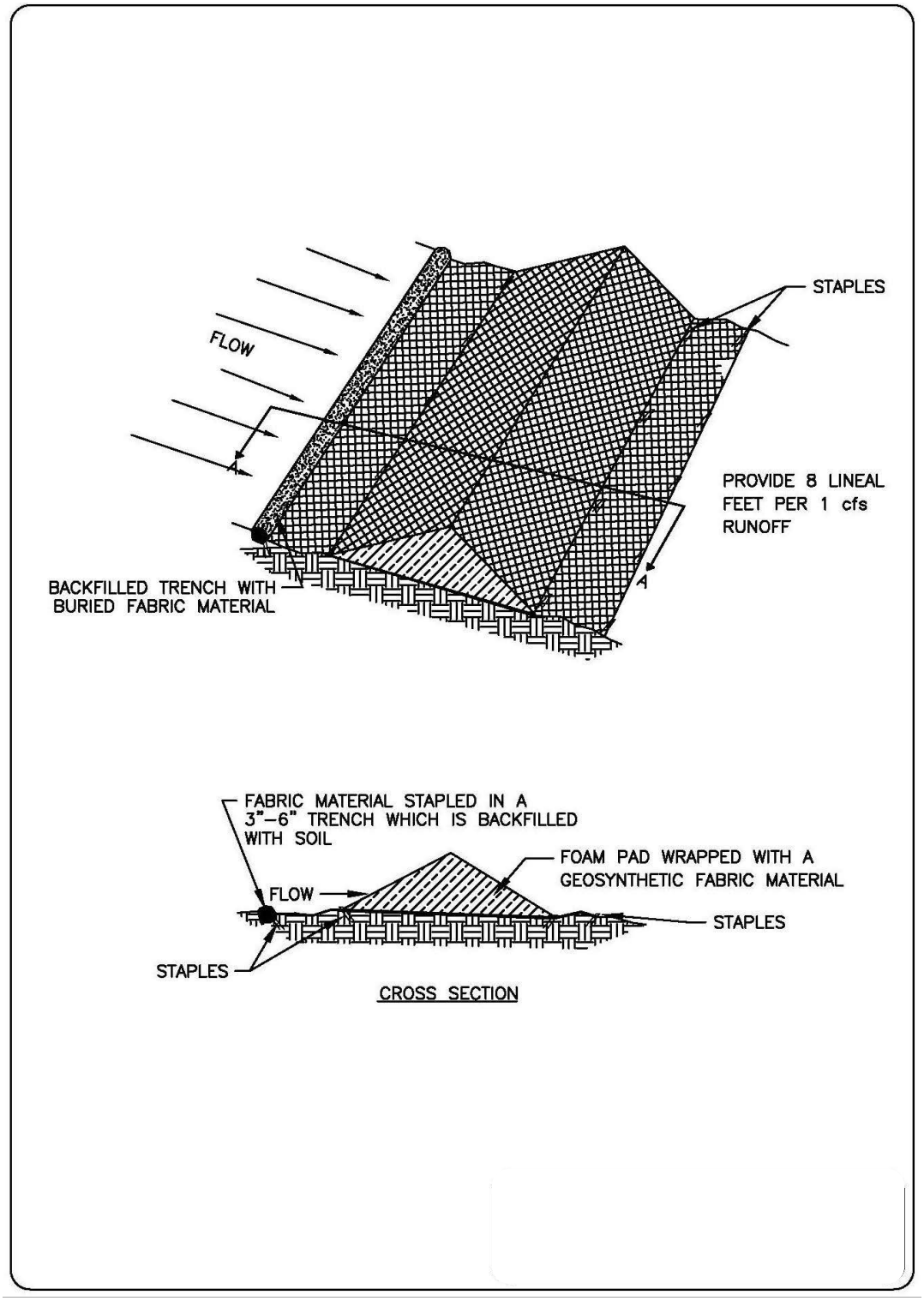


Figure 3 - 16: Sediment Barrier – Geosynthetic Dike

1.34 BMP C209: Outlet Protection

1.34.1 Purpose

Outlet protection prevents scour at conveyance outlets and minimizes the potential for downstream erosion by reducing the velocity of concentrated stormwater flows.

1.34.2 Conditions of Use

Outlet protection is required at stormwater system outlets.

1.34.3 Design and Installation Specifications

- Protect the receiving channel at the outlet of a culvert from erosion by rock lining a minimum of 6 feet downstream and extending rock lining up the channel sides a minimum of 1–foot above the maximum tailwater elevation or 1-foot above the crown, whichever is higher. For large pipes (more than 18 inches in diameter), the outlet protection lining of the channel is lengthened to four times the diameter of the culvert.
- See A400: End of Pipe Discharge Protection for permanent outlet protection.
- Organic or synthetic erosion blankets, with or without vegetation, may be, cheaper, and easier to install than rock. Materials can be chosen using manufacturer product specifications. ASTM test results are available for most products and the designer can choose the correct material for the expected flow.
- With low flows, vegetation (including sod) can be effective.
- Use the following guidelines for riprap outlet protection:
    - If the discharge velocity at the outlet is less than 5 feet per second (pipe slope less than 1 percent), use 2-inch to 8-inch riprap. Minimum thickness is 1-foot.
    - For 5 to 10 feet per second discharge velocity at the outlet (pipe slope less than 3 percent), use 24-inch to 4-foot riprap. Minimum thickness is 2 feet.
    - For outlets at the base of pipes with slopes greater than 10%, an engineered energy dissipater shall be used.
- Always use filter fabric or erosion control blankets under riprap to prevent scour and channel erosion.
- Bank stabilization, bioengineering, and habitat features may be required for disturbed areas. This work may require a Hydraulic Project Approval (HPA) from the Washington State Department of Fish and Wildlife.

1.34.4 Maintenance Standards

- Inspect and repair as needed.
- Add rock as needed to maintain the intended function.
- Clean energy dissipater if sediment builds up.

1.35 BMP C220: Stormwater System Inlet Protection

1.35.1 Purpose

To prevent coarse sediment from entering stormwater systems prior to permanent stabilization of the disturbed area.

1.35.2 Conditions of Use

- Use where inlets are to be made operational before permanent stabilization of the disturbed area.
- Provide protection for all stormwater system inlets downslope and within 500 feet of a disturbed or construction area, unless those inlets are preceded by another sediment trapping device.
- Table 3 - 11: Stormwater System Inlet Protection lists several options for inlet protection. All of the methods for stormwater system inlet protection are prone to plugging and require a high frequency of maintenance. Contributing areas should be limited to 1 acre or less. Emergency overflows may be required where stormwater ponding would cause a hazard. If an emergency overflow is provided, additional end-of-pipe treatment may be required.

Table 3 - 11: Stormwater System Inlet Protection

Type of Inlet Protection	Emergency Overflow	Applicable for Paved/ Earthen Surfaces	Conditions of Use
Excavated drop inlet protection	Yes, temporary flooding will occur	Earthen	Applicable for heavy flows. Easy to maintain. Large area requirement: 30’ x 30’ per acre.
Block and gravel drop filter	Yes	Paved or earthen	Applicable for heavy concentrated flows. Will not pond.
Gravel and mesh filter	No	Paved	Applicable for heavy concentrated flows. Will pond. Can withstand traffic.
Catch basin filters	Yes	Paved or earthen	Frequent maintenance required.
Curb inlet protection with a wooden weir	Small capacity overflow	Paved	Used for sturdy, more compact installation.
Block and gravel curb inlet protection	Yes	Earthen	Sturdy, but limited filtration.
Culvert inlet sediment trap			18-month expected life.

1.35.3 Design and Installation Specifications

Excavated Drop Inlet Protection

- An excavated impoundment around the inlet. Sediment settles out of the stormwater prior to entering the stormwater conveyance system.

- Provide depth of 1 to 2 feet, as measured from the crest of the inlet structure.
- Side slopes of excavation should be no steeper than 2H:1V.
- Minimum volume of excavation 35 cubic yards.
- Shape excavation to fit site with longest dimension oriented toward the longest inflow area.
- Install provisions for collection and conveyance to prevent standing water problems.
- Clear the area of all debris.
- Grade the approach to the inlet uniformly.
- Drill weep holes into the side of the inlet.
- Protect weep holes with screen wire and washed aggregate.
- Seal weep holes when removing structure and stabilizing area.
- It may be necessary to build a temporary dike to the down slope side of the structure to prevent bypass flow.

Block and Gravel Filter

- A block and gravel filter is a barrier formed around the stormwater system inlet with standard concrete blocks and gravel. See Figure 3 - 17: Drop Inlet with Block and Gravel Filter.
- Provide a height 1 to 2 feet above inlet.
- Recess the first row 2 inches into the ground for stability.
- Support subsequent courses by placing a piece of 2x4 lumber through the block opening.
- Do not use mortar.
- Lay some blocks in the bottom row on their side for dewatering the pool.
- Place hardware cloth or comparable wire mesh with ½-inch openings over all block openings.
- Place gravel just below the top of blocks on slopes of 2H:1V or flatter.
- An alternative design is a gravel berm surrounding the inlet with the following characteristics:
  - Provide an inlet slope of 3H:1V.
  - Provide an outlet slope of 2H:1V.
  - Provide a 1-foot wide level stone area between the structure and the inlet.
  - Use inlet slope stones 3 inches in diameter or larger.
  - For outlet slope use gravel ½- to ¾-inch at a minimum thickness of 1-foot.

Gravel and Wire Mesh Filter

- A gravel and wire mesh filter is a gravel barrier placed over the top of the inlet (see) . This structure does not provide an overflow.
- Use a hardware cloth or comparable wire mesh with 1/2-inch openings.

- Place wire mesh over the drop inlet so that the wire extends a minimum of 1-foot beyond each side of the inlet structure.
- Overlap the strips if more than one strip of mesh is necessary.

- Place coarse aggregate over the wire mesh.
  - Provide at least a 12-inch depth of aggregate over the entire inlet opening and extend at least 18-inches on all sides.

Catch Basin Filters

- Inserts (Figure 3 - 19: Catch Basin Filter) shall be designed by the manufacturer for use at construction sites. The limited sediment storage capacity increases the frequency of inspection and maintenance required, which may be daily for heavy sediment loads. The maintenance requirements can be reduced by combining a catch basin filter with another type of inlet protection. This type of inlet protection provides flow bypass without overflow and therefore may be a better method for inlets located along active rights-of-way.
- Provide a minimum of 5 cubic feet of storage.
- Requires dewatering provisions.
- Provide a high-flow bypass that will not clog under normal use at a construction site.
- The catch basin filter is inserted in the catch basin just below the grating.

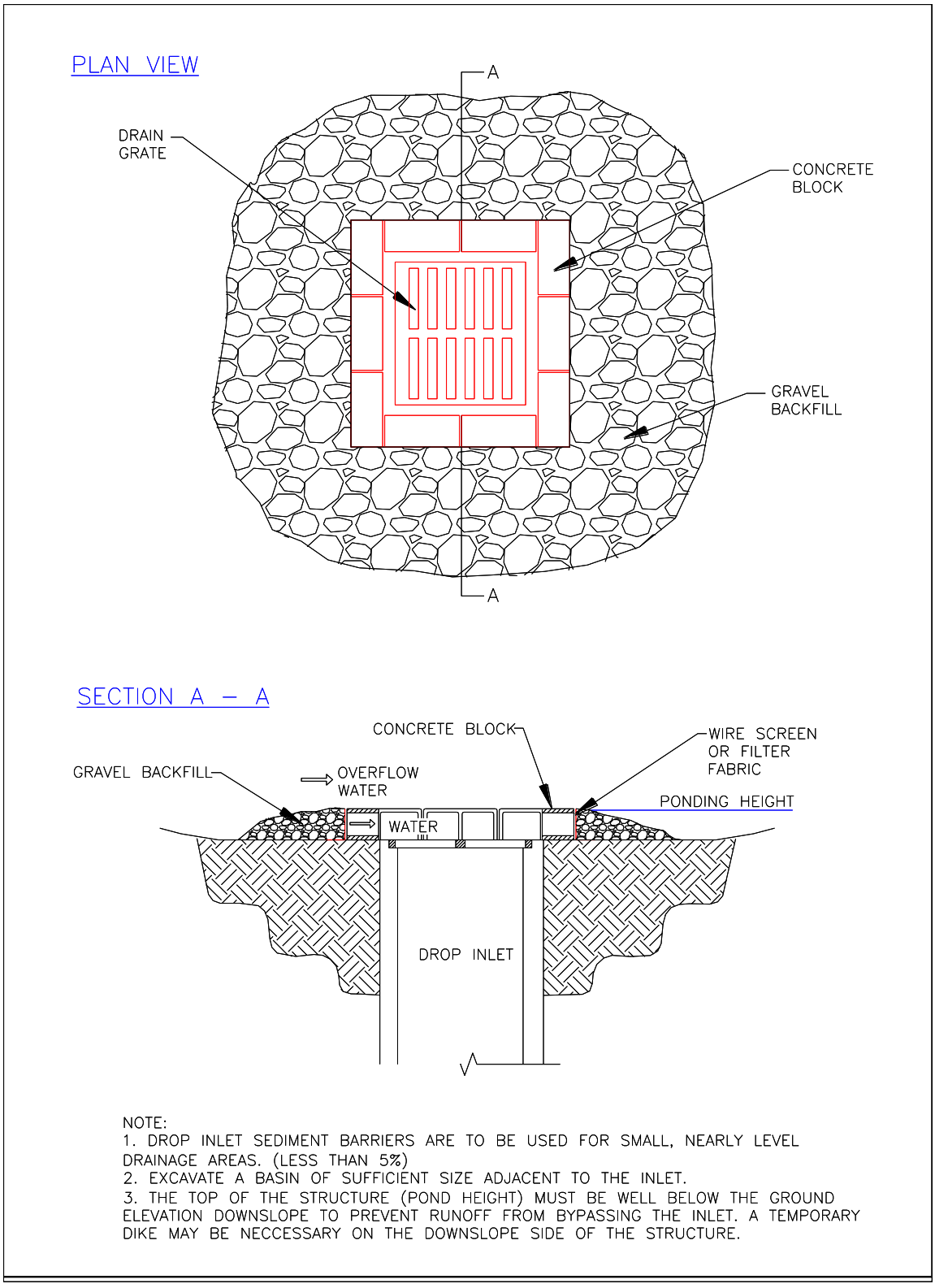


Figure 3 - 17: Drop Inlet with Block and Gravel Filter

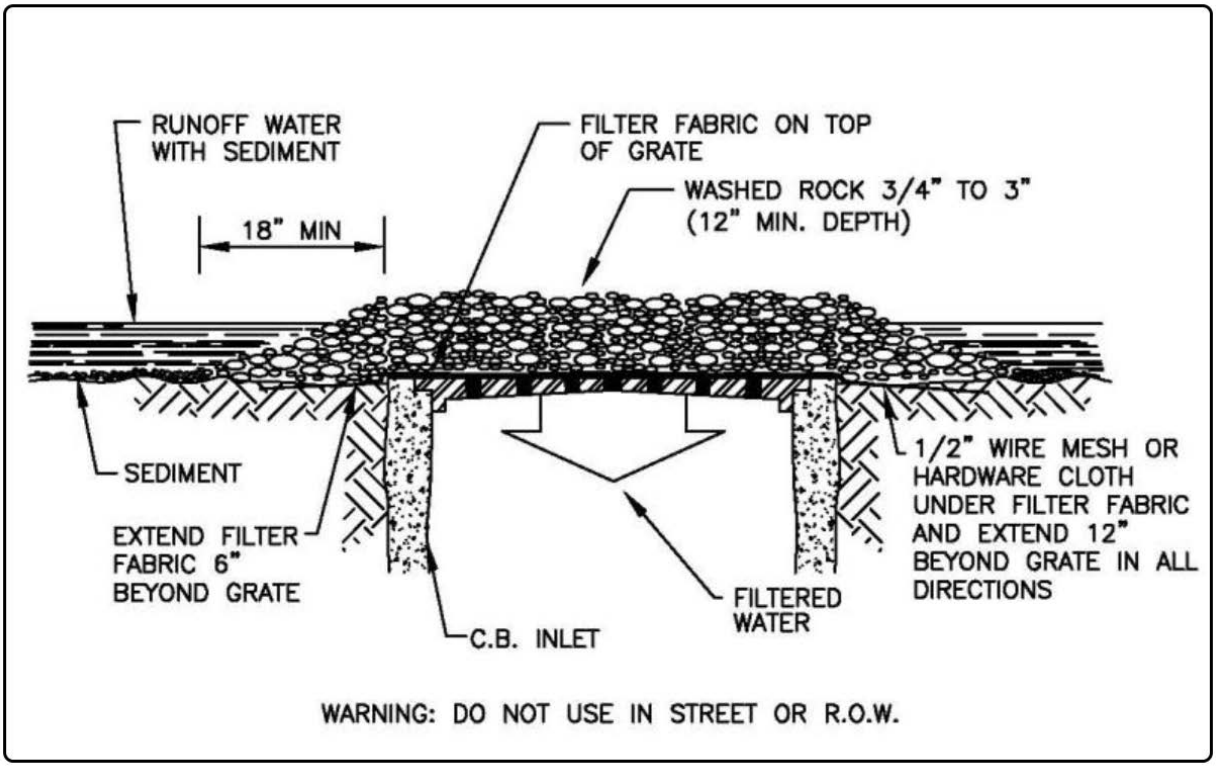


Figure 3 - 18: Gravel and Wire Mesh Filter

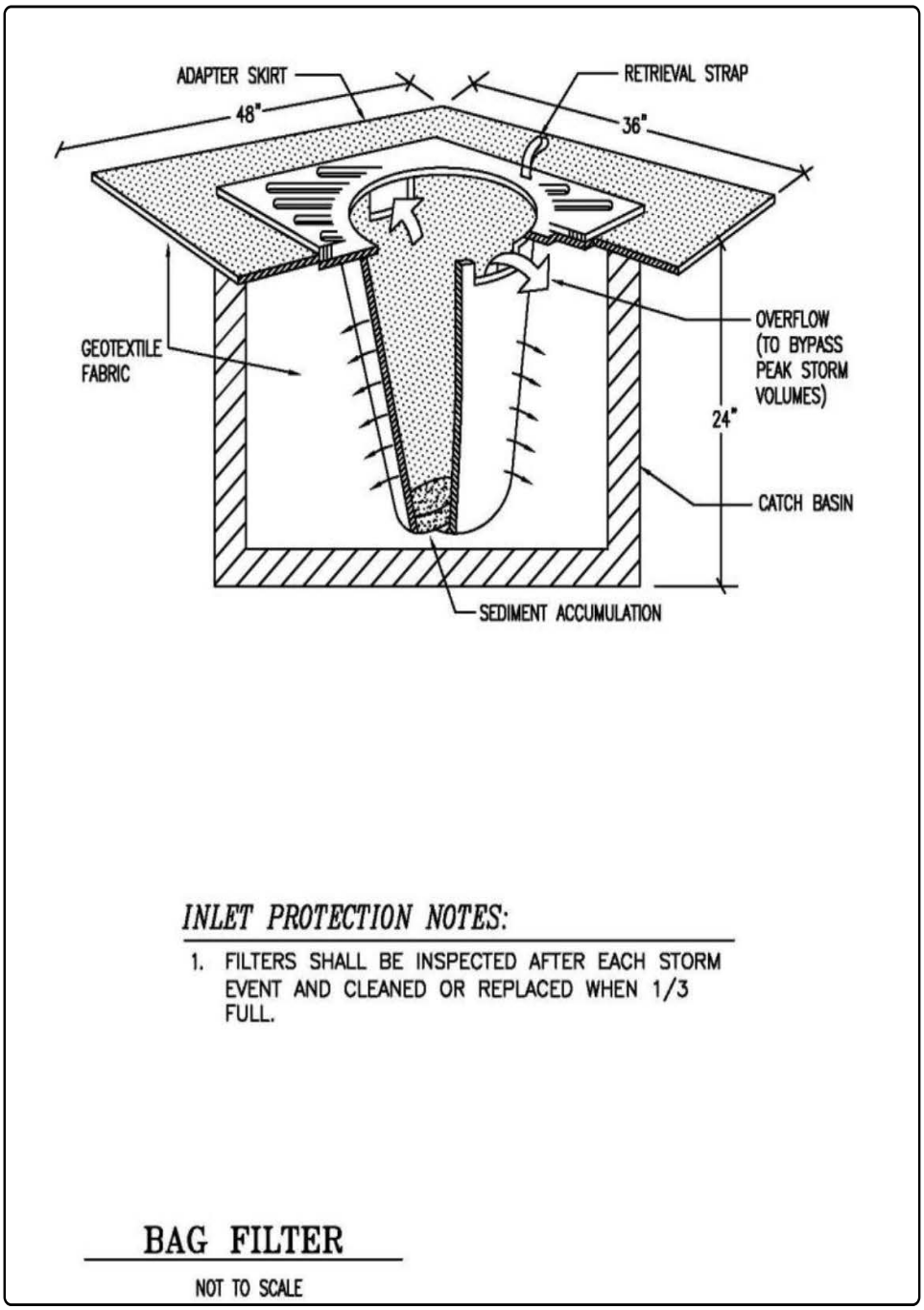


Figure 3 - 19: Catch Basin Filter

Curb Inlet Protection with Wooden Weir

Barrier formed around a curb inlet with a wooden frame and gravel.

- Use wire mesh with ½-inch openings.
- Use extra strength filter cloth.
- Construct a frame.
- Attach the wire and filter fabric to the frame.
- Pile coarse washed aggregate against the wire and fabric.
- Place weight on frame anchors.

Block and Gravel Curb Inlet Protection

Barrier formed around an inlet with concrete blocks and gravel. See Figure 3 - 20: Block and Gravel Curb Inlet Protection.

- Use wire mesh with ½-inch openings.
- Place two concrete blocks on their sides abutting the curb at either side of the inlet opening. These are spacer blocks.
- Place a 2x4 stud through the outer holes of each spacer block to align the front blocks.
- Place blocks on their sides across the front of the inlet and abutting the spacer blocks.
- Place wire mesh over the outside vertical face.
- Pile coarse aggregate against the wire to the top of the barrier.

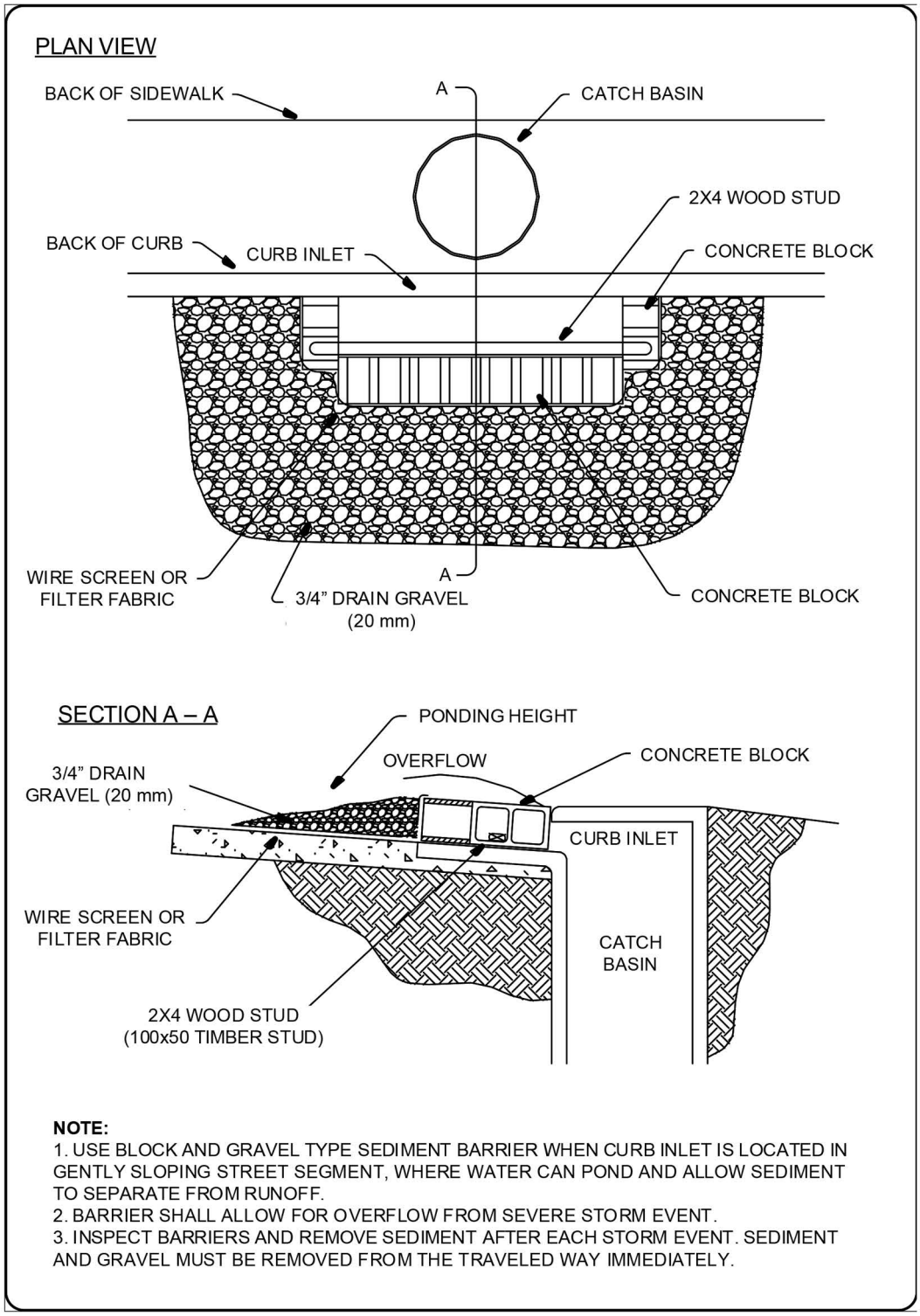


Figure 3 - 20: Block and Gravel Curb Inlet Protection

Curb and Gutter Sediment Barrier

Sandbag or rock berm (riprap and aggregate) 3 feet high and 3 feet wide in a horseshoe shape. See Figure 3 - 21: Curb and Gutter Sediment Barrier.

- Construct a horseshoe shaped berm, faced with coarse aggregate if using riprap, 3 feet high and 3 feet wide, at least 2 feet from the inlet.
- Construct a horseshoe shaped sedimentation trap on the outside of the berm sized to sediment trap standards for protecting a culvert inlet.

1.35.4 Maintenance Standards

- Inspect inlet protection frequently, especially after storm events. If the insert becomes clogged, clean or replace it.
- For systems using stone filters: If the stone filter becomes clogged with sediment, the stones must be pulled away from the inlet and cleaned or replaced. Since cleaning of gravel at a construction site may be difficult, an alternative approach would be to use the clogged stone as fill and put fresh stone around the inlet.
- Do not wash sediment into the stormwater system while cleaning. Spread all excavated material evenly over the surrounding land area or stockpile and stabilize as appropriate.
- Do not allow accumulated sediment to enter the stormwater system.
- Inlet protection shall be removed when area is fully stabilized and erosion and sediment controls are no longer needed.

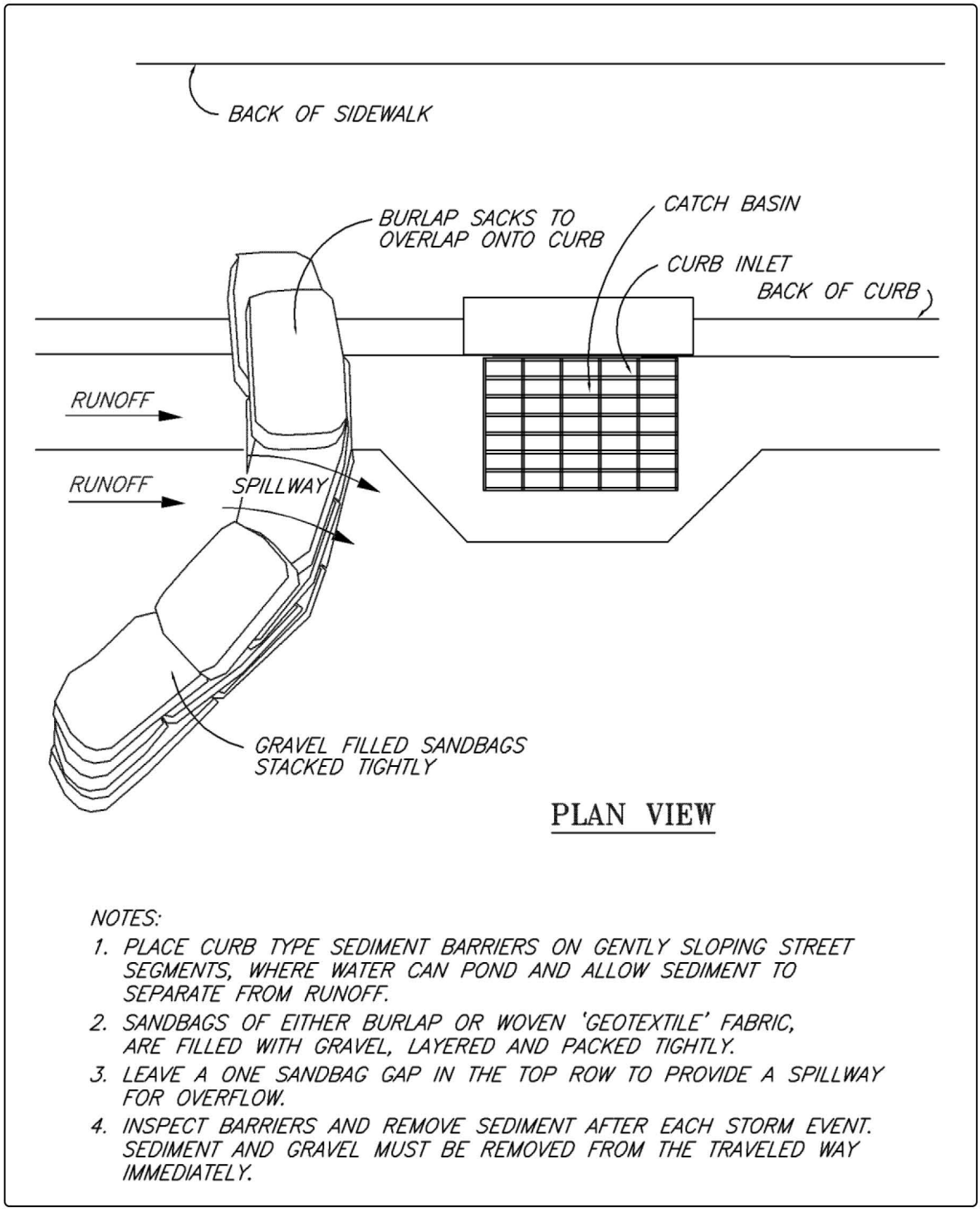


Figure 3 - 21: Curb and Gutter Sediment Barrier

1.36 BMP C231: Brush Barrier

1.36.1 Purpose

The purpose of brush barriers is to reduce the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow.

1.36.2 Conditions of Use

- Brush barriers may be used downslope of all disturbed areas of less than one-quarter acre.
- Brush barriers are not intended to treat concentrated flows, nor are they intended to treat substantial amounts of overland flow. Any concentrated flows must be conveyed through the stormwater system to a sediment pond. The only circumstance in which overland flow can be treated solely by a barrier, rather than by a sediment pond, is when the area draining to the barrier is small.
- Only install brush barriers on contours.

1.36.3 Design and Installation Specifications

- Height 2 feet (minimum) to 5 feet (maximum).
- Width 5 feet at base (minimum) to 15 feet (maximum).
- Filter fabric (geotextile) may be anchored over the brush berm to enhance the filtration ability of the barrier. Ten-ounce burlap is an adequate alternative to filter fabric.
- Chipped site vegetation, compost, or wood-based mulch (hog fuel) as specified in BMP C121: Mulching can be used to construct brush barriers.
- A 100 percent biodegradable installation can be constructed using 10-ounce burlap held in place by wooden stakes. Figure 3 - 22: Brush Barrier depicts a typical brush barrier.

1.36.4 Maintenance Standards

- Do not allow erosion or concentrated runoff under or around the barrier. If concentrated flows are bypassing the barrier, it must be expanded or augmented by toed-in filter fabric.
- Maintain the dimensions of the barrier.

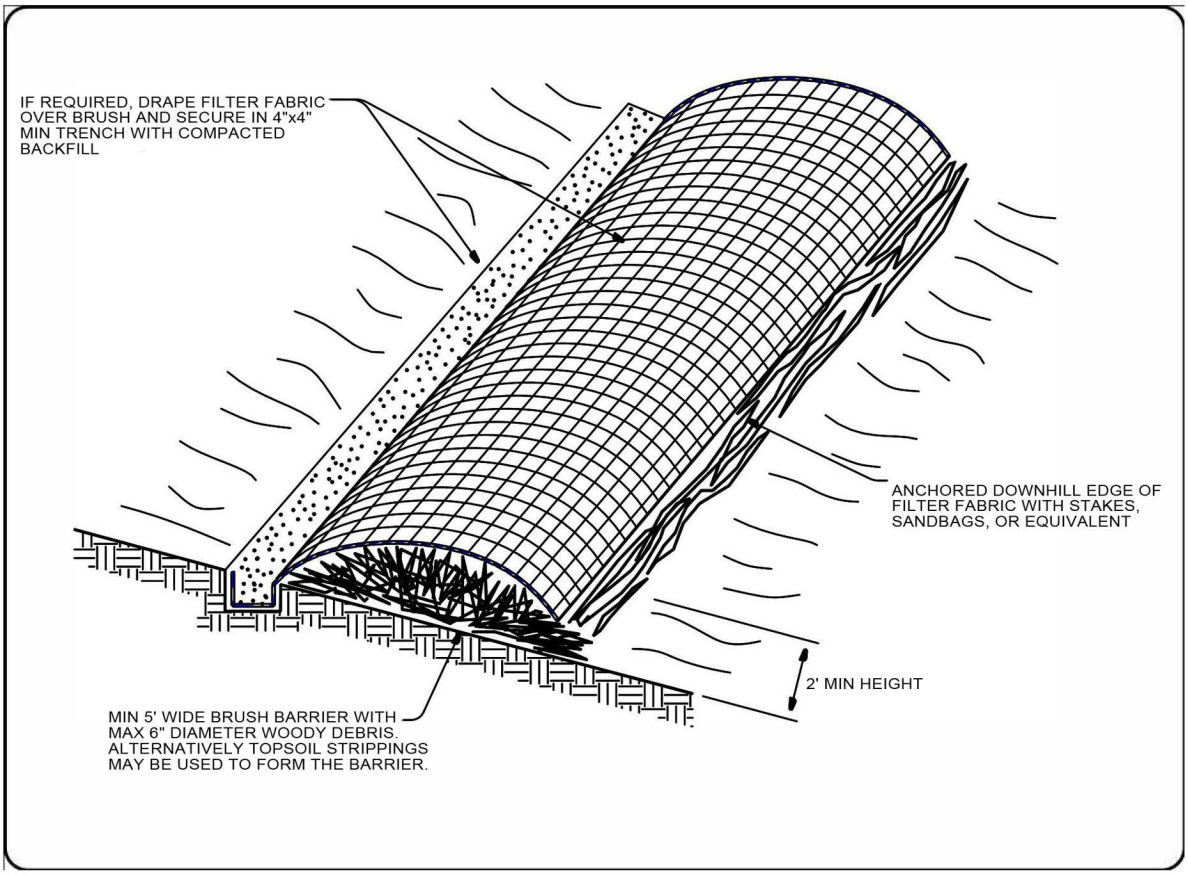


Figure 3 - 22: Brush Barrier

1.37 BMP C232: Gravel Filter Berm

1.37.1 Purpose

A gravel filter berm retains sediment by filtering runoff through a berm of gravel or crushed rock.

1.37.2 Conditions of Use

Use a gravel filter berm where a temporary measure is needed to retain sediment from construction sites.

Do not place gravel filter berms in traffic areas; gravel filter berms are not intended to be driven over.

Place gravel filter berms perpendicular to the flow of runoff, such that the runoff will filter through the berm prior to leaving the site.

1.37.3 Design and Installation Specifications

- Berm material shall be ¾ to 3 inches in size, washed well-graded gravel or crushed rock, with less than 5 percent fines. Do not use crushed concrete.
- Spacing of berms:
  - Every 300 feet on slopes less than 5 percent
  - Every 200 feet on slopes between 5 percent and 10 percent
  - Every 100 feet on slopes greater than 10 percent
- Berm dimensions:
  - 1 foot high with 3H:1V side slopes
  - 8 linear feet per 1 cubic foot per second runoff based on the 10-year, 24-hour design storm event assuming a Type 1A rainfall distribution (3.0-inches) using a 10-minute timestep.

1.37.4 Maintenance Standards

Regular inspection is required. Sediment shall be removed and filter material replaced as needed.

1.38 BMP C233: Silt Fence

1.38.1 Purpose

Silt fence reduces the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow.

1.38.2 Conditions of Use

- Silt fence may be used downslope of all disturbed areas.
- Silt fence shall prevent sediment carried by runoff from going beneath, through, or over the top of the silt fence, but shall allow the water to pass through the fence.
- Silt fence is not intended to treat concentrated flows, nor is it intended to treat substantial amounts of overland flow. Convey concentrated flows to a sediment trapping BMP.
- Do not construct silt fences in streams or use them in V-shaped ditches. Silt fences do not provide an adequate method of silt control for anything deeper than sheet or overland flow.

1.38.3 Design and Installation Specifications

- Use in combination with other construction stormwater BMPs.
- Maximum slope steepness (perpendicular to the silt fence line) 1H:1V.
- Maximum sheet or overland flow path length to the silt fence of 100 feet.
- Do not allow flows greater than 0.5 cfs.
- Use geotextile fabric that meets the following standards or WSDOT Standard Specification 9-33.2(1) Table 6 - Geotextile for Temporary Silt Fence. All geotextile properties listed below are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in Table 3 - 12: Geotextile Fabric Standards for Silt Fence):

Table 3 - 12: Geotextile Fabric Standards for Silt Fence

Standard	Description
Polymeric Mesh AOS (ASTM D4751)	0.60 mm maximum for silt film wovens (#30 sieve). 0.30 mm maximum for all other geotextile types (#50 sieve). 0.15 mm minimum for all fabric types (#100 sieve).
Water Permittivity (ASTM D4491)	0.02 sec^{-1} minimum
Grab Tensile Strength (ASTM D4632)	180 lbs. minimum for extra strength fabric. 100 lbs. minimum for standard strength fabric.
Grab Tensile Strength (ASTM D4632)	30% maximum
Ultraviolet Resistance (ASTM D4355)	70% minimum

- Support standard strength fabrics with wire mesh, chicken wire, 2-inch x 2-inch wire, safety fence, or jute mesh to increase the strength of the geotextile. Silt fence materials are available that have synthetic mesh backing attached.

- Silt fence material shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of 0° F to 120° F.
- 100 percent biodegradable silt fence is available that is strong, long lasting, and can be left in place after the project is completed, if permitted by the local jurisdiction.
- Refer to Figure 3 - 23: Silt Fence for standard silt fence details. Include the following Standard Notes for silt fence on construction plans and specifications:
  - The Contractor shall install and maintain temporary silt fences at the locations shown in the Plans.
  - Construct silt fences in areas of clearing, grading, or where runoff will drain prior to starting those activities.
  - The silt fence shall have a 2-feet min. and a 2½-feet max. height above the original ground surface.
  - The geotextile fabric shall be sewn together at the point of manufacture to form fabric lengths as required. Locate all sewn seams at support posts. Alternatively, two sections of silt fence can be overlapped, provided that the overlap is long enough and that the adjacent silt fence sections are close enough together to prevent silt laden water from escaping through the fence at the overlap.
  - Attach the geotextile fabric on the up-slope side of the posts and secure with staples, wire, or in accordance with the manufacturer's recommendations. Attach the geotextile fabric to the posts in a manner that reduces the potential for tearing.
  - Support the geotextile fabric with wire or plastic mesh, dependent on the properties of the geotextile selected for use. If wire or plastic mesh is used, fasten the mesh securely to the up-slope side of the posts with the geotextile fabric up-slope of the mesh.
  - Mesh support, if used, shall consist of steel wire with a maximum mesh spacing of 2-inches, or a prefabricated polymeric mesh. The strength of the wire or polymeric mesh shall be equivalent to or greater than 180 lbs. grab tensile strength. The polymeric mesh must be as resistant to the same level of ultraviolet radiation as the geotextile fabric it supports.
  - Bury the bottom of the geotextile fabric 4-inches min. below the ground surface. Backfill and tamp soil in place over the buried portion of the geotextile fabric, so that no flow can pass beneath the silt fence and scouring cannot occur. When wire or polymeric back-up support mesh is used, the wire or polymeric mesh shall extend into the ground 3-inches min.
  - Drive or place the silt fence posts into the ground 18-inches min. A 12–inch min. depth is allowed if topsoil or other soft subgrade soil is not present and 18-inches cannot be reached. Increase fence post min. depths by 6 inches if the fence is located on slopes of 3H:1V or steeper and the slope is perpendicular to the fence. If required post depths cannot be obtained, the posts shall be adequately secured by bracing or guying to prevent overturning of the fence due to sediment loading.
  - Use wood, steel or equivalent posts. The spacing of the support posts shall be a maximum of 6-feet. Posts shall consist of one of the following:

        - Wood with minimum dimensions of 2 inches by 2 inches by 3 feet. Wood shall be free of defects such as knots, splits, or gouges.
        - No. 6 steel rebar or larger.
        - ASTM A 120 steel pipe with a minimum diameter of 1-inch.
        - U, T, L, or C shape steel posts with a minimum weight of 1.35 lbs./ft.
        - Other steel posts having equivalent strength and bending resistance to the post sizes listed above.
    - Locate the silt fences on contour as much as possible, except at the ends of the fence, where the fence shall be turned uphill such that the silt fence captures the runoff water and prevents water from flowing around the end of the fence.
    - If the fence must cross contours, with the exception of the ends of the fence, place check dams perpendicular to the back of the fence to minimize concentrated flow and erosion.The slope of the fence line where contours must be crossed shall not be steeper than 3H:1V.
        - Check dams shall be approximately 1-foot deep at the back of the fence. Check dams shall be continued perpendicular to the fence at the same elevation until the top of the check dam intercepts the ground surface behind the fence.
        - Check dams shall consist of crushed surfacing base course, gravel backfill for walls, or shoulder ballast. Check dams shall be located every 10 feet along the fence where the fence must cross contours.
- Refer to Figure 3 - 24: Silt Fence Installation by Slicing for slicing method details. The following are specifications for silt fence installation using the slicing method:
    - The base of both end posts must be at least 2 to 4 inches above the top of the geotextile fabric on the middle posts for ditch checks to drain properly. Use a hand level or string level, if necessary, to mark base points before installation.
    - Install posts 3 to 4 feet apart in critical retention areas and a maximum of 6 feet apart in standard applications.
    - Install posts 24 inches deep on the downstream side of the silt fence, and as close as possible to the geotextile fabric, enabling posts to support the geotextile fabric from upstream water pressure.
    - Install posts with the nipples facing away from the geotextile fabric.
    - Attach the geotextile fabric to each post with three ties, all spaced within the top 8 inches of the fabric. Attach each tie diagonally 45 degrees through the fabric, with each puncture at least 1 inch vertically apart. Each tie should be positioned to hang on a post nipple when tightening to prevent sagging.
    - Wrap approximately 6 inches of geotextile fabric around the end posts and secure with 3 ties.
    - No more than 24 inches of a 36-inch geotextile fabric is allowed above ground level.
    - Compact the soil immediately next to the geotextile fabric with the front wheel of a tractor, skid steer, or roller exerting at least 60 pounds per square inch. Compact the upstream side first and then each side twice for a total of four trips. Check and correct

the silt fence installation for any deviation before compaction. Use a flat-bladed shovel to tuck the fabric deeper into the ground if necessary.

1.38.4 Maintenance Standards

- Repair any damage immediately.
- Intercept and convey all evident concentrated flows uphill of the silt fence to a sediment trapping BMP.
- Check the uphill side of the fence for signs of the fence clogging and acting as a barrier to flow and then causing channelization of flows parallel to the fence. If this occurs, replace the fence and remove the trapped sediment.
- Remove sediment deposits when the deposit reaches approximately one-third the height of the silt fence, or install a second silt fence.
- Replace geotextile fabric that has deteriorated due to ultraviolet breakdown.

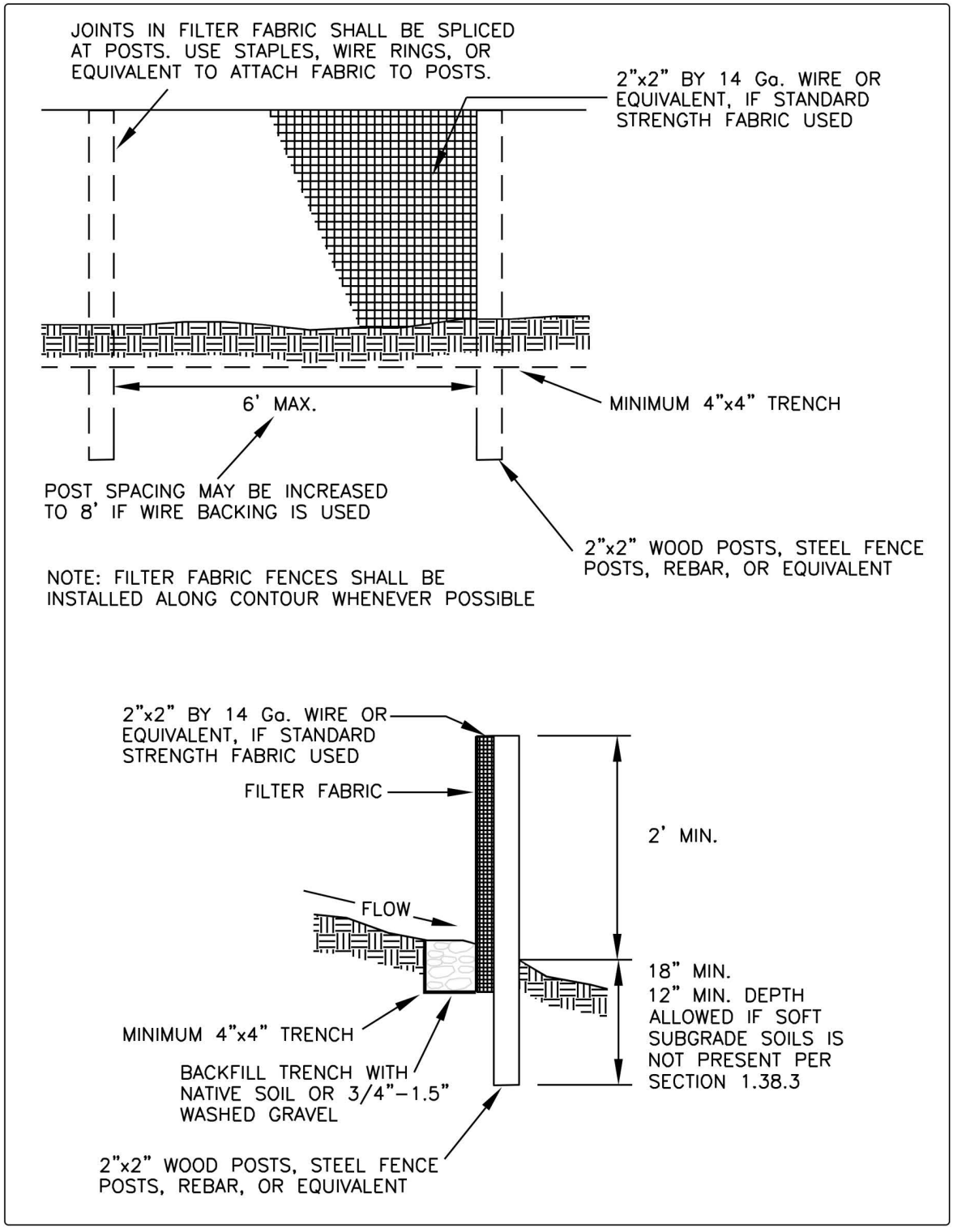


Figure 3 - 23: Silt Fence

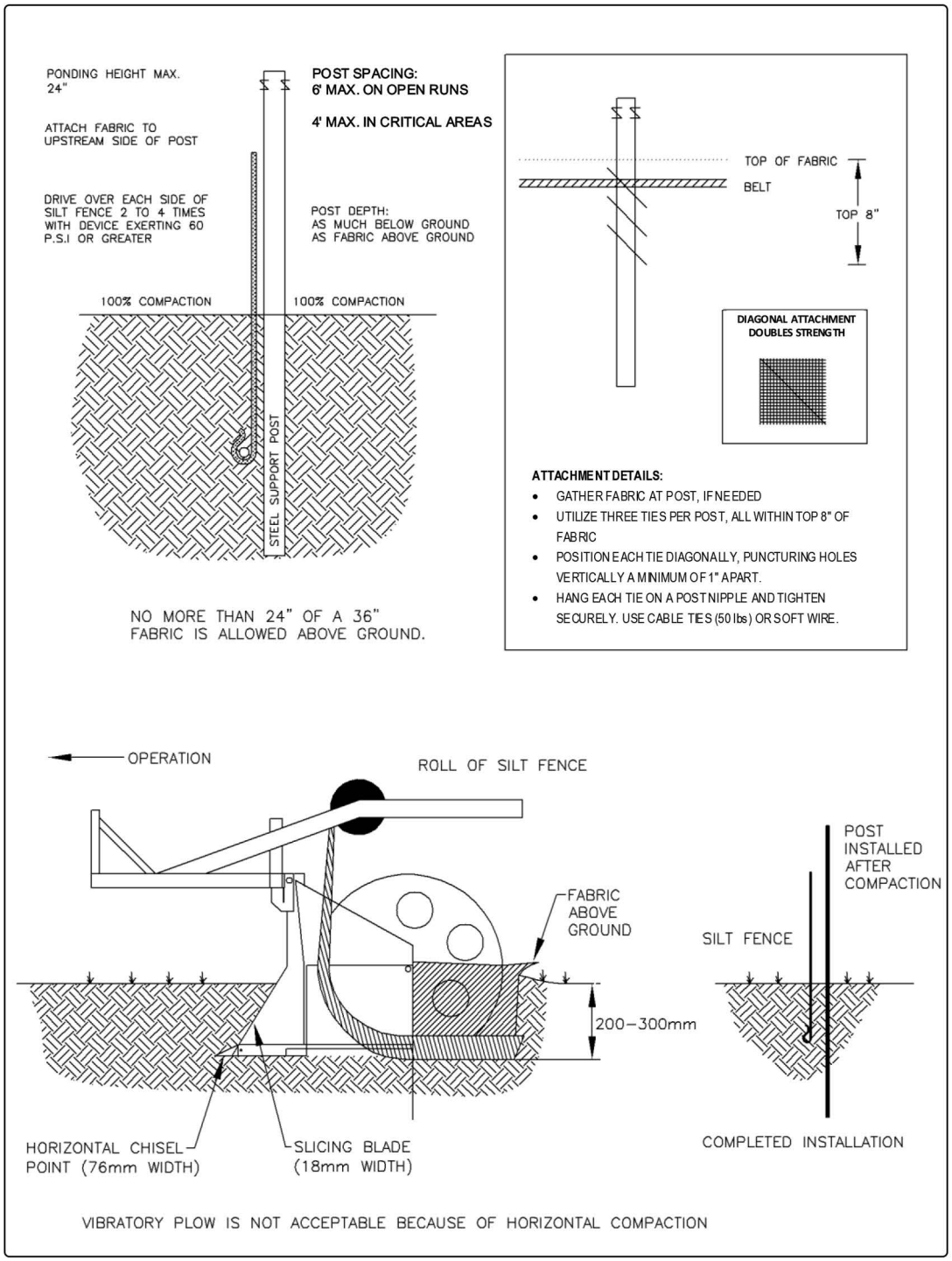


Figure 3 - 24: Silt Fence Installation by Slicing

1.39 BMP C234: Vegetated Strip

1.39.1 Purpose

Vegetated strips reduce the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow.

1.39.2 Conditions of Use

Vegetated strips may be used downslope of all disturbed areas.

Vegetated strips are not intended to treat concentrated flows, nor are they intended to treat substantial amounts of overland flow. Convey concentrated flows to a sediment pond. The only circumstance in which overland flow can be treated solely by a strip, rather than by a sediment pond, is when the criteria shown in Table 3 - 13: Vegetated Strips are met.

Table 3 - 13: Vegetated Strips

Average Slope	Slope Percent	Flowpath Length
1.5H:1V or less	67% or less	100 feet
2H:1V or less	50% or less	115 feet
4H:1V or less	25% or less	150 feet
6H:1V or less	16.7% or less	200 feet
10H:1V or less	10% or less	250 feet

1.39.3 Design and Installation Specifications

- The vegetated strip shall consist of a minimum of a 25-foot wide continuous strip of dense vegetation with permeable topsoil. Grass-covered, landscaped areas are generally not adequate because the volume of sediment overwhelms the grass. Ideally, vegetated strips shall consist of undisturbed native growth with a well-developed soil that allows for infiltration of runoff.
- The slope within the strip shall not exceed 4H:1V.
- Delineate the uphill boundary of the vegetated strip with clearing limits.

1.39.4 Maintenance Standards

- Seed any areas damaged by erosion or construction activity immediately and protect with mulch.
- If more than 5 feet of the original vegetated strip width has had vegetation removed or is being eroded, install sod.
- If there are indications that concentrated flows are traveling across the vegetated strip, surface water controls must be installed to reduce the flows entering the vegetated strip, or install additional perimeter protection.

1.40 BMP C235: Wattles

1.40.1 Purpose

Wattles are temporary erosion and sediment control barriers consisting of straw, compost or other material that is wrapped in netting made of natural plant fiber or similar encasing material. They reduce the velocity and can spread the flow of rill and sheet runoff, and can capture and retain sediment.

1.40.2 Conditions of Use

- Use wattles
  - In disturbed areas that require immediate erosion protection.
  - On exposed soils during the period of short construction delays, or over winter months.
  - On slopes requiring stabilization until permanent vegetation can be established.
- The material used dictates the effectiveness period of the wattle. Generally, wattles are effective for one to two seasons.
- Prevent rilling beneath wattles by entrenching and overlapping wattles to prevent water from passing between them.

1.40.3 Design Criteria

- Wattles shall consist of cylinders of plant material such as weed-free straw, coir, wood chips, excelsior, or wood fiber or shavings encased within netting made of natural plant fibers unaltered by synthetic materials.
- See Figure 3 - 25: Straw Wattles for typical construction details.
- Wattles are typically 8 to 10 inches in diameter and 25 to 30 feet in length.
- Install wattles perpendicular to the flow direction and parallel to the slope contour.
- Place wattles in shallow trenches, staked along the contour of disturbed or newly constructed slopes. Dig narrow trenches across the slope (on contour) to a depth of 3 to 5 inches on clay soils and soils with gradual slopes. On loose soils, steep slopes, and areas with high rainfall, dig the trenches to a depth of 5 to 7 inches, or 1/2 to 2/3 of the thickness of the wattle.
- Start building trenches and installing wattles from the base of the slope and work up. Spread excavated material evenly along the uphill slope and compact it using hand tamping or other methods.
- Construct trenches at contour intervals of 10-to 25- feet apart depending on the steepness of the slope, soil type, and rainfall. The steeper the slope the closer together the trenches.
- Install the wattles snugly into the trenches and overlap the ends of adjacent wattles 12 inches behind one another.
- Install stakes at each end of the wattle, and at 4-foot centers along entire length of wattle.
- If required, install pilot holes for the stakes using a straight bar to drive holes through the wattle and into the soil.

- Wooden stakes should be approximately 0.75 x 0.75 x 24 inches min. Live cuttings or 3/8-inch rebar can also be used for stakes.
- Stakes should be driven through the middle of the wattle, leaving 2 to 3 inches of the stake protruding above the wattle.

1.40.4 Maintenance Standards

- Wattles may require maintenance to ensure they are in contact with soil and thoroughly entrenched, especially after significant rainfall on steep sandy soils.
- Inspect the slope after significant storms and repair any areas where wattles are not tightly abutted or water has scoured beneath the wattles.

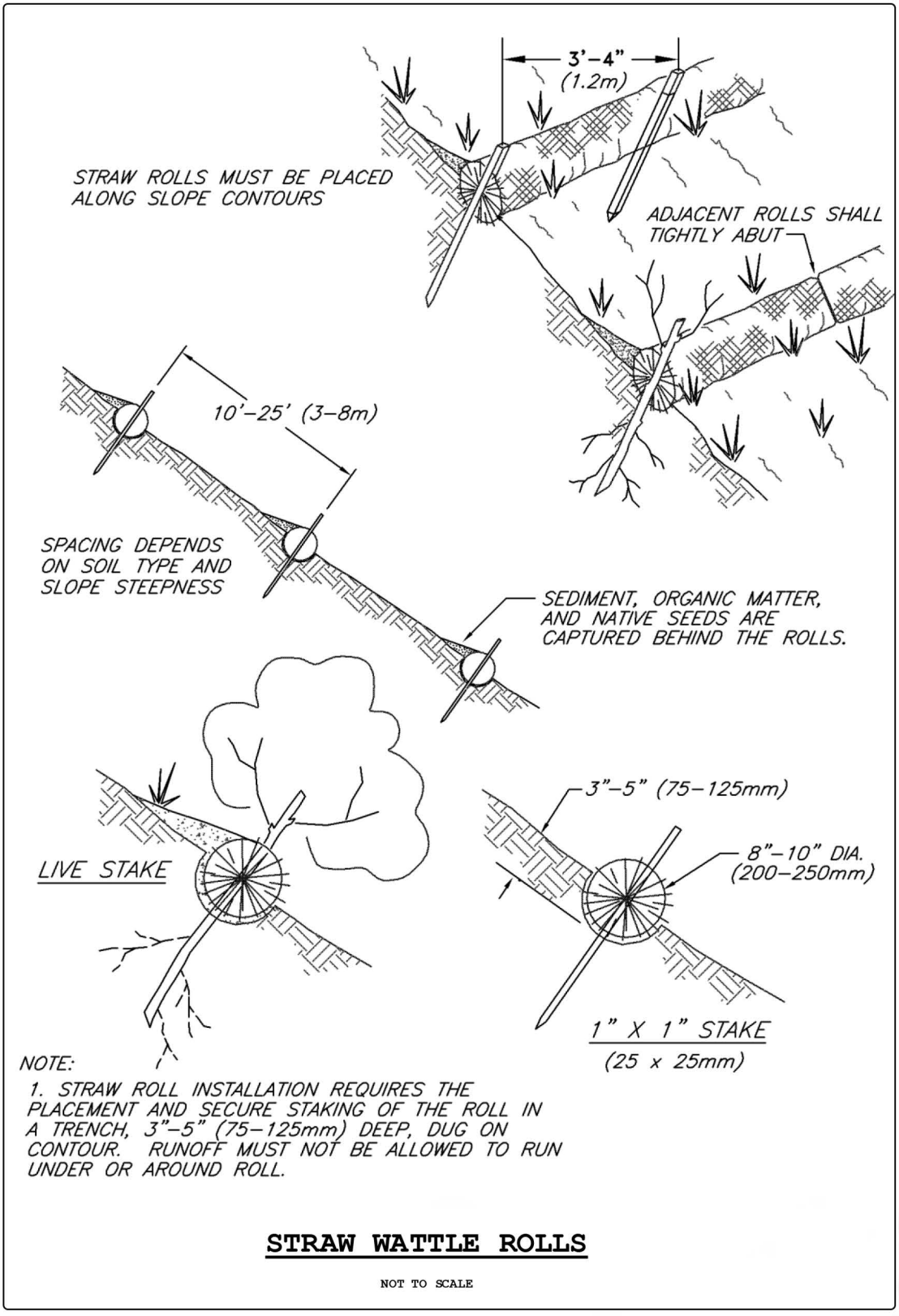


Figure 3 - 25: Straw Wattles

1.41 BMP C236: Vegetative Filtration

1.41.1 Purpose

Vegetative filtration as a BMP is used in conjunction with detention storage in the form of portable tanks or BMP C241: Temporary Sediment Pond, BMP C206: Level Spreader, and a pumping system with surface intake. Vegetative filtration improves turbidity levels of stormwater discharges by filtering runoff through existing vegetation where undisturbed forest floor duff layer or established lawn with thatch layer are present. Vegetative filtration can also be used to infiltrate dewatering waste from foundations, vaults, and trenches as long as runoff does not occur.

1.41.2 Conditions of Use

- For every five acre of disturbed soil use one acre of grass field, farm pasture, or wooded area. Reduce or increase this area depending on project size, groundwater table height, and other site conditions.
- Wetlands shall not be used for filtration.
- Do not use this BMP in areas with a high groundwater table, or in areas that will have a high seasonal groundwater table during the use of this BMP.
- This BMP may be less effective on soils that prevent the infiltration of the water, such as hard till.
- Using other effective source control measures throughout a construction site will prevent the generation of additional highly turbid water and may reduce the time period or area need for this BMP.
- Stop distributing water into the vegetated area if standing water or erosion results.
- On large projects that phase the clearing of the site, areas retained with native vegetation may be used as a temporary vegetative filtration area.

1.41.3 Design Criteria

- Find land adjacent to the project that has a vegetated field, preferably a farm field, or wooded area.
- If the site does not contain enough vegetated field area consider obtaining permission from adjacent landowners (especially for farm fields).
- Install a pump and downstream distribution manifold depending on the project size. Generally, the main distribution line should reach 100 to 200-feet long (large projects, or projects on tight soil, will require systems that reach several thousand feet long with numerous branch lines off of the main distribution line).
- The manifold should have several valves, allowing for control over the distribution area in the field.
- Install several branches of 4-inch diameter schedule 20 polyvinyl chloride (PVC) pipe, or 6-inch fire hose, which can convey the turbid water out to various sections of the field. See Figure 3 - 26: Manifold and Branches in a Wooded, Vegetated Spray Field.
- Determine the branch length based on the field area geography and number of branches. Typically, branches stretch from 200-feet to several thousand feet. Lay branches on contour with the slope.

- On uneven ground, sprinklers perform well. Space sprinkler heads so that spray patterns do not overlap.
- On relatively even surfaces, a level spreader using 4-inch diameter perforated pipe may be used as an alternative option to the sprinkler head setup. Install pipe at the highest point on the field and at various lower elevations to ensure full coverage of the filtration area. Place the pipe with the holes up to allow for a gentle weeping evenly out all holes. Leveling the pipe by staking and using sandbags may be required.
- To prevent over saturating of the vegetative filtration area, rotate the use of branches or spray heads.Repeat as needed based on monitoring the spray field.

Table 3 - 14: Flowpath Guidelines for Vegetative Filtration

Average Slope	Average Area % Slope	Estimated Flowpath Length (ft)
1.5H:1V	67%	250 feet
2H:1V	50%	200 feet
4H:1V	25%	150 feet
6H:1V	16.7%	115 feet
10H:1V	10%	100 feet

1.41.4 Maintenance Standards

- Monitor the spray field on a daily basis to ensure that over saturation of any portion of the field doesn't occur at any time. The presence of standing puddles of water or creation of concentrated flows visually signify that over saturation of the field has occurred.
- Monitor the vegetated spray field all the way down to the nearest surface water, or farthest spray area, to ensure that the water has not caused overland or concentrated flows, and has not created erosion around the spray nozzle(s).
- Do not exceed water quality standards for turbidity.
- It is recommended that a separate inspection log be developed, maintained and kept with the existing site logbook to aid the operator conducting inspections. This separate "Field Filtration Logbook" can also aid in demonstrating compliance with permit conditions.
- Inspect the spray nozzles daily, at a minimum, for leaks and plugging from sediment particles.
- If erosion, concentrated flows, or over saturation of the field occurs, rotate the use of branches or spray heads or move the branches to a new field location.
- Check all branches and the manifold for unintended leaks.

Figure 3 - 26: Manifold and Branches in a Wooded, Vegetated Spray Field

1.42 BMP C240: Sediment Trap

1.42.1 Purpose

A sediment trap is a small temporary ponding area with a gravel outlet used to collect and store sediment from sites cleared and/or graded during construction. Install sediment traps, along with other perimeter controls, before any land disturbance takes place.

1.42.2 Conditions of Use

- Sediment traps are intended for use on sites where the contributing area is less than 3 acres, with no unusual stormwater and surface water features, and a projected build-out time of six months or less. The sediment trap is a temporary measure (with a design life of approximately 6 months) and shall be maintained until the site area is permanently protected against erosion by the installation of vegetation and/or structures.
- Sediment traps are only effective in removing sediment down to about the medium silt size fraction. Runoff with sediment of finer grades (fine silt and clay) will pass through untreated, emphasizing the need to control erosion to the maximum extent first.
- When permanent facilities are used as temporary sedimentation facilities, the surface area requirement of a sediment trap must be met. If the surface area requirements are larger than the surface area of the permanent facility, then the trap or pond shall be enlarged to comply with the surface area requirement.
- A skimmer may be used for the sediment trap outlet.

1.42.3 Design and Installation Specifications

See Figure 3 - 27: Cross-Section of a Sediment Trap and Figure 3 - 28: Sediment Trap Outlet for details.

If permanent runoff control facilities are part of the project, they should be used for sediment retention.

- To determine the sediment trap geometry, first calculate the design surface area (*SA*) of the trap, measured at the invert of the weir. Use the following equation:

$$SA = FS\left(\frac{Q_2}{V_s}\right)$$

Where:

SA = Design surface area, in square feet, of the sediment trap measured at the invert of the weir.

Q_2= Design inflow, in cubic feet per second, is the peak volumetric flowrate from the contributing area calculated using a 10-minute timestep from a Type 1A, 2-year, 24-hour frequency storm using a single event model. A type 1A, 10-year, 24-hour frequency storm (Q10) shall be used in the calculation if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection. If no hydrologic analysis is required, the Rational Method may be used.

Alternatively, Q_2 = Design inflow (cfs) is the 2-year return period flowrate, indicated by an Ecology-approved continuous simulation model, using an 15-minute timestep. Use the 10-year return period flowrate (Q10) in the calculation if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection.

Vs= The settling velocity of the soil particle of interest. The 0.02 millimeter (medium silt) particle with an assumed density of 2.65 grams per cubic centimeter has been selected as the particle of interest and has a settling velocity (*Vs*) of 0.00096 feet per second.

FS= A safety factor of 2 to account for non-ideal settling.

Therefore, the equation for computing surface area becomes:

$$SA = \frac{2 \times Q_2}{0.00096} \text{ OR}$$

SA = 2080 (Q_2)

Note: Even if permanent facilities are used, they must still have a surface area that is at least as large as that derived from the above formula. If they do not, the pond must be enlarged.

- Smaller sites may use the minimum pond sizes in Table 3 - 15: Sediment Trap Sizing instead of providing calculations.

Table 3 - 15: Sediment Trap Sizing

Contributing Area (acres)	Required Surface Area of Pond (sq. ft.)
⅛ acre or less	130
¼ acre or less	260
½ acre or less	520
¾ acre or less	780
1 acre or less	1040

- To aid in determining sediment depth, all sediment traps shall have a staff gauge with a prominent mark 1-foot above the bottom of the trap.
- Sediment traps may not be feasible on utility projects due to the limited work space or short-term nature of the work. Portable tanks may be used in place of sediment traps for utility projects.
- The basic geometry of the pond can now be determined using the following design criteria:
  - Required surface area SA (from the equation above) at top of riser.
  - Minimum 3.5-foot depth from top of riser to bottom of pond.

- Maximum 3H:1V interior side slopes and maximum 2H:1V exterior slopes. The interior slopes can be increased to a maximum of 2H:1V if fencing is provided at or above the maximum water surface.
- One foot of freeboard between the top of the riser and the crest of the emergency spillway.
- Flat bottom.
- Minimum 1-foot deep spillway.
- Length-to-width ratio between 3:1 and 6:1.

1.42.4 Maintenance Standards

- Remove sediment from the trap when it reaches 1-foot in depth.
- Repair any damage to the pond embankments or slopes.

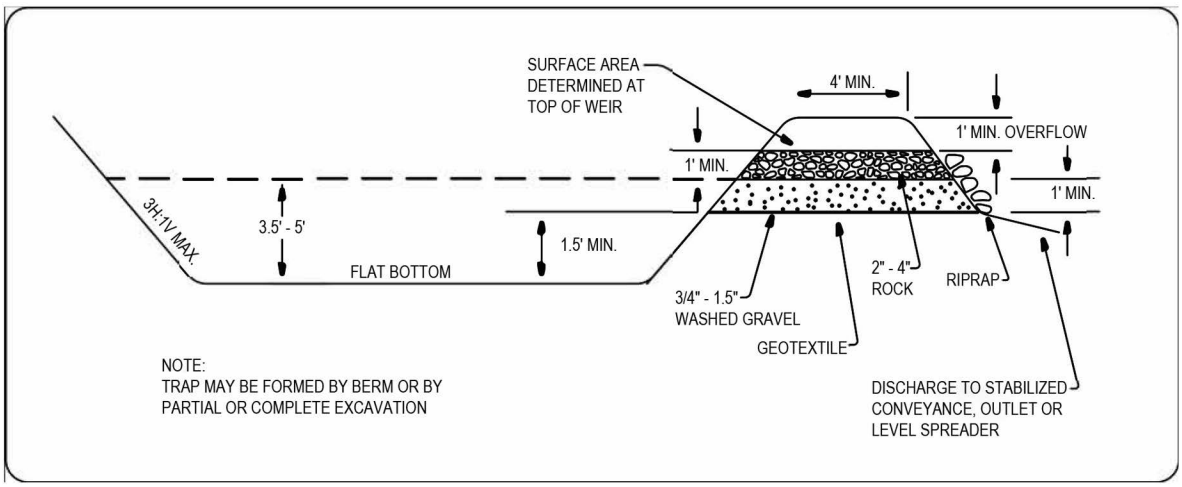


Figure 3 - 27: Cross-Section of a Sediment Trap

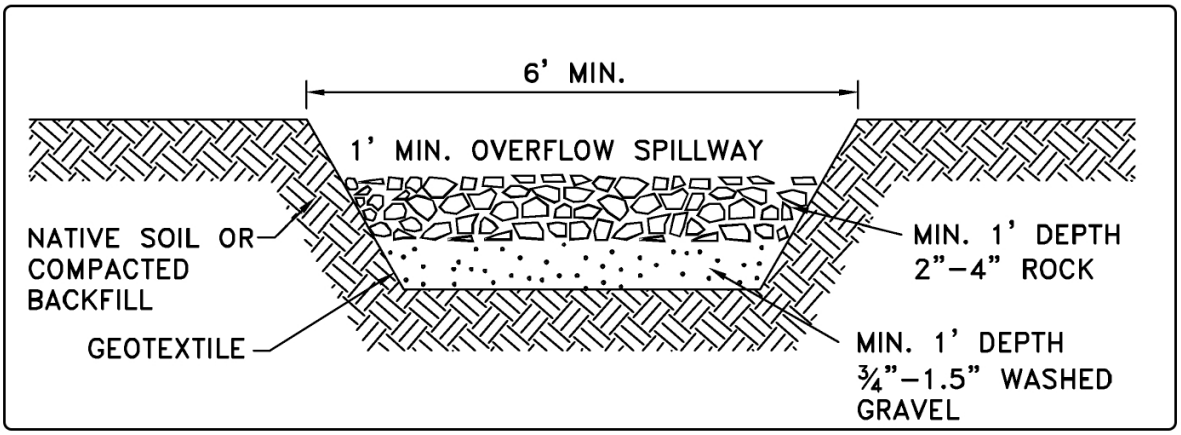


Figure 3 - 28: Sediment Trap Outlet

1.43 BMP C241: Temporary Sediment Pond

1.43.1 Purpose

Sediment ponds remove sediment from runoff originating from disturbed areas of the site. Sediment ponds are typically designed to remove sediment no smaller than medium silt (0.02 mm). Consequently, they usually reduce turbidity only slightly.

1.43.2 Conditions of Use

- Prior to leaving a construction site, dirty stormwater must pass through a sediment pond or other appropriate sediment removal best management practice.
- Use a sediment pond where the contributing area is 3 acres or more. Ponds must be used in conjunction with erosion control practices to reduce the amount of sediment flowing into the basin.

1.43.3 Design and Installation Specifications

- Only install sediment basins on sites where failure of the structure would not result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities. Also, sediment traps and ponds are attractive to children and can be very dangerous. Compliance with local ordinances regarding health and safety must be addressed. If fencing of the pond is required, show the type of fence and its location on the ESC plan.
- Structures having a maximum storage capacity at the top of the dam of 10 acre-feet (435,600 cubic feet) or more as measured at the crest elevation are subject to the Washington Dam Safety Regulations (Chapter 173-175 WAC).
- See Figure 3 - 29: Sediment Pond, Figure 3 - 30: Sediment Pond Cross Section and Figure 3 - 31: Sediment Pond Riser Detail for details.
- If permanent detention facilities are part of the project, they may be used for sediment retention. The surface area requirements of the sediment basin must be met. This may require enlarging the permanent basin to comply with the surface area requirements. If a permanent control structure is used, it may be advisable to partially restrict the lower orifice with gravel to increase residence time while still allowing dewatering of the basin.
- Use of infiltration facilities for sedimentation basins during construction tends to clog the soils and reduce their capacity to infiltrate. If infiltration facilities are to be used, the sides and bottom of the facility must only be rough excavated to a minimum of 2 feet above final grade. Final grading of the infiltration facility shall occur only when all contributing areas are fully stabilized. The infiltration pretreatment facility should be fully constructed and used with the sedimentation basin to help prevent clogging.

Determining Pond Geometry

- Determine the required surface area at the top of the riser pipe with the equation:

$$SA = \frac{2 \times Q_2}{0.00096} \text{ OR}$$

SA= 2080 (Q_2)

Where:

SA = Design surface area, in square feet, of the sediment trap measured at the invert of the weir.

Q_2= Design inflow, in cubic feet per second, is the peak volumetric flowrate from the contributing area calculated using a 10-minute timestep from a Type 1A, 2-year, 24-hour frequency storm using a single even model. A type 1A, 10-year, 24-hour frequency storm (Q10) shall be used in the calculation if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection. If no hydrologic analysis is required, the Rational Method may be used.

Alternatively, Q_2 = Design inflow (cfs) is the 2-year return period flowrate, indicated by an Ecology-approved continuous simulation model, using an 15-minute timestep. Use the 10-year return period flowrate (Q10) in the calculation if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection.

- See BMP C240: Sediment Trap for more information on the derivation of the surface area calculation.
- The basic geometry of the pond can now be determined using the following design criteria:
  - Required surface area SA (from the equation above) at top of riser.
  - Minimum 3.5-foot depth from top of riser to bottom of pond.
  - Maximum 3H:1V interior side slopes and maximum 2H:1V exterior slopes. The interior slopes can be increased to a maximum of 2H:1V if fencing is provided at or above the maximum water surface.
  - One foot of freeboard between the top of the riser and the crest of the emergency spillway.
  - Flat bottom.
  - Minimum 1-foot deep spillway.
  - Length-to-width ratio between 3:1 and 6:1.

Sizing of Discharge Mechanisms

The outlet for the basin consists of a combination of principal and emergency spillways. These outlets must pass the peak volumetric flowrate expected from the contributing area for a Type 1A, 100-year, 24-hour frequency storm. If, due to site conditions and basin geometry, a separate emergency spillway is not feasible, the principal spillway must pass the entire peak volumetric flowrate expected from Type 1A, 100-year, 24-hour frequency storm. However, an attempt to provide a separate emergency spillway should always be made. Base the calculations on the site conditions during construction. The flow through the dewatering orifice cannot be utilized when calculating the 100-year storm elevation because of its potential to become clogged; therefore, available spillway storage must begin at the principal spillway riser crest.

The principal spillway designed by the procedures contained in this standard will result in some reduction in the peak volumetric flowrate. However, the riser outlet design will not adequately control flowrates as required to meet Minimum Requirement #7 - Flow Control. The size of the basin, the expected life of the construction project, the anticipated downstream effects, and the anticipated weather conditions during construction should be considered to determine the need of additional discharge control.

Principal Spillway: Determine the required diameter for the principal spillway (riser pipe). The diameter shall be the minimum necessary to pass the peak volumetric flowrate calculated using a 10-minute timestep from a Type 1A, 10-year, 24-hour frequency storm using a single event model for the developed condition or the 10-year return period flowrate, indicated by an Ecology-approved continuous simulation model, using a 15-minute timestep. Use Figure 3 - 32: Riser Inflow Curves to determine this diameter (h = 1-foot).

Note: A permanent control structure may be used instead of a temporary riser.

Emergency Overflow Spillway: Size and design the emergency overflow spillway per A600: Emergency Overflow Spillway.

Dewatering Orifice: Determine the size of the dewatering orifice(s) (minimum 1-inch diameter) using a modified version of the discharge equation for a vertical orifice and a basic equation for the area of a circular orifice. Determine the required area of the orifice with the following equation:

$$A_o = \frac{A_s (2h)^{0.5}}{0.6\text{x}3600Tg^{0.5}}$$

Where:

Ao = orifice area (square feet)

As = pond surface area (square feet)

h = head of water above orifice (height of riser in feet)

T = dewatering time (24 hours)

g = acceleration of gravity (32.2 feet per second squared)

D = orifice diameter (inches)

Convert the required surface area to the required diameter D of the orifice:

$$D = 24\text{x}\sqrt{\frac{A_o}{\pi}} = 13.54\text{x}\sqrt{A_o}$$

The vertical, perforated tubing connected to the dewatering orifice must be at least 2 inches larger in diameter than the orifice to improve flow characteristics. The size and number of perforations in the tubing shall be large enough so the tubing does not restrict flow. The orifice shall control the flowrate.

Additional Design Specifications

The **pond shall be divided** into two roughly equal volume cells by a permeable divider that will reduce turbulence while allowing movement of water between cells. The divider shall be at least one-half the height of the riser and a minimum of one foot below the top of the riser. Wire-backed, 2- to 3-foot high, extra strength filter fabric supported by treated 4" x 4"s can be used as a divider. If the pond is more than 6 feet deep, a different mechanism must be proposed. A riprap embankment is one acceptable method of separation for deeper ponds. Other designs that satisfy the intent of this provision are allowed as long as the divider is permeable, structurally sound, and designed to prevent erosion under or around the barrier.

To aid in determining sediment depth, prominently mark **one-foot intervals** on the riser.

If an **embankment height** of more than 6 feet is proposed, the pond must comply with the criteria contained in Volume 4 regarding dam safety for detention BMPs.

The most common structural failure of sedimentation basins is caused by piping. Piping refers to two phenomena: (1) water seeping through fine-grained soil, eroding the soil grain by grain and forming pipes or tunnels and (2) water under pressure flowing upward through a granular soil with a head of sufficient magnitude to cause soil grains to lose contact and capability for support.

The most critical construction sequences to prevent piping will be:

- Tight connections between the riser and barrel and other pipe connections.
- Adequate anchoring of the riser.
- Proper soil compaction of the embankment and riser footing.
- Proper construction of anti-seep devices.

1.43.4 Maintenance Standards

- Remove sediment from the pond when it reaches 1–foot in depth.
- Repair any damage to the pond embankments or slopes.

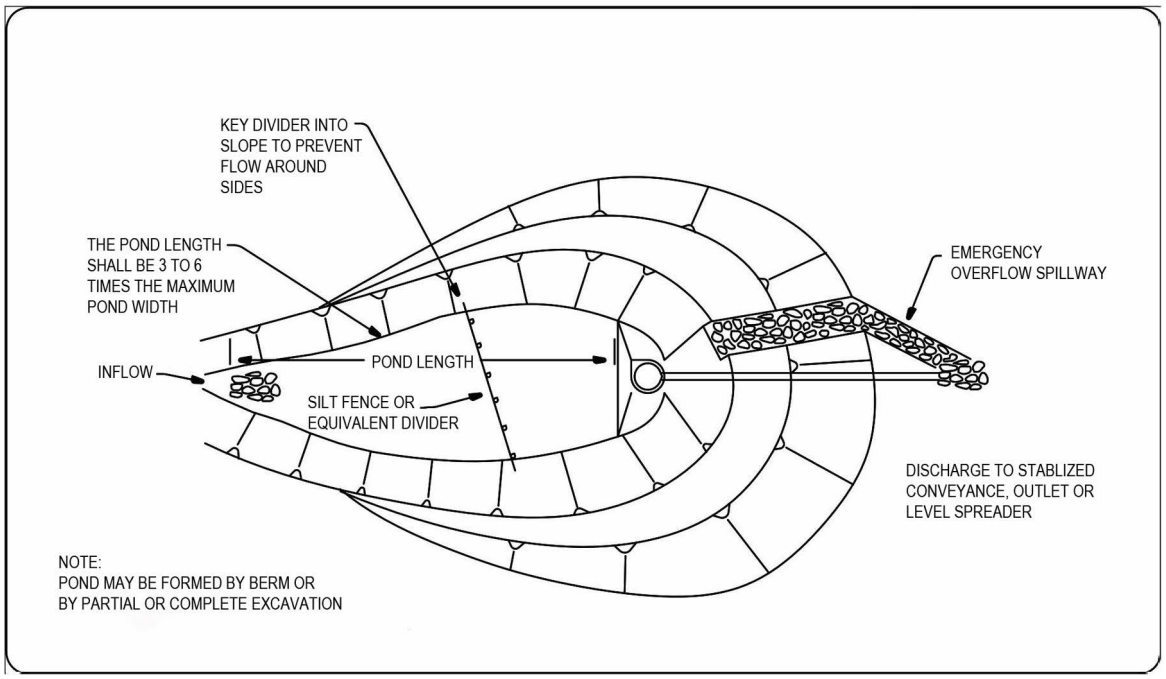


Figure 3 - 29: Sediment Pond

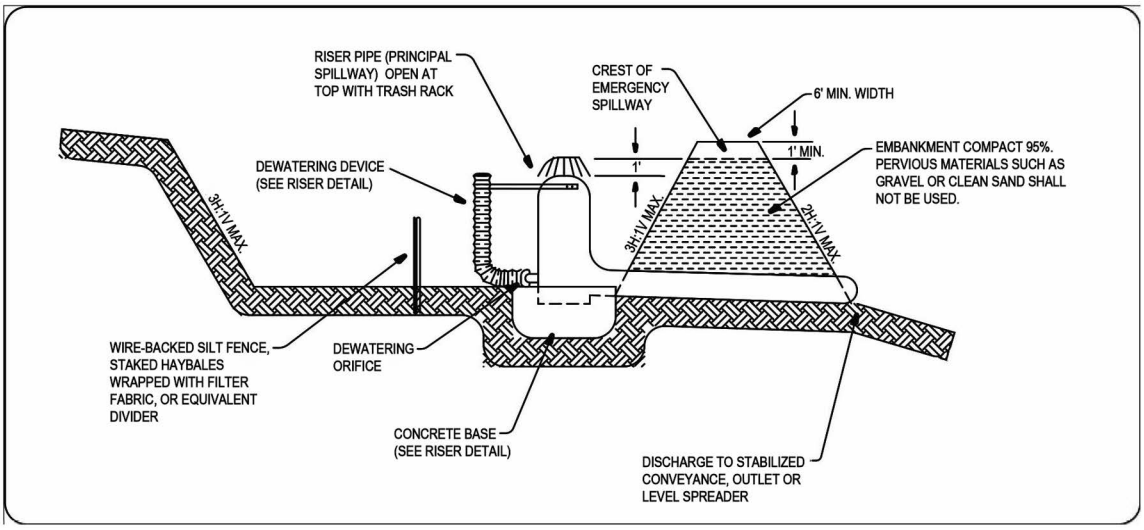


Figure 3 - 30: Sediment Pond Cross Section

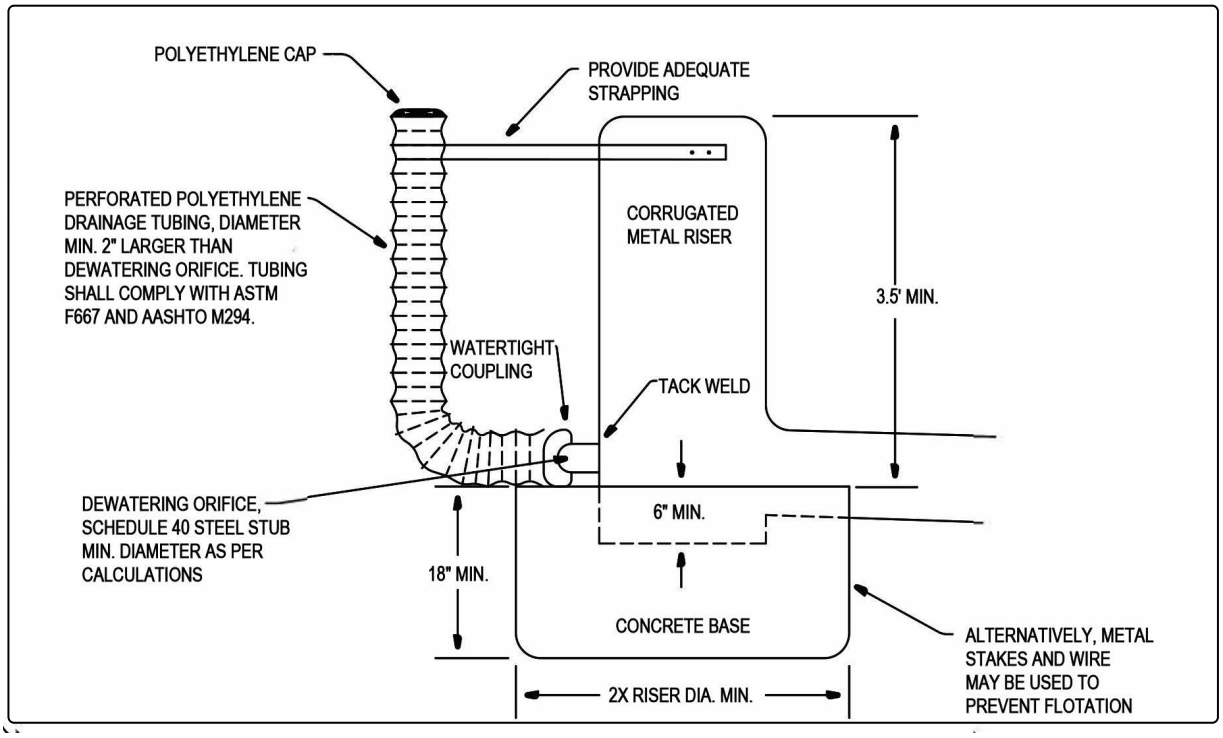


Figure 3 - 31: Sediment Pond Riser Detail

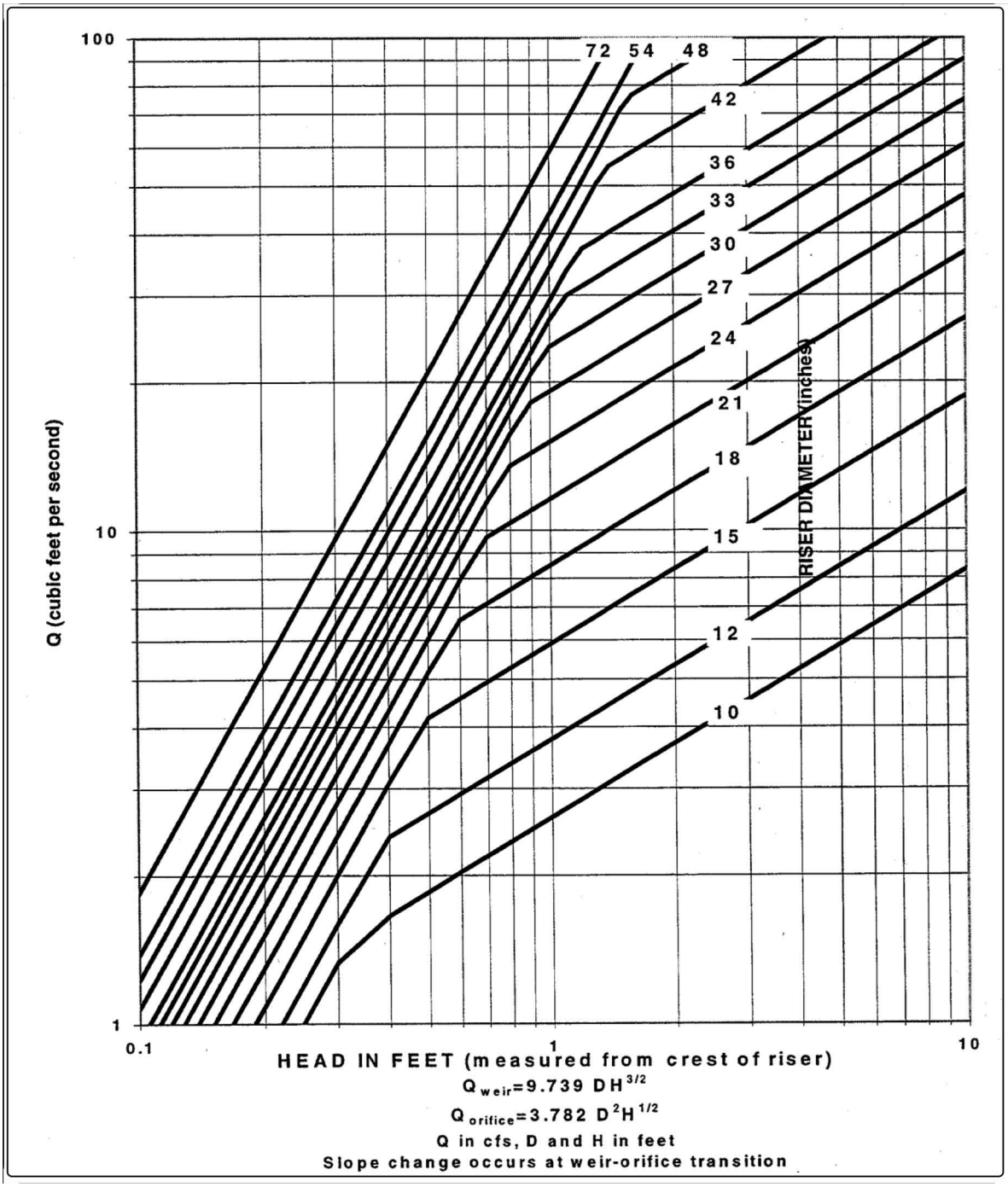


Figure 3 - 32: Riser Inflow Curves

1.44 BMP C250: Construction Stormwater Chemical Treatment

1.44.1 Purpose

This BMP applies when using stormwater chemicals in batch treatment or flow-through treatment.

Turbidity is difficult to control once fine particles are suspended in stormwater from a construction site. Sedimentation ponds are effective at removing larger particulate matter by gravity settling, but are ineffective at removing smaller particulates such as clay and fine silt. Traditional erosion and sediment control BMPs may not be adequate to ensure compliance with the water quality standards for turbidity in the receiving water.

1.44.2 Conditions of Use

Formal written approval from Ecology and the City is required for the use of chemical treatment regardless of site size. Ecology's Request for Chemical Treatment Form is available here: https://apps.ecology.wa.gov/publications/SummaryPages/ecy070258.htmlWhen approved, include the chemical treatment system in the Stormwater Pollution Prevention Plan (SWPPP).

Chemically treated stormwater discharged from construction site must be nontoxic to acquatic organisms. The Chemical Technology Assessment Protocol - Ecology (CTAPE) must be used to evaluate chemicals proposed for stormwater treatment. Only chemicals approved by Ecology undetr the CTAPE may be used for stormwater treatment. The approved chemicals, their applciation rates, and conditions of use can be found at the Department of Ecology Emerging Technologies website: https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies

1.44.3 Design and Installation Specifications

Treatment System Design Considerations

- Chemically treated stormwater must be nontoxic to aquatic organism.
- Only chemicals approved by Ecology through the CTAPE process may be used in system design.
- Care must be taken in the design of the withdrawal system to minimize outflow velocities and to prevent floc discharge. Stormwater that has been chemically treated must be filtered per BMP C251: Construction Stormwater Filtration prior to discharge.
- System discharge rates must take into account downstream conveyance integrity.
- The following equipment should be located onsite in a lockable shed:
  - The chemical injector.
  - Secondary containment for acid, caustic, buffering compound, and treatment chemical.
  - Emergency shower and eyewash.
  - Monitoring equipment which consists of a pH meter and a turbidimeter.
- There are two types of systems for applying chemical treatment to stormwater: batch chemical treatment systems and flow-through chemical treatment system.

Design and Installation of Batch Chemical Treatment Systems

A batch chemical treatment system consists of the stormwater collection system (either temporary diversion or the permanent site stormwater system), an untreated stormwater storage pond, pumps, a chemical feed system, treatment cells, and interconnecting piping.

The batch treatment system shall use a storage pond for untreated stormwater followed by minimum of two lined treatment cells. Multiple treatment cells allow for clarification of treated water while other cells are being filled or emptied. Treatment cells may be ponds or tanks. Ponds which impound more than 10 acre-feet as measured at the crest elevation are subject to the Washington Dam Safety Regulations (Chapter 173-175 WAC).

Stormwater is collected at interception point(s) on the site and is diverted by gravity or by pumping to an untreated stormwater storage pond or other untreated stormwater holding area. The stormwater is stored until treatment occurs. It is important that the holding pond be large enough to provide adequate storage.

The first step in the treatment sequence is to check the pH of the stormwater in the untreated stormwater storage pond. The pH is adjusted by the application of carbon dioxide or a base until the stormwater in the storage pond is within the desired pH range, 6.5 to 8.5. When used, carbon dioxide is added immediately downstream of the transfer pump. Typically sodium bicarbonate (baking soda) is used as a base, although other bases may be used. When needed, base is added directly to the untreated stormwater storage pond. The stormwater is recirculated with the treatment pump to provide mixing in the storage pond. Initial pH adjustments should be based on daily bench tests. Further pH adjustments can be made at any point in the process. See BMP C252: Treating and Disposing of High pH Water for more information on pH adjustment.

Once the stormwater is within the desired pH range (dependent on coagulant being used), the stormwater is pumped from the untreated stormwater storage pond to a lined treatment cell as coagulant is added. The coagulant is added upstream of the pump to facilitate rapid mixing.

After coagulant addition, the water is kept in a lined treatment cell for clarification. In a batch mode process, clarification typically takes from 30 minutes to several hours. Prior to discharge, samples are withdrawn for analysis of pH, coagulant concentration,and turbidity. If levels are acceptable, the treated water is withdrawn, filtered, and discharged.

Several configurations have been developed to withdraw treated water from the treatment cell. The original configuration is a device that withdraws the treated water from just beneath the water surface using a float with adjustable struts that prevent the float from settling on the cell bottom. This reduces the possibility of picking up sediment-floc from the bottom of the pond. The struts are usually set at a minimum clearance of about 12 inches; that is, the float will come within 12 inches of the bottom of the cell. Other systems have used vertical guides or cables which constrain the float, allowing it to drift up and down with the water level. More recent designs have an H-shaped array of pipes, set on the horizontal.

This scheme provides for withdrawal from four points rather than one. This configuration reduces the likelihood of sucking settled solids from the bottom. It also reduces the tendency for a vortex to form. Inlet diffusers - long floating or fixed pipes with many small holes in them - are also an option.

Safety is a primary concern. Design should consider the hazards associated with operations, such as sampling. Facilities should be designed to reduce slip hazards and drowning. Tanks and ponds should have life rings, ladder, or steps extending from the bottom to the top.

Sizing Criteria for Batch Chemical Treatment Systems

- Chemical treatment systems must be designed to control the velocity and peak volumetric flowrate discharged from the system and project site per Element #3 - Control Flow Rates.
- The total volume of the untreated stormwater storage pond and treatment ponds or tanks must be large enough to treat the volume of stormwater that is produced during multiple day storm events. At a minimum, size the untreated storage pond to hold 1.5 times the runoff volume of the 10-year, 24-hour storm event assuming a Type 1A rainfall distribution (3.0-inches). Provide bypass around the chemical treatment system to accommodate extreme storm events. Use worst-case land cover conditions (i.e., producing the most runoff) for analyses (in most cases, this would be the land cover conditions just prior to final landscaping).
- Primary settling should be encouraged in the untreated stormwater storage pond. A forebay with access for maintenance is beneficial.
- There are two opposing considerations in sizing the treatment cells. A larger cell is able to treat a larger volume of water each time a batch is processed. However, the larger the cell the longer the time is required to empty the cell. A larger cell may also be less effective at flocculation and therefore require a longer settling time. The simplest approach to sizing the treatment cell is to multiply the allowable discharge flowrate times the desired drawdown time. A 4-hour drawdown time allows one batch per cell per 8-hour work period, given 1 hour of flocculation followed by 2 hours of settling.
- If the chemical treatment system does not allow you to discharge at the rates as required by Element #3: Control Flow Rates, and if the site has a permanent Flow Control BMP that will serve the project, the discharge from the chemical treatment system may be directed to the permanent Flow Control BMP to comply with Element #3: Control Flow Rates. In this case, all discharge (including water passing through the treatment system and stormwater bypassing the treatment system) will be directed into the permanent Flow Control BMP. If site constraints make locating the untreated stormwater storage pond difficult, the permanent Flow Control BMP may be divided to serve as the untreated stormwater storage pond and the post-treatment temporary flow control pond. A berm or barrier must be used in this case so the untreated water does not mix with the treated water. Both untreated stormwater storage requirements and adequate post-treatment flow control must be achieved. The designer must document in the Construction SWPPP how the permanent Flow Control BMP is able to attenuate the discharge from the site to meet the requirements of Element #3: Control Flow Rates. If the design of the permanent Flow Control BMP was modified for temporary construction flow control purposes, the construction of the permanent Flow Control BMP must be finalized, as designed for its permanent function, at project completion.

Design and Installation of Flow-Through Chemical Treatment Systems

At a minimum, a flow-through chemical treatment system consists of a stormwater collection system (either a temporary diversion or the permanent stormwater system), an untreated stormwater storage pond, and a chemically enhanced sand filtration system.

Stormwater is collected at interception point(s) on the project site and is diverted by gravity or by pumping to an untreated stormwater storage pond or other untreated stormwater holding area. The stormwater is stored until treatment occurs. It is important that the holding pond be large enough to provide adequate storage.

Stormwater is then pumped from the untreated stormwater storage pond to the chemically enhanced sand filtration system where a coagulant is added. Adjustments to pH may be

necessary before coagulant addition. The sand filtration system continually monitors the stormwater effluent for turbidity and pH. If the discharge water is ever out of an acceptable range for turbidity or pH, the water is returned to the untreated stormwater pond where it will begin the treatment process again.

Sizing Criteria for Flow-Through Chemical Treatment Systems:

Refer to BMP C251: Construction Stormwater Filtration for sizing requirements of flow-through chemical treatment systems.

1.44.4 Monitoring

Conduct the following monitoring. Record test results on a daily log kept on site. Additional testing may be required by the NPDES permit based on site conditions.

Operational Monitoring:

- Total volume treated and discharged
- Flow must be continuously monitored and recorded at not greater than 15-minute intervals
- Type and amount of chemical used for pH adjustment, if any
- Type and amount of coagulant used for treatment
- Settling time

Compliance Monitoring

- Influent and effluent pH, flocculant chemical concentration, and turbidity must be continuously monitored and recorded at not greater than 15-minute intervals.
- pH and turbidity of the receiving water
- **Prior to discharge, treated stormwater must be sampled and tested for compliance with pH, flocculant chemical concentrations, and turbidity limits**. These limits may be established by the Construction Stormwater General Permit, or a site-specific discharge permit. Sampling and testing for other pollutants may also be necessary at some sites. pH must be within the range of 6.5 to 8.5 standard units and not cause a change in the pH of the receiving water of more than 0.2 standard units.
- Treated stormwater samples and measurements shall be taken from the discharge pipe or another location representative of the nature of the treated stormwater discharge. Samples used for determining compliance with the water quality standards in the receiving waterbody shall not be taken from the treatment pond prior to discharge. Compliance with the water quality standards is determined in the receiving water.

Biomonitoring

- Treated stormwater must be non-toxic to aquatic organisms. Treated stormwater must be tested for aquatic toxicity or residual chemical content. Frequency of biomonitoring will be determined by Ecology.
- Residual chemical tests must be approved by Ecology prior to their use.
- If testing treated stormwater for aquatic toxicity, you must test for acute (lethal) toxicity. Bioassays shall be conducted by a laboratory accredited by Ecology, unless otherwise approved by Ecology. Acute toxicity tests shall be conducted per the CTAPE protocol.

1.44.5 Operator Training

- Each project using chemical treatment must have a trained operator who is certified for operation of an Enhanced Chemcial Treatment System. The operator must be trained and certified by an organization approved by Ecology. Organizations approved for operator training can be found here: https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Contaminated-water-on-construction-sites

1.44.6 Maintenance Standards

- Remove sediment from the storage or treatment cells as necessary. Typically, sediment removal is required at least once during a wet season and at the decommissioning of the cells. Sediment remaining in the cells between batches may enhance the settling process and reduce the required chemical dosage.
- Sediment that is known to be non-toxic may be incorporated into the site away from the stormwater system.

1.45 BMP C251: Construction Stormwater Filtration

1.45.1 Purpose

Filtration removes sediment from runoff originating from disturbed areas of the site.

1.45.2 Conditions of Use

Traditional BMPs used to control soil erosion and sediment loss from sites under development may not be adequate to ensure compliance with the water quality standard for turbidity in the receiving water. Filtration may be used in conjunction with gravity settling to remove sediment as small as fine silt (0.5 µm). The reduction in turbidity will be dependent on the particle size distribution of the sediment in the stormwater. In some circumstances, sedimentation and filtration may be sufficient to achieve compliance with the water quality standard for turbidity.

The use of construction stormwater filtration does not require approval from Ecology as long as treatment chemicals are not used. Filtration in conjunction with BMP C250: Construction Stormwater Chemical Treatment requires testing under the Chemical Technology Assessment Protocol – Ecology (CTAPE) before it can be initiated. Approval from the appropriate regional Ecology office must be obtained at each site where chemical use is proposed prior to treatment. For more guidance on stormwater chemical treatment see BMP C250: Construction Stormwater Chemical Treatment.

1.45.3 Design and Installation Specifications

Two types of filtration systems may be applied to construction stormwater treatment: rapid and slow. Rapid filtration systems are the typical system used for water and wastewater treatment. They can achieve relatively high hydraulic flow rates, on the order of 2 to 20 gpm/sf, because they have automatic backwash systems to remove accumulated solids. In contrast, slow filtration systems have very low hydraulic rates, on the order of 0.02 gpm/sf, because they do not have backwash systems. Slow filtration systems are generally used to treat stormwater. Slow filtration is mechanically simple in comparison to rapid sand filtration but requires a much larger filter area.

Filtration Equipment

Sand media filters are available with automatic backwashing features that can filter to 50 µm particle size. Screen or bag filters can filter down to 5 µm. Fiber wound filters can remove particles down to 0.5 µm. Filters should be sequenced from the largest to the smallest pore opening. Sediment removal efficiency will be related to particle size distribution in the stormwater.

Treatment Process Description

Stormwater is collected at interception point(s) on the site and is diverted to an untreated stormwater sediment pond or tank for removal of large sediment and storage of the stormwater before it is treated by the filtration system. The untreated stormwater is pumped from the trap, pond, or tank through the filtration system in a rapid filtration system. Slow filtration systems are designed as flow through systems using gravity.

Sizing Criteria for Flow-Through Treatment Systems

Filtration treatment systems must be designed to control the velocity and peak volumetric flowrate that is discharged from the system and consequently the project site. See Element #3:

Control Flowrates. The untreated stormwater storage pond or tank should be sized to hold 1.5 times the runoff volume of the 10-year, 24-hour storm event assuming a Type 1A rainfall distribution (3.0-inches) minus the treatment system flowrate for an 8-hour period. For a chitosan-enhanced sand filtration system, the treatment flowrate should be sized using a hydraulic loading rate between 6-8 gpm/ft². Other hydraulic loading rates may be more appropriate for other systems. Bypass should be provided around the chemical treatment system to accommodate extreme storms. Runoff volumes shall be calculated using the methods presented in Volume 4. Worst-case conditions (i.e., producing the most runoff) should be used for analyses (most likely conditions present prior to final landscaping).

1.45.4 Maintenance Standards

- Rapid sand filters typically have automatic backwash systems that are triggered by a pre-set pressure drop across the filter. If the backwash water volume is not large or substantially more turbid than the untreated stormwater stored in the holding pond or tank, backwash return to the untreated stormwater pond or tank may be appropriate. However, other means of treatment and disposal may be necessary.
- Clean and/or replace screen, bag, and fiber filters when they become clogged.
- Remove sediment from the storage and/or treatment ponds as necessary. Typically, sediment removal is required once or twice during a wet season and at the decommissioning of the ponds.

1.46 BMP C252: Treating and Disposing of High pH Water

1.46.1 Purpose

When pH levels in stormwater rise above 8.5 it is necessary to lower the pH levels to the acceptable range of 6.5 to 8.5 prior to discharge to surface or groundwater. A pH level range of 6.5 to 8.5 is typical for most natural waterbodies and is ideal for the survival of aquatic organisms. Fish and other aquatic organisms may become stressed and die if the pH drops out of this range.

High pH at construction sites is most commonly caused by the contact of stormwater with poured or recycled concrete, cement, mortars, and other Portland cement or lime-containing construction materials. (See BMP C151: Concrete Handling for more information on concrete handling procedures). The principal caustic agent in cement is calcium hydroxide (free lime).

Calcium hardness can contribute to high pH values and cause toxicity that is associated with high pH conditions. A high level of calcium hardness in waters of the state is not allowed. Groundwater standard for calcium and other dissolved solids in Washington State is less than 500 mg/l.

1.46.2 Conditions of Use

- The water quality standard for pH in Washington State is in the range of 6.5 to 8.5. Stormwater with pH levels exceeding water quality standards may be either neutralized on site or disposed of to a wastewater system or concrete batch plant with pH neutralization capabilities.

- Neutralized process water such as concrete truck washout, hydrodemolition, or sawcutting slurry must be managed to prevent discharge to surface waters. Any stormwater contaminated during concrete work is considered process wastewater and must not be discharged to waters of the State or stormwater collection systems.

- Passive percolation of a limited volume of pH-affected stormwater is acceptable, with the understanding it does not "pond" resulting in runoff from the project boundary or to waters of the state. Any visible accumulation of such water must be considered pH-affected and managed to protect waters of the state. Note: this only applies to high pH stormwater or conditionally authorized non-stormwater, it does not apply to process water, which may be subject to numeric effluent limits under certain permits, or otherwise not authorized for discharge to waters of the state.

- The process used for neutralizing and/or disposing of high pH stormwater must be documented in the Construction Stormwater Pollution Prevention Plan.

Groundwater standard for calcium and other dissolved solids in Washington State is less than 500 mg/l.

1.46.3 Treating High pH Stormwater by Carbon Dioxide Sparging

Advantages of CO_2 Sparging

- Rapidly neutralizes high pH water.
- Cost effective and safer to handle than acid compounds.

- CO_2 is self-buffering. It is difficult to overdose and create harmfully low pH levels.
- Material is readily available.

The Chemical Process of CO2 Sparging

When carbon dioxide (CO_2) is added to water (H_2O), carbonic acid (H_2CO_3) is formed which can further dissociate into a proton (H^+) and a bicarbonate anion (HCO_3^-) as shown below:

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$$

The free proton is a weak acid that can lower the pH.

Water temperature has an effect on the reaction as well. The colder the water temperature is the slower the reaction occurs and the warmer the water temperature is the quicker the reaction occurs. Most construction applications in Washington State have water temperatures in the 50°F or higher range so the reaction is almost simultaneous.

Treatment Procedures of CO2 Sparging

High pH water may be treated using continuous treatment, continuous discharge systems. These manufactured systems continuously monitor influent and effluent pH to ensure that pH values are within an acceptable range before being discharged. All systems must have fail safe automatic shut off switches in the event that pH is not within the acceptable discharge range. Only trained operators may operate manufactured systems. System manufacturers often provide trained operators or training on their devices.

The following procedure may be used when not using a continuous discharge system:

- Prior to treatment, the appropriate jurisdiction should be notified in accordance with the regulations set by the jurisdiction.
- Every effort should be made to isolate the potential high pH water in order to treat it separately from other stormwater onsite.
- Water should be stored in an acceptable storage facility, detention pond, or containment cell prior to treatment.
- Transfer water to be treated for pH to the pH treatment structure. Ensure that the pH treatment structure size is sufficient to hold the amount of water that is to be treated. Do not fill the pH treatment structure completely, allow at least 2 feet of freeboard.
- The operator samples the water within the pH treatment structure for pH and notes the clarity of the water. As a rule of thumb, less CO_2 is necessary for clearer water. The results of the samples and water clarity observations should be recorded.
- In the pH adjustment structure, add CO_2 until the pH falls in the range of 6.9-7.1. Adjusting pH to within 0.2 pH units of receiving water (background pH) is recommended. It is unlikely that pH can be adjusted to within 0.2 pH units using dry ice. Compressed carbon dioxide gas should be introduced to the water using a carbon dioxide diffuser located near the bottom of the tank, this will allow carbon dioxide to bubble up through the water and diffuse more evenly.
- Slowly discharge the water making sure water does not get stirred up in the process. Release about 80% of the water from the pH treatment structure leaving any sludge behind.

- Discharge treated water through a pond or into the stormwater system.
- Excess sludge needs to be disposed of properly as concrete waste. If several batches of water are undergoing pH treatment, sludge can be left in treatment structure for the next batch treatment. Dispose of sludge when it fills 50% of tank volume.
- Dispose of sludge per applicable local, state, and federal regulations.

1.46.4 Treating High pH Stormwater using Food Grade Vinegar

Food grade vinegar that meets FDA standards may be used to neutralize high pH water. Food grade vinegar is only 4% to 18% acetic acid. The remainder is composed of water. Food grade vinegar may be used if dosed just enough to lower pH sufficiently. Use a treatment process as described above for CO2 sparging, but add food grade vinegar instead of CO2.

This treatment option for high pH stormwater does not apply to anything but food grade vinegar. Acetic acid is not vinegar. Any other product or waste containing acetic acid must be approved by the Washington State Department of Ecology.

1.46.5 Disposal of High ph Stormwater

Wastewater System Disposal

Discharges to the wastewater system are only allowed if approved per BMP C254: Discharge to Wastewater System.

Concrete Batch Plant Disposal

- Only permitted facilities may accept high pH water.
- Contact the facility to ensure they can accept high pH water

1.46.6 Safety and Materials Handling

- All equipment should be handled in accordance with OSHA rules and regulations.
- Follow manufacturer guidelines for materials handling.

1.46.7 Operator Records

Each operator should provide:

- A diagram of the monitoring and treatment equipment
- A description of the pumping rates and capacity the treatment equipment is capable of treating.

Each operator should keep a written record of the following:

- Client name and phone number
- Date of treatment
- Weather conditions
- Project name and location
- Volume of water treated
- pH of untreated water
- Amount of CO_2 needed to adjust water to a pH range of 6.9 - 7.1
- pH of treated water

- Discharge location and description

A copy of this record should be given to the client/contractor who should retain the record for three years.

1.47 BMP C253: Portable Sediment Tank

1.47.1 Purpose

A portable sediment tank is used during construction to remove sediment from runoff originating from disturbed areas of the site. Sediment-laden water is pumped into the tank where sediment settles. Portable sediment tanks are often known by their proprietary name: Baker Tank or Rain for Rent Tanks.

1.47.2 Conditions of Use

- Sediment tanks shall be placed on level, even ground.
- Sediment tanks can be used where space is limited.

1.47.3 Design and Installation Specifications

- Sediment tanks shall be a minimum of 2 feet deep.
- Sediment tanks shall have an emergency overflow that directs discharge to a safe, appropriate location. Show the emergency overflow discharge location on the TESC Plans.
- The outlet riser or pipe should be a minimum 1.5 feet above the bottom to avoid discharging sediment-laden water.
- Show the tank configuration, size, and location on the TESC Plans.
- The minimum storage volume shall be calculated as follows:
    - Pump Discharge (GPM) * 16 = Cubic Feet of Storage
- Any tank shape is acceptable as long as the minimum volume requirements is obtained.
- Ensure tank is clearly marked showing level when cleanout is needed.

1.47.4 Maintenance Standards

- Follow manufacturer or vendor specifications for maintenance.
- Inspect tank daily and during storm events to ensure tank does not need repair.
- Clean out tank when 1/3 of original sediment capacity has been used. Dispose of sediment in accordance with local, state and federal regulations.

1.48 BMP C254: Discharge to Wastewater System

The City of Tacoma may allow stormwater to be directed the wastewater system on a limited and case by case basis.

Only stormwater that cannot be adequately cleaned by Best Management Practices will be allowed to be discharged to the City of Tacoma wastewater system.

A Special Approved Discharge (SAD) Permit must be obtained before discharge into the wastewater system is allowed. This includes discharge into any private wastewater system that connects to the City system. Additional information about the SAD permitting process can be found at: tacoma.gov/government/departments/environmental-services/wastewater/wastewater-permits-and-manuals/

VOLUME

4

Best Management Practices Library

Introduction

This Volume describes and provides design criteria for the Best Management Practices (BMPs) that can be used to meet Minimum Requirement #5: Onsite Stormwater Management, Minimum Requirement #6: Stormwater Treatment, Minimum Requirement #7: Flow Control, and Minimum Requirement #8: Wetlands Protection.

This volume is broken into several chapters and appendices including:

Chapters

- Chapter 1: Choosing Your Best Management Practices
- Chapter 2: Modeling Your Best Management Practices
- Chapter 3: Design Criteria for All Stormwater Treatment and Flow Control BMPs
- Chapter 4: Constructing Your Best Management Practices
- Chapter 5: Accessing and Maintaining Your Best Management Practices
- Chapter 6: City of Tacoma Standard Plans and Details
- Chapter 7: Site Design BMPs
- Chapter 8: Downspout BMPs
- Chapter 9: Dispersion BMPs
- Chapter 10: Infiltration BMPs
- Chapter 11: Bioretention and Rain Gardens
- Chapter 12: Permeable Pavement
- Chapter 13: Biofiltration BMPs
- Chapter 14: Sand Filtration BMPs
- Chapter 15: Wetpool BMPs
- Chapter 16: Pretreatment BMPs

- Chapter 17: Emerging Technologies
- Chapter 18: Oil Water Separators
- Chapter 19: Other Low Impact Development Best Management Practices
- Chapter 20: Detention Facilities
- Chapter 21: BMP Components

Appendices

- Appendix A: Determining the Design Infiltration Rate
- Appendix B: Soils Reports
- Appendix C: Operation and Maintenance

Chapter 1 Choosing Your Best Management Practices

This chapter provides tools to help determine which BMPs can be used to meet certain Minimum Requirements.

1.1 Best Management Practices and Minimum Requirements.

Table 4 - 1: Best Management Practices and Minimum Requirements shows in table format each BMP and if that BMP can be used to meet a given Minimum Requirement. Table 4 - 1: Best Management Practices and Minimum Requirements is a simplified preliminary tool and should not be the sole basis for determining which BMP should be used for a given project. More than one BMP may be necessary in order to meet the Minimum Requirements, for example, detention ponds alone are not likely to Meet Minimum Requirement #5 but when used in conjunction with other BMPs may help to meet the requirements.

This chapter also provide lists of BMPs and how they can be used to meet the Minimum Requirements. The lists provide more detail than Table 4 - 1: Best Management Practices and Minimum Requirements and include information for determining what Best Management Practices can be used for each Stormwater Treatment Type.

The tables and lists are meant as a tool to help choose appropriate BMPs for a project. Review Siting your Best Management Practices, Constructing Your Best Management Practices, Accessing and Maintaining Your Best Management Practices and the criteria within each BMP to ensure the BMP is appropriate for a given project.

The Washington State Department of Ecology maintains a list of Functionally Equivalent Technologies. These are typically proprietary devices that Ecology has been deemed are functionally equivalent to BMPs contained in this manual. Functionally equivalent BMPs may be used to satisfy mitigation requirements.

Table 4 - 1: Best Management Practices and Minimum Requirements

BMP Name	Minimum Requirement #5 - The List Approach - List #1	Minimum Requirement #5 - The List Approach - List #2	Minimum Requirement #5 - The List Approach - List #3	Minimum Requirement #5 - LID Performance Standard	Minimum Requirement #6: Stormwater Treatment	Minimum Requirement #7: Flow Control	Minimum Requirement #8: Wetlands Protection
BMP L601: Rain Gardens	X						
BMP L602a: Downspout Infiltration Trenches	X	X	X	X		X	X
BMP L602b: Downspout Infiltration Drywells	X	X	X	X		X	X
BMP L603a: Downspout Dispersion Trenches	X	X	X	X		X	X
BMP L603b: Splashblocks	X	X	X	X		X	X
BMP L604: Perforated Stub-Out Connections	X	X	X				
BMP L611: Concentrated Flow Dispersion	X	X	X	X		X	X
BMP L612: Sheet Flow Dispersion	X	X	X	X		X	X
BMP L613: Post-Construction Soil Quality and Depth	X	X	X	X		X	X
BMP L614: Full Dispersion	X	X		X	X	X	X
BMP L615: Trees				X		X	X
BMP L620: Preserving Native Vegetation				X			

Table 4 - 1: Best Management Practices and Minimum Requirements

BMP Name	Minimum Requirement #5 - The List Approach - List #1	Minimum Requirement #5 - The List Approach - List #2	Minimum Requirement #5 - The List Approach - List #3	Minimum Requirement #5 - LID Performance Standard	Minimum Requirement #6: Stormwater Treatment	Minimum Requirement #7: Flow Control	Minimum Requirement #8: Wetlands Protection
BMP L621: Better Site Design				X			
BMP L630: Bioretention	X	X		X	X	X	X
BMP L631: Vegetated Rooftops (Green Roofs)				X		X	X
BMP L632: Rainwater Harvesting				X		X	X
BMP L633: Permeable Pavements	X	X		X	X	X	X
BMP L634: Minimal Excavation Foundations				X		X	X
BMP L635: Reverse Slope Sidewalks				X		X	X
BMP T1010: Basic Biofiltration Swale					X		X
BMP T1020: Wet Biofiltration Swale					X		X
BMP T1030: Continuous Inflow Biofiltration Swale					X		X
BMP T1040: Vegetated Filter Strip					X		X

Table 4 - 1: Best Management Practices and Minimum Requirements

BMP Name	Minimum Requirement #5 - The List Approach - List #1	Minimum Requirement #5 - The List Approach - List #2	Minimum Requirement #5 - The List Approach - List #3	Minimum Requirement #5 - LID Performance Standard	Minimum Requirement #6: Stormwater Treatment	Minimum Requirement #7: Flow Control	Minimum Requirement #8: Wetlands Protection
BMP T1050: Compost-Amended Vegetated Filter Strip (CAVFS)	X	X		X	X		X
BMP T1110: Wetponds - Basic and Large					X		X
BMP T1120: Wetvaults					X		X
BMP T1130: Stormwater Treatment Wetlands					X		X
BMP T1140a: Combined Detention and Wetponds					X	X	X
BMP T1140b: Combined Detention and Wetvault					X	X	X
BMP T1140c: Combined Detention and Stormwater Treatment Wetland					X	X	X
BMP T1200a: API (Baffle Type) Separators					X		X
BMP T1200b: Coalescing Plate (CP) Separators					X		X
BMP T1300: Emerging Technologies					X		

Table 4 - 1: Best Management Practices and Minimum Requirements

BMP Name	Minimum Requirement #5 - The List Approach - List #1	Minimum Requirement #5 - The List Approach - List #2	Minimum Requirement #5 - The List Approach - List #3	Minimum Requirement #5 - LID Performance Standard	Minimum Requirement #6: Stormwater Treatment	Minimum Requirement #7: Flow Control	Minimum Requirement #8: Wetlands Protection
BMP T610: Presettling Basin					X		
BMP 710: Infiltration Ponds				X	X	X	X
BMP 720: Infiltration Trenches				X	X	X	X
BMP 730: Drywells				X	X	X	X
BMP T808: Basic Sand Filter					X		X
BMP T809: Large Sand Filter					X		X
BMP T810: Sand Filter Vault					X		X
BMP T820: Linear Sand Filter					X		X
BMP T900: Media Filter Drain					X		X
BMP F110: Detention Ponds						X	X
BMP F120: Detention Tanks						X	X
BMP F130: Detention Vaults						X	X
BMP F140: Parking Lots for Additional Detention						X	X
BMP F150: Roofs for Detention						X	X

1.1.1 Onsite Stormwater Management BMPs

See Volume 1 to determine when Minimum Requirement #5: Onsite Stormwater Management is applicable to a project.

1.1.1.1 The List Approach BMPs

See Minimum Requirement #5: Onsite Stormwater Management for BMPs that must be considered when utilizing The List Approach.

1.1.1.2 Low Impact Development Performance Standard BMPs

Only BMPs that provide some form of flow control can be used to help meet the LID Performance Standard. Below is a list of the BMPs within this manual that when used can help meet the LID Performance Standard. More than one BMP may be necessary.

- BMP L602: Downspout Full Infiltration
  - BMP L602a: Downspout Infiltration Trenches
  - BMP L602b: Downspout Infiltration Drywells
- BMP L603: Downspout Dispersion
  - BMP L603a: Downspout Dispersion Trenches
  - BMP L603b: Splashblocks
- BMP L611: Concentrated Flow Dispersion
- BMP L612: Sheet Flow Dispersion
- BMP L613: Post-Construction Soil Quality and Depth
- BMP L614: Full Dispersion
- BMP L615: Trees
- BMP 710: Infiltration Ponds
- BMP 720: Infiltration Trenches
- BMP 740: Infiltration Swales
- BMP 730: Drywells
- BMP L630: Bioretention (*when designed to infiltrate)
- BMP L631: Vegetated Rooftops (Green Roofs)
- BMP L632: Rainwater Harvesting
- BMP L633: Permeable Pavements
- BMP L634: Minimal Excavation Foundations
- BMP L635: Reverse Slope Sidewalks
- BMP L620: Preserving Native Vegetation
  - This BMP seeks to maintain vegetation and limit the amount of hard surface which helps meet the LID Performance Standard.
- BMP L621: Better Site Design
  - This BMP seeks to maintain vegetation and limit the amount of hard surface which helps meet the LID Performance Standard.

1.1.2 Stormwater Treatment BMPs

See Volume 1 to determine when Minimum Requirement #6: Stormwater Treatment applies to a project and to determine which treatment type(s) apply to a project. Below are list of BMPs that can be used to help provide Stormwater Treatment. When designed per this manual, the BMPs are presumed to meet performance goals as established by the Washington State Department of Ecology - see the 2019 Stormwater Management Manual for Western Washington - III-1.2: Choosing Your Runoff Treatment BMPs if you are interested in seeing the established performance goals.

1.1.2.1 Oil Control BMP Options

The following are options that can be used to provide oil control.

- BMP T1200a: API (Baffle Type) Separators
- BMP T1200b: Coalescing Plate (CP) Separators
- BMP T820: Linear Sand Filter

  BMP T820: Linear Sand Filter is also an option for meeting the Basic, Metals, or Phosphorus Treatment Goals. If used to satisfy one of those treatment requirements, the same facility shall not also be used to satisfy the oil control requirement unless enhanced maintenance is assured. This is to prevent clogging of the filter by oil so that it will function for suspended solids and other pollutant removal as well. Quarterly cleaning is required when used as a combination facility.

- BMP T1300: Emerging Technologies

1.1.2.1.1 Oil Control - Application on the Project Site

Place oil control facilities upstream of other facilities, as close to the source of oil generation as practical. For sites that require oil control located within a larger commercial center, oil control BMPs are only required for the surfaces subject to the activities that require oil control. If common parking for multiple businesses is provided, treatment shall be applied to the number of parking stalls required for the business that requires oil control. If the treatment collection area also receives runoff from other areas, the treatment facility must be sized to treat all water passing through the facility.

Roadway intersections that trigger the thresholds for oil control shall provide oil control for lanes where vehicles accumulate during the traffic signal cycle, including left and right turn lanes and through lanes, from the beginning of the left turn pocket. If no left turn pocket exists, the treatable area shall begin at a distance equal to three car lengths from the stop line. If runoff from the intersection drains to more than two collection areas that do not combine within the intersection, treatment may be limited to any two of the collection areas.

1.1.2.2 Phosphorus Treatment BMP Options

The following BMPs can be used to provide Phosphorus Treatment:

- BMP 710: Infiltration Ponds
  - Soils must meet the Soil Physical and Chemical Suitability for Treatment (Volume 4, Section 10.1.4.1.3) and Pretreatment is required. If the soils do not meet the Soil Physical and Chemical Suitability for Treatment (Volume 4, Section 10.1.4.1.3), the infiltration basin must be preceeded by a Basic Treatment BMP and be a minimum

distance of 1/4 mile between the infiltration location and the phosphorus sensitive receiving waterbody (or area contributing to that waterbody).

- BMP 720: Infiltration Trenches
  - Soils must meet the Soil Physical and Chemical Suitability for Treatment (Volume 4, Section 10.1.4.1.3) and Pretreatment is required. If the soils do not meet the Soil Physical and Chemical Suitability for Treatment (Volume 4, Section 10.1.4.1.3), the infiltration basin must be preceeded by a Basic Treatment BMP and be a minimum distance of 1/4 mile between the infiltration location and the phosphorus sensitive receiving waterbody (or area contributing to that waterbody).
- BMP 730: Drywells
  - Soils must meet the Soil Physical and Chemical Suitability for Treatment (Volume 4, Section 10.1.4.1.3) and Pretreatment is required. If the soils do not meet the Soil Physical and Chemical Suitability for Treatment (Volume 4, Section 10.1.4.1.3), the infiltration basin must be preceeded by a Basic Treatment BMP and be a minimum distance of 1/4 mile between the infiltration location and the phosphorus sensitive receiving waterbody (or area contributing to that waterbody).
- BMP 740 - Infiltration Swales – Designed to be Either:
  - Vegetated with a minimum 18” treatment soil depth, or
  - Rock-lined with a minimum 18” treatment soil depth.
- BMP L630: Bioretention – Bioretention Options for Phosphorus Treatment Include:
  - High Performance Bioretention Soil Mix Type 2
  - High Performance Bioretention Soil Mix Type 3
- BMP T1140 - Combined Detention and Wetpool Facilities
- BMP L633: Permeable Pavement with Any of the Following Treatment Layers:
  - Native Soils - The native soils below the permeable pavement must meet the Soil Physical and Chemical Suitability Criteria for Treatment or engineered soils must be provided that meet the Soil Physical and Chemical Suitability Criteria for Treatment (Volume 4 – Section 10.1.4.1.3) and the measured (initial) saturated hydraulic conductivity must be 12 inches/hour or less.
  - A 12” layer of sand meeting the following gradation (by weight) is provided:

Table 4-2 Sand Specifications for Treatment

U.S. Sieve Size	Percent Passing
4	95-100
8	70-100
16	40-90
30	25-75
50	2-25
100	<4

U.S. Sieve Size	Percent Passing
200	<2
Source: King County Stormwater Design Manual – September 1998	

- BMP T809: Large Sand Filter
- BMP T1110: Wetponds - (Large Wetpond Only)
- BMP T1300: Emerging Technologies
- BMP T900: Media Filter Drain
- Two-Facility Treatment Trains – as shown in, Table 4 - 3: Treatment Trains for Phosphorus Removal. The two-facility treatment train combines two facilities. The first treatment BMP shall be placed upstream of the second treatment BMP.

Table 4 - 3: Treatment Trains for Phosphorus Removal

First Treatment BMP	Second Treatment BMP
One of the Following BMPs: • BMP T1010: Basic Biofiltration Swale • BMP T1020: Wet Biofiltration Swale • BMP T1030: Continuous Inflow Biofiltration Swale • BMP T1110: Wetponds - Basic • BMP T1120: Wetvaults • BMP T1130: Stormwater Treatment Wetlands • BMP T1140: Combined Detention and Wetpool Facilities (Basic)	One of the Following BMPs: • BMP T808: Basic Sand Filter • BMP T810: Sand Filter Vault
BMP T1040: Vegetated Filter Strip	BMP T820: Linear Sand Filter (no presettling needed)
BMP T820: Linear Sand Filter Note: The concentrated flow from the linear sand filter will need to be converted to sheet flow prior entering the vegetaed filter strip. See A300 - Flow Spreading Devices.	BMP T1040: Vegetated Filter Strip

Some BMPs provide both Metals Treatment and Phosphorus Treatment. If a BMP is listed in both the Phosphorus Treatment Options List and the Metals Treatment Options List, that BMP may be used to provide both Phosphorus Treatment and Metals Treatment. If a site requiring both Phosphorus Treatment and Metals Treatment chooses a BMP that is on the Metals

Treatment Options List but not the Phosphorus Treatment List, a separate Phosphorus Treatment BMP must be provided.

1.1.2.3 Metals Treatment BMP Options

The following BMPs can be used to provide Metals Treatment:

- BMP 710: Infiltration Ponds
  - Soils must meet the Soil Physical and Chemical Suitability for Treatment (Volume 4, Section 10.1.4.1.3) and Pretreatment is required.
- BMP 720: Infiltration Trenches
  - Soils must meet the Soil Physical and Chemical Suitability for Treatment (Volume 4, Section 10.1.4.1.3) and Pretreatment is required.
- BMP 730: Drywells
  - Soils must meet the Soil Physical and Chemical Suitability for Treatment (Volume 4, Section 10.1.4.1.3) and Pretreatment is required.
- BMP L614: Full Dispersion
- BMP T809: Large Sand Filter
- BMP T1130: Stormwater Treatment Wetlands
- BMP T1050: Compost-Amended Vegetated Filter Strip (CAVFS)
- BMP L630: Bioretention – Bioretention Soil Mix Options for Metals Treatment Are:
  - Default Bioretention Soil Mix
  - Custom Bioretention Soil Mix
  - High Performance Bioretention Soil Mix Type 1
  - High Performance Bioretention Soil Mix Type 2
  - High Performance Bioretention Soil Mix Type 3

  Stormwater that filters through the bioretention soil mix will receive Metals Treatment. Where bioretention is intended to meet Stormwater Treatment requirements, it must be designed, using an approved continuous simulation model, to pass at least 91% of the influent runoff file through the bioretention soil mix.

- BMP L633: Permeable Pavement with Any of the Following Treatment Layers:
  - Native Soils - The native soils below the permeable pavement must meet the Soil Physical and Chemical Suitability Criteria for Treatment or engineered soils must be provided that meet the Soil Physical and Chemical Suitability Criteria for Treatment (Volume 4 – Section 10.1.4.1.3) and the measured (initial) saturated hydraulic conductivity must be 12 inches/hour or less.
  - A 12” layer of sand meeting the following gradation (by weight) is provided:

Table 4-4 Sand Specifications for Treatment

U.S. Sieve Size	Percent Passing
4	95-100
8	70-100
16	40-90
30	25-75
50	2-25
100	<4
200	<2
Source: King County Stormwater Design Manual – September 1998	

- BMP 740 - Infiltration Swales – Designed to be Either:
  - Vegetated with a minimum 18” treatment soil depth, or
  - Rock-lined with a minimum 18” treatment soil depth.
- BMP T900: Media Filter Drain
- BMP T1300: Emerging Technologies

- Two Facility Treatment Trains – See Table 4 - 5: Treatment Trains for Metals Treatment. The two-facility treatment train combines two facilities. The first treatment BMP shall be placed upstream of the second treatment BMP.

Table 4 - 5: Treatment Trains for Metals Treatment

First Treatment BMP	Second Treatment BMP
One of the Following BMPs: • BMP T1010: Basic Biofiltration Swale • BMP T1020: Wet Biofiltration Swale • BMP T1030: Continuous Inflow Biofiltration Swale • BMP T1110: Wetponds - Basic and Large • BMP T1120: Wetvaults • BMP T1140: Combined Detention and Wetpool Facilities (Basic)	One of the Following BMPs: • BMP T808: Basic Sand Filter • BMP T810: Sand Filter Vault • BMP T1300: Emerging Technologies (The Emerging Technology must have a General Use Level Designation for Basic or Metals Treatment)
BMP T1040: Vegetated Filter Strip	BMP T820: Linear Sand Filter (no presettling needed)
BMP T820: Linear Sand Filter (Note that the concentrated flow from the linear sand filter will need to be converted to sheet flow prior to entering the Vegetated Filter Strip)	BMP T1040: Vegetated Filter Strip
One of the Following BMPs: • BMP T808: Basic Sand Filter • BMP T810: Sand Filter Vault These options must include a presettling cell if the sand filter is not preceded by a detention BMP.	BMP T1300: Emerging Technologies (The Emerging Technology must have a General Use Level Designation for Basic or Metals Treatment)

1.1.2.4 Basic Treatment BMP Options

Any one of the following options may be chosen to satisfy the basic treatment requirement:

- BMP 710: Infiltration Ponds
  - Soils must meet the Soil Physical and Chemical Suitability for Treatment (Volume 4, Section 10.1.4.1.3) and Pretreatment is required.
- BMP 720: Infiltration Trenches
  - Soils must meet the Soil Physical and Chemical Suitability for Treatment (Volume 4, Section 10.1.4.1.3) and Pretreatment is required.
- BMP 730: Drywells

    - Soils must meet the Soil Physical and Chemical Suitability for Treatment (Volume 4, Section 10.1.4.1.3) and Pretreatment is required.
- BMP L614: Full Dispersion
- BMP T808: Basic Sand Filter
- BMP T809: Large Sand Filter
- BMP T810: Sand Filter Vault
- BMP T820: Linear Sand Filter
- BMP T900: Media Filter Drain
- BMP T1010: Basic Biofiltration Swale
- BMP T1020: Wet Biofiltration Swale
- BMP T1030: Continuous Inflow Biofiltration Swale
- BMP T1040: Vegetated Filter Strip
- BMP T1050: Compost-Amended Vegetated Filter Strip (CAVFS)
- BMP T1110: Wetponds - Basic and Large
- BMP T1120: Wetvaults
- BMP T1130: Stormwater Treatment Wetlands
- BMP T1140: Combined Detention and Wetpool Facilities
- BMP L630: Bioretention – Bioretention Soil Mix Options for Basic Treatment Are:
    - Default Bioretention Soil Mix
    - Custom Bioretention Soil Mix
    - High Performance Bioretention Soil Mix Type 1
    - High Performance Bioretention Soil Mix Type 2
    - High Performance Bioretention Soil Mix Type 3

  Stormwater that filters through the bioretention soil mix will receive Basic Treatment. Where bioretention is intended to meet Stormwater Treatment requirements, it must be designed, using an approved continuous simulation model, to pass at least 91% of the influent runoff file through the bioretention soil mix.

- BMP L633: Permeable Pavement with Any of the Following Treatment Layers:
    - Native Soils - The native soils below the permeable pavement must meet the Soil Physical and Chemical Suitability Criteria for Treatment or engineered soils must be provided that meet the Soil Physical and Chemical Suitability Criteria for Treatment (Volume 4 – Section 10.1.4.1.3) and the measured (initial) saturated hydraulic conductivity must be 12 inches or less.
    - A 12” layer of sand meeting the following gradation (by weight) is provided:

Table 4 - 6: Sand Specifications for Treatment

U.S. Sieve Size	Percent Passing
4	95-100
8	70-100
16	40-90
30	25-75
50	2-25
100	<4
200	<2
Source: King County Stormwater Design Manual – September 1998	

- BMP 740 - Infiltration Swales – Designed to Be Either:
  - Vegetated with a minimum 6” treatment soil depth, or
  - Rock-lined with a minimum 18” treatment soil depth.
- BMP T1300: Emerging Technologies

1.1.2.5 Pretreatment Options

Any of the following BMPs can be used to satisfy the pretreatment requirement.

- BMP T610: Presettling Basin
- BMP T1300: Emerging Technologies
- Any Basic, Metals, or Phosphorus BMP
- BMP T1200a: API (Baffle Type) Separators
  - Only if the influent suspended solids concentration is not high.
  - Frequent inspections are required to ensure accumulated sediment does not exceed 6" in depth.
- BMP T1200b: Coalescing Plate (CP) Separators
  - Only if the influent suspended solids concentration is not high.
  - Frequent inspections are required to ensure accumulated sediment does not exceed 6" in depth.
- BMP F110: Detention Ponds
  - When designed to meet Minimum Requirement #7: Flow Control - for Forested Land Cover Conditions
- BMP F120: Detention Tanks
  - When designed to meet Minimum Requirement #7: Flow Control - for Forested Land Cover Conditions
- BMP F130: Detention Vaults

- When designed to meet Minimum Requirement #7: Flow Control - for Forested Land Cover Conditions

1.1.3 Flow Control BMPs

See Volume 1 to determine when Minimum Requirement #7: Flow Control applies to a project.

1.1.3.1 Flow Control BMP Options

The following BMPs may be used to help ensure compliance with Minimum Requirement #7: Flow Control. Many BMPs are also used to help ensure compliance with Minimum Requirement #5: Onsite Stormwater Management and Minimum Requirement #8: Wetlands Protection. Several BMPs may be needed to meet the flow control mitigation requirements. The Best Management Practices must provide flow control to be considered (ex. some facilities may be installed with underdrains or liners and may not provide a flow control function).

- BMP L602: Downspout Full Infiltration
  - BMP L602a: Downspout Infiltration Trenches
  - BMP L602b: Downspout Infiltration Drywells
- BMP L603: Downspout Dispersion
  - BMP L603a: Downspout Dispersion Trenches
  - BMP L603b: Splashblocks
- BMP L614: Full Dispersion
- BMP L611: Concentrated Flow Dispersion
- BMP L612: Sheet Flow Dispersion
- BMP L613: Post-Construction Soil Quality and Depth
- BMP L615: Trees
- BMP 710: Infiltration Ponds
- BMP 720: Infiltration Trenches
- BMP 730: Drywells
- BMP 740: Infiltration Swales
- BMP F110: Detention Ponds
- BMP F120: Detention Tanks
- BMP F130: Detention Vaults
- BMP F140: Parking Lots for Additional Detention
- BMP F150: Roofs for Detention
- BMP T1140: Combined Detention and Wetpool Facilities
  - BMP T1140a: Combined Detention and Wetponds
  - BMP T1140b: Combined Detention and Wetvault
  - BMP T1140c: Combined Detention and Stormwater Treatment Wetland
- BMP L630: Bioretention
- BMP L631: Vegetated Rooftops (Green Roofs)

- BMP L632: Rainwater Harvesting
- BMP L633: Permeable Pavements
- BMP L634: Minimal Excavation Foundations
- BMP L635: Reverse Slope Sidewalks
- BMP L620: Preserving Native Vegetation
    - This BMP does not directly provide Flow Control but seeks to maintain vegetation and limit the amount of hard surface.
- BMP L621: Better Site Design
    - This BMP does not directly provide Flow Control but seeks to maintain vegetation and limit the amount of hard surface.

1.1.4 Wetland Protection BMPs

A combination of Onsite Stormwater Management BMPs, Stormwater Treatment BMPs, and Flow Control BMPs may be needed to ensure compliance with Minimum Requirement #8: Wetlands Protection. The type of BMP needed is based upon the needs of the specific wetland. See Volume 1 - Minimum Requirement #8: Wetlands Protection for additional information.

Chapter 2 Modeling Your Best Management Practices

This chapter describes general requirements for modeling BMPs. Additional information about modeling BMPs can be found within each BMP. The information within this chapter shall be used in addition to information within each BMP.

2.1 Hydrologic Analysis Overview

The purpose of this chapter is to define the minimum computational standards required, and outline how these computational standards may be applied.

2.1.1 Minimum Computational Standards

The minimum computational standards depend on the type of information required and the size of the contributing area to be analyzed, as follows:

- An Ecology approved continuous simulation model, assuming a 15-minute timestep, shall be used for designing flow control and stormwater treatment BMPs.

  Note: Certain facilities may be sized using a single event model. The sizing criteria within each BMP states which model is appropriate.

- Model calibration shall be required for basins greater than 320 acres.
- Single event modeling shall be used to size conveyance systems and verify current system capacity.

The NRCS did not map the soils within the City of Tacoma. For modeling purposes, when site-specific soils information is not known to substantiate soils types, modeling shall be completed assuming both Hydrologic Soil Group A/B and Hydrologic Soil Group C inputs and the most conservative design shall be used. This assumption of soil type cannot be used to prove infeasibility for onsite infiltration, nor can it be used as a basis to design onsite infiltration facilities.

2.1.1.1 Rounding

Values shall typically be rounded to the nearest 100th for stormwater facility design and when determining which Minimum Requirements apply to a project. The City of Tacoma, reserves the right to make the final determination for appropriate rounding.

2.1.2 Continuous Simulation Model

Use only Ecology approved continuous simulation models. See https://fortress.wa.gov/ecy/ezshare/wq/SWMMs/2024SWMMWW/2024_SWMMWW.htm#Topics/Shared/AdditionalResources/AppStatusOfContSimMod.htm for a list of current Ecology approved models. Model elements chosen shall match the proposed BMP being used. Where proprietary devices elements are provided for the models, those elements shall be used.

2.1.3 Single-Event Modeling

Single event models shall use the SCS (TR-20) method and utilize the City of Tacoma Design Storm as shown in The following design storms assuming a Type 1A rainfall distribution shall be used for the City of Tacoma: below.

2.1.3.1 Design Storm

The following design storms assuming a Type 1A rainfall distribution shall be used for the City of Tacoma:

Table 4 - 7: Design Storm Precipitation Values

Return Frequency 24-Hour Storm Event (Years)	Precipitation (Inches)
0.5	1.44
2	2.0
10	3.0
25	3.5
100	4.1

2.1.3.2 Curve Number

Use the following curve numbers for design. Other curve numbers may be used based upon site specific information:

- Lawn/Landscaped Areas: 92
- Impervious Surfaces: 98
- Use Table 4 - 8: Runoff Curve Numbers for Selected Agricultural, Suburban and Urban Areas for other surface types

Table 4 - 8: Runoff Curve Numbers for Selected Agricultural, Suburban and Urban Areas shows the curve numbers (CNs), by land use description, for the four hydrologic soil groups. These numbers are for a 24-hour duration storm and the typical antecedent soil moisture condition preceding 24-hour storms.

The following are important criteria/considerations for selection of CN values.

Many factors may affect the CN value for a given land use. For example, the movement of heavy equipment over bare ground may compact the soil so that it has a lower infiltration rate and greater runoff potential than would be indicated by strict application of the CN value to developed site conditions.

CN values can be area weighted when they apply to pervious areas of similar CNs (within 20 CN points). However, high CN areas should not be combined with low CN areas. In this case, separate estimates of S (potential maximum natural detention) and Qd (runoff depth) should be generated and summed to obtain the cumulative runoff volume unless the low CN areas are less than 15 percent of the sub-basin.

Separate CN values must be selected for the pervious and impervious areas of an urban basin or sub-basin. The pervious area CN value must be a weighted average of all the pervious area CNs within the sub-basin. The impervious area CN value shall be 98.

Table 4 - 8: Runoff Curve Numbers for Selected Agricultural, Suburban and Urban Areas[1]

Cover type and hydrologic condition	CNs for hydrologic soil group[2] A	B	C	D
Curve Numbers for Pre-Development Conditions				
Pasture, grassland, or range-continuous forage for grazing:				
Fair condition (ground cover 50% to 75% and not heavily grazed)	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Fair condition (grazed but not burned, and some forest litter covers the soil)	36	60	73	79
Good condition (protected from grazing, and litter & brush adequately cover the soil)	30	55	70	77
Curve Numbers for Post-Development Conditions				
Open space (lawns, parks, golf courses, cemeteries, landscaping, etc.):				
Fair condition (grass cover on 50% to 75% of the area)	77	85	90	92
Good condition (grass cover on >75% of the area)	68	80	86	90
Impervious areas:				
Open water bodies (lakes, wetlands, ponds, etc.)	100	100	100	100
Paved parking lots, roofs, driveways, etc. (excluding right-of way)	98	98	98	98
Landscaped area	77	85	90	92
100% impervious area	98	98	98	98
Pasture, grassland, or range-continuous forage for grazing:				
Poor condition (ground cover <50% or heavily grazed with no mulch)	68	79	86	89
Fair condition (ground cover 50% to 75% and not heavily grazed)	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Poor condition (forest litter, small trees & brush are destroyed by heavy grazing or regular burning)	45	66	86	89
Fair condition (grazed but not burned, and some forest litter covers the soil)	36	60	73	79
Good condition (protected from grazing, and litter & brush adequately cover the soil)	30	55	70	77

Percentage impervious for modeling fully-developed conditions	
Land use description[3]	**% impervious**
Commercial	85
Industrial	70
Residential	60

1. Source: Soil Conservation Services Technical Release No. 55 (210 - VI TR55, Second Edition, June 1986)
2. Sites in the City of Tacoma shall be considered Type C soils unless a site specific soils investigation is conducted.
3. For the land use descriptions, roads are included in the percentage impervious.

2.1.4 Closed Depression Analysis

The analysis of closed depressions requires careful assessment of the existing hydrologic performance in order to evaluate the impacts of a proposed project. A calibrated continuous simulation hydrologic model must be used for closed depression analysis and design of mitigation facilities.

2.1.5 Considerations for Seeps

Facility sizing must account for any flows intercepted from groundwater sources. Adjustments to facility design may be necessary to account for baseflow conditions. Flow monitoring may be necessary for design purposes.

2.2 Stormwater Treatment Facility Modeling

2.2.1 Flows Requiring Treatment

Runoff from pollution-generating hard surfaces or converted vegetation areas exceeding the thresholds outlined in Minimum Requirement #6: Stormwater Treatment must be treated using one or more of the stormwater treatment facilities in this manual. Facilities must be sized for the entire contributing area even if some of the area is non-pollution generating and/or if some of the area was not included in the project threshold determination.

Facilities must be sized to include increased volumes and/or flowrates created by fields and/or vegetated areas (natural) with underdrains. Artificial fields with underdrains are considered to be impervious surfaces. In an Ecology approved continuous simulation model, assuming a 15-minute timestep, model these areas using the permeable pavement element. A default porosity of 0.3 may be used for all layers or an applicant can provide supporting materials to justify continuous simulation model inputs. Infiltration can only be included if a soils report is included to justify the infiltration rate used.

Stormwater treatment facilities installed to provide treatment of pollution generating surfaces for street sections within the right-of-way shall size those facilities to include stormwater that enters the street through existing through-curb connections from onsite properties to the street and to include the potential for onsite properties to fully develop and connect to the street system via through-curbs in the future. The onsite fully developed condition assumed to reach the facility shall be derived from the following percentages of impervious area:

- In commercial areas, the percent impervious shall be 85%.
- In industrial areas, the percent impervious shall be 70%.
- In residential areas, the percent impervious shall be 60%.

If an applicant proposes to collect and convey onsite stormwater discharges to the City system the applicant shall ensure that any existing downstream stormwater facilities are appropriately sized for the additional flow. If the facilities are not sized to handle additional stormwater discharges; modification to the facility or onsite treatment may be required to mitigate for the proposed impact. It is not the City's intent to require applicants to install regional stormwater treatment facilities. The City of Tacoma will determine the extent to which this requirement applies to each project. Calculations may also need to be provided showing that facilities are appropriately sized to handle the amount of stormwater that enters the unit. Many facility types have a maximum flowrate that can be managed - in some instances upstream flowsplitters may need to be installed to ensure facilites are not damaged by increased flowrates.

2.2.2 Water Quality Design Flow Volume

Stormwater treatment facilities are sized using either a water quality design volume or a water quality design flowrate. Refer to the design criteria within each BMP to determine whether the water quality design volume or water quality design flowrate is used for sizing the facility.

The water quality design volume shall be calculated using an Ecology approved continuous simulation model, assuming a 15-minute timestep.

2.2.3 Water Quality Design Flowrate

Stormwater treatment facilities are sized using either a water quality design volume or a water quality design flowrate. Refer to the design criteria within each BMP to determine whether the water quality design volume or water quality design flowrate is used for sizing the facility.

The water quality design flowrate is dependent on the location of the stormwater treatment facility relative to detention BMPs:

A. Upstream of Detention or Where No Detention Exists:
    - The water quality design flowrate is the flowrate at or below which 91% of the total runoff volume, as estimated by an Ecology approved continuous simulation model, assuming a 15-minute timestep, is treated.
    - At a minimum 91% of the total runoff volume must pass through the stormwater treatment BMP at or below the approved hydraulic loading rate for the BMP.
B. Downstream of Detention Facilities: The water quality design flowrate is the full 2-year release rate from the detention facility.
    - An Ecology approved continuous simulation model, assuming a 15-minute timestep, shall identify the 2-year return frequency flowrate discharged by a detention facility that is designed to meet the flow duration standard.

Approved continuous runoff models calculate both an on-line and off-line water quality design flowrate.

Off-Line Stormwater Treatment BMPs utilizes a flow splitter upstream of the BMP or have an internal bypass built into the facility design which sends the water quality flowrate to treatment. The Use Level Designations for Emerging Technologies will typically state whether to utilize the on-line or off-line for design.

On-Line Stormwater Treatment BMPs receive all stormwater from the contributing basin and are sized using the on-line water quality design flowrate. Flows higher than the water quality design flowrate pass through the facility untreated. When designing on-line stormwater treatment BMPs, documentation that the higher flows will not damage the BMP must be provided.

2.3 Flow Control Facility Modeling

2.3.1 Flows Requiring Mitigation

Flow control facilities shall be sized for the entire flow that is directed to them; however, bypass may be allowed as described below.

Facilities must be sized to include increased volumes and/or flowrates created by fields and/or vegetated areas (natural) with underdrains. Artificial fields with underdrains are considered to be impervious surfaces. In an Ecology approved continuous simulation model, assuming a 15-minute timestep, these areas using the permeable pavement element. A default porosity of 0.3 may be used or an applicant can provide supporting materials to justify the model inputs. Infiltration can only be included if a soils report is provided to justify the infiltration rate used.

2.3.2 Bypass

A portion of stormwater created by surfaces that require flow control may bypass the flow control facility (unless using Equivalent Areas) provided all the following conditions are met:

1. Runoff from both the bypass area and the flow control facility converges within ¼ mile downstream of the project site discharge location.
2. Any existing contributions or flows to an onsite wetland must be maintained (See Minimum Requirement #8 and Tacoma Municipal Code 13.11)
3. The flow control facility is designed to compensate for the uncontrolled bypass areas such that the net effect at the point of convergence downstream is the same with or without bypass.
4. The 100-year return period flowrate from the bypass area will not exceed 0.4 cfs.
5. Runoff from the bypass area will not create a significant adverse impact to the downstream stormwater system or properties and shall meet the requirements of Minimum Requirement #4: Preserving Drainage Patterns and Outfalls.
6. Stormwater treatment requirements applicable to the bypass area are met.

2.3.3 Inflow from Areas that Don't Require Flow Control

This guidance applies to Flow Control BMPs that are receiving flow from areas not requiring mitigation in addition to the areas that must be mitigated.

Depending on site layout and topography, Flow Control BMPs may need to be positioned on a site such that runoff from areas that do not need to be mitigated are directed to the Flow Control BMP. These additional areas may come from on-site or off-site.

For example, a redevelopment project may need to provide Flow Control for the new hard surfaces (and not for the replaced or existing hard surfaces), but the proposed Flow Control BMP is placed such that flow from the new AND replaced (and existing) hard surfaces is directed to it. The flow from the replaced and existing hard surfaces would be considered additional flow to the Flow Control BMP.

Runoff from these additional areas that do not require flow control may be modeled assuming existing land cover conditions (as opposed to forested land cover). For the purposes of modeling in an Ecology approved continuous simulation model, these additional areas that do not require flow control are entered under both the “Predeveloped” and “Mitigated” scenarios.

The performance of Flow Control BMPs can be compromised if the additional area, beyond the area that needs to be mitigated, is too large. Therefore, if the existing 100-year peak return period flowrate from the additional area not requiring flow control is greater than 50% of the 100-year developed return period flowrate (undetained) from the area requiring mitigation, then the runoff from the additional area not requiring flow control must not flow to the Flow Control BMP. The bypass of the additional area not requiring flow control must be designed to achieve the following:

1. Any existing contribution of flows to an on-site wetland must be maintained.
2. Flows from the additional areas not requiring flow control that are naturally attenuated by the project site under predeveloped conditions must remain attenuated, either by natural means or by providing additional on-site Flow Control BMP(s) so that return period flowrates do not increase. If additional flow control is required, it must be modeled in an Ecology approved continuous simulation model, assuming a 15-minue timestep.

Chapter 3 Design Criteria for All Stormwater Treatment and Flow Control BMPs

This chapter describes design criteria that may be applicable to any stormwater treatment and/or flow control facility. Additional information can be found within each BMP. The information within this chapter shall be used in addition to information within each BMP as applicable to each project.

3.1 Site Suitability

This section describes general requirements and considerations for determining if a BMP is appropriate for your project. Additional information about siting BMPs can be found within each BMP. The information within this chapter shall be used in addition to information within each BMP.

3.1.1 Site Characterization

Site characterization is necessary to help determine the appropriateness of siting stormwater treatment facilities on a site and/or project site.

3.1.1.1 Overall Consideration

The following site characteristics shall be considered when siting any stormwater treatment or flow control facility.

- Site topography within 500 feet of the proposed facility.
- Anticipated site use (residential, commercial, industrial, right-of-way)
- Vehicular and Pedestrian Safety
- Impacts of Surrounding Activities
- Anticipated pollutant loading
- Anticipated end-user
- Space, Including Considerations for:
  - Setback Requirements
  - Access for Inspection and Maintenance
  - Pretreatment (if needed)
  - Operation and Maintenance including inspection
- Ability for vegetation to grow (as applicable)
- Backwater effects
  - If backwater conditions have the potential to affect stormwater systems, analysis of the system function must be provided which may be include documentation from the manufacturer.
- Evaluate the following conditions for all stormwater treatment and/or flow control facilities designed to infiltrate stormwater and surface water or that may impact groundwater (unlined wetponds, dispersion facilities, etc.). If there are any potential impacts discovered the facility may not be appropriate or may need to be setback from areas that may be impacted.

- Potential impacts to drinking water wells, septic tanks or drainfields, and springs used for public drinking water supplies.
- Potential impacts from roadways subject to deicers or herbicides that are likely to be present in the influent to the infiltration system.
- Potential impacts to all building foundations near the proposed infiltration facility. Recommend investigating all building foundations: within 100 feet upslope and 20 feet downslope from the facility.
- Potential impacts to all property lines within 20 feet of the facility.
- Potential impacts to any Native Growth Protection Easement (NGPE) that is located within 20 feet of the proposed facility.
- Potential impacts to the top of slopes equal to or greater than 15% that are 50 feet or less from the facility.
- Potential impacts to known contaminated sites or landfills.
- On-site and off-site structural stability due to extended subgrade saturation and/or head loading of the permeable layer, including the potential impacts to downgradient properties, especially on hills with known side-hill seeps.

3.1.1.2 Site Characteristics Specific to Stormwater Treatment and Flow Control Facilities Designed to Infiltrate

Groundwater Protection Areas

A site is not suitable if the infiltration facility will cause a violation of Ecology's Groundwater Quality Standards.

The City of Tacoma Public Works Department and Tacoma-Pierce County Health Department developed a guidance document that provides the circumstances and requirements for approval of infiltration facilities for managing pollution-generating stormwater in the STGPD. The document, “Implementation of Stormwater Infiltration for Pollution-Generating Surfaces in the South Tacoma Groundwater Protection District” is available at tacoma.gov/stormwatermanual.

Areas that Infiltrate and Require Oil Control

An infiltration BMP may be considered for stormwater from areas that require Oil Control. For those areas, ensure the oil control BMP is placed upstream of the infiltration BMP.

Cold Climate and Impact of Roadway Deicers

Potential impact of roadway deicers on potable water wells must be considered in the siting determination. Mitigation measures must be implemented if infiltration of roadway deicers can cause a violation of groundwater quality standards.

Seepage Analysis and Control

Determine whether there would be any adverse effects caused by seepage zones on nearby building foundations, basements, roads, parking lots or sloping sites.

Previously Contaminated Soils or Unstable Soil

Infiltration of stormwater is not recommended on or upgradient of contaminated sites where infiltration of even clean water could cause contaminants to mobilize. If the site is know or suspected to contain contaminated soils, investigate whether the soil under the proposed infiltration BMP contains contaminants that could be transported by infiltrated water from the BMP. If so, measures shall be taken to remediate the site prior to constructing the infiltration BMP, or an alternative location should be chosen.

If the site history, regional geology or local geology indicate that the soil beneath the proposed infiltration BMP could be unstable, a geotechnical analysis shall be performed before installing the BMP and any recommendations for amending the soil shall be followed.

Additional Miscellaneous Design Criteria

- The slope of the base of the infiltration BMP should not exceed 3% in any direction.
- Construct a non-erodible outlet or spillway with a firmly established elevation to discharge overflow. Calculate ponding depth, drawdown time, and storage volume from that reference point.
- For infiltration BMPs that provide stormwater treatment, side-wall seepage is not a concern if seepage occurs through the same stratum as the bottom of the BMP. However, soils with very low permeability, the potential to bypass the treatment soil through the side walls may be significant. In those cases, line the side walls with 18” or more of treatment soil to prevent seepage of untreated flows through the side walls.

3.1.2 Setbacks

Setback requirements are generally required by the City of Tacoma Municipal Code, Uniform Building Code, the Tacoma Pierce County Health Department, or other state regulations. Where a conflict between setbacks occurs, the City shall require compliance with the most stringent of the setback requirements from the various codes/regulations. The following are the minimum setbacks required per this manual.

Setbacks are typically measured from the overflow elevation.

Additional setbacks may be required by other local, state, or federal agencies. See the individual BMPs for BMP specific setback criteria.

- At least 100 feet from drinking water wells, and springs used for public water supplies. Infiltration facilities, unlined wetponds, and detention ponds upgradient of drinking water wells and within 1, 5, and 10-year time of travel zones must comply with Health Department requirements (Washington Wellhead Protection Program, DOH, Publication #331-018). Infiltration BMPs should be located outside the sanitary control area of drinking water systems.

- Set dispersion areas back ≥ 100 feet from drinking water wells and springs used for public drinking water supplies. Ensure dispersion areas upgradient of drinking water supplies and within the 1-, 5-, and 10-year time of travel zones comply with the Washington State Department of Health (DOH) requirements (DOH, 2010).

- All systems shall be at least 10 feet from any building structure and at least 5 feet from any other structure or property line. If necessary, setbacks shall be increased from the

minimum 10 feet in order to maintain a 1H:1V side slope for future excavation and maintenance. Vertical pond walls may necessitate an increase in setbacks.

- Facility discharge locations shall be setback a minimum of 50 feet from the top of any slope greater than 15% and from geologically hazardous areas. The facility discharge location or infiltration facility may be sited within 50 feet of a slope greater than 15% and/or geologically hazardous area if a geotechnical analysis performed by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist determines that there will be no negative impacts to the slopes and/or geologically hazardous areas caused by the stormwater facility.
- Setbacks from Onsite Sewage Systems shall conform to WAC 246-272A-0210.
- Infiltration BMPs should be located >100 feet from septic tanks, and drain fields.
- Infiltration BMPs that qualify as Underground Injection Control Wells must comply with the setback requirements of the UIC Guidance contained in Volume 1, Chapter 2.

3.2 Underground Utilities

- Stormwater facility installation must carefully consider impacts to underground utilities. Underground utilities are susceptible to damage during construction and certain stormwater facilities may increase inflow and infiltration (I&I) concerns.
- Stormwater facilities proposed to be located over shallow City of Tacoma maintained stormwater or wastewater pipes shall only be allowed if approved by The City of Tacoma. The City will assess the existing condition of the pipes and if necessary may require the applicant to conduct video inspection of stormwater pipes, wastewater pipes, and side sewer laterals before approval. Post construction video inspection may also be required based upon the City's assessment of the site conditions.
    - Shallow stormwater lines are lines located within 6 feet from the stormwater facility to the top of the stormwater pipe.
    - Shallow wastewater (and side sewer laterals) lines are lines located within 10 feet from the stormwater facility to the top of the stormwater pipe.

3.3 Buoyancy

Consideration shall be given when placing stormwater facilities where buoyancy is a concern such as areas with year-round high groundwater or seasonal high groundwater inundation. A Washington State Licensed Professional Engineer is required to design measures to mitigate buoyancy.

3.4 Dam Safety

Stormwater facilities that can impound 10 acre-feet or more (including both water and sediment storage volume) as measured at the crest elevation are subject to require design per the Washington State Dam Safety Regulations (Chapter 173-175 WAC) and review by the Washington State Department of Ecology. See https://ecology.wa.gov/Water-Shorelines/Water-supply/Dams for additional information.

3.5 Underground Injection Control

Certain facilities that infiltrate stormwater are considered to be Underground Injection Control facilities and must follow applicable UIC regulations which may include Washington State Department of Ecology review and registration. Some examples of UIC wells are drywells, infiltration facilities which distribute stormwater via perforated pipes, and underground structures that temporarily store water before infiltration. See https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Underground-injection-control-program and Volume 1, Chapter 2 - Underground Injection Control Guidelines for additional information.

3.6 Sequencing

- Stormwater treatment facilities may be placed in a variety of configurations though generally they are installed upstream from detention. Certain facilities do not function efficiently when placed downstream of detention. The design criteria within each BMP specifies whether a facility can be located downstream of detention and whether or not the facility can be located online or offline.
- Oil control BMPs must be located upstream of other stormwater treatment facilities and flow control facilities and as close to the source of the oil-generating activity as possible.
- Stormwater facilities used as part of a Treatment Train must be sited in the order provided in the Treatment Train tables.

3.7 Separation of Public and Private Stormwater for Stormwater Treatment and Flow Control

Typically, private and public stormwater are separated for purposes of stormwater treatment and flow control. However, the City recognizes that this is not always practical. Therefore, the City has developed the following guidance:

- For commercial new development and redevelopment, public and private stormwater shall be separated. The City may allow incidental amounts of private stormwater to enter the City system with written approval from the City of Tacoma.
- Under certain circumstances, incidental amounts of public stormwater may be allowed to discharge to private stormwater treatment and/or flow control systems with written approval from the City of Tacoma. A written agreement between the City and owner and Notice to Title may be required.
- For residential new development and redevelopment, for areas adjacent to public roads, such as driveways, the City will typically allow driveway runoff to drain to the street if onsite management is not feasible and the amount of driveway area is small compared to the public road area. All new and replaced hard surfaces and land conversions required to provided stormwater treatment and/or flow control must do so. Private accessway runoff shall be handled in separate private stormwater treatment and/or flow control facilities.

3.8 Materials

Acceptable materials for stormwater facilities include thermoplastics, iron, steel, aluminum, and concrete. Steel and iron shall be aluminum coated (aluminized Type 2). Zinc coated (galvanized) materials are prohibited. Painted metal parts shall not be used because of poor longevity.

3.9 Fencing

Fences may be required for certain Best Management Practices for safety purposes.

Where interior side slopes are steeper than 3H:1V or where walls are used for impoundment that are greater than 24" in height a fence or other appropriate barrier is required. If more than 10% of the slopes are steeper than 3H:1V, it is recommended that the entire facility be fenced. Other federal, state, or local regulations may also require fencing. Fences shall comply with A700: Fencing.

3.10 Signage

Stormwater facility signs are a useful educational tool to both describe a facility function and to provide contact information for operation and maintenance needs.

It is recommended to install stormwater facility signs for stormwater facilities in areas with high pedestrian traffic. Certain BMPs require signage as noted within the design criteria of those BMPs. Signage shall be a consideration for all visible stormwater facilities.

Signage shall conform to A800: Signage.

Chapter 4 Constructing Your Best Management Practices

This chapter describes requirements for constructing BMPs. Additional information can be found within each BMP. The information within this chapter shall be used in addition to information within each BMP.

4.1 Sediment Removal and Site Stabilization

Construction debris and sediment shall be removed from all stormwater facilities when construction is complete and site is fully stabilized before facility is placed online.

4.2 Acceptance and Verification

A Washington State Licensed Professional Engineer shall verify that facilities designed to meet Minimum Requirement #6: Stormwater Treatment, Minimum Requirement #7: Flow Control and/or Minimum Requirement #8: Wetlands Protection are constructed as designed and develop Record Drawings (As-Built Plans) before facilities are accepted and placed online. See Volume 2 - Documentation for additional information.

Stormwater facilities require a final inspection by City of Tacoma staff before they may be placed online. See tacomapermits.org for additional information about inspections.

Chapter 5 Accessing and Maintaining Your Best Management Practices

This chapter describes requirements for accessing and maintaining BMPs. Additional information can be found within each BMP. The information within this chapter shall be used in addition to information within each BMP.

5.1 Access

All components of the stormwater system must be accessible for inspection and maintenance purposes.

Construction of access roads and ramps may be necessary to ensure all components of the stormwater system are accessible for inspection and maintenance. Access ramps and roads shall conform to A3000: Access Ramps and Roads.

Manholes shall be placed in or at the edge of access roads when possible.

5.2 Dedicated Easements and Dedicated Tracts

For access and maintenance purposes components of the stormwater system may need to acquire easements or be dedicated as separate tracts.

5.2.1 Conveyance Systems

5.2.1.1 Public

All publicly maintained conveyance systems shall be located in dedicated tracts, dedicated easements, or public rights-of-way. Public easements are easement granted by private entities to the City for access, maintenance, and protection of City infrastructure. Public easements are separate documents prepared by the City Real Property Services and are recorded with the Pierce County Auditor. Public easements must be granted to the City and fully executed before final permit closeout. See the City of Tacoma Design Manual - Chapter 11, Section 9 for public easement requirements.

Preliminary project planning should account for the potential loss of buildable area or the need to purchase more property as a result of the stormwater system and their required easements/ tracts.

5.2.1.2 Private

All privately maintained conveyance systems crossing parcel boundaries shall be located in dedicated tracts, dedicated easements, or private roadways with appropriate easements. Any new conveyance system located on private property designed to convey runoff from other private properties must be located in a private stormwater system easement granted to the contributors of stormwater to said systems. The easement shall permit access for maintenance or replacement in the case of failure.

Private maintenance agreements are required for facilities owned by or served by multiple owners. All agreements shall be recorded with the Pierce County Assessor.

Unless prohibited by topography or existing site conditions, new conveyance system alignments, on private property, must be located in stormwater system easements that are adjacent and parallel to property lines.

The depth or proximity of a private system to slopes 20% or greater may necessitate a larger easement for future excavation and maintenance purposes. Typically this requires a 1:1 slope from the bottom of the trench.

Private easement width shall be based upon pipe diameter, depth of pipe, soil type, and maintenance access. Easement width shall be sufficient to ensure the system can be completely removed and replaced if necessary.

5.2.2 Structural Stormwater Best Management Practices

5.2.2.1 Public

When not located in the city right of way, stormwater facilities to be maintained by the City shall be located in dedicated tracts or dedicated easements. Tracts and easement must also maintain appropriate setbacks as required for each BMP.

5.2.2.2 Private

Privately owned facilities shall be located outside of dedicated public right-of-way areas.

A covenant and easement agreement is required for all proposed private stormwater facilities to ensure proper maintenance and access. The covenant and easement agreement is an agreement between the City of Tacoma and the property owner(s). The document shall be recorded on title.

Additional private easements may be required if stormwater facilities are located on more than one parcel of land. Private maintenance agreements are required for facilities owned by or served by multiple owners. All agreements shall be recorded with the Pierce County Assessor.

5.3 Operation and Maintenance

Per Minimum Requirement #9: Operation and Maintenance, an operation and maintenance plan shall be prepared for all stormwater management facilities. See Appendix C: Operation and Maintenance of this volume for Maintenance Standards and Volume 2 for items to include in an Operation and Maintenance Manual. More than one maintenance standard may apply to a given facility because a BMP may contain many components.

Standing water and sediment removed during the maintenance operation must be disposed appropriately. Sediment must be disposed of in accordance with Tacoma Pierce County Health Department requirements and cleanup standards set forth in the Model Toxic Control Act (Chapter 70.105D RCW) and Regulations Chapter 173-304 WAC. Disposal of sediment and standing water shall also comply with the Washington State Department of Ecology Stormwater Management Manual for Western Washington - Appendix IV-B: Management of Street Waste Solids and Liquids.

Maintenance shall be a basic consideration in design and cost-determination of the stormwater management facility.

Facilities shall be designed and constructed to be safely and easily inspected by one person and safely maintained. Installation of additional inspection ports or access manholes may be necessary to allow inspection access to be opened by one person.

Chapter 6 City of Tacoma Standard Plans and Details

The City of Tacoma maintains many Standard Plans and Typical Details. All projects can use the City of Tacoma Standard Plans and Green Stormwater Infrastructure Typical Details as appropriate for the project. Stormwater facilities that will be maintained by the City of Tacoma shall utilize the City of Tacoma Standard Plans. Plans can be found at: tacoma.gov/government/departments/public-works/engineering/right-of-way-design-manual/

Chapter 7 Site Design BMPs

7.1 Introduction

Site Design BMPs should be used for all projects. Site Design BMPs include suggestions on how to design a project to limit hard surfaces and preserve site vegetation. Site Design BMPs help ensure compliance with Minimum Requirements by minimizing stormwater impacts on receiving waters.

7.2 BMP L620: Preserving Native Vegetation

7.2.1 Purpose

Preserving native vegetation on-site to the maximum extent practicable will minimize the impacts of development on stormwater.

7.2.2 Applications

Preserving native vegetation helps to ensure compliance with Minimum Requirements by limiting the amount of new and replaced hard surfaces, land disturbances, and vegetation conversions.

Native vegetation preservation should be a consideration for every project.

7.2.3 Design Criteria

- Preserve native vegetation and maintain tree canopy to the maximum extent practicable.
- Situate the preserved area to maximize the preservation of wetlands, and to buffer stream corridors and minimize clearing of existing forest.
- Place the preserved area in a separate tract or protect through recorded easements for individual lots.
- If feasible, locate the preserved area downslope from the building sites, since flow control and water quality are enhanced by flow dispersion through duff, undisturbed soils, and native vegetation.
- Show the preserved area on all property maps and clearly mark the area during clearing and construction on the site.

7.2.4 Maintenance

- Do not remove vegetation and trees from undisturbed areas, except for approved timber harvest activities and the removal of dangerous and diseased trees.

7.3 BMP L621: Better Site Design

7.3.1 Purpose

Fundamental hydrological concepts and stormwater management concepts can be applied at the site design phase that are:

- More integrated with natural topography,
- Reinforce the hydrologic cycle,
- More aesthetically pleasing, and
- Often less expensive to build.

7.3.2 Applications

Better Site Design helps to ensure compliance with Minimum Requirements by limiting the amount of new and replaced hard surfaces, land disturbances, and vegetation conversions.

7.3.3 Design Criteria

- **Define Development Envelope and Protected Areas** – The first step in site planning is to define the development envelope. This is done by identifying protected areas, setbacks, easements and other site features, and by consulting applicable local standards and requirements. Site features to be protected may include important existing trees, steep slopes, erosive soils, riparian areas, and wetlands.

  By keeping the development envelope compact, environmental impacts can be minimized, construction costs can be reduced, and many of the site's most attractive landscape features can be retained. In some cases, economics or other factors may not allow avoidance of all sensitive areas. In these cases, care can be taken to mitigate the impacts of development through site work and other landscape treatments.

- **Minimize Directly Connected Impervious Areas** – Impervious areas directly connected to the stormwater system are the greatest contributors to urban nonpoint source pollution. Minimize these directly connected impervious areas. This can be done by limiting overall impervious land coverage or by infiltrating and/or dispersing runoff from these impervious areas.
- **Maximize Permeability** - Within the development envelope, many opportunities are available to maximize the permeability of new construction. These include minimizing impervious areas, paving with permeable materials, clustering buildings, and reducing the land coverage of buildings by smaller footprints. All of these strategies make more land available for infiltration and dispersion through natural vegetation.
- **Build Narrower Streets** - More than any other single element, street design has a powerful impact on stormwater quantity and quality. In residential development, streets and other transportation-related structures typically can comprise between 60 and 70 percent of the total impervious area, and, unlike rooftops, streets are almost always directly connected to the stormwater conveyance system.
- **Maximize Choices for Mobility** - Given the costs of automobile use, both in land area consumed and pollutants generated, maximizing choices for mobility is a basic principle for environmentally responsible site design. By designing residential developments to promote alternatives to automobile use, a primary source of stormwater pollution can be mitigated.

- **Use Drainage as a Design Element** - Unlike conveyance stormwater systems that hide water beneath the surface and work independently of surface topography, a stormwater system for stormwater infiltration or dispersion can work with natural land forms and land uses to become a major design element of a site plan.

Chapter 8 Downspout BMPs

8.1 BMP L602: Downspout Full Infiltration

8.1.1 Purpose

Downspout full infiltration systems are trenches and drywells intended only for use in infiltrating stormwater from roof downspouts. They are not designed to infiltrate stormwater from pollution generating surfaces.

8.1.2 Application

- This BMP can be utilized to ensure compliance with Minimum Requirement #5: Onsite Stormwater Management.
- The BMP can be used solely to mitigate for roof surfaces if utilizing the List Approach or may be used in combination with other BMPs to satisfy the LID Performance Standard.
- This BMP may also be used to help ensure compliance with Minimum Requirement #7: Flow Control and Minimum Requirement #8: Wetlands Protection.
- Where compliance with Minimum Requirements is not required, where feasible, this BMP is recommended to be used to help protect receiving waterbodies from the effects of stormwater.
- BMP L602: Downspout Full Infiltration is appropriate for residential and small commercial development that has similar runoff characteristics to residential development. BMP L602 is limited to roof areas of less than 5,000 square feet. If proposing infiltration trenches for larger areas, utilize BMPs from Chapter 10 - Infiltration BMPs.

8.1.3 Infeasibility Criteria for Downspout Full Infiltration Systems

The following infeasibility criteria describe conditions that make downspout full infiltration systems infeasible when applying The List Approach for compliance with Minimum Requirement #5: Onsite Stormwater Management.

The infeasibility criteria shall also be used to determine the appropriateness of installing downspout infiltration. Project proponents may be allowed to install downspout infiltration facilities even if considered infeasible, unless otherwise stated within the specific infeasibility criteria, provided documentation is included that substantiates the design. Documentation may be required by a Washington State Licensed Professional Engineer or other appropriate professional depending on the project conditions.

A site characterization study must be completed in order to determine if the infeasibility criteria apply and to determine the appropriateness of installing downspout infiltration systems.

- The design standards per BMP L602a: Downspout Infiltration Trenches or BMP L602b: Downspout Infiltration Drywells cannot be met.
- The setback criteria below cannot be met. Setback criteria are generally required by Tacoma Municipal Code, Uniform Building Code, the Tacoma-Pierce County Health Department, or other state regulation. Where a conflict between setbacks occurs, the City shall require compliance with the most stringent of the setback requirements from the various codes/regulations. Setbacks are typically measured from the overflow elevation.The following are the minimum setbacks required per this manual:

- At least 10 feet from any building structure and at least 5 feet from any other structure or property line unless approved by the City of Tacoma.
- A minimum of 50 feet from the top of any slope greater than 20% and from geologically hazardous areas. The infiltration facility may be sited within 50 feet of a slope greater than 20% and/or geologically hazardous area if a geotechnical analysis performed by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist determines that there will be no negative impacts to the slopes and/or geologically hazardous area caused by the discharge location of the infiltration facility.
- Setbacks from Onsite Sewage Systems shall conform to WAC 246-272A-0210.
- The City of Tacoma may require additional setbacks or analysis for infiltration facilities proposed to be sited within the influence of known contaminated sites or abandoned landfills.

- Additional setbacks may be required by other local, state, or federal agencies. If there are any conflicts with any of the following competing needs criteria:
  - Requirements of the following federal or state laws, rules, and standards:
    - Historic Preservation Laws and Archaeology Laws as listed at: https://dahp.wa.gov/project-review/preservation-laws.
    - Federal Superfund or Washington State Model Toxics Control Act
    - Federal Aviation Administration requirements for airports
    - American with Disabilities Act
  - When found to be in conflict with special zoning district design criteria adopted and being implemented pursuant to a community planning process.
  - Public health and safety standards
  - Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.
  - City of Tacoma Critical Area Ordinances that provides protection of tree species or other critical areas.
- Where the placement of the infiltration facility would require removal of an established mature tree(s).

The following infeasibility criteria are based upon subsurface characteristics and require a soils report to determine infeasibility. See Appendix B: Soils Reports for Soils Report Requirements.

- The particle size distribution of the soil is classified according to the USDA Textural Triangle (see Figure 4 - 1: USDA Textural Triangle) as clay, sandy clay, silty clay, clay loam, silty clay loam, sandy clay loam, or silt based on ASTM Standard Test Method for Particle Size Analysis of Soils ASTM D422-63 (2002).
- The depth from proposed final grade to seasonal high groundwater table or other impermeable layer is less than 3 feet.
- The depth from the bottom of the infiltration trench or drywell to the seasonal high groundwater table or other impermeable layer is less than one foot.

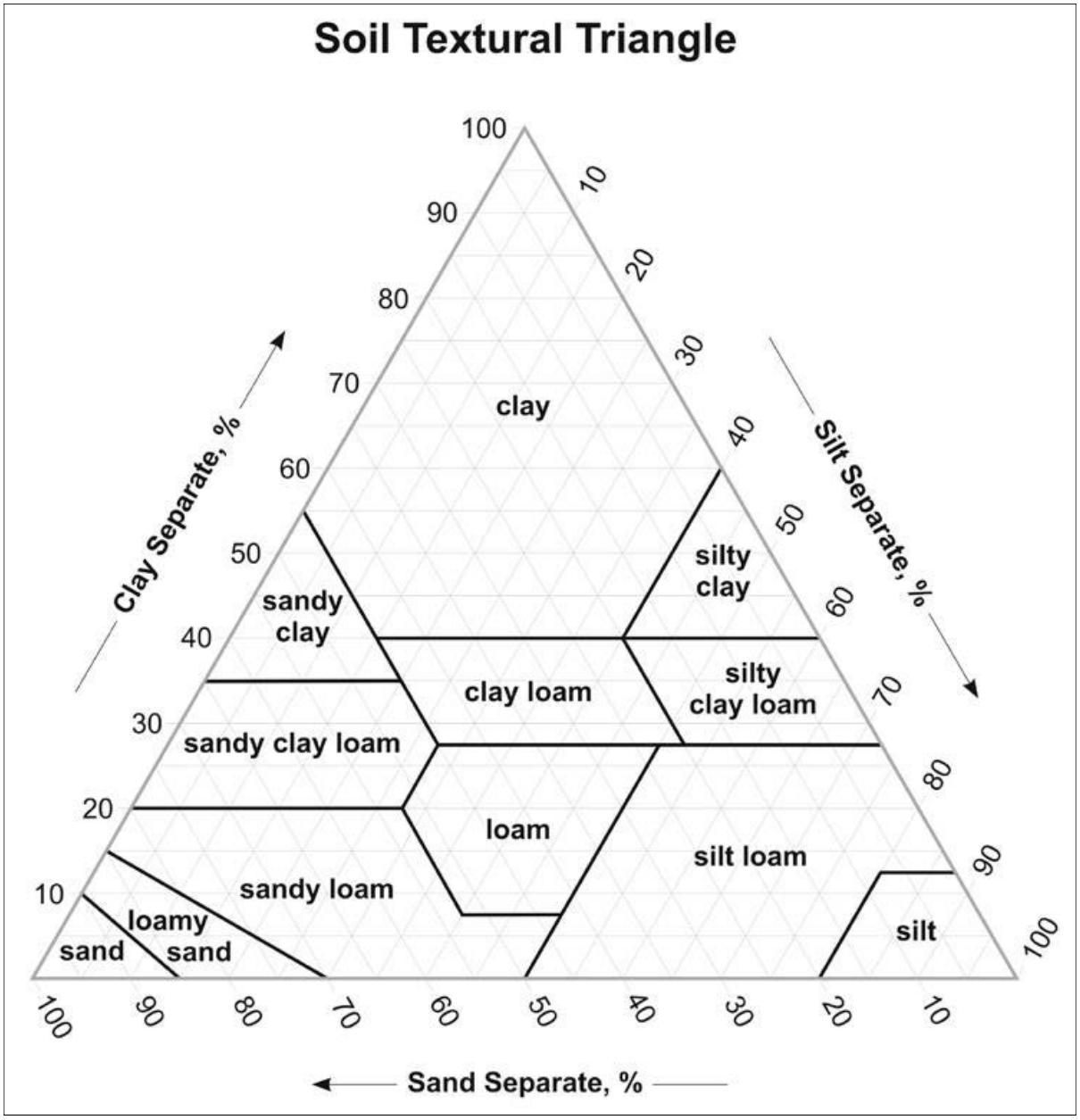


Figure 4 - 1: USDA Textural Triangle

8.1.4 Subsurface Characterization

- A soils report is required to design downspout full infiltration facilities. A soils report is also required if citing that downspout full infiltration is not feasible due to subsurface characteristics. See Appendix B: Soils Reports for Soils Report requirements.

8.1.5 BMP L602a: Downspout Infiltration Trenches

8.1.5.1 Design Criteria for Downspout Infiltration Trenches

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

- Use Figure 4 - 2: Typical Downspout Infiltration Trench (also called Green Stormwater Infrastructure - Figure 001) which shows a typical downspout infiltration trench system, or Figure 4 - 3: Alternative Infiltration Trench System for Coarse Sand and Gravel which shows an alternative infiltration trench system for sites with coarse sand and cobble soils for design criteria.
- Minimum trench bottom area shall be based on native soil type as shown in Table 4 - 9: Downspout Infiltration Trench Sizing Table. Native soil type shall be determined using methods described in Subsurface Characterization.

Table 4-9 Downspout Infiltration Sizing Table

USDA Soil Type	Minimum Rock Layer	Minimum Trench Bottom Area (ft2) per 500 ft2 of contributing area
Coarser than Sand	1.5	10
Sand	1.5	10
Loamy Sand (and Fill)	1.5	25
Sandy Loam	1.5	35
Loam	1.5	50
Silt Loam	1.5	105

USDA Soil Type	Minimum Rock Layer	Minimum Trench Bottom Area (ft2) per 500 ft2 of contributing area
Coarser than Sand	2	10
Sand	2	10
Loamy Sand (and Fill)	2	25
Sandy Loam	2	30
Loam	2	45
Silt Loam	2	90

USDA Soil Type	Minimum Rock Layer	Minimum Trench Bottom Area (ft2) per 500 ft2 of contributing area
Coarser than Sand	2.5	10
Sand	2.5	10
Loamy Sand (and Fill)	2.5	20
Sandy Loam	2.5	30
Loam	2.5	45
Silt Loam	2.5	80

USDA Soil Type	Minimum Rock Layer	Minimum Trench Bottom Area (ft2) per 500 ft2 of contributing area
Coarser than Sand	3.5	10
Sand	3.5	10
Loamy Sand (and Fill)	3.5	20
Sandy Loam	3.5	20
Loam	3.5	35
Silt Loam	3.5	65

USDA Soil Type	Minimum Rock Layer	Minimum Trench Bottom Area (ft2) per 500 ft2 of contributing area
Coarser than Sand	4	10
Sand	4	10
Loamy Sand (and Fill)	4	15
Sandy Loam	4	25
Loam	4	35
Silt Loam	4	65

- The minimum bottom width shall be 24". If alternative sizes are proposed the applicant shall utlize BMP 720.
- Maximum length of trench shall not exceed 100 feet from the inlet sump.
- Minimum spacing between trenches shall be 6 feet measured from trench centerline.

- Non-woven geotextile fabric shall be placed over the trench aggregate prior to backfilling. Geotextile fabric shall not be placed on the bottom of the trench to avoid clogging. The non-woven geotextile shall conform to A2000: Geotextile Specifications, Geotextile for Underground Drainage - Low Survivability, Class C. Scarify the bottom of the facility 2", minimum to enhance infiltration capabilities.
- Distribution pipe shall be minimum 4” PVC slotted or perforated pipe placed at 0% slope.
- Install a rock layer as follows:
  - A minimum 12" thick layer of rock shall be placed under the top of the distribution pipe.
  - A minimum 2" thick layer of rock shall be placed above the top of the distribution pipe.
  - The rock layer shall be ¾" to 1 ½" washed rock or rock meeting the WSDOT Standard Specification 9-03.12(5) - Gravel Backfill for Drywells.
- Place final cover measures over the rock layer.
  - All disturbed areas not covered with impervious surfaces must be fully stabilized by planting and amended per BMP L613: Post-Construction Soil Quality and Depth.
  - Ensure the appropriate subgrade material is installed for paved areas.

  The rock layer shall not extend to the surface unless using the alternative trench design (Figure 4 - 3: Alternative Infiltration Trench System for Coarse Sand and Gravel) which is only allowed where the native soils are coarse sand or gravel.

- Cleanout are recommended at all bends in pipe and at the infiltration trench terminus for inspection and maintenance practices.
  - Install a catch basin or yard drain upstream from the infiltration trench.
  - Catch basin or yard drain shall have a minimum 6" sump depth below the tee.
  - The tee shall have a ½" mesh screen on top and bottom to capture large debris.
  - Catch basin or yard drain shall be traffic-bearing in areas subject to traffic.
  - A short section of non-perforated pipe shall lead from the catch basin to the slotted or perforated pipe section.

  The catch basin or yard drain is not required for projects using the alternative trench design (Figure 4 - 3: Alternative Infiltration Trench System for Coarse Sand and Gravel) which is only allowed where the native soils are coarse sand or gravel.

- A minimum of three feet of separation is required from the proposed final grade to the seasonal high groundwater table.
- A minimum of 1 foot of separation is required from the bottom of the infiltration trench to the seasonal high groundwater table.
- Infiltration trenches may be placed in fill material if the fill is placed and compacted under the direct supervision of a Washington State Licensed Professional Engineer, and if the measured infiltration rate is at least 8 inches per hour. Infiltration rates can be tested using the methods described in Appendix A: Determining the Design Infiltration Rate.
- Trenches may be located under pavement if a small yard drain or catch basin with grate cover is placed at the end of the trench pipe such that overflow would occur out of the catch basin at an elevation at least one foot below that of the pavement, and in a location

which can accommodate the overflow without creating a significant adverse impact to downhill properties or stormwater systems. This is intended to prevent saturation of the pavement in the event of system failure.

8.1.6 BMP L602b: Downspout Infiltration Drywells

8.1.6.1 Design Criteria for Downspout Infiltration Drywells

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

- Figure 4 - 4: Typical Downspout Infiltration Drywell (also known as Green Stormwater Infrastructure Figure 002) shows a typical downspout infiltration drywell system. The applicant shall use this design in conjunction with the design criteria below.
- A minimum of 1 foot of separation is required from the bottom of the drywell to the seasonal high groundwater table.
- Drywells shall be 48 inches in diameter minimum and contain the washed rock volume specified below. The following minimum washed rock volumes per 1,000 square feet of roof areas based on soil type may be used for sizing the downspout dry well. For soil types other than those presented in Table 4 - 10: Downspout Infiltration Drywell Sizing Table, additional soils information and engineering analysis are required.

Table 4 - 10: Downspout Infiltration Drywell Sizing Table

USDA Soil Type	Volume of Washed Rock (cubic feet)	Dry Well Rock Layer Height
"Coarse Sand" - more than 50% of the sand fraction remains on #4 sieve	60	4’9”
"Medium Sand" - more than 50% of the sand fraction remains on the #40 sieve.	90	7’2”

- Washed rock shall be 1½ - 3” Washed Drain Rock with no fines.
- Distribution pipe shall be a minimum 4" PVC pipe at 0.5% slope. The pipe shall end at the center of the drywell.
- Mark the center of the drywell with a minimum 1" diameter PVC or other means flush with the surface.
- Place a minimum 12" lawn or landscaped layer over the rock layer. The rock layer shall not extend to the surface.
    - All disturbed areas must be fully stabilized by planting and amended per BMP L613: Post-Construction Soil Quality and Depth.
- Non-woven geotextile fabric shall be placed on the sides of the drywell and over the drain rock prior to backfilling. Geotextile fabric shall not be placed on the bottom of the trench to

avoid clogging. The non-woven geotextile shall conform to A2000: Geotextile Specifications, Geotextile for Underground Drainage - Low Survivability, Class C.

- Spacing between dry wells shall be a minimum of 10 feet, measured edge to edge.
- Install a catch basin or yard drain upstream from the drywell.
  - Catch basin or yard drain shall have a minimum 6" sump depth below the tee.
  - The tee shall have a ½" mesh screen on top and bottom to capture large debris.
  - Catch basin or yard drain shall be traffic-bearing in areas subject to traffic.

8.1.7 Flow Credit for Roof Downspout Full Infiltration

If roof runoff is infiltrated according to the requirements of this section, the area contributing to the infiltration facility is not entered into an Ecology approved continuous simulation model. The area is still considered when determining project thresholds.

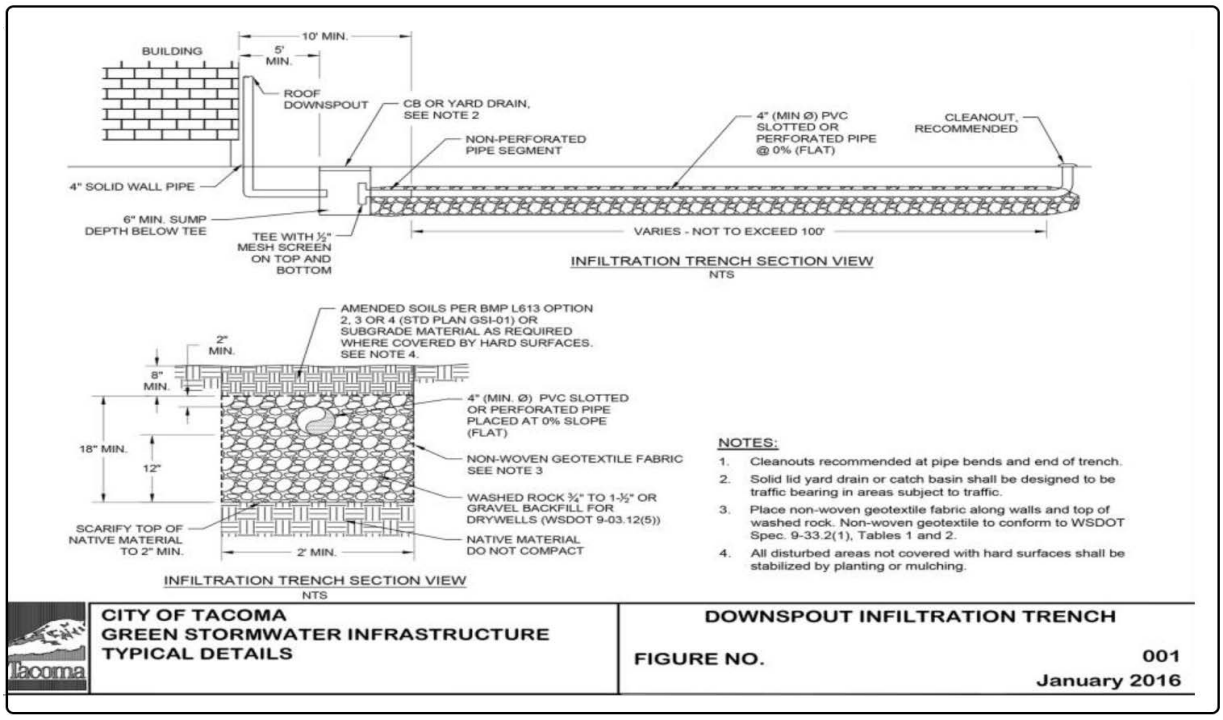


Figure 4 - 2: Typical Downspout Infiltration Trench

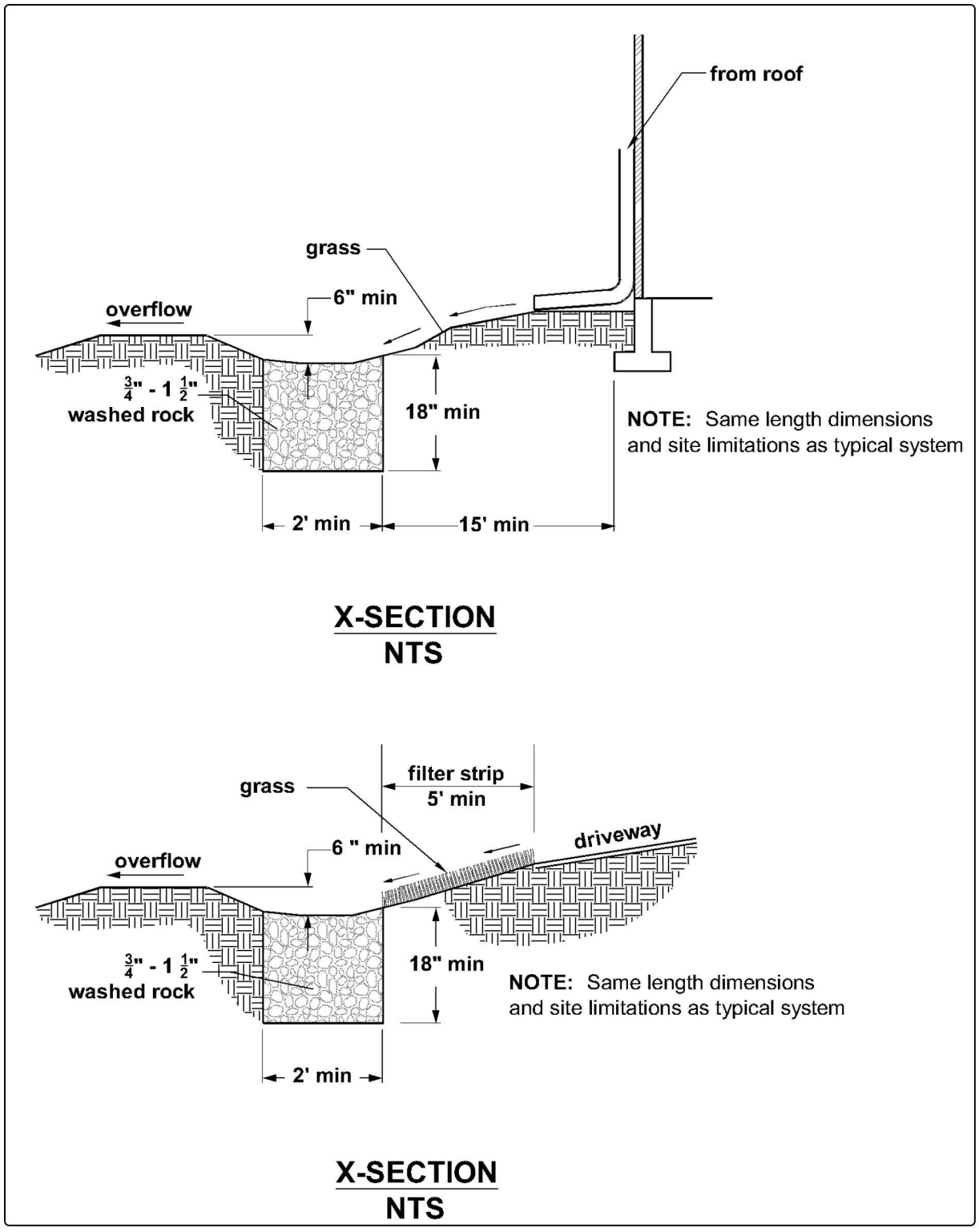


Figure 4 - 3: Alternative Infiltration Trench System for Coarse Sand and Gravel

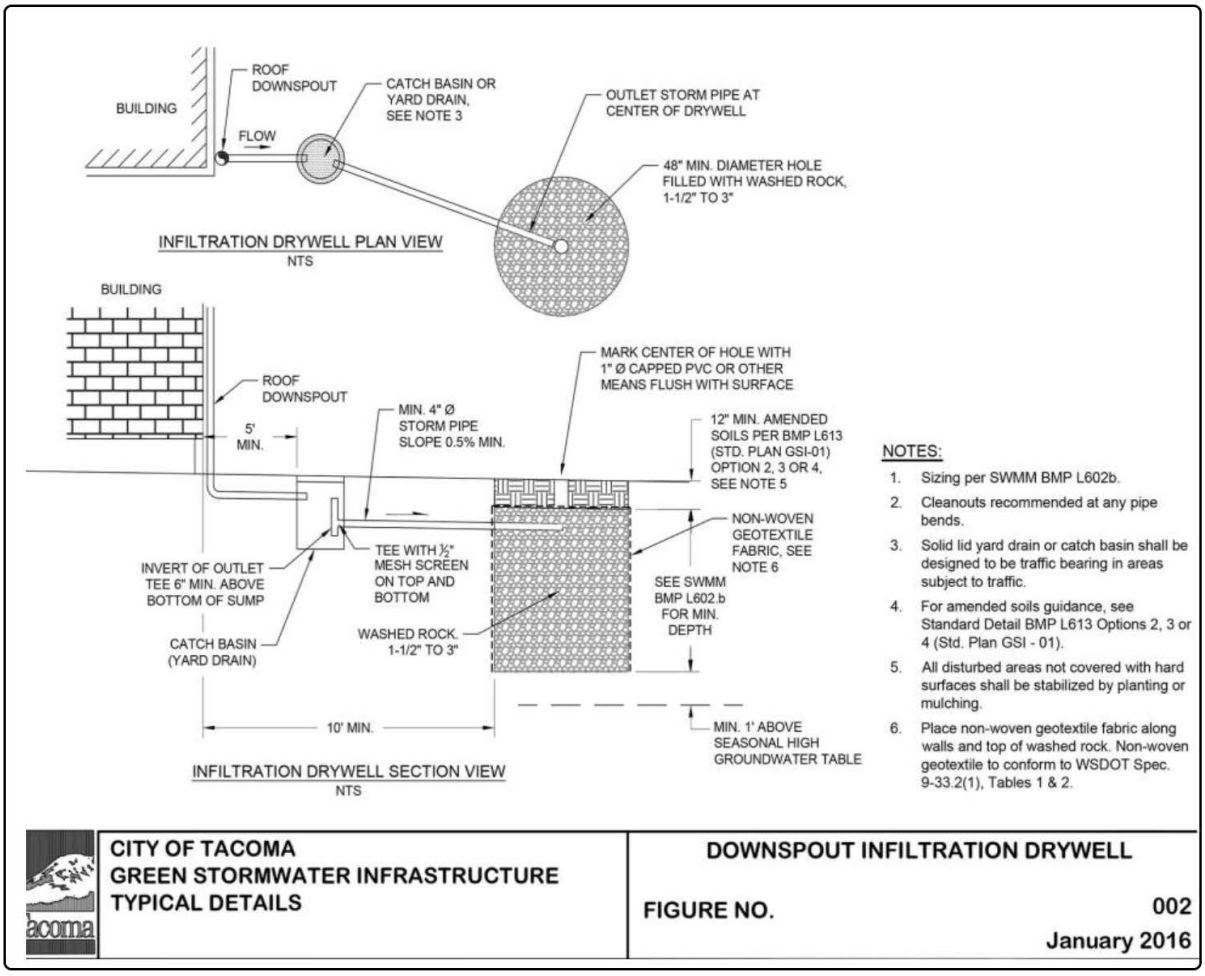


Figure 4 - 4: Typical Downspout Infiltration Drywell

8.2 BMP L603: Downspout Dispersion

8.2.1 Purpose

Downspout dispersion systems are splash blocks or dispersion facilities that spread roof runoff over vegetated pervious areas. Dispersion attenuates peak flows by slowing stormwater.

8.2.2 Application

- This BMP can be utilized to ensure compliance with Minimum Requirement #5: Onsite Stormwater Management.
    - The BMP can be used solely to mitigate for roof surfaces if utilizing the List Approach or may be used in combination with other BMPs to satisfy the LID Performance Standard.
- This BMP may also be used to help ensure compliance with Minimum Requirement #7: Flow Control and Minimum Requirement #8: Wetlands Protection.
- Where compliance with Minimum Requirements is not required, where feasible, this BMP is recommended to be used to help protect receiving waterbodies from the effects of stormwater.

8.2.3 Infeasibility Criteria for Roof Downspout Dispersion

The following infeasibility criteria describe conditions that make downspout dispersion infeasible when applying The List Approach for compliance with Minimum Requirement #5: Onsite Stormwater Management.

The infeasibility criteria shall also be used to determine the appropriateness of installing downspout dispersion. Project proponents may be allowed to install downspout dispersion even if considered infeasible provided documentation is included that substantiates the design. Documentation may be required by a Washington State Licensed Professional Engineer or other appropriate professional depending on the project conditions.

A site characterization study must be completed in order to determine if the infeasibility criteria apply and to determine the appropriateness of installing downspout dispersion systems.

- The design standards per BMP L603a: Downspout Dispersion Trenches Specific Infeasibility Criteria or BMP L603b: Splashblocks Specific Infeasibility Criteria cannot be met.
- The setback criteria below cannot be met. Setback criteria are generally required by the Tacoma Municipal Code, Uniform Building Code requirements, the Tacoma Pierce County Health Department, or other state regulations. Where a conflict between setbacks occurs, the City shall require compliance with the most stringent of the setback requirements from various codes/regulations. Setbacks are typically measured from the overflow elevation.The following are the minimum setbacks required per this manual.
    - At least 10 feet from any building and at least 5 feet from any property line or structure. If necessary, setbacks shall be increased from the minimum 5 feet in order to maintain a 1:1 side slope for future excavation and maintenance.
    - A minimum of 50 feet from the top of any slope greater than 15% and from geologically hazardous areas. The dispersion system may be sited within 50 feet of a slope greater than 15% and/or geologically hazardous area if a geotechnical analysis performed by a Washington State Licensed Professional Engineer or Washington

State Licensed Professional Geologist determines that there will be no negative impacts to the slopes and/or geologically hazardous areas caused by the dispersion system.

- Figure 4 - 5: Setbacks for Splashblocks and Trench Dispersion (also Green Stormwater Infrastructure Figure 005) provides a detail showing setback requirements for dispersion BMPs.

- If there are any conflicts with any of the following competing needs criteria:
  - Requirements of the following federal or state laws, rules, and standards:
    - Historic Preservation Laws and Archaeology Laws as listed at: https://dahp.wa.gov/project-review/preservation-laws
    - Federal Superfund or Washington State Model Toxics Control Act
    - Federal Aviation Administration requirements for airports
    - American with Disabilities Act
  - When found to be in conflict with special zoning district design criteria adopted and being implemented pursuant to a community planning process.
  - Public health and safety standards
  - Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.
  - City of Tacoma Critical Area Ordinances that provides protection of tree species or other critical areas.
- Where the placement of the dispersion facility would require removal of an established mature tree(s).
- The use of a splash block or dispersion trench would cause erosion or flooding problems onsite or on adjacent properties. Citation of this infeasibility criterion requires evaluation of site specific conditions and a stamped and signed memo or report from a Washington State Licensed Professional Engineer.

BMP L603a: Downspout Dispersion Trenches Specific Infeasibility Criteria

- The vegetated flowpath is less than 25 feet between the trench outlet and any property line, structure, stream, wetland, other infiltration or dispersion system, or impervious surface.
- The vegetated flowpath is less than 50 feet between the trench outlet and any slope 15% or greater.

Sensitive area buffers may count towards flowpath lengths if approved by the City of Tacoma.

BMP L603b: Splashblocks Specific Infeasibility Criteria

- The vegetated flowpath is less than 50 feet between the discharge location and any property line, structure, slopes over 15%, stream, wetland, lake, other infiltration or dispersion system, or impervious surface.

  Sensitive area buffers may count towards flowpath lengths if approved by the City of Tacoma.

8.2.4 General Design Criteria for Downspout Dispersion

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

- Downspout dispersion trenches designed as shown in Figure 4 - 6: Downspout Dispersion Trench or Figure 4-7: Dispersion Trench with Notched Grade BoardFigure 4 - 7: Dispersion Trench with Notched Grade Board(also called Green Stormwater Infrastructure Figure 003 and Figure 004 shall be used for all downspout dispersion applications except where splash blocks are allowed.
- The vegetated flowpath must consist of well-established lawn or pasture, landscaping with well-established vegetative groundcover, native vegetation with natural groundcover, or an area that has been amended to meet BMP L613: Post-Construction Soil Quality and Depth and Depth. Groundcover must be dense enough to disperse stormwater and prevent erosion. Vegetation shall be established before the system is put online to avoid erosion.
- Install a catch basin or yard drain where the roof downspout system pipe connects to the dispersion trench.
    - Catch basin or yard drain shall have a minimum 6" sump depth below the tee.
- Setbacks from Onsite Sewage Systems shall conform to WAC 246-272A-0210.
- For sites with multiple dispersion systems, the outer edge of the vegetated flowpath segment for the dispersion trench must not overlap with other flowpath segments, except those associated with sheet flow from a native or non-native pervious surface.
- Dispersion system shall be setback a minimum of 50 feet from the top of any slope greater than 15% and from geologically hazardous areas. The dispersion system may be sited within 50 feet of a slope greater than 15% and/or geologically hazardous area if a geotechnical analysis performed by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist determines that there will be no negative impacts to the slopes and/or geologically hazardous areas caused by the dispersion system.

8.2.5 BMP L603a: Design Criteria for Downspout Dispersion Trenches

- Design downspout dispersion trenches as shown in Figure 4 - 6: Downspout Dispersion Trench or Figure 4-7: Dispersion Trench with Notched Grade BoardFigure 4 - 7: Dispersion Trench with Notched Grade Board(also called Green Stormwater Infrastructure Figure 003 and Figure 004 available at tacoma.gov/government/departments/public-works/engineering/right-of-way-design-manual/).
- A vegetated flowpath of at least 25 feet in length must be maintained between the outlet of the trench and any property line, structure, stream, wetland, or impervious surface. A vegetated flowpath of at least 50 feet in length must be maintained between the outlet of the trench and any slope, 15% or greater. Sensitive area buffers may count towards flowpath lengths if approved by the City of Tacoma.
- Trenches serving up to 700 square feet of roof area may be simple 10-foot-long by 2-foot wide washed rock filled trenches as shown in Figure 4 - 6: Downspout Dispersion Trench. For roof areas larger than 700 square feet, a dispersion trench with notched grade board

may be used as approved by the City. The total length of this design must not exceed 50 feet and must provide at least 10 feet of trench per 700 square feet of roof area.

- Trenches shall not be placed closer than 10 feet from edge of trench to edge of trench or be placed closer than 100 feet along the flowpath.
- Distribution pipe shall be minimum 4" PVC slotted or perforated pipe placed at 0% slope.
- Rock layer material shall be ¾" to 1½" washed rock or rock meeting WSDOT Standard Specification 9-03.12(5) Gravel Backfill for Drywells. Wrap rock layer in a non-woven geotextile fabric. The non-woven geotextile shall conform to A2000: Geotextile Specifications, Geotextile for Underground Drainage - Low Survivability, Class C.
- Cleanout are recommended at all bends in pipe and at the trench terminus for inspection and maintenance practices.
- Catch basin or yard drain shall have a minimum 6" sump depth below tee invert elevation.

8.2.6 BMP L603b: Design Criteria for Splashblocks

Design splashblocks as shown in Figure 4 - 8: Downspout Splashblock Dispersion (also known as Green Stormwater Infrastructure Figure 006 - available at tacoma.gov/government/departments/public-works/engineering/right-of-way-design-manual/). In general, if the ground is sloped away from the foundation and there is adequate vegetation and area for effective dispersion, splashblocks will adequately disperse runoff. If the ground is fairly level, if the structure includes a basement, or if footing drains are proposed, splashblocks with downspout extensions may be a better choice because the discharge location is moved away from the footing. Downspout extensions can include piping to a splashblock/discharge location a considerable distance from the downspout, as long as the runoff can travel through a well-vegetated area as described below.

- A vegetated flowpath of at least 50 feet shall be maintained between the discharge location and any property line, structure, slopes over 15%, stream, wetland, lake, or other impervious surface. Sensitive area buffers may count toward flowpath lengths.
- Flows shall not be directed onto sidewalks.
- A maximum of 700 square feet of roof area may discharge to each splashblock.
- A splashblock or a pad of cobbles or ballast (2 feet wide by 3 feet long by 6 inches deep) shall be placed at each downspout discharge location. Cobbles shall conform to WSDOT Standard Specification 9-03.11(2) - Streambed Cobbles. Ballast shall conform to WSDOT Standard Specification 9-03.9(1) - Ballast.

8.2.7 Downspout Dispersion Modeling

Use one of the following options to model the system:

- When downspout dispersion trenches or splashblocks are used per the design criteria, and the vegetated flowpath length is 50 feet or more:
  - Model the connected roof area as a lateral flow impervious area.
  - Where multiple dispersion areas will be used, it is permissible to model the roof areas as landscaped areas so the project schematic in the continuous simulation model is manageable.
- When downspout dispersion trenches or are used per the design criteria, and the vegetated flowpath is 25-50 feet:

- Model the connected roof area as a lateral flow impervious area.
- Where multiple dispersion areas will be used, it is permissible to model the roof area as 50% landscaped and 50% impervious area so the project schematic in the continuous simulation model is manageable.

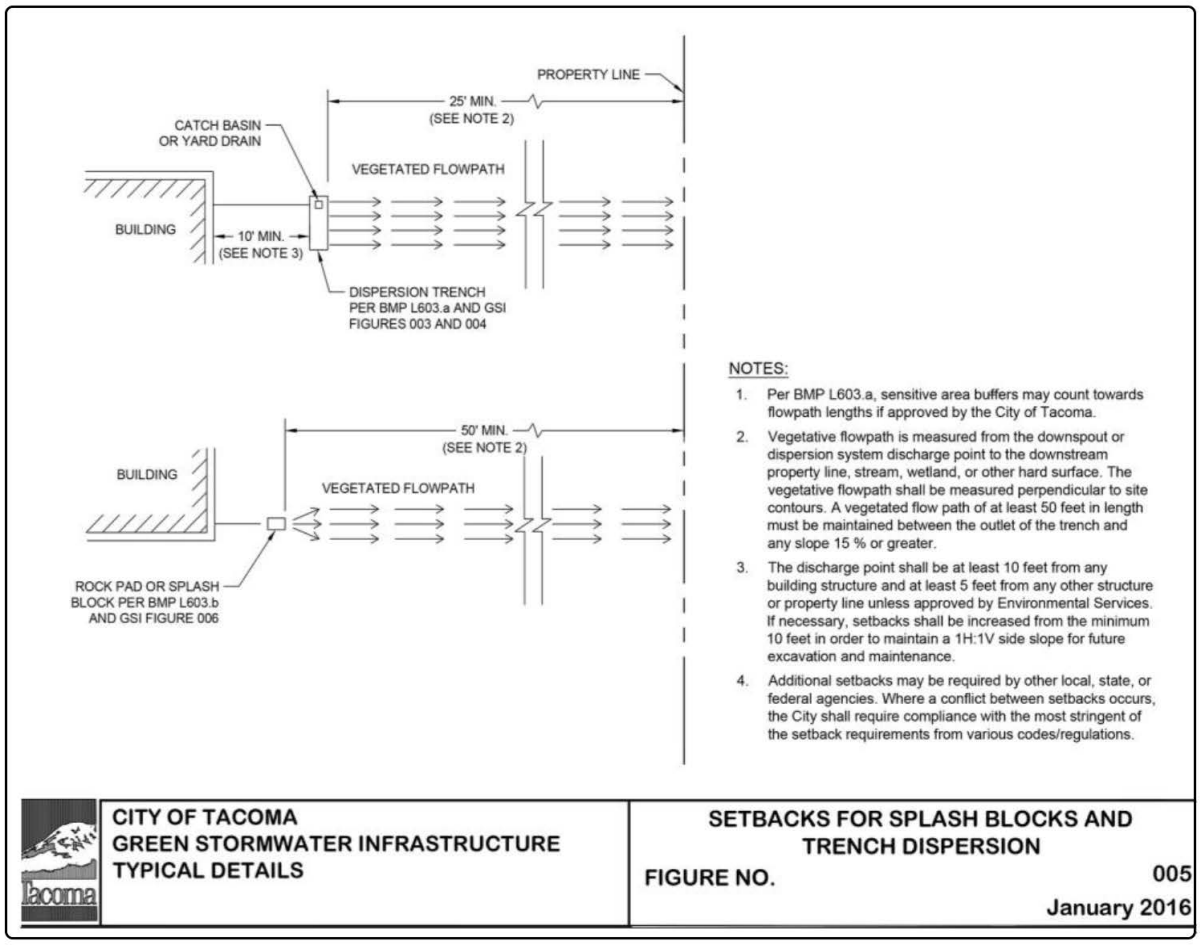


Figure 4 - 5: Setbacks for Splashblocks and Trench Dispersion

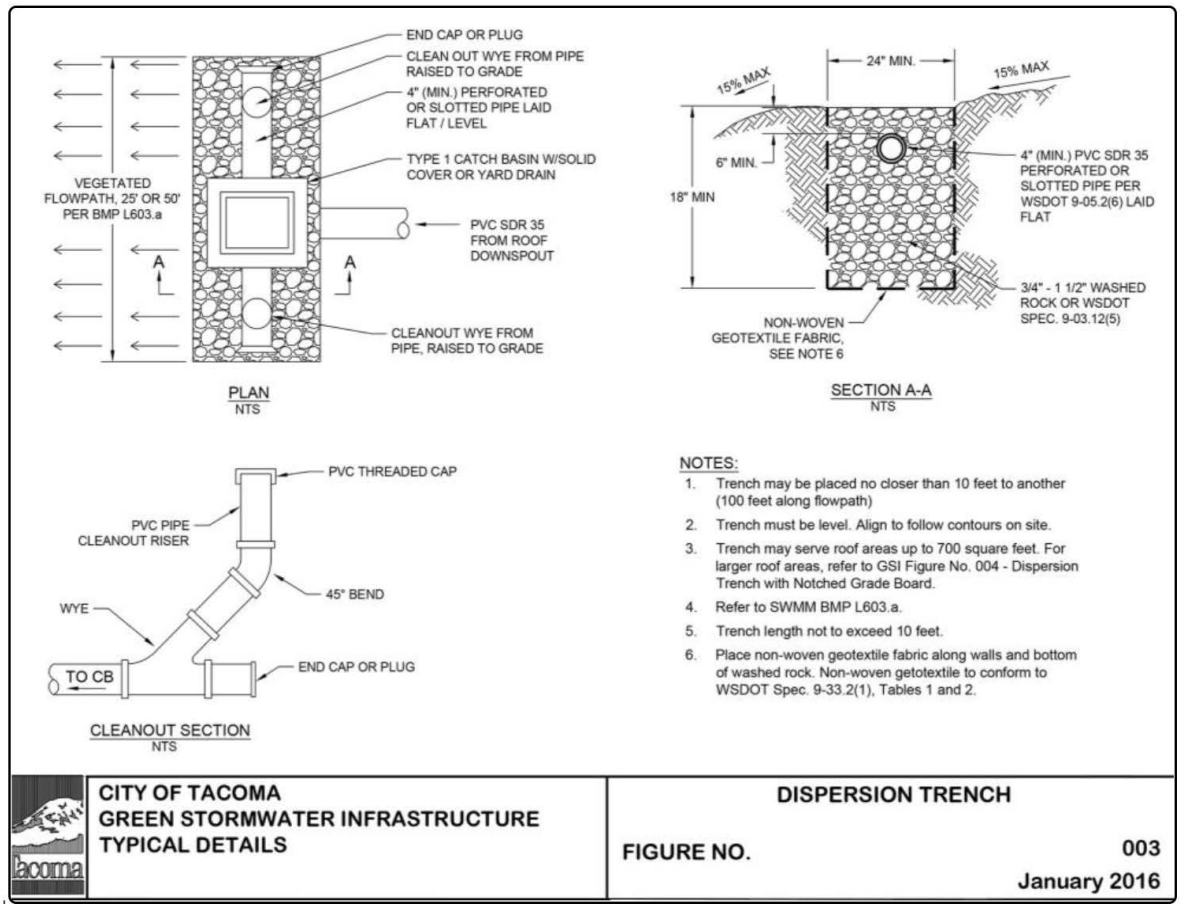


Figure 4 - 6: Downspout Dispersion Trench

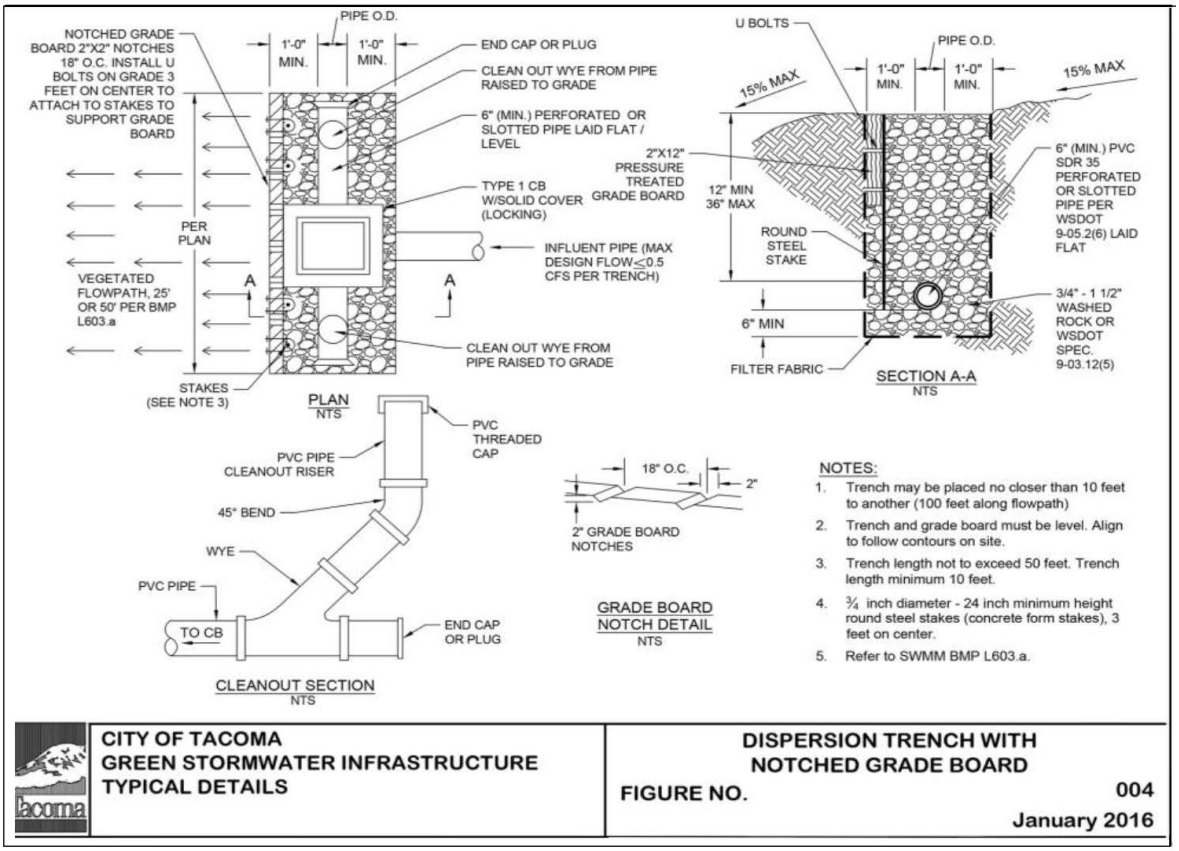


Figure 4 - 7: Dispersion Trench with Notched Grade Board

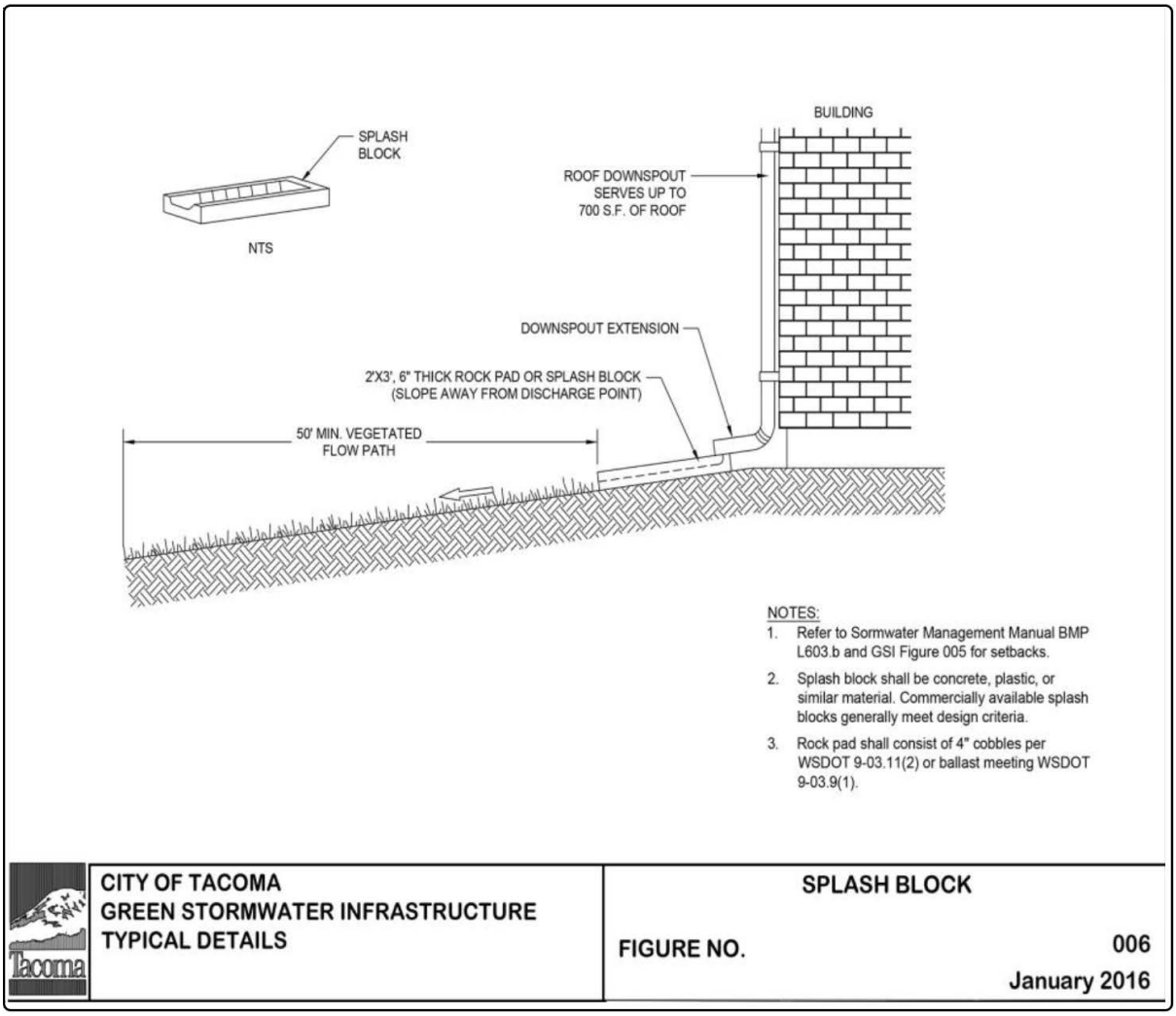


Figure 4 - 8: Downspout Splashblock Dispersion

8.3 BMP L604: Perforated Stub-Out Connections

8.3.1 Purpose

A perforated stub-out connection is a length of perforated pipe within a washed rock-filled trench that is placed between roof downspouts and a stub-out to the City stormwater system. These systems are intended to provide some infiltration during drier months. During the wet winter months, they may provide little or no flow control.

8.3.2 Application

- This BMP can be utilized to ensure compliance with Minimum Requirement #5: Onsite Stormwater Management.
- Where compliance with Minimum Requirements is not required, where feasible, this BMP is recommended to be used to help protect receiving waterbodies from the effects of stormwater.

8.3.3 Infeasibility Criteria for Perforated Stub-Out Connections

The following infeasibility criteria describe conditions that make perforated stub-out connections infeasible when applying The List Approach for compliance with Minimum Requirement #5: Onsite Stormwater Management.

The infeasibility criteria shall also be used to determine the appropriateness of installing perforated stub-outs. Project proponents may be allowed to install perforated stub-outs even if considered infeasible, unless otherwise stated within the specific infeasibility criteria, provided documentation is included that substantiates the design. Documentation may be required by a Washington State Licensed Professional Engineer or other appropriate professional depending on the project conditions.

A site characterization study is required to determine infeasibility and to determine the appropriateness of installing Perforated Stub-Outs.

- The setback criteria and design standards cannot be met.
- The depth from the bottom of the trench to the seasonal high groundwater table or other impermeable layer is less than one foot. Citation of this infeasibility criterion requires evaluation of site specific conditions and a soils report.
- If there are any conflicts with any of the following competing needs criteria:
  - Requirements of the following federal or state laws, rules, and standards:
    - Historic Preservation Laws and Archaeology Laws as listed at: https://dahp.wa.gov/project-review/preservation-laws
    - Federal Superfund or Washington State Model Toxics Control Act
    - Federal Aviation Administration requirements for airports
    - American with Disabilities Act
  - When found to be in conflict with special zoning district design criteria adopted and being implemented pursuant to a community planning process.
  - Public health and safety standards

  - Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.
  - City of Tacoma Critical Area Ordinances that provides protection of tree species or other critical areas.
- Where the placement of the infiltration facility would require removal of an established mature tree(s).
- The following are minimum setbacks. Setbacks are typically measured from the overflow elevation.
  - At least 10 feet from any building structure and at least 5 feet from any other structure or property line unless approved by the City of Tacoma.
  - Perforated pipe systems shall be setback a minimum of 50 feet from the top of any slope greater than 20% and from geologically hazardous areas. The perforated pipe system may be sited within 50 feet of a slope greater than 20% and/or geologically hazardous area if a geotechnical analysis performed by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist determines that there will be no negative impacts to the slopes and/or geologically hazardous areas caused by the perforated pipe system.
  - Setbacks from Onsite Sewage Systems shall conform to WAC 246-272A-0210.
  - Additional setbacks may be required by other local, state, or federal agencies.

8.3.4 Subsurface Characterization

- A soils report is required if citing that perforated stub-outs are not feasible due to subsurface characteristics. See Appendix B: Soils Reports for Soils Report requirements.

8.3.5 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

- A minimum of one foot of separation is required from the bottom of the trench section to the seasonal high groundwater table.
- Perforated stub-out connections consist of at least 10 feet of perforated pipe per 5,000 square feet of roof area laid in a level, 2-foot wide trench backfilled with washed drain rock. Extend the drain rock to a depth of at least 8 inches below the bottom of the pipe and cover the pipe. Lay the pipe level and cover the rock trench with filter fabric and 6 inches of amended soil. (see Figure 4 - 9: Perforated Stub-Out Connections).
- Select the location of the connection to allow a maximum amount of runoff to infiltrate into the ground (ideally a dry, relatively well drained, location).
- To facilitate maintenance, do not locate the perforated pipe portion of the system under impervious or heavily compacted (e.g., driveways and parking areas) surfaces.
- Perforated stub-outs may be placed in fill material if the fill is placed and compacted under the direct supervision of a Washington State Licensed Professional Engineer, and if the measured infiltration rate of the fill material is at least 8 inches per hour. Infiltration

rate must be determined using methods in Appendix A: Determining the Design Infiltration Rate.

- Non-woven geotextile fabric shall be placed over the trench aggregate prior to backfilling. The non-woven geotextile shall conform to A2000: Geotextile Specifications, Geotextile for Underground Drainage - Low Survivability, Class C.
- Distribution pipe shall be minimum 4” PVC slotted or perforated pipe placed at 0% slope.
- Rock layer shall be ¾” to 1½” washed rock or rock meeting WSDOT Standard Specification 9-03.12(5) - Gravel Backfill for Drywells. A minimum 12” layer of rock shall be placed under the perforated or slotted pipe.

8.3.6 Perforated Stub-Out Modeling

Flow credits are not applicable to perforated stub-out connections. Any flow reduction is variable and unpredictable. No computer modeling techniques are allowed that would predict any reduction in flow rates and volumes from the connected area.

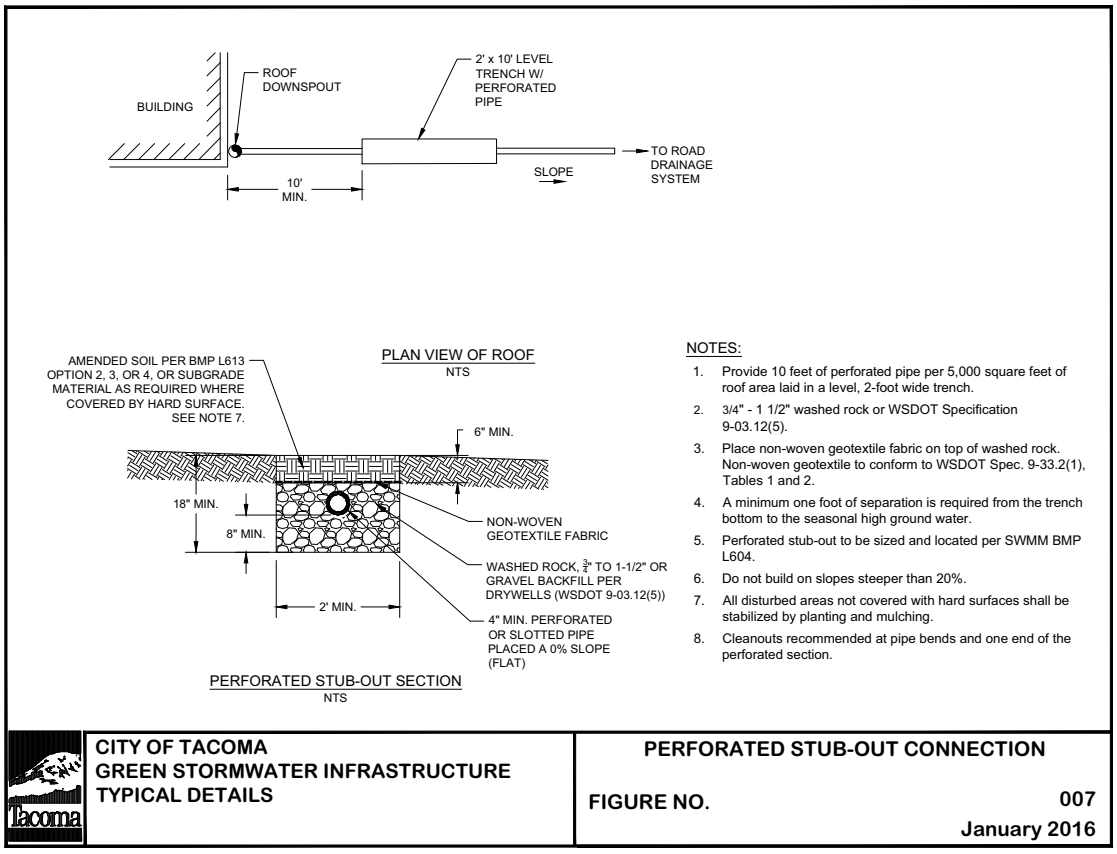


Figure 4 - 9: Perforated Stub-Out Connections

Chapter 9 Dispersion BMPs

9.1 BMP L614: Full Dispersion

9.1.1 Purpose

This BMP allows for "fully dispersing" runoff from impervious surfaces and cleared areas of project sites into areas preserved as forest, native vegetation, or cleared area.

9.1.2 Applications

- This BMP can be used to ensure compliance with Minimum Requirement #5: Onsite Stormwater Management, Minimum Requirement #6: Stormwater Treatment and/or Minimum Requirement #7: Flow Control. Sites that can fully disperse are not required to provide additional stormwater treatment or flow control.
- The area of the project site that is using full dispersion must be sited to allow stormwater from the impervious (or cleared) surface to fully disperse into the preserved dispersion area.
    - The dispersion area may be a previously cleared area that has been replanted in accordance with native vegetation landscape specifications described within this BMP.
    - Situate the dispersion area to minimize the clearing of existing forest cover, to maximize the preservation of wetlands, and to buffer stream corridors.
    - A covenant and easement agreement or separate recorded tract of land will be required to protect the dispersion area.
    - Show the dispersion area on all maps and plans and clearly mark the area during clearing and construction.
    - Retain all trees within the dispersion area (except as allowed in the bullet below for passive recreation), aside from approved timber harvest activities regulated under WAC Title 222, except for Class IV General Forest Practices that are conversions from timberland to other uses, and the removal of dangerous or diseased trees.
    - The dispersion area may be used for passive recreation with related recreational facilities, including pedestrian and bicycle trails, nature viewing area, fishing and camping areas, and other similar activities that do not require permanent structures, provided that cleared areas and areas of compacted soil associated with these areas and facilities do not exceed eight percent of the preserved area.
    - The dispersion area may contain utilities and utility easements, but not on-site sewage disposal systems such as septic tanks or septic fields.
    - The dispersion of stormwater must not create flooding or erosion impacts.

9.1.3 Infeasibility Criteria

The BMP is infeasible if any of the following criteria are met:

- If the design criteria cannot be met.
- If the setback criteria cannot be met. Setback criteria are generally required by Tacoma Municipal Code, Uniform Building Code, the Tacoma Pierce County Health Department,

or other state regulations. Where a conflict between setback requirements occurs, the City shall require compliance with the most stringent of the setback requirements from the various codes and regulations. The following are the minimum setbacks required by this manual.

- The flow spreader and dispersion area shall be at least 10 feet from any building structure and at least 5 feet from any other structure or property line. If necessary, setbacks shall be increased from the minimum 10 feet in order to maintain a 1H:1V side slope for future excavation and maintenance.
- The dispersion area shall not be located in critical areas, critical area buffers, streams, or lakes.
- The dispersion area shall be setback a minimum of 50 feet from the top of any slope greater than 15% and from geologically hazardous areas. The dispersion area may be sited within 50 feet of a slope greater than 15% and/or geologically hazardous area if a geotechnical analysis performed by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist determines that there will be no negative impacts to the slopes and/or geologically hazardous area caused by the location of the dispersion area.
- Setbacks from Onstie Sewage Systems shall conform to WAC 246-272A-0210.

- If there are any conflicts with any of the following competing needs criteria:
  - Requirements of the following federal or state laws, rules, and standards:
    - Historic Preservation Laws and Archaeology Laws as listed at: https://dahp.wa.gov/project-review/preservation-laws
    - Federal Superfund or Washington State Model Toxics Control Act
    - Federal Aviation Administration requirements for airports
    - American with Disabilities Act
  - When found to be in conflict with special zoning district design criteria adopted and being implemented pursuant to a community planning process.
  - Public health and safety standards
  - Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.
  - City of Tacoma Critical Area Ordinances that provides protection of tree species or other critical areas.
- If dispersion of stormwater is likely to create flooding or erosion problems. A report from a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist with appropriate expertise must be included if citing flooding or erosion concerns as the infeasibility criteria.

9.1.4 Elements of a Full Dispersion System

The area of the project site that applies full dispersion consists of the following elements:

- An impervious (or cleared area). This is the area that requires mitigation.

- A flow spreader. Stormwater from the impervious (or cleared) area may need to be routed through a flow spreader depending on the layout and type of impervious surface, as further described below.
- A dispersion area. This area defines the limits of the Full Dispersion BMP. The impervious or cleared area must disperse into the preserved dispersion area.
    - The dispersion area must be forest, native vegetation, or a cleared area.
    - The dispersion area is not allowed in critical area buffers unless approved through a Critical Area Code.
    - Wetlands, streams, lakes and their buffers, if situated within a dispersion area, do not count toward the required area.
    - The dispersion area shall be setback a minimum of 50 feet from the top of any slope greater than 15% and from geologically hazardous areas. The dispersion area may be sited within 50 feet of a slope greater than 15% and/or geologically hazardous area if a geotechnical analysis performed by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist determines that there will be no negative impacts to the slopes caused by the location of the dispersion area.
- A flowpath through the dispersion area. The length of the flowpath from the impervious (or cleared) area through the dispersion area varies based on the project layout and type of impervious surface. Regardless of the layout and type of impervious surface, the flowpath must meet the following criteria:
    - The slope of the flowpath must be less than 15% for any 20' reach of the flowpath. Slopes up to 20% are allowed where flow spreaders are located upstream of the dispersion area and at sites where vegetation can be established.
    - The flowpaths from adjacent flow spreaders must be sufficiently spaced to prevent overlap of flows in the flowpath areas.
- Set dispersion areas back ≥ 100 feet from drinking water wells and springs used for public drinking water supplies. Ensure dispersion areas upgradient of drinking water supplies and within the 1-, 5-, and 10-year time of travel zones comply with the Washington State Department of Health (DOH) requirements (DOH, 2010).

9.1.5 Design Criteria for Residential Projects

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

9.1.5.1 Full Dispersion for Impervious Surfaces in Residential Projects

- Impervious surfaces within residential projects may be "fully dispersed" if they are within a TDA that is less than 10% impervious. If the TDA has more than 10% impervious area, the design may still fully disperse up to 10% of the TDA's area. The impervious area beyond the 10% cannot drain to the dispersion area and those areas are subject to Minimum Requirement #6: Stormwater Treatment and Minimum Requirement #7: Flow Control (if thresholds are met) and the areas must be considered when determining if those requirements apply to a project.

- The lawn and landscaped areas adjacent to the impervious area being mitigated (for example a lawn associated with a single family home) may be dispersed into the dispersion area. Those lawn and landscaped areas must comply with BMP L613: Post-Construction Soil Quality and Depth.
- The dispersion area must be preserved as forest or native vegetation.
- The dispersion area shall have a minimum area 6.5 times the area of the impervious surface draining to it.
- The flowpath from the impervious surface through the area preserved as forest or native vegetation must be at least 100 feet in length.
    - The slope of the flowpath must be less than 15% for any 20' reach of the flowpath. Slopes up to 20% are allowed where flow spreaders are located upstream of the dispersion area and at sites where vegetation can be established.
    - The flowpaths from adjacent flow spreaders must be sufficiently spaced to prevent overlap of flows in the flowpath areas.

The following additional guidance must be followed dependent on the type of impervious surface in the residential project.

- ***Full dispersion from roof surfaces*:** Stormwater from roof surfaces must either:
    - Provide dispersion BMPs per BMP L603: Downspout Dispersion prior to stormwater entering the dispersion area.

      OR

    - Combine the roof runoff with the road runoff and follow the guidance for full dispersion from roadway surfaces below.
- ***Full dispersion from driveway surfaces*:** Stormwater from driveway surfaces must either:
    - Provide dispersion BMPs per BMP L611: Concentrated Flow Dispersion and BMP L612: Sheet Flow Dispersion prior to stormwater entering the dispersion area.

      OR

    - Combine the driveway runoff with the road runoff and follow the guidance for full dispersion from roadway surfaces below.
- ***Full dispersion from roadway surfaces*:** Stormwater from roadway surfaces shall comply with all the following requirements:
    - Design the road section to minimize collection and concentration of roadway runoff. Use sheet flow over roadway fill slopes (i.e., where roadway subgrade is above adjacent right-of-way) wherever possible to avoid concentration.
    - When it is necessary to collect and concentrate runoff from the roadway and adjacent upstream areas (e.g., in a ditch on a cut slope), concentrated flows shall be incrementally discharged from the ditch via cross culverts or at the ends of cut sections. These incremental discharges of newly concentrated flows shall not exceed 0.5 cfs at any one discharge location from a ditch for the 100-year return period flowrate. Where flows at a particular ditch discharge location were already concentrated under existing site conditions (e.g., in a natural channel that crosses the

roadway alignment), the 0.5 cfs limit would be in addition to the existing concentrated peak flows.

- Ditch discharge locations with up to 0.2 cfs discharge for the 100-year return period flowrate shall use rock pads or dispersion trenches to disperse flows. Ditch discharge locations with between 0.2 and 0.5 cfs discharge for the 100-year return period flowrate shall use only dispersion trenches to disperse flows. See A400: End of Pipe Discharge Protection for design criteria.
  - Dispersion trenches shall:
    - Be designed to accept surface flows (free discharge) from a pipe, culvert, or ditch end.
    - Be aligned perpendicular to the flowpath.
    - Have a minimum 2 foot by 2 foot cross section.
    - Be 50 feet in length.
    - Be filled with ¾" to 1.5" washed rock.
    - Have a level notched grade board.
    - Have a minimum spacing of 50 feet between centerlines of other dispersion trenches.

    Manifolds may be used to split flows up to 2 cfs for the 100-year peak flow between a maximum of 4 trenches.

9.1.5.2 Full Dispersion for Cleared Areas in Residential Projects

Stormwater from cleared areas of residential projects that are comprised of bare soil, non-native landscaping, lawn, and/or pasture is fully dispersed if it meets all of the following criteria:

- Cleared areas must comply with BMP L613: Post-Construction Soil Quality and Depth.
- The dispersion area must be preserved as forest or native vegetation.
- The flowpath through the cleared area (and leading to the dispersion area) must be 25 feet or less.
- The minimum flowpath from the cleared area through the dispersion areas must be 25 feet.
  - If the cleared area is greater than 25 feet:
    - Add an additional foot of flowpath length for every three feet of width area (up to a maximum width of 250 feet).
  - The slope of the flowpath must be less than 15% for any 20' reach of the flowpath. Slopes up to 20% are allowed where flow spreaders are located upstream of the dispersion area and at sites where vegetation can be established.
  - The flowpaths from adjacent flow spreaders must be sufficiently spaced to prevent overlap of flows in the flowpath areas.
- The topography of the cleared area must be such that stormwater will not concentrate prior to discharge to the dispersion area.
- The width of the dispersion area must equal the width of the cleared area. The maximum width of the cleared area is 250 feet.

9.1.6 Design Criteria for Road-Related Projects

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

9.1.6.1 Full Dispersion by Sheet Flow from Uncollected, Unconcentrated Stormwater into the Dispersion Area

The stormwater shall be considered fully dispersed if it meets all of the following criteria.

- The minimum flowpath lengths shall be based upon the native soil type of the dispersion area as follows:
  - Outwash Soils (Type A- Sand and Sandy Gravels and Some Type B – Loamy Sands)
    - Must have an initial saturated hydraulic conductivity rate of 4 inches per hour or greater. The saturated hydraulic conductivity must be based on an in-situ infiltration method as identified in Appendix A: Determining the Design Infiltration Rate.
    - Provide a 10 foot vegetated flowpath for up to 20 feet of impervious surface flowpath. Provide an additional 0.25 foot of vegetated flowpath for every additional 1 foot of impervious flowpath.
  - Other Soils (Type C and D and Type B not meeting the criteria above)
    - Provide a 6.5 foot vegetated flowpath for every 1 foot of flowpath length across the impervious surface.
    - The minimum flowpath length through the dispersion area shall be 100 feet.
- The dispersion area must be legally preserved as forest or native vegetation.
- The slope of the flowpath must be less than 15% for any 20' reach of the flowpath. Slopes up to 20% are allowed where flow spreaders are located upstream of the dispersion area and at sites where vegetation can be established.
- The flowpaths from adjacent flow spreaders must be sufficiently spaced to prevent overlap of flows in the flowpath areas.
- The minimum depth to the seasonal high groundwater elevation shall be 3 feet.
- The flowpath through any impervious surface leading to the dispersion area shall be less than 75 feet.
- The flowpath through any pervious area leading to the dispersion area shall be less than 150 feet. Pervious surface flowpaths include those upgradient road side slopes that run onto the road and down gradient road side slopes that precede the dispersion area.
- Lateral slope of impervious contributing area shall be less than 8%.
- Road side slopes shall be less than 25%. Road side slopes do not count as part of the dispersion area unless native vegetation is reestablished and slopes are less than 15%.
- Road shoulders that are paved or graveled to withstand occasional vehicle loading are considered impervious surfaces.
- Longitudinal slope of road shall be less than 5%.

- The width of the dispersion area should be equivalent to the width of impervious surface sheet flowing into it.
- Average longitudinal (parallel to road) slope of dispersion area shall be less than 15%.
- Average lateral slope of dispersion area shall be less than 15%.

9.1.6.2 Full Dispersion of Channelized (Collected and Re-dispersed) Stormwater into the Dispersion Area

The stormwater from road-related projects that is collected and re-dispersed is fully dispersed if it meet all of the following criteria.

- The minimum flowpath length shall be based upon the native soil type of the dispersion area as follows:
  - Outwash Soils (Type A- Sand and Sandy Gravels and Some Type B. Loamy Sands)
    - Must have an initial saturated hydraulic conductivity rate of 4 inches per hour or greater. The saturated hydraulic conductivity must be based on an in-situ infiltration method as identified in Appendix A: Determining the Design Infiltration Rate.
    - Provide a dispersion area of at least ½ of the impervious contributing area.
  - Other Soils (Type C and D and Type B not meeting the criteria above)
    - Provide a 6.5 foot vegetated flowpath for every 1 foot of flowpath length across the impervious surface. The minimum flowpath length through the dispersion area shall be 100 feet.
- The minimum depth to the seasonal high groundwater elevation shall be 3 feet.
- Channelized flow shall be redispersed to produce the longest possible flowpath.
- Flows shall be evenly dispersed across the vegetated flowpath.
- Ditch discharge locations with up to 0.2 cfs discharge for the 100-year return period flowrate shall use rock pads or dispersion trenches to disperse flows. Ditch discharge locations with between 0.2 and 0.5 cfs discharge for the 100-year return period flowrate shall use only dispersion trenches to disperse flows. See A400: End of Pipe Discharge Protection for design criteria.
  - Dispersion trenches shall:
    - Be designed to accept surface flows (free discharge) from a pipe, culvert, or ditch end.
    - Be aligned perpendicular to the flowpath.
    - Have a minimum 2 foot by 2 foot cross section.
    - Be 50 feet in length.
    - Be filled with ¾" to 1.5" washed rock.
    - Have a level notched grade board.
    - Have a minimum spacing of 50 feet between centerlines of other dispersion trenches.

Manifolds may be used to split flows up to 2 cfs for the 100-year peak flow between a maximum of 4 trenches.

- The impervious surface area is limited to onsite (associated with roads only) flows.
- The width of the dispersion area shall be equivalent to the length of the road from which stormwater is collected.
- Average longitudinal and lateral slopes of the dispersion areas shall be less than or equal to 8%.
- The slopes of any flowpath segment shall be less than 15% for any 20-foot reach of the flowpath segment.
- The dispersion area must be legally preserved as forest or native vegetation.
- Limit onsite flows.
- The slope of the flowpath must less than 15% for any 20' reach of the flowpath. Slopes up to 20% are allowed where flow spreaders are located upstream of the dispersion area and at sites where vegetation can be established.
- The flowpaths from adjacent flow spreaders must be sufficiently spaced to prevent overlap of flows in the flowpath areas.

9.1.6.3 Full Dispersion by Engineered Dispersion

Stormwater from road-related projects is fully dispersed if it meets all of the following criteria:

The minimum flowpath lengths shall be based upon the native soil type of the dispersion area as follows.

- Outwash Soils (Type A- Sand and Sandy Gravels and Some Type B. Loamy Sands)
  - Must have an initial saturated hydraulic conductivity rate of 4 inches per hour or greater. The saturated hydraulic conductivity must be based on an in-situ infiltration method as identified in Appendix A: Determining the Design Infiltration Rate.
  - Soils must be compost amended in accordance with BMP L613: Post-Construction Soil Quality and Depth.
  - Provide a 10 foot vegetated flowpath for up to 20 feet of impervious surface flowpath. Provide an additional 0.25 foot of vegetated flowpath for every additional 1 foot of impervious flowpath.
- Other Soils (Type C and D and Type B not meeting the criteria above)
  - Soils must be compost amended in accordance with BMP L613: Post-Construction Soil Quality and Depth.
  - The dispersion area must be 6.5 times the area of the surface(s) draining to it.
- The minimum depth to the seasonal high groundwater elevation shall be 3 feet.
- Flows shall be evenly dispersed across the vegetated flowpath.
- Average longitudinal and lateral slopes of the dispersion areas shall be less than or equal to 15%.
- The dispersion area shall be planted with native trees and shrubs where possible.
- A covenant and easement agreement or separate recorded tract of land will be required to protect the dispersion area.

9.1.7 Native Vegetation Landscape Specifications

The following design criteria may be used in areas where previously developed surfaces are being converted to a native vegetation area for purposes of meeting full dispersion requirements.

Conversion of a developed surface to native vegetation landscape requires the removal of impervious surface, decompaction of soils, and the planting of native trees, shrubs, and groundcover in compost-amended soil. The following criteria must be met:

- Existing impervious surface and any underlying base course shall be completely removed from the conversion area(s).
- Underlying soil shall be scarified to a depth of 18 inches.
- A minimum of 4 inches of well-decomposed compost shall be tilled into the scarified soils. The finished surface should be gently undulating and lightly compacted.
- Plant the area of native vegetation with native species trees, shrubs, and groundcover. Select species appropriate for the site's shade and moisture conditions and in accordance with the following requirements:
    - Trees: Plant a minimum of two tree species, one species shall be an evergreen. Space trees at the recommendation of a professional landscaper or according to other City of Tacoma landscape codes as applicable. Where frequent watering is not practical, bare-root stock may be substituted at variable spacing from 10 to 12 feet on center. Bare root stock types shall be 1-1, 2-1, P-1 and P-2. Live stakes at 4 feet on center may be substituted for willow and red-osier dogwood in wet areas.
    - Shrubs: Plant a minimum of two species of shrubs. Space plants to cover landscaped area, except where trees are present. Where frequent watering is not practical, bareroot stock may be substituted at variable spacing from 4 to 6 feet on center. Bare root stock types shall be 1-1, 2-1, P-1 and P-2.
    - Groundcover: Plant a minimum of two species of ground cover. Space plants to cover all remaining bare soils.
    - Increase the number of native species if possible based upon native vegetation area size.
- Place at least 4 inches of mulch between plants for weed control.
- Water plantings as necessary to ensure proper plant growth.
- A minimum of 90% plant survival is required after 3 years.

Conversion of an area under cultivation to native vegetation requires elimination of non-native cultivated plants, grasses, and weeds before planting and continuously during native vegetation establishment. The following criteria must be met:

- Till the soil to a minimum depth of 18 inches.
- The soil shall:
    - Be a minimum of 8 inches having an organic content of 6-12%, OR
    - Place a 4 inch layer of compost on the surface before planting, OR
    - Till 4 inches of clean wood chips into the soil (only upon recommendation of a landscape architect or forester)

- Plant the area of native vegetation with native species trees, shrubs, and ground cover. Select species appropriate for the sites shade and moisture conditions and in accordance with the following requirements:
    - Trees: Plant a minimum of two tree species, one species shall be an evergreen. Space trees at the recommendation of a landscape professional or according to other City of Tacoma landscape codes as applicable. Where frequent watering is not practical, bare-root stock may be substituted at variable spacing from 10 to 12 feet on center. Bare root stock types shall be 1-1, 2-1, P-1 and P-2. Live stakes at 4 feet on center may be substituted for willow and red-osier dogwood in wet areas.
    - Shrubs: Plant a minimum of two species of shrubs. Space plants to cover landscaped area, except where trees are present. Where frequent watering is not practical, bareroot stock may be substituted at variable spacing from 4 to 6 feet on center. Bare root stock types shall be 1-1, 2-1, P-1 and P-2.
    - Groundcover: Plant a minimum of two species of ground cover. Space plants to cover all remaining bare soils.
    - Increase the number of native species if possible based upon native vegetation area size.
- Place at least 4 inches of mulch or compost between plants for weed control.
- Water plantings as necessary to ensure proper plant growth.
- A minimum of 90% plant survival is required after 3 years

9.1.8 Full Dispersion Modeling

Sites that can fully disperse are not required to provide stormwater treatment or flow control facilities. No modeling is necessary.

9.2 BMP L612: Sheet Flow Dispersion

9.2.1 Purpose

Sheet flow dispersion is the simplest method of runoff control. This BMP can be used for any impervious or pervious surface that is graded so as to avoid concentrating flows. Because flows are already dispersed as they leave the surface, they need only traverse a narrow band of adjacent vegetation for effective attenuation and some treatment.

There are two types of sheet flow dispersion: natural and engineered. Natural sheet flow dispersion uses existing soils, vegetation, and topography to disperse runoff into the surrounding landscape. Engineered sheet flow dispersion is similar to natural dispersion but uses newly developed dispersion areas with engineered soils to disperse stormwater.

9.2.2 Applications

- This BMP can be utilized to ensure compliance with Minimum Requirement #5: Onsite Stormwater Management.
    - The BMP can be used solely to mitigate for other hard surfaces if utilizing the List Approach or may be used in combination with other BMPs to satisfy the LID Performance Standard.
- This BMP may also be used to help ensure compliance with Minimum Requirement #7: Flow Control and Minimum Requirement #8: Wetlands Protection.
- Where compliance with Minimum Requirements is not required, where feasible, this BMP is recommended to be used to help protect receiving waterbodies from the effects of stormwater.

9.2.3 Infeasibility Criteria for Sheet Flow Dispersion

The following infeasibility criteria describe conditions that make sheet flow dispersion infeasible when applying The List Approach for compliance with Minimum Requirement #5: Onsite Stormwater Management.

The infeasibility criteria shall also be used to determine the appropriateness of installing sheet flow dispersion. Project proponents may be allowed to install sheet flow dispersion even if considered infeasible, unless otherwise stated within the specific infeasibility criteria, provided documentation is included that substantiates the design. Documentation may be required by a Washington State Licensed Professional Engineer or other appropriate professional depending on the project conditions.

Sheet flow dispersion is considered infeasible if any of the following criteria are met:

- If the design criteria below cannot be met.
- The setback criteria below cannot be met. Setback criteria are generally required by the Tacoma Municipal Code, Uniform Building Code requirements, the Tacoma Pierce County Health Department, or other state regulations. Where a conflict between setbacks occurs, the City shall require compliance with the most stringent of the setback requirements from various codes/regulations. The following are the minimum setbacks required per this manual.
    - At least 10 feet from any building and at least 5 feet from any property line or structure. If necessary, setbacks shall be increased from the minimum 5 feet in order to maintain a 1:1 side slope for future excavation and maintenance.

- A minimum of 50 feet from the top of any slope greater than 15% and from geologically hazardous areas. The dispersion system may be sited within 50 feet of a slope greater than 15% and/or geologically hazardous area if a geotechnical analysis performed by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist determines that there will be no negative impacts to the slopes and/or geologically hazardous areas caused by the dispersion system.
- Setbacks from Onsite Sewage Systems shall conform to WAC 246-272A-0210.

- If there are any conflicts with any of the following competing needs criteria:
  - Requirements of the following federal or state laws, rules, and standards:
    - Historic Preservation Laws and Archaeology Laws as listed at: https://dahp.wa.gov/project-review/preservation-laws
    - Federal Superfund or Washington State Model Toxics Control Act
    - Federal Aviation Administration requirements for airports
    - American with Disabilities Act
  - When found to be in conflict with special zoning district design criteria adopted and being implemented pursuant to a community planning process.
  - Public health and safety standards
  - Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.
  - City of Tacoma Critical Area Ordinances that provides protection of tree species or other critical areas.
- Where the placement of the dispersion facility would require removal of an established mature tree(s).
- Where the resultant slope of the contributing pavement is greater than 9.4%.
- Where the sheet flowpath leading to the dispersion area is 150 feet or greater.
- Where the depth to average annual maximum groundwater elevation is less than 3 feet.
- If erosion or flooding of downstream properties might occur as the result of using sheet flow dispersion. A report prepared by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist with supporting documentation is needed to substantiate this infeasibility criteria.

9.2.4 Design Criteria

- Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.Provide a 2-foot-wide transition zone (lateral flow spreader) to discourage channeling between the edge of the impervious surface and the downslope vegetation, or under building eaves. Tis may be an extension of subgrade material (crushed rock), modular pavement, drain rock, or other material acceptable to the City.

- Dispersion areas must be protected from compaction and future development. It is recommended to physically and permanently mark the location of the dispersion area and provide signage to ensure the area is not cleared and is not disturbed after construction.
- The design must not result in erosion or flooding of downstream properties.
- The sheet flow path leading to the dispersion area must be less than 150 feet. The sheet flow path is measured in the direction of flow.
- Pervious shoulders and side slopes do not count as part of the sheet flow path.
- Ensure the longitudinal length of the dispersion area is equivalent to the longitudinal length of the contributing area.
- Ensure the resultant slope from the contributing pavement is less than or equal to 9.4%, calculated as follows:

$$S_{CFS} \leq (G^2 + e^2)^{0.5}$$

S_{CFS} = resultant slope of the lateral and longitudinal slopes (%)

e = lateral slope elevation (superelevation) (%)

G = longitudinal slope (grade) (%)

- Separation between the existing groundwater elevation and the average annual maximum groundwater elevation shall be 3 feet. The separation requirement applies to the entire limits of the dispersion area.
- Flows shall not create channels through the dispersion area. Dispersion areas shall be as uniform and possible to ensure channels will not be created. To help ensure channelization does not occur:
  - Sides slopes leading to dispersion area shall be less than 25% unless well vegetated to ensure no erosion.
  - For existing slopes leading to the dispersion area, if evidence of channelized flow (rills or gullies) are present, install a flow-spreading device before those flows enter the dispersion area.
- Dispersion areas shall:
  - Be well vegetated with established root zones.
  - Have an average longitudinal slope of 15% or less.
  - Have an average lateral slope of 15% or less for both the hard surface side slope and the vegetated dispersion area.
  - Have an average lateral slope of 3H:1V or less where the transition zone (level spreader) is located immediately upstream of the dispersion area
- Set dispersion areas back ≥ 100 feet from drinking water wells and springs used for public drinking water supplies. Ensure dispersion areas upgradient of drinking water supplies and within the 1-, 5-, and 10-year time of travel zones comply with the Washington State Department of Health (DOH) requirements (DOH, 2010).

9.2.5 Sizing the Dispersion Area

Size the dispersion area using Option 1 – Sizing Based on Contributing Area and Slope or Option 2 – Sizing Based on Soil Characteristics.

Option 1 – Sizing Based on Contributing Area and Slope

- See Figure 4-10 Sheet Flow Dispersion for Driveways (also called Green Stormwater Infrastructure - Figure 008 - Available at tacoma.gov/government/departments/public-works/engineering/right-of-way-design-manual/ for details for driveways.
- Provide a 10-foot-wide dispersion area (vegetated buffer/vegetated flowpath) for up to 20 feet of width of contributing impervious surface. Provide an additional 10 feet of dispersion area for each additional 20 feet of impervious surface width or fraction thereof. For example, if a driveway is 30 feet wide and 60 feet long, provide a 20-foot wide by 60-foot long dispersion area.
- Provide a 25-foot-wide dispersion area for up to 150 foot width of contributing cleared area (ex. bare soil, nonnative vegetation, lawn, and/or pasture).
- Slopes within the dispersion area shall be no steeper than 8%. If site constraints require steeper slopes, the dispersion area must be increased by 1.5 foot for each 1% increase in slope over 8%.

Option 2 – Sizing Based on Soil Characteristics

- The following criteria are specific to sheet flow dispersion on all Type A soils and Type B soils with a saturated hydraulic conductivity rate of 4 inches or greater on slopes 15% or less:
  - For the first 20 feet (along the sheet flowpath) of impervious surface that drains to the dispersion area, provide a dispersion area width of 10 lateral feet. For each additional foot of impervious surfaces (along the sheet flow path) that drains to the dispersion area, provide an additional 0.25 lateral feet of dispersion area.
  - For dispersion areas that receive sheet flow from only disturbed pervious areas, for every 6 feet (along the sheet flow path) of disturbed pervious area, provide a dispersion area width of 1 lateral foot.
- The following criteria are specific to sheet flow dispersion on all Type C and D soils and Type B soils with saturated hydraulic conductivity rates of less than 4 inches per hour or less on slopes 15% or less.
  - For every 1 foot of contributing pavement width, provide a dispersion area width of 6.5 feet.
  - The dispersion area shall have a minimum width of native vegetation of 100 feet (measured in the direction of the flow path).

9.2.6 Sheet Flow Dispersion Modeling

If the runoff is dispersed according to the requirements of this section into an undisturbed native landscape area or an area amended to meet BMP L613: Post-Construction Soil Quality and Depth, model the connected area using the lateral flow element to send the impervious area onto the lawn/landscaped area that will be used for dispersion. The deduction cannot be applied to pollutant-generating surfaces. If the thresholds for stormwater treatment for the project are met, stormwater treatment is required.

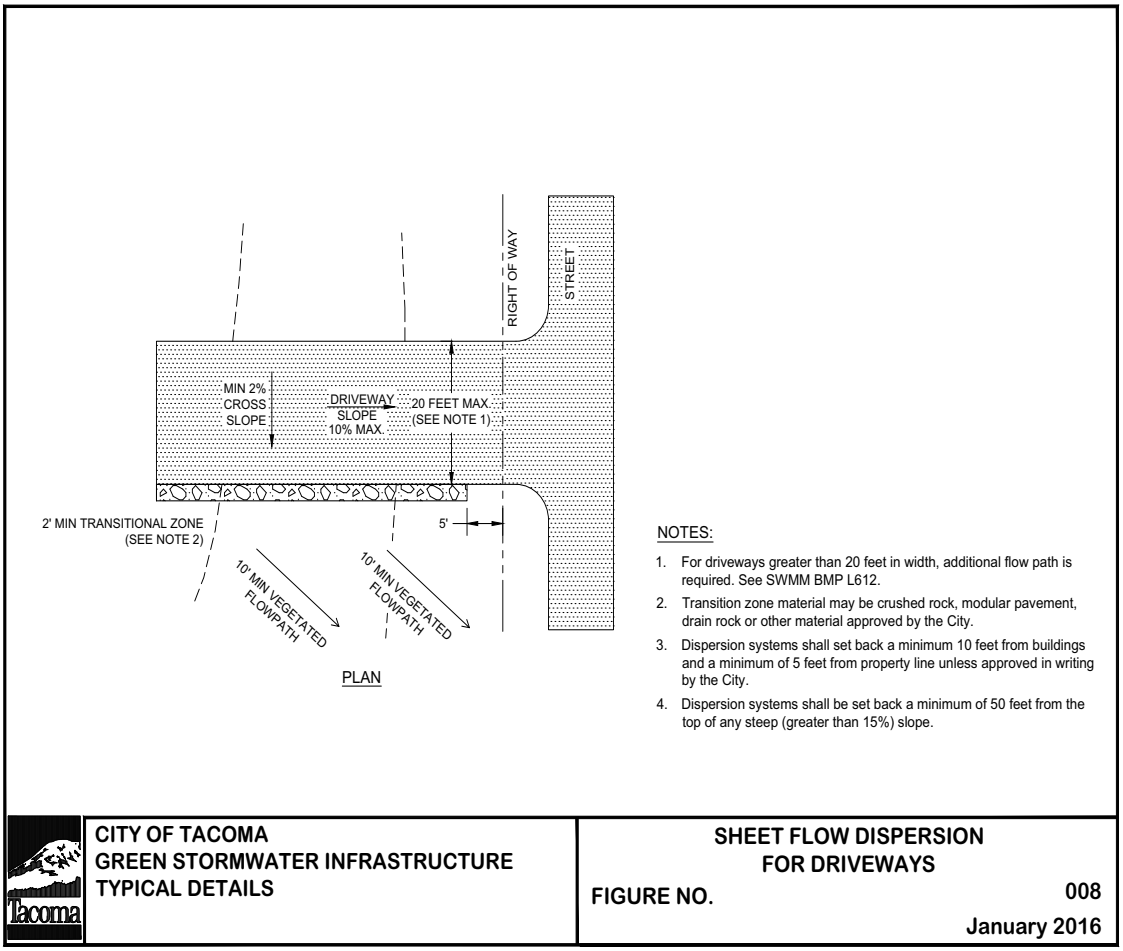


Figure 4 - 10: Sheet Flow Dispersion for Driveways

9.3 BMP L611: Concentrated Flow Dispersion

9.3.1 Purpose

Dispersion of concentrated flows from driveways or other pavement through a vegetated pervious area attenuates peak flows by slowing stormwater.

9.3.2 Applications

- Any situation where concentrated flow can be dispersed through vegetation.
- This BMP can be utilized to ensure compliance with Minimum Requirement #5: Onsite Stormwater Management.
    - The BMP can be used solely to mitigate for other hard surfaces if utilizing the List Approach or may be used in combination with other BMPs to satisfy the LID Performance Standard.
- This BMP may also be used to help ensure compliance with Minimum Requirement #7: Flow Control and Minimum Requirement #8: Wetlands Protection.
- Where compliance with Minimum Requirements is not required, where feasible, this BMP is recommended to be used to help protect receiving waterbodies from the effects of stormwater.

9.3.3 Infeasibility Criteria for Concentrated Flow Dispersion

The following infeasibility criteria describe conditions that make concentrated flow dispersion infeasible when applying The List Approach for compliance with Minimum Requirement #5: Onsite Stormwater Management. If any of the infeasibility criteria or design criteria cannot be met, the BMP is considered infeasible.

The infeasibility criteria shall also be used to determine the appropriateness of installing concentrated flow dispersion. Project proponents may be allowed to install concentrated flow disperison even if considered infeasible, unless otherwise stated within the specific infeasibility criteria, provided documentation is included that substantiates the design. Documentation may be required by a Washington State Licensed Professional Engineer or other appropriate professional depending on the project conditions.

Concentrated flow dispersion is considered infeasible if any of the following criteria are met:

- If the design criteria below cannot be met.
- The setback criteria below cannot be met. Setback criteria are generally required by the Tacoma Municipal Code, Uniform Building Code requirements, the Tacoma Pierce County Health Department, or other state regulations. Where a conflict between setback occurs, the City shall require compliance with the most stringent of the setback requirements from various codes/regulations. The following are the minimum setbacks required per this manual.
    - At least 10 feet from any building and at least 5 feet from any property line or structure. If necessary, setbacks shall be increased from the minimum 5 feet in order to maintain a 1:1 side slope for future excavation and maintenance.
    - A minimum of 50 feet from the top of any slope greater than 15% and from geologically hazardous areas. The dispersion system may be sited within 50 feet of a slope greater than 15% and/or geologically hazardous area if a geotechnical analysis performed by a Washington State Licensed Professional Engineer or Washington

State Licensed Professional Geologist determines that there will be no negative impacts to the slopes and/or geologically hazardous areas caused by the dispersion system.

- Setbacks from Onsite Sewage Systems shall conform to WAC 246-272A-0210

- If there are any conflicts with any of the following competing needs criteria:
  - Requirements of the following federal or state laws, rules, and standards:
    - Historic Preservation Laws and Archaeology Laws as listed at: https://dahp.wa.gov/project-review/preservation-laws
    - Federal Superfund or Washington State Model Toxics Control Act
    - Federal Aviation Administration requirements for airports
    - American with Disabilities Act
  - When found to be in conflict with special zoning district design criteria adopted and being implemented pursuant to a community planning process.
  - Public health and safety standards
  - Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.
  - City of Tacoma Critical Area Ordinances that provides protection of tree species or other critical areas.
- Where the placement of the dispersion facility would require removal of an established mature tree(s).
- If erosion or flooding of downstream properties might occur as the result of using concentrated flow dispersion. A report prepared by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist with supporting documentation is needed to substantiate this infeasibility criteria.

9.3.4 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

- Figure 4 - 11: Concentrated Flow Driveway Dispersion (also called Green Stormwater Infrastructure - Figure 009 - available at tacoma.gov/government/departments/public-works/engineering/right-of-way-design-manual/) shows design criteria for concentrated flow dispersion from driveways.

- A maximum of 700 square feet of impervious area may drain to each concentrated flow dispersion BMP.
- Maintain a minimum vegetated flowpath of 25 feet between the discharge location and any property line, structure, surface water, or other hard surface. Maintain a vegetated flowpath of 50 feet between the discharge location and any slope steeper than 15%.
  - If the vegetated flowpath is 25-50 feet, a dispersion trench must be used prior to discharge over the vegetated flowpath.

    - If the vegetated flowpath is 50 feet or more, a dispersion trench or a rock pad may be used prior to discharge over the vegetated flowpath.
- Dispersion areas must be protected from compaction and future development. It is recommended to physically and permanently mark the location of the dispersion area and provide signage to ensure the area if not cleared and is not disturbed after construction.
- The design must not result in erosion or flooding of downstream properties.
- Separation between the existing groundwater elevation and the average annual maximum groundwater elevation shall be 3 feet. The separation requirement applies to the entire limits of the dispersion area.
- Dispersion areas shall:
    - Be well vegetated with established root zones.
    - Have an average longitudinal slope of 15% or less.
    - Have an average lateral slope of 15% or less for both the hard surface side slope and the vegetated dispersion area.
    - Have an average lateral slope of 3H:1V or less where the transition zone (level spreader) is located immediately upstream of the dispersion area.
- Asphalt or concrete berms used to concentrate flow shall be 2-4” in height and 6” in width.
- Trench drains shall be modular slotted drain units with a minimum width of 4 inches.
- Place a dispersion trench per BMP L603a: Downspout Dispersion Trenches or a pad of clean crushed rock or 4" cobbles per WSDOT Standard Specification 9-03.11(2) - Streambed Cobbles that is 2 feet wide by 3 feet long by 6 inches deep at each discharge location.
- Set dispersion areas back ≥ 100 feet from drinking water wells and springs used for public drinking water supplies. Ensure dispersion areas upgradient of drinking water supplies and within the 1-, 5-, and 10-year time of travel zones comply with the Washington State Department of Health (DOH) requirements (DOH, 2010).

9.3.5 Concentrated Flow Dispersion Modeling

If the runoff is dispersed according to the requirements of this section into an undisturbed native landscape area or an area amended to meet BMP L613: Post-Construction Soil Quality and Depth, model the connected area using the lateral flow element to send the impervious area onto the lawn/landscaped area that will be used for dispersion.

Where multiple concentrated flow dispersion BMPs will be used for a project, to allow for the model schematic to be manageable, the following modeling options may be used:

- When a pad of crushed rock or dispersion trenches are used per the guidance above, and the length of the vegetated flowpath is at least 50 feet, the impervious area may be modeled as a landscaped area.
- When dispersion trenches are used and the length of vegetated flowpath is 25-50 feet, the impervious area may be modeled as 50% landscaped and 50% impervious.

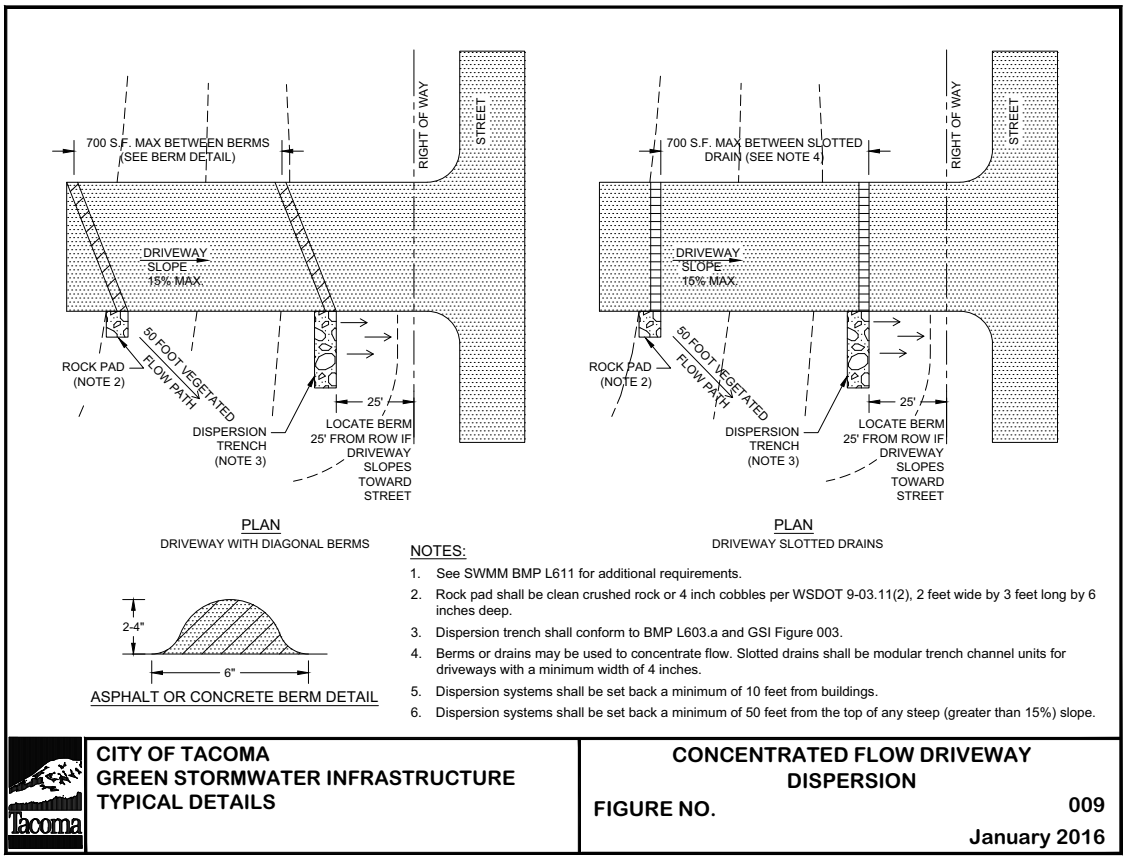


Figure 4 - 11: Concentrated Flow Driveway Dispersion

9.4 BMP L616: Channelized Flow Dispersion

9.4.1 Purpose

Redisperse influent channelized flow to natural or engineered dispersion areas.

9.4.2 Applications

1. Any situation where channelized flow can be redispersed through vegetation.
2. This BMP can be utilized to ensure compliance with Minimum Requirement #5: Onsite Stormwater Management.
3. This BMP can be used solely to mitigate for other hard surfaces if utilizing the List Approach or may be used in combination with other BMPs to satisfy the LID Performance Standard.
4. This BMP may also be used to help ensure compliance with Minimum Requirement #7: Flow Control and Minimum Requirement #8: Wetlands Protection.
5. Where compliance with Minimum Requirements is not required, where feasible, this BMP can be used as an option to help protect receiving waterbodies from the effects of stormwater.

9.4.3 Infeasibility Criteria for Channelized Flow Dispersion

The following infeasibility criteria describe conditions that make channelized flow dispersion infeasible when applying The List Approach for compliance with Minimum Requirement #5: Onsite Stormwater Management.

The infeasibility criteria shall also be used to determine the appropriateness of installing channelized flow dispersion on a project site. Project proponents may be allowed to install channelized flow dispersion even if considered infeasible, unless otherwise stated within the specific infeasibility criteria, provided documentation is included that substantiates the design. Documentation may be required by a Washington State Licensed Professional Engineer or other appropriate professional depending on the project conditions.

Channelized flow dispersion is considered infeasible if any of the following criteria are met:

- If the design criteria below cannot be met.
- The setback criteria below cannot be met. Setback criteria are generally required by the Tacoma Municipal Code, Uniform Building Code requirements, the Tacoma Pierce County Health Department, or other state regulations. Where a conflict between setbacks occurs, the City shall require compliance with the most stringent of the setback requirements from various codes/regulations. The following are the minimum setbacks required per this manual.
    - At least 10 feet from any building and at least 5 feet from any property line or structure. If necessary, setbacks shall be increased from the minimum 5 feet in order to maintain a 1:1 side slope for future excavation and maintenance.
    - A minimum of 50 feet from the top of any slope greater than 15% and from geologically hazardous areas. The dispersion system may be sited within 50 feet of a slope greater than 15% and/or geologically hazardous area if a geotechnical analysis performed by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist determines that there will be no negative impacts to the slopes and/or geologically hazardous areas caused by the dispersion system.
    - Setbacks from Onsite Sewage Systems shall conform to WAC 246-272A-0210.

- If there are any conflicts with any of the following competing needs criteria:
  - Requirements of the following federal or state laws, rules, and standards:
    - Historic Preservation Laws and Archaeology Laws as listed at: https://dahp.wa.gov/project-review/preservation-laws
    - Federal Superfund or Washington State Model Toxics Control Act
    - Federal Aviation Administration requirements for airports
    - American with Disabilities Act
  - When found to be in conflict with special zoning district design criteria adopted and being implemented pursuant to a community planning process.
  - Public health and safety standards
  - Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.
  - City of Tacoma Critical Area Ordinances that provides protection of tree species or other critical areas.
- Where the placement of the dispersion facility would require removal of an established mature tree(s).
- Where the newly concentrated flows exceed 0.5 cubic feet per second at a single discharge location from the conveyance system for the 100-year return period flowrate.
- Where the depth to average annual maximum groundwater elevation is less than 3 feet.
- If erosion or flooding of downstream properties might occur as the result of using sheet flow dispersion. A report prepared by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist with supporting documentation is needed to substantiate this infeasibility criteria.

9.4.4 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within each specific BMP.

- Concentrated stormwater from the contributing area and adjacent upstream area must be incrementally discharged from the conveyance system via cross culverts or at the ends of cut sections. These incremental discharges of newly concentrated flows must not exceed 0.5 cubic feet per second at any discharge location from the conveyance system for the 100-year return period flowrate. Where flows at a particular discharge location are already concentrated under existing site conditions, the 0.5 cfs limit would be in addition to the existing concentrated peak flows.
- Stormwater from discharge locations with flowrates up to 0.2 cfs for the 100-year return period flowrate may use rock pads or dispersion trenches to disperse flows.
- Stormwater from discharge locations >0.2 cfs but <0.5 cfs for the 100-year return period flowrate must use dispersion trenches to disperse flows.

- Design dispersion trenches to accept flows from a conveyance system (pipe, culvert, ditch) as follows (See Figure 4-7: Dispersion Trench with Notched Grade Board in BMP L603: Dispersion Trench):
  - Aligned perpendicular to the flowpath
  - A minimum 2 foot by 2 foot in section.
  - 50 feet in length
  - Filled with ¾" to 1.5" washed rock
  - Provided with a level notched grade board.
- Manifolds shall be used to split flows up to 2 cfs as calculated for the 100-year return period flowrate between a maximum of 4 trenches.
- Provide a minimum of 50 feet between trenches.
- After being dispersed via rock pads or trenches, stormwater must traverse the required flowpath length of the dispersion area before entering any existing channel carrying existing concentrated flows away from the roadway alignment.
- Flowpaths from adjacent discharge locations shall not intersect.
- Ensure dispersed flow from a discharge location is not intercepted by another discharge location.
- Locate discharge locations a minimum of 100 feet upgradient of slopes over 40%, wetlands, and streams.
- Set dispersion areas back ≥ 100 feet from drinking water wells and springs used for public drinking water supplies. Ensure dispersion areas upgradient of drinking water supplies and within the 1-, 5-, and 10-year time of travel zones comply with the Washington State Department of Health (DOH) requirements (DOH, 2010).
- Flows shall not create channels through the dispersion area. Dispersion areas shall be as uniform and possible to ensure channels will not be created. To help ensure channelization does not occur:
  - Sides slopes leading to dispersion area shall be less than 25% unless well vegetated to ensure no erosion
  - For existing slopes leading to the dispersion area, if evidence of channelized flow (rills or gullies) are present, install a flow-spreading device before those flows enter the dispersion area.
- Dispersion areas must be protected from compaction and future development. It is recommended to physically and permanently mark the location of the dispersion area and provide signage to ensure the area if not cleared and is not disturbed after construction.
- The design must not result in erosion or flooding of downstream properties.
- Separation between the existing groundwater elevation and the average annual maximum groundwater elevation shall be 3 feet. The separation requirement applies to the entire limits of the dispersion area.
- Dispersion areas shall:
  - Be well vegetated with established root zones.
  - Have an average longitudinal slope of 15% or less.

- Have an average lateral slope of 15% or less for both the hard surface side slope and the vegetated dispersion area.

Have an average lateral slope of 3H:1V or less where the transition zone (level spreader) is located immediately upstream of the dispersion area.

9.4.5 Sizing the Dispersion Area

Size the dispersion area based upon if it is Natural Channelized Flow Dispersion or Engineered Channelized Flow Dispersion.

Natural Channelized Flow Dispersion

- The following criteria are specific to channelized flow dispersion on all Type A soils and Type B soils with a saturated hydraulic conductivity rate of 4 inches or greater on slopes 15% or less:
  - The dispersion area shall be greater than or equal to 50% of the contributing drainage area.
- The following criteria are specific to sheet flow dispersion on all Type C and D soils and Type B soils with saturated hydraulic conductivity rates of less than 4 inches per hour or less on slopes 15% or less.
  - For every 1 foot of contributing pavement width, provide a dispersion area width of 6.5 feet.
  - The dispersion area shall have a minimum width of native vegetation of 100 feet (measured in the direction of the flow path).

Engineered Channelized Flow Dispersion

- The following criteria are specific to sheet flow dispersion on all Type A soils and Type B soils with a saturated hydraulic conductivity rate of 4 inches or greater on slopes 15% or less:
  - For the first 20 feet (along the sheet flowpath) of impervious surface that drains to the dispersion area, provide a dispersion area width of 10 lateral feet. For each additional foot of impervious surfaces (along the sheet flow path) that drains to the dispersion area, provide an additional 0.25 lateral feet of dispersion area.
- The following criteria are specific to sheet flow dispersion on all Type C and D soils and Type B soils with saturated hydraulic conductivity rates of less than 4 inches per hour or less on slopes 15% or less.
  - For every 1 foot of contributing pavement width, provide a dispersion area width of 6.5 feet.
  - The dispersion area shall have a minimum width of native vegetation of 100 feet (measured in the direction of the flow path).

9.4.6 Channelized Flow Dispersion Modeling

If runoff is dispersed according to the requirements of this section into an undisturbed native landscape area or an area amended to meet BMP L613: Post-Construction Soil Quality and Depth, model the connected area using the lateral flow element to send the impervious area onto the lawn/landscaped area that will be used for dispersion. The deduction cannot be applied to pollutant-generating surfaces. If the thresholds for stormwater treatment for the project are met, stormwater treatment is required.

Chapter 10 Infiltration BMPs

10.1 BMP 700: Infiltration - Ponds, Trenches, Swales, and Drywells

10.1.1 Purpose

This Chapter provides site suitability, design, and maintenance criteria for infiltration ponds, trenches and drywells.

The infiltration BMPs described in this chapter include:

BMP 710: Infiltration Ponds
BMP 720: Infiltration Trenches
BMP 730: Drywells
BMP 740: Infiltration Swales

10.1.2 Application

- Depending on how the infiltration facility is sized, infiltration ponds, trenches, swales, and drywells can be used to ensure compliance with Minimum Requirement #5: Onsite Stormwater Management, Minimum Requirement #6: Stormwater Treatment, Minimum Requirement #7: Flow Control, and Minimum Requirement #8: Wetlands Protection.
- Infiltration ponds, trenches, swales, and drywells can provide phosphorus treatment, metals treatment, and basic treatment.
- Infiltration ponds, trenches, swales, and drywells can only be used where subsurface conditions are appropriate. The stormwater treatment function is achieved as stormwater filters through the native soils or through the engineered soils below the facility.
- Pretreatment is required before infiltration ponds, infiltration trenches, infiltration swales, and drywells.

10.1.3 Screening/Infeasibility Criteria for Infiltration BMPs

The following screening criteria describe conditions that make infiltration BMPs infeasible or inefficient.

The screening criteria shall be used to determine the appropriateness of installing infiltration BMPs on a project site. Project proponents may install infiltration BMPs even if considered infeasible/inefficient provided documentation is included that substantiates the design. Documentation may be required by a Washington State Licensed Professional Engineer or other appropriate professional depending on the project conditions. These screening criteria should be evaluated based on site-specific conditions by a licensed professional.

- Where the design standards of the specific BMP cannot be met.
- Where the setback criteria below cannot be met. Setbacks are generally required by Tacoma Municipal Code, Uniform Building Code, the Tacoma-Pierce County Health Department, or other state regulations. Where a conflict between setback occurs, the City shall require compliance with the most stringent of the setback requirements from the various codes/regulations. Setbacks are typically measured from the overflow elevation. The following are minimum setbacks required per this manual:
    - At least 10 feet from any building structure

  - At least 5 feet from any other structure or property line
  - A minimum of 50 feet from the top of any slope greater than 20% and from geologically hazardous areas. The infiltration facility may be sited within 50 feet of a slope greater than 20% and/or geologically hazardous area if a geotechnical analysis performed by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist determines there will be no negative impacts to the slopes and/or geologically hazardous areas caused by the discharge location of the infiltration facility.
- Where professional geotechnical evaluation recommends infiltration not be used due to reasonable concerns about erosion, slope failure, or downgradient flooding.
- Within an area where groundwater drains into an erosion hazard, or landslide hazard area.
- Where the only area available for siting would threaten the safety or reliability of preexisting underground utilities, preexisting underground storage tanks, preexisting structures, or preexisting road or parking lot surfaces.
- Where the only area available for siting does not allow for a safe overflow pathway.
- Where there is a lack of usable space for infiltration BMPs at redevelopment sites, or where there is insufficient space within the existing public right-of-way on public road projects.
- Where infiltrating water would threaten existing below grade basements.
- Where infiltrating water would threaten shoreline structures (such as bulkheads).
- Where treatment soils containing compost amendments for treatment prior to infiltration would exacerbate phosphorus loading to phosphorus-sensitive receiving waters.
- Where they are not compatible with the surrounding stormwater system (e.g. surfaces drain to an existing stormwater system whose elevation precludes proper connection to the facility).
- Where land for infiltration BMPs is within area designated as an erosion hazard, or landslide hazard.
- For properties with known soil or groundwater contamination (typically federal Superfund sites or state cleanup sites under the Model Toxics Control Act (MTCA):
  - Within 100 feet of an area known to have deep soil contamination
  - Where groundwater analysis indicates infiltration will likely increase or change the direction of the migration of pollutants in the groundwater
  - Wherever surface soils have been found to be contaminated unless those soils are removed within 10 horizontal feet from the infiltration area
  - Any area where these BMPs are prohibited by an approved cleanup plan under the state MTCA or federal Superfund Law, or an environmental covenant under Chapter 64.70 RCW
- Within 100 feet of a closed or active landfill.
- Within 100 feet of a drinking water well, within the sanitary control area of a public drinking water well, within 200 feet of a spring used for drinking water supply, or within a wellhead protection area.

- Within 10 feet of a small on-site sewage disposal drain field, including reserve areas, and grey water reuse systems. For setbacks from a “large on-site sewage disposal system”, see Chapter 246-272B WAC.
- Within 10 feet of an underground storage tank and connecting underground pipes when the capacity of the tank and pipe system is 1,100 gallons or less. As used in these criteria, an underground storage tank means any tank used to store petroleum products, chemicals, or liquid hazardous wastes of which 10% or more of the storage volume [including volume in the connecting piping system] is beneath the ground surface.
- Within 100 feet of an underground storage tank and connecting underground pipes when the capacity of the tank and pipe system is greater than 1,100 gallons.
- Where the placement of the infiltration facility would require removal of an established mature tree(s).

10.1.4 Design Criteria for Infiltration Ponds, Infiltration Trenches, Infiltration Swales, and Drywells

10.1.4.1 Site Suitability for Infiltration Ponds, Infiltration Trenches, Infiltration Swales, and Drywells

10.1.4.1.1 Infiltration Rates: Measured (initial) and Design (Long-term)

Refer to Volume 4 - Appendix A: Determining the Design Infiltration Rate for the allowable methods for determining infiltration rates.

The design (long-term) infiltration rate should be used for drawdown time and routing calculations.

For treatment purposes, the measured (initial) soil infiltration rate shall be 9 inches/hour or less. Design (long-term) infiltration rates up to 3 inches/hour can be considered if the infiltration receptor is not a sole-source aquifer, and the treatment soils meet the physical and chemical suitability criteria in Section 10.1.4.1.3 - Soil Physical and Chemical Suitability for Treatment.

10.1.4.1.2 Drawdown Time

Document that the maximum ponded depth from the infiltration BMP (indicated by an Ecology approved continuous simulation model, assuming a 15-minute timestep) can infiltrate through the infiltration surface within 48 hours. If the BMP does not meet the drawdown time criteria, redesign the infiltration BMP. This is a method to check that the design is sufficient, not a means of designing the facility. See Section 10.1.4.2 - Sizing Criteria for Infiltration Ponds, Infiltration Trenches, Infiltration Swales, and Drywells for sizing these BMPs.

- This drawdown restriction is intended to meet the following objectives:
- Restore hydraulic capacity to receive stormwater from the next storm.
- Maintain infiltration rates.
- Prevent Anoxic conditions in treatment soils.
- Aerate vegetation and soil to keep the vegetation healthy, and
- Enhance the biodegradation of pollutants and organics in the soil.

10.1.4.1.3 Soil Physical and Chemical Suitability for Treatment

The soil texture and design infiltration rates shall be considered along with the physical and chemical characteristics specified below to determine if the native soil is adequate for removing

the target pollutants. The following soil properties must be carefully considered in making such a determination:

- Cation exchange capacity (CEC) of the treatment soil must be ≥5 milliequivalents CEC/ 100 g dry soil (USEPA Method 9081). *Consider empirical testing of soil sorption capacity, if practicable*. Ensure that soil CEC is sufficient for expected pollutant loadings, particularly heavy metals. CEC values of >5 meq/100g are expected in loamy sands, according to Rawls, et al.
- Depth of soil used for infiltration treatment must be a minimum of 18 inches.
- Organic content shall be a minimum of 1%. Organic content shall be measured on a dry weight basis using ASTM D2974.
- Waste fill materials should not be used as infiltration soil media nor should such media be placed over uncontrolled or non-engineered fill soils.

Perform the analysis of the soils below the bottom of the proposed infiltration BMP, regardless of the depth of the BMP. If the applicant proposes to use a deep UIC well, the soils analysis should show the adequacy of the deep soils.

Engineered soils may be used to meet the design criteria. The engineered soils must meet the criteria above. Soil properties must be verified against actual soil used and provided to the City to verify that the soil used meets the requirements.

10.1.4.1.4 Depth to Bedrock, Water Table, or Impermeable Layer

The base of BMP 710: Infiltration Ponds, BMP 720: Infiltration Trenches, BMP 740: Infiltration Swales and BMP 730: Drywells shall be ≥ 5 feet above the seasonal high-water mark, bedrock (or hardpan) or other low permeability layer. Separations less than 5 feet from the seasonal high-water mark may be considered if a complete groundwater mounding analysis is included. In these instances, the design must consider the additional water while still ensuring the Minimum Requirements are met. Note, UIC wells must maintain vertical separation requirements of Volume 1, Chapter 2 in order to be Rule Authorized.

10.1.4.1.5 Subsurface Characterization

- A soils report is required to design an infiltration trench, infiltration pond, or drywell. See Appendix B: Soils Reports requirements.

10.1.4.2 Sizing Criteria for Infiltration Ponds, Infiltration Trenches, Infiltration Swales, and Drywells

The size of the infiltration facility can be determined by routing the influent runoff file generated by an Ecology approved continuous simulation model, assuming a 15-minute timestep, through it. The primary mode of discharge from an infiltration facility is infiltration into the ground. However, when the infiltration capacity of the facility is reached, additional runoff to the facility will cause the facility to overflow.

Infiltration facilities can be sized using an Ecology approved continuous simulation model, assuming a 15-minute timestep:

In the Ecology approved continuous simulation model, assuming a 15-minute timestep, use:

- The pond element to represent infiltration ponds for BMP 710 sizing.
- The trench element to represent infiltration/infiltration swales for BMP 720/BMP 740 sizing.
- The trench element or SSD Table element to represent drywells for BMP 730 sizing.

(A) For 100% infiltration

Facilities sized for 100% infiltration meet the stormwater treatment sizing requirements, flow control sizing requirements, and LID Performance Standard Requirements.

1. Input the dimensions of the proposed facility.
2. Input the infiltration rate and reduction factor (safety factor)
    a. When the infiltration rate was calculated using the Simplified Approach (see Volume 4 - Appendix A: Determining the Design Infiltration Rate), either
        i. Enter the measured (initial) saturated hydraulic conductivity (K_{sat}) as the infiltration rate and the Total Correction Factor as the reduction factor, OR
        ii. Enter the estimated design infiltration rate as the infiltration rate and use a reduction factor of 1.
    b. When the infiltration rate was calculated using the Detailed Approach, enter the preliminary design infiltration rate as the infiltration rate and the aspect ratio (Ar) as the reduction factor.
3. Input a riser height and diameter.
4. Run the model for the Developed Mitigated Scenario
5. Check to see if the Percent Infiltrated is 100%. If the Percent Infiltrated is less than 100%, increase the facility size.

(B) For 91% infiltration (stormwater treatment)

Use the same steps as used when determining the facility size for 100% infiltration except the target Percent Infiltrated is 91%.

Complete a drawdown analysis.

Ensure that the water quality design flowrate can infiltrate through the BMP within 48 hours using the equation below.

$$t = \frac{V}{K_{sat} \times SA} < 48 Hours$$

Where:

t - drawdown time (hours)

V - Facility Volume Below Overflow - Not Including Freeboard (in^3)

K_{sat} - Estimated Design Infiltration Rates (in/hr)

SA - Surface Area at Mid-Depth Dimension (in^2)

(C) Partial Infiltration to Meet Flow Control or LID Performance Standard and Stormwater Treatment Requirements

Use the same steps as used when determining the facility size for 91% Infiltration and also ensure the design meets the required flow control standard or LID Performance Standard. This may require the Percent Infiltrated to be greater than 91%.

(D) To meet the Flow Control and/or LID performance standard

This design allows something less than 100% infiltration. Using the output files from an Ecology approved continuous simulation model, assuming a 15-minute timestep, ensure the total of any bypass and overflow from the facility meets the applicable LID performance standard and/or Flow Control Standard. Discharge structures with orifices and risers may be necessary in addition to the infiltration to meet the performance standard.

10.1.4.3 Treatment Before Infiltration

10.1.4.3.1 Presettling Prior to Infiltration

- Volume 4, Section 1.1 describes instances where pretreatment BMPs are required before infiltration BMPs.

- When stormwater treatment is not required before infiltration BMPs it is still recommended to include a presettling device to reduce potential plugging of the soil and prolong the life of the infiltration BMP. Some examples of presettling devices include:

    - Stormwater Treatment BMPs (see Volume 4, Section 1.1)
    - Detention BMPs that include settling storage.
    - Catch basins with a downturned elbow on the outlet pipe (though these do not remove as much sediment as stormwater treatment BMPs and will require more frequent inspection and maintenance.)

10.1.4.3.2 Stormwater Treatment Prior to Infiltration

There are two different regulations related to stormwater treatment prior to infiltration:

1. Infiltration BMPs that are NOT Underground Injection Control (UIC) Wells
    - These projects must comply with the Minimum Requirements as described in Volume 1.
2. Infiltration BMPs that are Underground Injection Control (UIC) Wells
    - Projects that are proposing a UIC well with no discharge to the City's stormwater system (100% infiltration of the entire runoff file) must utilize the UIC Program Guidelines contained in Volume 1 – Chapter 2. Note, the City has included some key information from this guidance within certain sections of this SWMM to help ensure applicants recognize the regulations have different requirements.

      Note, when the UIC Program Guidance refers to the Minimum Requirements – reference shall mean referring to the language within this manual.

      Note, the requirements of a Stormwater Site Plan still apply which include documentation of how the Minimum Requirements are met. Discussion of how the BMP complies with the UIC Program Guidelines is required.

    - Projects that are proposing a UIC well that will have a discharge to the City of Tacoma stormwater system shall comply with the Minimum Requirements of this Manual – See Volume 1.

10.1.4.4 Construction Criteria for Infiltration Ponds, Infiltration Trenches, Infiltration Swales, and Drywells

Initial basin excavation should be conducted to within 1-foot of the final elevation of the basin floor. Excavate infiltration trenches and basins to final grade only after all disturbed areas in the upgradient project contributing area have been permanently stabilized. The final phase of excavation should remove all accumulation of silt in the infiltration facility before putting it in service.

Infiltration facilities should generally not be used as temporary sediment traps during construction. If an infiltration facility is to be used as a sediment trap, it must not be excavated to final grade until after the upgradient contributing area has been stabilized. Any accumulation of silt in the basin must be removed before putting it in service.

Relatively light-tracked equipment is recommended for use within infiltration areas for excavation and cleaning to avoid compaction of the infiltration facility floor. The use of draglines and trackhoes should be considered for constructing infiltration facilities. The infiltration area should be flagged or marked to keep heavy equipment away.

10.1.4.5 Verification Testing of the Completed Infiltration Pond, Infiltration Trench, Infiltration Swale and/or Drywell

Verification testing of the completed facility is recommended to demonstrate that the facility performs as designed. Use the same method for saturated hydraulic conductivity as used in the planning stages to ensure comparable results. Perform the testing after stabilizing the construction site. If the rates are lower than the design saturated hydraulic conductivity, the applicant shall implement measures to improve infiltration capability of the facility and retest. Replacement of the top foot of soil or more may be needed to ensure the facility performs as designed. Longer-term monitoring of the facility may be needed for some facilities. The City of Tacoma may require verification testing on a case-by-case basis.

10.2 BMP 710: Infiltration Ponds

10.2.1 Description

Infiltration ponds are earthen impoundments used for the collection, temporary storage and infiltration of incoming stormwater.

10.2.2 Design Criteria Specific to Infiltration Ponds

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, BMP 700 - Infiltration - Ponds, Trenches, Swales, and Drywells,Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

10.2.2.1 Geometry

- The slope of the basin bottom should not exceed 3% in any direction.
- A minimum of one foot of freeboard is recommended when establishing the design ponded water depth. Freeboard is measured from the rim of the infiltration facility to the maximum ponding level or from the rim down to the overflow point if overflow or a spillway is included.
- Maximum ponding depth shall be between 2 and 6 feet.

10.2.2.2 Inlet and Outlet

- Provide erosion protection for all inlets per A400: End of Pipe Discharge Protection.
- Provide a primary overflow structure (either a Type 2 catch basin with a grated opening or a manhole with a beehive grate). The overflow structure shall be designed to bypass the stormwater above the water quality design volume (if the basin is designed for treatment only) or designed to bypass stormwater above the flow control or LID Performance Standard Requirements.
- In addition to the primary overflow, ponds must have an emergency overflow spillway. Design the Emergency Overflow Spillway per A600: Emergency Overflow Spillway.

10.2.2.3 Lining

- Lining material – Basins can be open or covered with a 6 to 12-inch layer of filter material such as coarse sand, or a suitable filter fabric to help prevent the buildup of impervious deposits on the soil surface. A nonwoven geotextile should be selected that will function sufficiently without plugging. The non-woven geotextile shall conform to A2000: Geotextile Specifications, Geotextile for Underground Drainage - Low Survivability, Class C.Replace or clean the filter layer when/if it becomes clogged.

10.2.2.4 Vegetation

- Sod or seed exposed earth on the pond bottom and interior side slopes with an appropriate seed mixture. Plant all remaining areas around the infiltration pond with grass or landscape and mulch with a 3" cover of shredded wood mulch. The mulch should be free of garbage and weeds and should not contain excessive resin, tannin, or other material detrimental to plant growth. Do not use construction materials, wood debris, or wood treated with preservatives for producing wood mulch.

10.2.2.5 Access

- Provide maintenance access road(s) to the inlet and outlet. Access roads and ramps shall conform to A3000: Access Ramps and Roads.
- An access ramp is required for removal of sediment. For small, shallow ponds, an access ramp may not be required if the trackhoe can load a truck parked at the pond edge. Extend the access ramp to the bottom of the first cell unless all portions of the cell can be reached and sediment loaded from the top of the pond.
- The internal berm may be used as access only if all the following apply:
  - The internal berm is no more than 4' above the first wetpool cell.
  - The first wetpool cell is less than 1,500 square feet (measured without the ramp)
  - The internal berm is designed to support a loaded truck, 80,000 pounds minimum, considering the berm is normally submerged and saturated.

10.2.2.6 Signage

Provide a stormwater facility sign. Sign shall conform to A800: Signage.

10.3 BMP 720: Infiltration Trenches

10.3.1 Description

Infiltration trenches are generally at least 24 inches wide, and are backfilled with a coarse stone aggregate, allowing for temporary storage of stormwater in the voids of the aggregate material. Stored runoff gradually infiltrates into the surrounding soil. The surface of the trench can be covered with grating and/or consist of stone, gabion, sand, or a grassed covered area with a surface inlet. Perforated rigid pipe of at least 8-inch diameter can also be used to distribute the stormwater in a stone trench.

Underground Injection Control (UIC) regulations typically apply to infiltration trenches with perforated pipe unless the perforated pipe is included for the purpose of conveying overflows to the surface. See Volume 1, Chapter 2 - Underground Injection Control Guidelines.

10.3.2 Design Criteria Specific to Infiltration Trenches

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, BMP 700 - Infiltration - Ponds, Trenches, Swales, and Drywells, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

Due to accessibility and maintenance limitations, infiltration trenches must be carefully designed and constructed.

Infiltration trenches may be placed in fill material if the fill is placed and compacted under the direct supervision of a Washington State Licensed Professional Engineer, and if the measured infiltration rate is at least 8 inches per hour.

The base of the infiltration facility shall be level.

10.3.2.1 Cleanouts/Access Ports

Install cleanouts and/or access ports to allow cleaning and inspection of the system.

10.3.2.2 Backfill Material

The aggregate material for the infiltration trench shall consist of a clean aggregate with a maximum diameter of 1.5 inches and a minimum diameter of 3/4 inches meeting the WSDOT Standard Specification 9-03.12(5) - Gravel Backfill for Drywells.For calculations assume a void space of 30% maximum.

10.3.2.3 Geotextile Fabric Liner

The aggregate fill material shall be completely encased in an engineering geotextile material. Geotextile should surround all of the aggregate fill material except for the top one-foot, which is placed over the geotextile. Geotextile fabric shall be selected to avoid plugging and shall be non-woven. The non-woven geotextile shall conform to A2000: Geotextile Specifications, Geotextile for Underground Drainage - Low Survivability, Class C.

The bottom sand or geotextile fabric is optional.

Refer to the Federal Highway Administration Manual “Geosynthetic Design and Construction Guidelines,” Publication No. FHWA HI-95-038, May 1995 for design guidance on geotextiles in drainage applications. Refer to the NCHRP Report 367, “Long-Term Performance of

Geosynthetics in Drainage Applications," 1994, for long-term performance data and background on the potential for geotextiles to clog, blind, or to allow piping to occur and how to design for these issues.

10.3.2.4 Overflow Channel

Because an infiltration trench is generally used for small contributing areas, an emergency spillway is not necessary. However, a non-erosive overflow channel leading to a stabilized watercourse or other City of Tacoma approved, approved location should be provided.

10.3.2.5 Surface Cover

An infiltration trench can be placed under a porous or impervious surface cover to conserve space.

10.3.2.6 Observation Well

An observation well should be installed at the lower end of the infiltration trench to check water levels, drawdown time, sediment accumulation, and conduct water quality monitoring. See City of Tacoma Standard Detail GSI-02 as an example though simpler stand-pipes may be appropriate depending on the application. It should consist of a perforated PVC pipe which is 4 to 6 inches in diameter and it should be constructed flush with the ground elevation. For larger trenches, a 12-36 inch diameter well can be installed to facilitate maintenance operations such as pumping out the sediment. The top of the well should be capped to discourage vandalism and tampering.

10.3.2.7 Distribution Pipe

- Distribution pipe (if used) shall be level and shall be either perforated or slotted pipe.
- Perforated pipe shall conform to WSDOT Standard Specification 9-05.2.
- Slotted pipe shall have slots cut perpendicular to the long axis of the pipe and be 0.04 to 0.069 inches by 1 inch long and be spaced 0.25 inches apart longitudinally.
- Distribution pipe shall be a minimum of 8 inches in diameter but shall be sized based upon contributing area.
- Pipe length shall not be so long that flow cannot be even distributed throughout the facility. Pipes shall be a maximum 100 feet in length unless calculations are provided showing distribution can be even with longer pipe length.

10.3.3 Construction Criteria

- **Trench Preparation** –Place excavated materials away from the trench sides to enhance trench wall stability. Keep excavated material away from slopes, neighboring property, sidewalks and streets.
- **Stone Aggregate Placement and Compaction** – Place the stone aggregate in lifts and compact using plate compactors. As a rule of thumb, a maximum loose lift thickness of 12 inches is recommended. The compaction process ensures geotextile conformity to the excavation sides, thereby reducing potential piping and geotextile clogging, and settlement problems.
- **Potential Contamination** - Prevent natural or fill soils from intermixing with the stone aggregate. Remove all contaminated stone aggregate and replace with uncontaminated stone aggregate.
- **Overlapping and Covering** - Following the stone aggregate placement, fold the geotextile over the stone aggregate to form a 12 inch minimum longitudinal overlap.

When overlaps are required between rolls, overlap the upstream roll a minimum of 2 feet over the downstream roll in order to provide a shingled effect.

- **Voids behind Geotextile** – Avoid voids between the geotextile and excavation sides. Remove boulders or other obstacles from the trench walls. Place natural soils in voids at the most convenient time during construction to ensure geotextile conformity to the excavation sides. Soil piping, geotextile clogging, and possible surface subsidence will be avoided by this remedial process.
- **Unstable Excavation Sites** - Vertically excavated walls may be difficult to maintain in areas where the soil moisture is high or where soft or cohesionless soils predominate. Trapezoidal, rather than rectangular, cross-sections may be needed.

10.4 BMP 730: Drywells

10.4.1 Description

Drywells are subsurface concrete structures that convey stormwater into the underlying soil.

Underground Injection Control (UIC) regulations typically apply to Drywells. See Volume 1, Chapter 2 Underground Injection Control Guidelines.

10.4.2 Design Criteria Specific to Drywells

- See Figure 4 - 12: Typical Infiltration Drywell - Type 1 and Figure 4 - 13: Typical Infiltration Drywell - Type 2 which show common drywell configurations.
- Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, BMP 700 - Infiltration - Ponds, Trenches, Swales, and Drywells, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.
- The base of the drywell shall be a minimum of 5 feet above the seasonal high groundwater table or other impermeable layer.
- Drywells area typically 48" in diameter and 10-15 feet deep.
- Depending on local soil conditions, geotextile may need to be placed on top of the drain rock and on sidewalls to prevent migration of fines into the drain rock. The non-woven geotextile shall conform to A2000: Geotextile Specifications, Geotextile for Underground Drainage - Low Survivability, Class C.
- Multiple drywells shall not be placed closer than 30 feet on center or twice the drywell depth, whichever is greater.

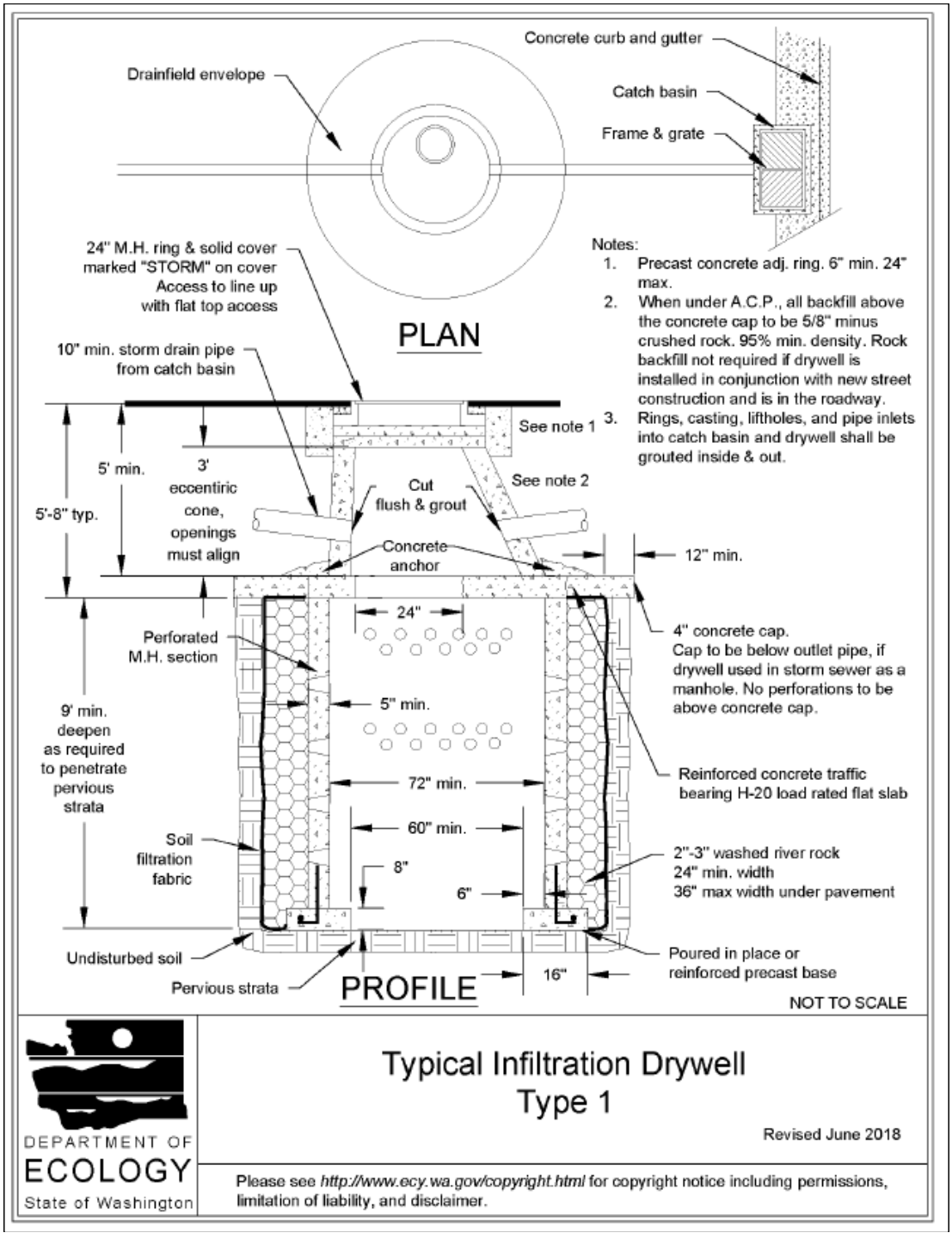


Figure 4 - 12: Typical Infiltration Drywell - Type 1

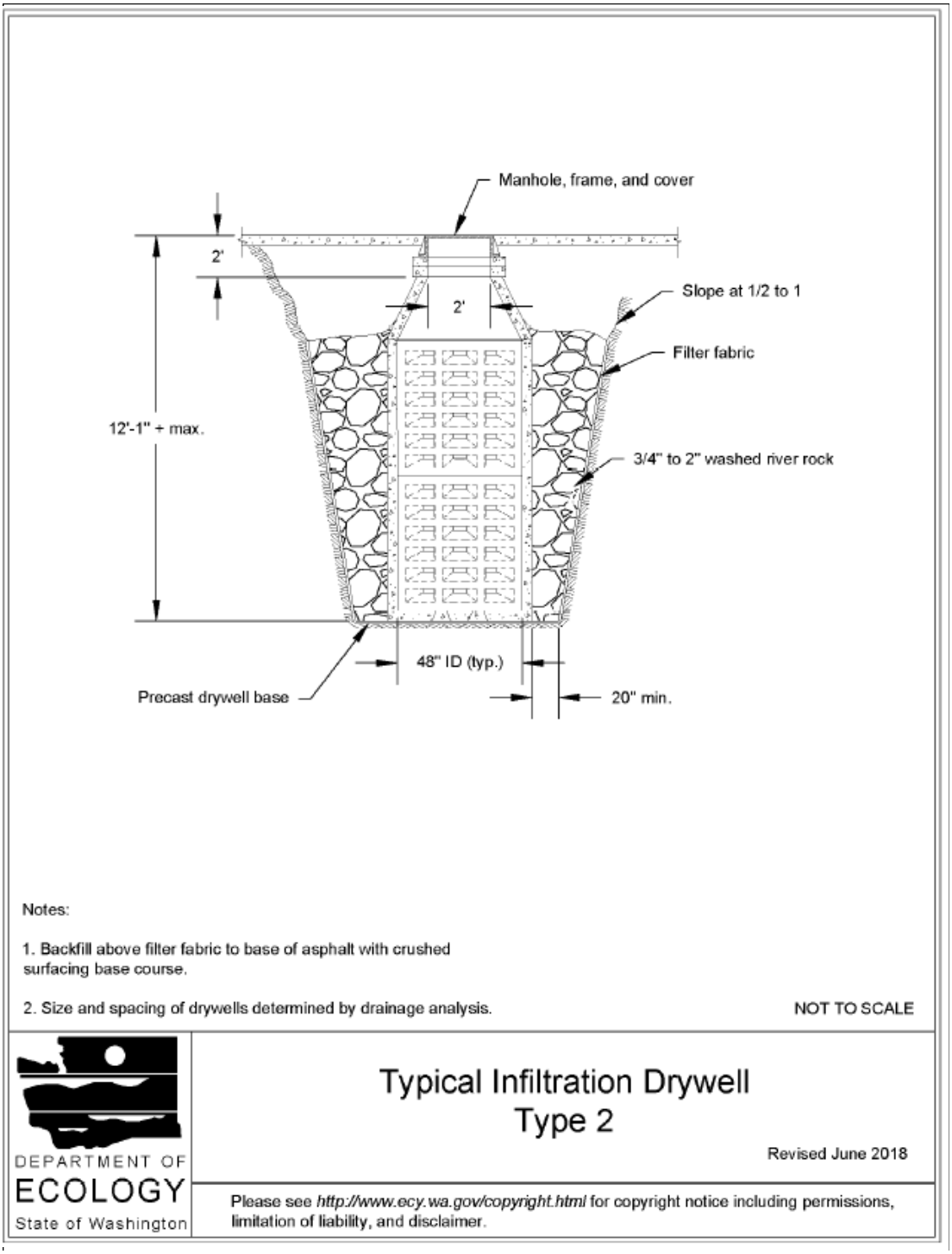


Figure 4 - 13: Typical Infiltration Drywell - Type 2

10.5 BMP 740 Infiltration Swales

10.5.1 Description

Infiltration swales are vegetated or rock-lined swales designed to infiltrate stormwater.

10.5.2 Design Criteria Specific to Infiltration Swales

- Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, BMP 700-Infiltration – Ponds, Trenches, Swales, and Drywells, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.
- A concrete or rip-rap apron must be provided at the swale entrance to prevent vegetation from blocking the inlet and provide erosion protection.
- The swale bottom shall have a longitudinal slope of 1% or less unless check dams are used.
- Slopes greater than 2.5% need check dams (riprap) at vertical drops of 12 to 15 inches.
- The maximum ponding depth of water shall be 6 inches.
- If the infiltration swale will be used for treatment, treatment soils must meet the following:
    - For vegetated infiltration swales, the treatment soil must be a minimum of 6 inches deep and meet the Soil Physical and Chemical Suitability for Treatment (Volume 4, Section 10.1.4.1.3).
        - If the treatment soil depth is less than 18 inches, the vegetated infiltration swale is presumed to provide Basic Treatment.
        - If the treatment soil depth is 18 inches or greater, the vegetated infiltration swale is presumed to provide Basic Treatment, Metals Treatment, and Phosphorus Treatment.
    - For rock-lined infiltration swales, the treatment soils must be 18 inches deep and meet the Soil Physical and Chemical Suitability for Treatment (Volume 4, Section 10.1.4.1.3). With the treatment soil as specified, rock-lined infiltration swales provide Basic Treatment, Metals Treatment, and Phosphorus Treatment.
- Infiltration swales shall be surfaced as follows:
    - For vegetated infiltration swales, native grasses, adapted grasses, or other vegetation with significant root mass should be used. See A-1000 – Vegetation. Grasses should be drought tolerant or irrigation should be provided
    - For rock-lined infiltration swales, select appropriate rock, such as 3-5” river rock, to facilitate maintenance.

10.6 BMP 750 Ballasted Sidewalks

10.6.1 Description

Ballasted sidewalks are a standard sidewalk section that drains into a ballasted section located beneath the sidewalk. This ballasted section serves to infiltrate the stormwater. Ballasted sidewalks are an alternative to a permeable sidewalk section.

10.6.2 Applications

- This BMP can be utilized to ensure compliance with Minimum Requirement #5: Onsite Stormwater Management.
    - The BMP can be used solely to mitigate for other hard surfaces, specifically sidewalks, if utilizing the List Approach or may be used in combination with other BMPs to satisfy the LID Performance Standard. Not other hard surfaces besides sidewalks will have to utilize other BMPs to ensure mitigation of all surfaces.
- This BMP may also be used to help ensure compliance with Minimum Requirement #7: Flow Control and Minimum Requirement #8: Wetlands Protection.
- Where compliance with Minimum Requirements is not required, where feasible, this BMP is recommended to be used to help protect receiving waterbodies from the effects of stormwater.

10.6.3 Infeasibility Criteria

The following infeasibility criteria describe conditions that make ballasted sidewalks infeasible when applying The List Approach for compliance with Minimum Requirement #5: Onsite Stormwater Management.

The infeasibility criteria shall also be used to determine the appropriateness of installing ballasted sidewalks on a project site. Project proponents may be allowed to install ballasted sidewalks even if considered infeasible, unless otherwise stated within the specific infeasibility criteria, provided documentation is included that substantiates the design. Documentation may be required by a Washington State Licensed Professional Engineer or other appropriate professional depending upon the project conditions.

Setback distances are measures from the edge of the pavement section.

A site characterization study must be completed in order to determine if the following infeasibility criteria apply.

The following infeasibility criteria require evaluation of site specific conditions and a written recommendation from an appropriate Washington State Licensed Professional (e.g., Professional Engineer, Professional Geologist, Professional Hydrogeologist)

- Where professional geotechnical evaluation recommends infiltration not be used due to reasonable concerns about erosion, slope failure, or down gradient flooding.
- Within an area whose groundwater flows into an erosion hazard or landslide hazard area.
- Where infiltrating and ponded water below ballasted sidewalks would compromise existing adjacent impervious pavements.
- Where infiltrating and ponded water below ballasted sidewalks would threaten existing below grade basements.
- Where infiltrating water would threaten shoreline structures such as bulkheads.

- Downslope of steep, erosion prone areas that are likely to erode sediment.
- Where fill soils are used that can become unstable when saturated.
- Excessively steep slopes where water within the aggregate base layer or at the subgrade surface cannot be controlled by detention structures and may cause erosion and structural failure, or where surface runoff velocities may preclude adequate infiltration at the pavement surface.
- Where installation of ballasted sidewalks would threaten the safety or reliability of preexisting underground utilities, preexisting underground storage tanks, preexisting structures, or preexisting road or parking lot surfaces.

The following infeasibility criteria are based upon subsurface characteristics and require a soils report to determine infeasibility. See Appendix B: Soils Reports for Soils Report Requirements.

- Where the minimum vertical separation between the bottom of the ballast and the seasonal high groundwater elevation, bedrock or other impermeable layer is 1 foot or less.
- Where the field testing indicates potential locations have a measured (initial) native soil saturated hydraulic conductivity less than 0.3 inches/hour.
- Ballasted Sidewalks installed for the purposes of Minimum Requirement #5 shall only be constructed where infiltration is feasible.
    - If the measured soil infiltration rate is less than 0.30 inches/hour, ballasted sidewalks cannot be used to meet The List Approach.

The following infeasibility criteria are based on conditions such as topography and distances to predetermined boundaries. Citation of the following do not need site-specific written recommendations from a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist though some criteria may require professional services to determine if the infeasibility criteria apply.

- Within an area designated as an erosion hazard or landslide hazard.
- For properties with known soil or groundwater contamination:
    - Within 100 feet of an area known to have deep soil contamination;
    - Where groundwater modeling indicates infiltration will likely increase or change the direction of the migration of pollutants in the groundwater;
    - Wherever surface soils can be found to be contaminated unless those soils are removed within 10 horizontal feet from the infiltration area;
    - Any area where these facilities are prohibited by an approved cleanup plan under the state Model Toxics Control Act or Federal Superfund Law, or an environmental covenant under Chapter 64.70 RCW.
- Within 100 feet of a closed or active landfill.
- Within 100 feet of a drinking water well, or a spring used for drinking water supply if the permeable pavement is (or has run-on from) a pollution-generating hard surface
- Within 10 feet of small on-site sewage disposal drainfield, including reserve areas, and greywater reuse systems. For setbacks from a “large on-site sewage disposal system”, see WAC Chapter 246-272B.
- Within 10 feet of an underground storage tank and connecting underground pipes, regardless of tank size. As used in this criteria, an underground storage tank means any

tank used to store petroleum products, chemicals, or liquid hazardous wastes of which 10% or more of the storage volume (including volume in the connecting piping system) is beneath the ground surface.

- Where the subgrade slope exceeds 6% after reasonable efforts to grade.
- Where routine, heavy applications of sand occur in frequent snow zones to maintain traction during weeks of snow and ice accumulation. Most lowland western Washington areas do not fit this criterion.
- If there are any conflicts with any of the following competing needs criteria:
  - Requirements of the following federal or state laws, rules, and standards:
    - Historic Preservation Laws and Archaeology Laws as listed at: https://dahp.wa.gov/project-review/preservation-laws
    - Federal Superfund or Washington State Model Toxics Control Act
    - Federal Aviation Administration requirements for airports
    - American with Disabilities Act
  - When found to be in conflict with special zoning district design criteria adopted and being implemented pursuant to a community planning process.
  - Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.
  - City of Tacoma Critical Area Ordinances that provides protection of tree species or other critical areas.
- Within 10 feet of a building structure.
- Where infiltration could negatively affect downgradient properties.
- Within 50 feet from the top of any slope greater than 20% and from geologically hazardous areas. The ballasted sidewalk may be sited within 50 feet of a slope greater than 20% and/or geologically hazardous area if a geotechnical analysis performed by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist determines that there will be no negative impacts to the slopes and/or geologically hazardous areas caused by the ballasted sidewalk.

10.6.4 Subsurface Characteristics

A soils report is required to design ballasted sidewalks. A soils report is also required if citing that ballasted sidewalks are not feasible due to subsurface characteristics. See Appendix B: Soils Reports for requirements.

10.6.5 Design Criteria

Ballasted sidewalks shall be designed per City of Tacoma Standard Plan SU-04a with a minimum 6” permeable ballast section below the sidewalk.

Limit run-on to the maximum extent practicable. Run-on shall only be allowed from fully stabilized areas.

Modeling in an Ecology approved continuous simulation model is required to obtain flow credits. Model the facility using the gravel trench bed element.

Chapter 11 Bioretention and Rain Gardens

11.1 BMP L601: Rain Gardens

11.1.1 Purpose

Rain gardens are non-engineered, shallow, landscaped depressions with compost-amended soils and adapted plants. Rain gardens temporarily store stormwater from adjacent areas. Stormwater passes through the amended soil profile and into the native soil beneath. Stormwater that exceeds the rain garden is designed to overflow to an adjacent stormwater system.

Rain Gardens are not BMP L630: Bioretention BMPs. Rain gardens cannot be used in place of Bioretention (BMP L630). Bioretention and rain gardens have different design specifications and sizing guidance. It is possible to quantify the amount of stormwater treatment and flow control provided by a bioretention BMP due to the specific design, sizing, bioretention soil mix, and modeling requirements. Although rain gardens are presumed to provide some amount of stormwater treatment and flow control, it is not possible to quantify that amount due to the allowable variations in the installation. See BMP L630 – Bioretention for further guidance

11.1.2 Application

- This BMP can be utilized to ensure compliance with Minimum Requirement #5: Onsite Stormwater Management.
- Where compliance with Minimum Requirements is not required, where feasible, this BMP is recommended to be used to help protect receiving waterbodies from the effects of stormwater.

11.1.3 Infeasibility Criteria

The following infeasibility criteria describe conditions that make rain gardens infeasible when applying The List Approach for compliance with Minimum Requirement #5: Onsite Stormwater Management.

The infeasibility criteria shall also be used to determine the appropriateness of installing rain gardens. Project proponents may be allowed to install a rain garden even if considered infeasible, unless otherwise stated within the specific infeasibility criteria, provided documentation is included that substantiates the design. Documentation may be required by a Washington State Licensed Professional Engineer or other appropriate professional depending upon the project conditions.

Setback distances are measured from the bottom edge of the rain garden soil mix.

A site characterization study must be completed in order to determine if the following infeasibility criteria apply and to determine the appropriateness of installing a rain garden.

The following infeasibility criteria are based on conditions such as topography and distances to predetermined boundaries. Citation of the following do not need site-specific written recommendations from a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist though some criteria may require professional services to determine if the infeasibility criteria apply.

- Within 10 feet of a building structure.
- Within 5 feet of any other structure or property line.

- Within 50 feet from the top of any slope greater than 20% and geologically hazardous areas. The rain garden may be sited within 50 feet of a slope greater than 20% and/or geologically hazardous area if a geotechnical analysis performed by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist determines that there will be no negative impacts to the slopes and/or geologically hazardous area caused by the rain garden.
- Where land for the rain garden is within an area designated as an erosion hazard or landslide hazard.
- Within 100 feet of an underground storage tank and connecting underground pipes when the capacity of the tank and pipe system is greater than 1100 gallons.
- Within 10 feet of an underground storage tank and connecting underground pipes when the capacity of the tank and pipe system is 1100 gallons or less. (As used in this criteria, an underground storage tank means any tank used to store petroleum products, chemicals, or liquid hazardous wastes of which 10% or more of the storage volume (including volume in the connecting piping system) is beneath the ground surface.)
- Within 100 feet of a closed or active landfill.
- Within 100 feet of a drinking water well, or a spring used for drinking water supply.
- Within 10 feet of small on-site sewage disposal drainfield, including reserve areas, and greywater reuse systems. For setbacks from a “large on-site sewage disposal system”, see WAC Chapter 246-272B.
- Where the site cannot be reasonably designed to locate rain garden on slopes less than 8%.
- Where they are not compatible with the surrounding stormwater system (e.g., surfaces drain to an existing stormwater system whose elevation precludes proper connection to the bioretention facility).
- For properties with known soil or groundwater contamination:
  - Within 100 feet of an area known to have deep soil contamination;
  - Where groundwater modeling indicates infiltration will likely increase or change the direction of the migration of pollutants in the groundwater.
  - Wherever surface soils can be found to be contaminated unless those soils are removed within 10 horizontal feet from the infiltration area;
  - Any area where these facilities are prohibited by an approved cleanup plan under the state Model Toxics Control Act or Federal Superfund Law, or an environmental covenant under Chapter 64.70 RCW.
- Where rain gardens are constructed with imported compost material within ¼ mile of the rain garden. The restriction does not apply to construction within ¼ mile of Wapato Lake.
- If there are any conflicts with any of the following competing needs criteria:
  - Requirements of the following federal or state laws, rules, and standards:
    - Historic Preservation Laws and Archaeology Laws as listed at: https://dahp.wa.gov/project-review/preservation-laws
    - Federal Superfund or Washington State Model Toxics Control Act
    - Federal Aviation Administration requirements for airports
    - American with Disabilities Act

- When found to be in conflict with special zoning district design criteria adopted and being implemented pursuant to a community planning process.
- Public health and safety standards
- Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.
- City of Tacoma Critical Area Ordinances that provides protection of tree species or other critical areas.

The following infeasibility criteria are based upon subsurface characteristics and require a soils report to determine infeasibility. See Appendix B: Soils Reports for Soils Report Requirements.

- Where the minimum vertical separation between the lowest elevation of the rain garden soil mix and the seasonal high groundwater elevation, bedrock or other impermeable layer is 1 foot or less.
- Where the field testing indicates potential rain garden locations have a measured (initial) native soil saturated hydraulic conductivity less than 0.3 inches/hour.
  - Rain gardens installed for the purposes of Minimum Requirement #5: Onsite Stormwater Management shall only be constructed where infiltration is feasible.
  - If the measured soil infiltration rate is less than 0.30 inches/hour, rain gardens cannot be used to meet The List Approach.

The following infeasibility criteria require evaluation of site specific conditions and a written recommendation from an appropriate Washington State Licensed Professional (e.g., Professional Engineer, Professional Geologist, Professional Hydrogeologist)

- Where the only area available for siting would threaten the safety or reliability of preexisting underground utilities, preexisting underground storage tanks, preexisting structures, or preexisting road or parking lot surfaces.
- Where the only area available for siting does not allow for a safe overflow pathway to the City stormwater system or a private stormwater system.
- Where professional geotechnical evaluation recommends infiltration not be used due to reasonable concerns about erosion, slope failure, or down gradient flooding.
- Within an area whose groundwater drains into an erosion hazard or landslide hazard area.
- Where infiltrating water would threaten existing below grade basements.
- Where infiltrating water would threaten shoreline structures such as bulkheads.
- Where there is lack of usable space onsite for rain gardens at redevelopment sites.
- For work within the public right of way, for public road projects, where there is insufficient space.

11.1.4 Subsurface Characterization

- A soils report is required to design a rain garden. A soils report is also required if citing that a rain garden is not feasible due to subsurface characteristics. See Appendix B - Soils Reports for Soils Report requirements.

11.1.5 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

11.1.5.1 Rain Garden Siting

Project design shall consider the following for siting the rain garden.

- *Utility conflicts*: See Volume 5 for utility separation requirements.
- *Transportation safety*: The design configuration and selected plant types should provide adequate sight distances, clear zones, and appropriate setbacks for roadway applications in accordance with City of Tacoma Design Standards.
- *Impacts of surrounding activities*: Human activity influences the location of the facility in the development. For example, locate rain gardens away from traveled areas on individual lots to prevent soil compaction and damage to vegetation or provide elevated or bermed pathways in areas where foot traffic is inevitable. Provide barriers, such as wheel stops, to restrict vehicle access in roadside applications.
- *Visual buffering*: Rain gardens can be used to buffer structures from roads, enhance privacy among residences, and for an aesthetic site feature.

11.1.5.2 Flow Entrance

- Use one of the following types of flow entrances (other alternatives may be considered on a case-by-case basis):
  - Dispersed across a landscaped area.
  - Dispersed through an open swale with plants and decorative rock. For slopes greater than 2%, add rock check dams every 5 to 10 feet to slow water flow.
  - Pipe flow entrance.

    Place a rock pad where stormwater enters the rain garden from a swale or pipe. It is recommended to use washed round rock that is a minimum of 2 inches in diameter. Rock pad should be 4” thick and 2 feet wide and extend 2 feet.

    Avoid the use of angular rock or quarry spalls as sediment removal is difficult.
- The City of Tacoma may require flow dispersion for rain gardens depending upon type of inlet design and size of the facility.
- Do not place plants directly in the entrance flowpath as they can restrict or concentrate flows.
- Install flow diversion and erosion control measures to protect the rain garden from sedimentation until the upstream area is stabilized.

11.1.5.3 Cell Ponding Area

- The ponding depth shall be 6" minimum and 18” maximum.
- The minimum freeboard measured from the maximum ponding water surface elevation to the top of the facility shall be 2” for contributing areas less than 1,000 square feet and 6” for contributing areas 1,000 square feet or greater.

- If berming is used to achieve the minimum top elevation, maximum slope on berm shall be 2H:1V, and minimum top width of design berm shall be 1 foot. Berm shall be a material which is water tight. Imported soil may be necessary to ensure berm does not fail. Berm shall be tightly packed during construction.

11.1.5.4 Overflow

- Provide an overflow pathway lined with a 4” thick washed rock pad. Washed rock shall be a minimum of 2 inches in diameter. Extend overflow 4 feet past rain garden edge.
- Overflow shall not be directed to structures, neighboring properties, or over sidewalks.
- Overflow shall not cause damage to downstream properties or receiving waters.

11.1.5.5 Rain Garden Soil Mix

- Minimum depth of rain garden mix shall be 12 inches.
- The compost component shall meet the specifications in A900: Compost.
- Obtain a rain garden soil mix by one of the following methods.
    - Method 1: Excavate and replace existing soil with a rain garden soil mix.
        - Use this method if existing soils are poor quality.
            - If clay content is greater than 5%.
            - In gravel soils as plant growth will be inhibited.

        A rain garden soil mix typically contains about 60% sand content and 40% compost by volume.

    - Method 2: Excavate and amend existing soil
        - Use 1/3 compost to every 2/3 of existing soil.
        - Use this method when existing soils are moderately good to good quality soils.
            - Do not use this method if clay content is greater than 5%. Use Method 1.
    - Method 3: Amend Soil in Place
        - Use this method if the existing soils are good quality.
            - Do not use this method if the clay content is greater than 5%. Use Method 1.
            - Use this option only if the infiltration rate is 1 inch per hour or greater.
        - Amend soil by excavating to the ponding depth plus 3 inches. Spread 3 inches of compost and till to depth of 4 to 5 inches to fully incorporate compost component.

11.1.5.6 Underdrain

Do not use underdrains in rain gardens.

11.1.5.7 Planting

Submit a planting plan showing the type (species), location and size of each plant.

Plants must be tolerant of summer drought, ponding fluctuation, and saturated soil conditions.

Rain gardens have three planting zones. Zone 1 is bottom area of the rain garden, which is frequently wet during the rainy season. Zone 2 includes the side slopes, which occasionally become wet during rain events. Zone 3 includes the area around the perimeter of the rain garden, starting above the top surface of ponding elevation, which has drier soil.

See A1000: Vegetation for plants appropriate for rain gardens. For rain gardens that will be publicly maintained, plants must be chosen from the list and approved by the City of Tacoma. Additional information on planting zones and appropriate plants for each zone can be obtained through the Rain Garden Handbook for Western Washington, available at https://extension.wsu.edu/raingarden/homeowner-resources/.

- In general, the following guidelines should be used when considering which plants to use:
  - At least 50% (by quantity) should be evergreen plants. Leaf fall can reduce the function of the facility.
  - Do not leave large areas of the soil unplanted/uncovered. Exposed soil can cause erosion and reduce the function of the facility. Plant types can be overlapped (tree canopy can overlap shrubs and groundcover) to reduce the area of exposed soil.
  - Provide a variety of plant types with various rooting structures. Plant variety encourages good soil health. Typical plant types used in rain garden construction include:
    - Emergents: Rushes, grasses, and sedges have shallow, fibrous roots that remain close to the soil surface. Planting solely with shallow rooted plants can cause thick root mats to form decreasing the infiltrative ability of the soil.
    - Woody shrubs and trees: Woody shrubs and trees have a mixture of shallow fibrous roots and deeper structural roots that can penetrate deeper into the soil and increase soil porosity over time.
    - Groundcover: Groundcover tends to form dense masses of vegetation low to the ground surface. Low, dense vegetation can be effective at consolidating soil in areas otherwise prone to erosion such as the side slopes of the facility (Zone 2).
    - Herbaceous perennials: Herbaceous perennials do not have woody plant parts and the above ground growth typically dies back in the winter.
- Roots must not damage underground infrastructure.
- Consider adjacent plant communities and avoid potential invasive species.
- Consider aesthetics, rain gardens should blend into surrounding landscapes.
- Irrigation may be required until plants are fully established and in the summer months.

11.1.5.8 Mulch Layer

Rain garden facilities should be designed with a mulch layer. Properly selected mulch material reduces weed establishment, regulates soil temperatures and moisture, and adds organic matter to the soil.

- Mulch should be free of weed seeds, soil, roots, and other material that is not trunk or branch wood and bark. Mulch shall not include grass clippings, mineral aggregate, pure bark, or beauty bark. Mulch should be coarse mulch.
- Mulch should be:
  - Wood chip mulch composed of shredded or chipped hardwood or softwood, depth 2-3 inches. Additional rain garden depth will be needed to ensure appropriate ponding and freeboard.
- A dense groundcover can be used as an alternative to mulch although mulch should be used until the dense groundcover is established.

11.1.5.9 Sizing and Geometry

- The top of the ponded surface area below the overflow shall be at least 5% of the total area draining to it.
- The maximum side slopes allowed shall be 2:1.

The following table provides the minimum top of ponded surface area, minimum bottom pond area, and minimum top of berm area based upon side slope and contributing area. The applicant shall determine the geometry of their rain garden based upon contributing square footage, minimum sizing criteria and preferred side slope. The applicant shall submit the proposed ponding area, bottom ponding area and top of berm area to the City of Tacoma.

Table 4 - 11: Rain Garden Sizing and Geometry

Side Slope	Contributing Area (square feet)	Minimum Top of Ponding Area (square feet)	Minimum Bottom of Ponding Area (square feet)	Minimum Top of Berm Area (square feet)
2:1	800 or less	40	0.11	50
2:1	1400 or less	70	0.13	110
3:1	3000 or less	150	0.06	235

11.1.6 General Construction Criteria

- Do not install media or excavate rain garden during soil saturation periods.
- Excavation and soil placement should be done from equipment operating adjacent to the facility – no heavy equipment should be operated in the facility.
- If equipment must be operated within the facility for excavation, use lightweight, low ground pressure equipment and scarify the base to reduce compaction upon completion. Do not use equipment on top of rain garden soil mix.
- Do not use fully excavated rain garden for erosion and sediment control during construction.
- Clogged soil and silt shall be removed during excavation to finished bottom grade prior to installing rain garden soil mix.
- Scarify sides and bottom to roughen where equipment may have compacted soil.
- Ensure the rain garden is protected from erosion and sedimentation until all contributory areas are fully stabilized.

- If sedimentation occurs within the rain garden, excavate the area a minimum of 12 inches below final grade to remove sediment and replace media, mulch, and plants as necessary.

11.1.7 Rain Garden Modeling

No flow credits are allowed for rain gardens and therefore rain gardens should not be included as BMPs that mitigate for stormwater for flow control purposes in the model. Areas contributing to the rain garden and the rain garden itself shall be modeled as impervious surface area.

11.2 BMP L630: Bioretention

11.2.1 Purpose

Bioretention areas are shallow landscaped depressions with a designed soil mix and plants adapted to the local climate and soil moisture conditions that receive stormwater from a contributing area. Bioretention areas can provide effective removal of many stormwater pollutants and reduce stormwater flowrates and volume.

Bioretention BMPs are not BMP L601 - Rain Gardens. Bioretention and rain gardens have different design specifications and sizing guidance. It is possible to quantify the amount of stormwater treatment and flow control provided by a bioretention BMP due to the specific design, sizing, bioretention soil mix, and modeling requirements. Although rain gardens are presumed to provide some amount of stormwater treatment and flow control, it is not possible to quantify that amount due to the allowable variations in the installation. See BMP L601 – Rain Gardens for further guidance.

In this manual, bioretention areas are categorized as follows:

- Bioretention cells: Shallow depressions with bioretention soil mix and a variety of plant material, including trees, shrubs, grasses, and/or other herbaceous plants. Bioretention cells may or may not have an underdrain and are not designed as a conveyance system.
- Bioretention swales: Incorporate the same design features as bioretention cells; however, bioretention swales are designed as part of a system that can convey stormwater when maximum ponding depth is exceeded.
- Bioretention planters and planter boxes: Bioretention soil mix and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants within a vertical walled container usually constructed from formed concrete, but could include other materials. Planter boxes are completely impervious and include a bottom (must include an under-drain). Planters have an open bottom and allow infiltration to the subgrade. These designs are often used in ultra-urban settings.

Note: Ecology has approved use of certain patented treatment systems that use specific, high rate media for treatment. Such systems are not considered LID BMPs and are not options for meeting the requirements of Minimum Requirement #5: Onsite Stormwater Management. The Ecology approval is meant to be used for Minimum Requirement #6: Stormwater Treatment, where appropriate.

11.2.2 Application

- This BMP can be utilized to ensure compliance with Minimum Requirement #5: Onsite Stormwater Management.
    - The BMP can be used solely to mitigate for roof surfaces and other hard surfaces if utilizing the List Approach or may be used in combination with other BMPs to satisfy the LID Performance Standard.
    - Bioretention facilities installed for Minimum Requirement #5: Onsite Stormwater Management shall only be constructed where infiltration is feasible.
- This BMP may also be used to help ensure compliance with Minimum Requirement #6: Stormwater Treatment, Minimum Requirement #7: Flow Control, and Minimum Requirement #8: Wetlands Protection.

- Where compliance with Minimum Requirements is not required, where feasible, this BMP is recommended to be used to help protect receiving waterbodies from the effects of stormwater.

11.2.3 Infeasibility Criteria

The following infeasibility criteria describe conditions that make bioretention infeasible when applying The List Approach for compliance with Minimum Requirement #5: Onsite Stormwater Management.

The infeasibility criteria shall also be used to determine the appropriateness of installing bioretention facilities. Project proponents may be allowed to install a bioretention facility even if considered infeasible, unless otherwise stated within the specific infeasibility criteria, provided documentation is included that substantiates the design. Documentation may be required by a Washington State Licensed Professional Engineer or other appropriate professional depending upon the project conditions.

Setback distances are measures from the bottom edge of the bioretention soil mix.

A site characterization study must be completed in order to determine if the infeasibility criteria apply and to determine appropriateness of installing a bioretention facility.

The following infeasibility criteria are based on conditions such as topography and distances to predetermined boundaries. Citation of the following do not need site-specific written recommendations from a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist though some criteria may require professional services to determine if the infeasibility criteria apply.

- Within 10 feet of a building structure.
- Within 5 feet of any other structure or property line.
- Within 50 feet from the top of any slope greater than 20% and geologically hazardous areas. The bioretention facility may be sited within 50 feet of a slope greater than 20% and/or geologically hazardous area if a geotechnical analysis performed by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist determines that there will be no negative impacts to the slopes and/or geologically hazardous area caused by bioretention facility.
- Where land for the bioretention facility is within an area designated as an erosion hazard or landslide hazard.
- Within 100 feet of an underground storage tank and connecting underground pipes when the capacity of the tank and pipe system is greater than 1100 gallons.
- Within 10 feet of an underground storage tank and connecting underground pipes when the capacity of the tank and pipe system is 1100 gallons or less. (As used in this criteria, an underground storage tank means any tank used to store petroleum products, chemicals, or liquid hazardous wastes of which 10% or more of the storage volume (including volume in the connecting piping system) is beneath the ground surface.)
- Within 100 feet of a closed or active landfill.
- Within 100 feet of a drinking water well, or a spring used for drinking water supply.
- Within 10 feet of small on-site sewage disposal drainfield, including reserve areas, and greywater reuse systems. For setbacks from a “large on-site sewage disposal system”, see WAC Chapter 246-272B.

- Where the site cannot be reasonably designed to locate bioretention facilities on slopes less than 8%.
- Where they are not compatible with the surrounding stormwater system (e.g., surfaces drain to an existing stormwater system whose elevation precludes proper connection to the bioretention facility).
- For properties with known soil or groundwater contamination:
  - Within 100 feet of an area known to have deep soil contamination;
  - Where groundwater modeling indicates infiltration will likely increase or change the direction of the migration of pollutants in the groundwater.
  - Wherever surface soils can be found to be contaminated unless those soils are removed within 10 horizontal feet from the infiltration area;
  - Any area where these facilities are prohibited by an approved cleanup plan under the state Model Toxics Control Act or Federal Superfund Law, or an environmental covenant under Chapter 64.70 RCW.
- Where bioretention facilities are constructed with imported compost material and are located within ¼ mile of a phosphorus-sensitive waterbody and the underlying native soil does not meet the Soil Physical and Chemical Suitability for Treatment (Volume 4, Section 10.1.4.1.3). Monitoring indicates that new bioretention BMPs using either the Default BSM or Custom BSM can add phosphorus to stormwater. The restriction does not apply to construction within ¼ mile of Wapato Lake as Wapato Lake is considered a losing lake (ie. water infiltrated does not reach the lake).
  - Bioretention BMPs using the High Performance BSM may be used with or without an underdrain within 1/4 mile of phosphorus-sensitive waterbodies.
- Where bioretention facilities with underdrains discharge to a stormwater system that discharges to phosphorus-sensitive waterbody within ¼ mile of the facility.
- If there are any conflicts with any of the following competing needs criteria:
  - Requirements of the following federal or state laws, rules, and standards:
    - Historic Preservation Laws and Archaeology Laws as listed at: https://dahp.wa.gov/project-review/preservation-laws
    - Federal Superfund or Washington State Model Toxics Control Act
    - Federal Aviation Administration requirements for airports
    - American with Disabilities Act
  - When found to be in conflict with special zoning district design criteria adopted and being implemented pursuant to a community planning process.
  - Public health and safety standards
  - Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.
  - City of Tacoma Critical Area Ordinances that provides protection of tree species or other critical areas.

The following infeasibility criteria are based upon subsurface characteristics and require a soils report to determine infeasibility. See Appendix B: Soils Reports for Soils Report Requirements.

- Where the minimum vertical separation between the lowest elevation of the bioretention soil mix or any underlying gravel infiltration layer and the seasonal high groundwater elevation, bedrock or other impermeable layer is 1 foot or less. This applies only if the contributing area to the bioretention facility has:
  - less than 5,000 square feet of pollution-generating impervious surface, and
  - less than 10,000 square feet of impervious surface, and
  - less than ¾ acre of pervious surface.
- Where the minimum vertical separation between the lowest elevation of the bioretention soil mix or any underlying gravel infiltration layer and the seasonal high groundwater elevation, bedrock or other impermeable layer is 3 foot or less. This applies if the contributing area to the bioretention facility has:
  - 5,000 square feet or more of pollution-generating impervious surface, or
  - 10,000 square feet or more of impervious surface, or
  - more than ¾ acre of pervious surface.

  AND the bioretention facility cannot reasonably be broken into amounts smaller than those listed above.
- Where the field testing indicates potential bioretention locations have a measured (initial) native soil saturated hydraulic conductivity less than 0.3 inches/hour.
  - Bioretention facilities installed for the purposes of Minimum Requirement #5: Onsite Stormwater Management shall only be constructed where infiltration is feasible.
  - If the measured soil infiltration rate is less than 0.30 inches/hour, bioretention cannot be used to meet The List Approach.
  - If an elevated underdrain is proposed, bioretention may be used to help achieve the LID Performance Standard (Minimum Requirement #5) and/or help provide flow control as needed to meet the intent of Minimum Requirement #7: Flow Control and/ or Minimum Requirement #8: Wetlands Protection.

The following infeasibility criteria require evaluation of site specific conditions and a written recommendation from an appropriate Washington State Licensed Professional (e.g., Professional Engineer, Professional Geologist, Professional Hydrogeologist)

- Where the only area available for siting would threaten the safety or reliability of preexisting underground utilities, preexisting underground storage tanks, preexisting structures, or preexisting road or parking lot surfaces.
- Where the only area available for siting does not allow for a safe overflow pathway to the City stormwater system or a private stormwater system.
- Where professional geotechnical evaluation recommends infiltration not be used due to reasonable concerns about erosion, slope failure, or down gradient flooding.
- Within an area whose groundwater drains into an erosion hazard or landslide hazard area.
- Where infiltrating water would threaten existing below grade basements.
- Where infiltrating water would threaten shoreline structures such as bulkheads.
- Where there is lack of usable space onsite for bioretention facilities at redevelopment sites.

- For work within the public right of way, for public road projects, where there is insufficient space.

11.2.4 Subsurface Characterization

A soils report is required to design a bioretention facility that will infiltrate. A soils report is also required if citing that a bioretention facility is not feasible due to subsurface characteristics. See Appendix B: Soils Reports for Soils Report requirements.

11.2.5 Design Steps

Below are the general steps to take when designing a bioretention facility. Note, some approved continuous simulation models may complete many of these steps for you.

1. Determine the water quality design flow rate. See Volume 4 – Section 2.2.3 – Water Quality Design Flowrate.
2. Determine the subgrade (i.e., the native soil) long-term design infiltration rate. See Volume 4 – Appendix A – Determine the Design Infiltration Rate.
3. Determine the long-term infiltration rate of the BSM. See Volume 4 – Section 11.2.6.6 – Bioretention Soil Mix
4. Calculate the required surface area (i.e. the horizontally projected area at the BMP overflow) of the bioretention BMP by dividing the water quality design flowrate by either:

    a. The long-term design infiltration rate of the BSM, or

    b. The long-term design infiltration rate of the subgrade soils

    If the design proposes to infiltrate stormwater into the subgrade soils: use whichever of a. or b. above that has the lowest infiltration rate.

    If the design proposes to utilize an underdrain below the BSM layer, use the long-term design infiltration rate of the BSM.
5. Define the bioretention BMP geometry including: bottom width, longitudinal slope, side slopes, BSM depth, and ponding area depth (including maximum ponding depth and freeboard).
6. Define the available storage in the bioretention BMP, including storage in the ponding area and in the voids of the BSM. For BMPs with longitudinal slopes greater than 1%, account for the reduced available storage volume due to slopes. Also account for the effect of weirs or check dams on available storage volume, if applicable.
7. If designs include an underdrain, account for the reduced or eliminated infiltration benefits of the system when analyzing Flow Control and/or Stormwater Treatment performance.
8. Conduct continuous simulation modeling to confirm and/or iterate BMP sizing to meet Stormwater Treatment, Flow Control, and/or LID Performance Standard requirements. Include appropriate orifices or other flow control structures and overflows in the analysis, as applicable.
9. Check that the design freeboard and maximum drawdown time of 24 hours are met.

11.2.6 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

11.2.6.1 Bioretention Siting

The following factors shall be considered when siting the bioretention facility.

- *Utility conflicts*: See Volume 5 for utility separation requirements.
- *Transportation safety*: The design configuration and selected plant types should provide adequate sight distances, clear zones, and appropriate setbacks for roadway applications in accordance with local jurisdiction requirements. The following website contains information for landscaping within the City of Tacoma right of way: tacoma.gov/government/departments/environmental-services/urban-forestry/. The following website contains information for clearance standards within the City of Tacoma: tacoma.gov/government/departments/environmental-services/urban-forestry/.
- *Impacts of surrounding activities*: Human activity influences the location of the facility in the development. For example, locate bioretention areas away from traveled areas on individual lots to prevent soil compaction and damage to vegetation or provide elevated or bermed pathways in areas where foot traffic is inevitable. Provide barriers, such as wheel stops, to restrict vehicle access in roadside applications and parking areas.
- *Visual buffering*: Bioretention facilities can be used to buffer structures from roads, enhance privacy among residences, and for an aesthetic site feature.

11.2.6.2 Flow Entrance/Presettling

- Flow velocity entering the facility shall be less than 1 ft/sec for the 100-year, 24-hour storm event. If 1 ft/sec cannot be obtained, a designed flow dispersion or energy dissipation device may be required depending on the type of inlet and the size of facility.
- Use the following types of flow entrances (other alternatives may be considered on a case-by-case basis):
    - *Dispersed, low velocity flow across a landscape area:* Landscape areas and vegetated buffer strips slow incoming flows and provide an initial settling of particulates and are the preferred method of delivering flows to the bioretention cell. A minimum 1-inch grade change between the edge of the contributing area and the flow entrance is required.
    - *Dispersed or sheet flow across pavement or gravel and past wheel stops for parking areas.*
    - *Curb cuts for roadside, driveway or parking lot areas:*
        - Curb cuts shall include a rock pad, concrete or other erosion protection material in the channel entrance to dissipate energy.
        - Minimum curb cut width: 12 inches; Design curb cut width based on site and runoff conditions.

        - Avoid the use of angular rock or quarry spalls and instead use round (river) rock if needed. Removing sediment from angular rock is difficult.
        - Flow entrance should drop at least 3" from curb line and provide an area for settling and periodic removal of sediment and coarse material before flow dissipates to the remainder of the cell.
    - *Curb cuts for high use parking lots or roadways* require increased level of maintenance due to high coarse particulates and trash accumulation. The following are methods recommended for areas where heavy trash and coarse particulates are anticipated:
        - Minimum Curb cut width: 18 inches.
        - At a minimum, the flow entrance should drop 3 inches from gutter line into the bioretention area and provide an area for settling and periodic removal of debris.
        - Anticipate relatively more frequent inspection and maintenance for areas with large impervious areas, high traffic loads and larger debris loads.
        - Presettling areas (such as catch basins or forebays) may be necessary at the flow entrance to adequately capture debris and sediment load from large contributing areas and high use areas. Piped flow entrance in this setting can easily clog and catch basins with regular maintenance are necessary to capture coarse and fine debris and sediment.
    - *Pipe flow entrance:* Piped entrances shall include rock or other erosion protection material in the channel entrance to dissipate energy and disperse flow.*Trench drains:* can be used to cross sidewalks or driveways where a deeper pipe conveyance creates elevation problems.
    - *Trench drains* tend to clog and may require additional maintenance.
- Do not place plants directly in the entrance flowpath as they can restrict or concentrate flows.
- Install flow diversion and erosion control measures to protect the bioretention area from sedimentation until the upstream area is stabilized.
- Presettling is recommended for concentrated flow entrances (curb cuts, trench drains, and pipes) to reduce accumulation of sediment and trash in the bioretention area. Catch basins and open forebays are examples of presettling areas.
    - Catch basins. Where higher than usual sediment is anticipated (road sanding, heavy traffic, etc), catch basins can be used to settle sediment and release water through the grate.
    - Open forebays (presettling areas designed to capture and hold flows that first enter the bioretention BMP). The bottom of the presettling area should be large rock (4”-8” streambed or round cobbles) or a concrete pad with a porous berm or weir that ponds the water to a maximum depth of 12”.

11.2.6.3 Ponding Area

The cell ponding area provides storage for runoff and particulate settling (the first stage of pollutant removal). The ponding depth and drawdown times requirements ensure facility function by providing sufficient storage, ensuring adequate infiltration, and ensuring soil moisture conditions allow for a range of plant species. Soils must dry out periodically in order to restore hydraulic capacity to receive flows from subsequent storms; maintain infiltration rates; maintain adequate soil oxygen levels for healthy soil biota and vegetation; and provide proper soil conditions for biodegradation and retention of pollutants.

The following design criteria apply to the ponding area:

- The surface pool drawdown time shall be less than 24 hours after cessation of flow to the BMP.
- Maximum ponding depth shall be 12 inches.
- If berming is used to achieve the minimum top elevation, maximum slope on berm shall be 3H:1V, and minimum top width of design berm shall be 1 foot. Soil for berming shall be imported bioretention soil or amended native soil compacted to a minimum of 90% dry density.

11.2.6.4 Bioretention Slopes

The recommended maximum and minimum dimensions are as follows:

- **Maximum planted side slope if total cell depth is greater than 3 feet:** 3H:1V. If steeper side slopes are necessary, rockeries, concrete walls, or soil wraps may be required. Bike and/or pedestrian safety features, such as railings or curbs with curb cuts, when steep side slopes are adjacent to sidewalks, walkways, or bike lanes may be required.
- **Minimum bottom width for bioretention swales:** 2 feet recommended; 1 foot minimum. Carefully consider flow depths and velocities, flow velocity control (check dams), and appropriate vegetation or rock mulch to prevent erosion and channelization if considering a bottom width less than 2 feet.
- Bioretention areas should have a minimum shoulder of 12 inches between the road edge and the beginning of the bioretention side slope where flush curbs are used. Compaction effort for the shoulder should be 90% standard Proctor.
- The maximum bottom slope is 8%.

11.2.6.5 Overflow

- A vertical pipe stand pipe connected to the downstream system, armored overflow channels, or curb cuts at the downstream end of the bioretention facility can be used as overflows. The overflow shall be set at the designed maximum ponding elevation.
- The minimum freeboard measured from the overflow elevation to the top of the facility shall be 2” for contributing areas less than 1,000 square feet and 6” for contributing areas 1,000 square feet or greater.
- Overflows shall be designed to convey the 100-year recurrence interval flow or maximum flow that can reach the facility if a flow splitter is utilized.
- Overflow channels shall be rock-lined.

- An emergency overflow pathway shall be provided for all facilities to ensure that all potential overflows are directed into the downstream conveyance system or the public right of way.

11.2.6.6 Bioretention Soil Mix

- The long-term design infiltration rate of BSM (any type) shall be based upon the contributing area to the bioretention facility as shown in the table below:

Table 4 - 12: Long-Term Design Infiltration Rate of Bioretention Soil Mix

Contributing Area Thresholds	Initial Saturated Hydraulic Conductivity (Ksat) of BSM (inches/ hour)	Ksat Safety Factor	Long-term Design Infiltration Rate of BSM (inches/hour)
Equal or greater than any of the following: • 5,000 ft^2 of pollution-generating impervious surface; • 10,000 ft^2 of impervious surface; • ¾ acre of lawn and landscaped area	12	4	3
Less than any thresholds above	12	2	6
If the design includes an approved pretreatment BMP. See Volume 4, Chapter 1. *The presettling area of the BMP would not count.	12	2	6

11.2.6.6.1 Default Bioretention Soil Mix

Projects that use the following bioretention soil mix do not have to test the media for the saturated hydraulic conductivity.

The depth of the bioretention soil mix shall be 18". Depths greater than 18" are not recommended due to concerns about phosphorus leaching.

The bioretention soil media (BSM) shall meet the following standards:

- Have a 60-65% mineral aggregate component by volume as specified below and a 35-40% compost component by volume as specified below. Compost used as a component of the default bioretention soil mix (BSM) in bioretention facilities shall meet the specifications in A900: Compost.
- Have organic matter content of 5-8% by weight.

- Have a cation exchange capacity (CEC) ≥5 milliequivalents/100 g dry soil. BSM meeting the above specifications do not have to be tested for CEC value; it is assumed the CEC value is met.

The mineral aggregate component shall meet the following standards:

- Have a maximum of 5% fines with an ideal range between 2-4% fines using ASTM D422.
- Be well graded. According to ASTM D 2487-98, well graded sand should have the following gradation coefficients:
  - Coefficient of Uniformity, $C_u = \left(\frac{D_{60}}{D_{10}}\right)$, equal to or greater than 4 and
  - Coefficient of Curvature, $C_c = \left(\frac{(D_{30})^2}{D_{60} \times D_{10}}\right)$, equal to or greater than 1 and less than or equal to 3
- The gradation in Table 4 - 13: Bioretention Soil Mix Aggregate Component Gradation is considered to be well graded.

Table 4 - 13: Bioretention Soil Mix Aggregate Component Gradation

Aggregate Component (60% by Volume)	
Sieve Size	Percent Passing
3/8”	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

11.2.6.6.2 Custom Bioretention Soil Mix

Projects which prefer to create a custom Bioretention Soil Mix rather than using the default requirements above must demonstrate compliance with the following criteria using the specified test method:

- CEC ≥ 5 meq/100 grams of dry soil; USEPA 9081
- pH between 5.5 and 7.0
- 5 - 8 percent organic matter content before and after the saturated hydraulic conductivity test; ASTM D2974(Standard Test Method for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils)
- 2-5 percent fines passing the 200 sieve; TMECC 04.11-A
- Measured (Initial) saturated hydraulic conductivity of at least 12 inches per hour; ASTM D 2434 (Standard Test Method for Permeability of Granular Soils (Constant Head)) at 85% compaction per ASTM D 1557 (Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort). Use Recommended Modifications for ASTM D 2434 When Measuring Hydraulic Conductivity for Bioretention Soil Mixes (see Section 11.2.6.6.2.1 Recommended Modifications for ASTM D2434 below).
- Design (long-term) saturated hydraulic conductivity of more than 1 inch per hour.

  Note: Design saturated hydraulic conductivity is determined by applying the appropriate infiltration correction factors as shown in Table 4 - 56: Measured Hydraulic Saturated Conductivity Rate Reduction Factors in Appendix A: Determining the Design Infiltration Rate.

- If compost is used in creating the custom mix, it must meet all of the specifications listed above for the Default Bioretention Mix, except for the gradation specification. An alternate gradation may be proposed. The applicant is required to submit the alternate gradation specification which shall indicate the minimum percent passing for a range of similar particle sizes.

  Note: If compost is not used in the custom mix and the custom mix itself does not leach phosphorus or is installed in series with phosphorus treatment, then the custom mix may be used near phosphorus sensitive waterbodies.

The depth of the bioretention soil mix shall be 18". Depths greater than 18" are not recommended due to concerns about phosphorus leaching.

11.2.6.6.2.1 Recommended Modifications for ASTM D2434

Proctor method ASTM D1557 Method C (6-inch mold) shall be used to determine maximum dry density values for compaction of the bioretention soil sample. Sample preparation for the Proctor test shall be amended in the following ways:

1. Maximum grain size within the sample shall be no more than ½ inches in size.
2. Snip larger organic particles (if present) into ½ inch long pieces.
3. When adding water to the sample during the Proctor test, allow the sample to pre-soak for at least 48 hours to allow the organics to fully saturate before compacting the sample. This pre-soak ensures the organics have been fully saturated at the time of the test.

ASTM D2434 shall be used and amended in the following ways:

1. Apparatus:
    a. 6-inch mold size shall be used for the test.
    b. If using porous stone disks for the testing, the permeability of the stone disk shall be measured before and after the soil tests to ensure clogging or decreased permeability has not occurred during testing.
    c. Use the confined testing method, with 5- to 10-pound force spring
    d. Use de-aired water.
2. Sample:
    a. Maximum grain size within the sample shall not be more than ½ inch in size.
    b. Snip larger organic particles (if present) into ½-inch long pieces.
    c. Pre-soak the sample for at least 48 hours prior to loading it into the mold. During the pre-soak, the moisture content shall be higher than optimum moisture but less than full saturation (i.e. there shall be no free water). This pre-soak ensures the organics have been fully saturated at the time of the test.
3. Preparation of Sample:
    a. Place soil in cylinder via a scoop.
    b. Place soil in 1-inch lifts and compact using a 2-inch-diameter round tamper. Pre-weigh how much soil is necessary to fill 1-inch lift at 85% of maximum dry density, then tamp to 1-inch thickness. Once mold is full, verify that density is at 85% of maximum dry density (+ or – 0.5%). Apply vacuum (20 inches Hg) for 15 minutes before inundation.
    c. Inundate sample slowly under a vacuum of 20 inches Hg over a period of 60 to 75 minutes.
    d. Slowly remove vacuum (> 15 seconds).
    e. Sample shall be soaked in the mold for 24 to 72 hours before starting test.
4. Procedure:

a. The permeability test shall be conducted over a range of hydraulic gradients between 0.1 and 2.

b. Steady state flow rates shall be documented for four consecutive measurements before increasing the head.

c. The permeability test shall be completed within one day (one-day test duration).

11.2.6.6.3 High Performance Soil Mix

In 2021, Ecology approved a new, "High Performance" Bioretention Soil Mix (HPBSM).
See *Guidance on Using New High Performance Bioretention Soil Mixes* (Ecology, 2024a) for additional information on the HPBSM.
HPBSM has the advantage over the "Default" and "Custom" BSMs that include compost, in that it may be used, with or without an underdrain, near and within 1/4 mile of phosphorus sensitive waterbodies.

There are 3 layers used in HPBSM. The level of Stormwater Treatment achieved depends on which layers are included in the HPBSM (i.e. HPBSM Type 1, Type 2, or Type 3 as described below). The layers are:

- **HPBSM Compost Surface Layer**
  - 2 inches in depth
  - Compost must meet the "Compost for Default BSM" specifications (above)

  Do not use the HPBSM Compost Surface Layer without the HPBSM Polishing Layer. The HPBSM Polishing Layer is necessary to limit phosphorus and nitrogen export from the HPBSM Compost Surface Layer.

- **HPBSM Primary Layer:**
  - 18 inches in depth
  - 70% sand, 20% coir, and 10% high carbon wood ash (biochar) by volume
- **HPBSM Polishing Layer:**
  - 12 inches in depth
  - 90% sand, 7.5% activated alumina, and 2.5% iron aggregate by volume

  Note: The HPBSM Polishing Layer, when used, is intended to treat immediately after the HPBSM Surface and Primary Layers, either by being located directly beneath those layers or directly in-series.

See *Guidance on Using New High Performance Bioretention Soil Mixes* (Ecology, 2024a) for further details, including specifications and required media testing.

There are 3 alternative configurations for HPBSM, each resulting in a different level of Stormwater Treatment. The Ecology approved configurations for HPBSM are:

- **HPBSM Type 1:** Includes the HPBSM Primary Layer only.
  - HPBSM Type 1 can be used for basic treatment.
- **HPBSM Type 2:** Includes the HPBSM Primary Layer and the HPBSM Polishing Layer
  - HPBSM Type 2 can be used for basic, metals, and phosphorus treatment.

- **HPBSM Type 3:** Includes the HPBSM Compost Surface Layer, the HPBSM Primary Layer, and the HPBSM Polishing Layer.
    - HPBSM Type 3 can be used for basic, metals, and phosphorus treatment. The compost surface layer will help with plant success.

Blending, Delivery, Protection, and Placement of HPBSM

The blending, handling, and placement of the HPBSM Primary and Polishing Layers needs to be done carefully to ensure a successful installation. The contractor shall prepare a Blending, Delivery, Protection, and Placement plan and submit it for review. The HPBSM Primary Layer and HPBSM Polishing Layer media shall be mechanically blended to produce a homogeneous mix by a blending vendor/contractor with soil blending experience. The blending should occur on an impervious (asphalt or concrete) surface pad that has been thoroughly washed clean (e.g. pressure washed) prior to blending or in purpose-built soil blending equipment that has been washed. The blending pad shall be clean and large enough to be able to turn and mix the media without introducing contamination. The blending pad shall be free of standing water before blending and shall be protected from stormwater run-on.

The measurement of the components to be blended shall be by dry weight on scale equipment capable of measuring within 1 pound or in full vessels of a known volume. Estimating the volumes of materials of partially full buckets or vessels shall not be used. Prior to blending, the coconut coir fiber shall be loose and hydrated such that its density is 4-5 pounds per cubic foot. The materials shall be blended until they are in a homogenous mixed state and then protected from contamination or saturation during storage, delivery, stockpiling, and placement.

The HPBSM layers should not be placed if the area is frozen, has standing water, is excessively wet or saturated, or has been subjected to more than 1/2 inch of precipitation within 48 hours before placement, unless approved otherwise by the Engineer. Do not place the HPBSM layers if adequate temporary erosion and sediment control measures are not in place to protect the media from contamination by silt laden run-off.

Place HPBSM layers loosely and evenly, no deeper than these specifications unless otherwise approved by the Engineer, on a properly prepared subgrade. After each lift, rake the surface to a uniform grade. Consolidate the entire surface area of each lift by boot compaction or a lawn roller and rake again to scarify before placing subsequent lifts or planting.

11.2.6.7 Filter Fabric

Do not use filter fabric between the subgrade and the Bioretention Soil Media.

11.2.6.8 Underdrain

Only install underdrains in bioretention areas if:

- Located near sensitive infrastructure where flooding is likely
- The facility if used for treating stormwater discharge from gas stations or other pollutant hotspots.
- A liner is used.
- Infiltration is not permitted due to site suitability criteria.
- The longitudinal slopes are less than 2%.

A bioretention facility with elevated underdrain may be used to satisfy Minimum #5 – List #2 provided the following criteria are met (though an underdrain is not required):

- The measured initial Ksat of the underlying native soils is between 0.3 and 0.6 inches.
- The invert of the underdrain shall be elevated 6” above the bottom of the aggregate bedding layer.
- The distance between the bottom of the bioretention soil mix and the crown of the underdrain pipe shall be greater than 6” but less than 12”.
- The aggregate bedding layer must run the full length and full width of the bottom of the bioretention facility.
- A low permeability liner must not be present.

Underdrains should only be used in areas where the underdrain discharge would not be routed to a phosphorus-sensitive waterbody, unless using the HPBSM.

The underdrain pipe shall meet the following criteria:

- Underdrain pipe diameter will depend on hydraulic capacity required, 4-inch minimum. A minimum 6-inch pipe is required for installations to be maintained by the City of Tacoma.
- Underdrains shall be slotted, thick-walled plastic pipe. The slot opening should be smaller than the smallest aggregate gradation for the gravel filter bed (see underdrain filter bed below) to prevent migration of material into the underdrain pipe. This configuration allows for pressurized water cleaning and root cutting if necessary. Perforated PVC or flexible slotted HDPE pipe cannot be cleaned with pressurized water or root cutting equipment, are less durable and are not recommended. Wrapping the underdrain pipe in filter fabric increases chances of clogging and is not recommended.
- Slotted subsurface PVC pipe per ASTM D1785-12 SCH 40.
- Slots shall be cut perpendicular to the long axis of the pipe and be 0.04 to 0.069 inches by 1 inch long and be spaced 0.25 inches apart (spaced longitudinally). Slots should be arranged in two rows spaced on 45-degree centers and cover ½ of the circumference of the pipe.
- Slots can be oriented on the top or the bottom of the pipe.
- Underdrains shall be sloped a minimum of 0.5 percent unless otherwise specified by the design engineer.
- Provide a 6-inch rigid non-perforated observation pipe or other maintenance access every 250 to 300 feet to provide a clean-out port, as well as an observation well to monitor dewatering rates. Ensure access is placed so that it can be found with full vegetation growth.
- Place underdrain on a bed of mineral aggregate with a minimum thickness of 6 inches and cover with 6” of mineral aggregate to provide a 1-foot minimum depth around the top and sides of the slotted pipe. The following table provides the gradation for the mineral aggregate. All filter media shall be double washed to ensure removal of fines.

Table 4 - 14: Underdrain Mineral Aggregate Gradation

Sieve Size	Percent Passing
¾ inch	100
US No. 4	28-56
US No. 8	20-50
US No. 50	3-12
US No. 200	0-1

- Underdrains connected directly to a stormwater conveyance system structure shall be non-slotted for at least 2 feet from the structure interface.

11.2.6.9 Orifice for Flow Control

Orifices may be used to help provide flow control. The minimum orifice diameter shall be 0.5 inches.

11.2.6.10 Check Dams and Weirs

Check dams or weirs may be necessary for reducing flow velocity and potential erosion, as well as increasing detention time and infiltration capability on sloped sites. Typical materials include concrete, wood, rock, compacted dense soil covered with vegetation, and vegetated hedge rows. Design depends on flow control goals, local regulations for structures within road right-of-ways and aesthetics. Optimum spacing is determined by flow control benefit (modeling) in relation to cost consideration. See the Low Impact Development Technical Guidance Manual for Puget Sound for figures of typical check dams.

If check dams are used, only include the effective storage available behind the check dams and/ or weirs in the modeled volume.

11.2.6.11 Hydraulic Restriction Layer

Adjacent roads, foundations or other infrastructure may require that infiltration pathways are restricted to prevent excessive hydrologic loading. Two types of restricting layers can be incorporated into bioretention designs.

- Clay (bentonite) liners are low permeability liners. Where clay liners are used, underdrain systems are required. See A100: Liners for guidelines.
- Geomembrane liners completely block infiltration. They may line the entire facility or may be used to line sidewalls to restrict lateral flows. Where geomembrane liners are used to line the entire facility underdrain systems are necessary. See A100: Liners for additional guidelines.

11.2.6.12 Planting

Submit a planting plan showing the type (species), location and size of each plant.

Plants must be tolerant of summer drought, ponding fluctuation, and saturated soil conditions.

Locate slotted pipe at least 5 feet from tree roots and other utilities.

Bioretention cells have three planting zones. Zone 1 is bottom area of the bioretention cell, which is frequently wet during the rainy season. Zone 2 includes the side slopes, which occasionally

become wet during rain events. Zone 3 includes the area around the perimeter of the bioretention cell, starting above the top surface of ponding elevation, which has drier soil.

See A1000: Vegetation for plants appropriate for bioretention facilities. For bioretention facilities that will be publically maintained, plants must be chosen from the list and approved by the City of Tacoma. Additional information on planting zones and appropriate plants for each zone can be obtained through “Low Impact Development: Technical Guidance Manual for Puget Sound.”

In general, the following guidelines should be used when considering which plants to use:

- At least 50% (by quantity) should be evergreen plants. Leaf fall can reduce the function of the facility.
- Do not leave large areas of the soil unplanted/uncovered. Exposed soil can cause erosion and reduce the function of the facility. Plant types can be overlapped (tree canopy can overlap shrubs and groundcover) to reduce the area of exposed soil.
- Provide a variety of plant types with various rooting structures. Plant variety encourages good soil health. Typical plant types used in bioretention construction include:
    - Emergents: Rushes, grasses, and sedges have shallow, fibrous roots that remain close to the soil surface. Planting solely with shallow rooted plants can cause thick root mats to form decreasing the infiltrative ability of the soil.
    - Woody shrubs and trees: Woody shrubs and trees have a mixture of shallow fibrous roots and deeper structural roots that can penetrate deeper into the soil and increase soil porosity over time.
    - Groundcover: Groundcover tends to form dense masses of vegetation low to the ground surface. Low, dense vegetation can be effective at consolidating soil in areas otherwise prone to erosion such as the side slopes of the facility (Zone 2).
    - Herbaceous perennials: Herbaceous perennials do not have woody plant parts and the above ground growth typically dies back in the winter.
- Roots must not damage underground infrastructure.
- Consider adjacent plant communities and avoid potential invasive species.
- Consider aesthetics, bioretention facilities should blend into surrounding landscapes.

Irrigation may be required until plants are fully established and in the summer months.

11.2.6.13 Mulch Layer

Bioretention facilities should be designed with a mulch layer. Properly selected mulch material reduces weed establishment, regulates soil temperatures and moisture, and adds organic matter to soil.

- Mulch should be free of weed seeds, soil, roots, and other material that is not trunk or branch wood and bark. Mulch shall not include grass clippings, mineral aggregate or pure bark.
- Mulch shall be:
    - Coarse compost in the bottom of the facility, placed a maximum of 3" deep. Compost shall conform to the WSDOT Standard Specification 9-14.5(8) - Compost using the coarse compost gradation. Additionally, compost shall not include biosolids or manure.

    - Wood chip mulch composed of shredded or chipped hardwood or softwood on side slopes, above ponding elevation, depth 4 inches. Do not use wood chips that may have been contaminated by preservatives, such as construction debris.

- A dense groundcover can be used as an alternative to mulch although mulch shall be required until the dense groundcover is established.
- Where higher flow velocities are anticipated, aggregate mulch may be used. Aggregate mulch must be clean washed rock that is free of fines. 1" to 1 1/2" rounded decorative rock is recommended.

11.2.7 Bioretention Modeling

For facilities sized to meet Minimum Requirement #5: Onsite Stormwater Management using the list approach:

The top of the ponded surface area below the overflow shall be at least 5% of the total surface area draining to it.

For facilities sized to meet the Low Impact Development Performance Standard.

Model the facility using the bioretention element within a Washington State Department of Ecology approved continuous simulation model, assuming a 15-minute timestep. Size the facility to meet the Low Impact Development Performance Standard. The surface pool drawdown time shall be 24 hours or less.

For facilities sized to meet Minimum Requirement #6: Stormwater Treatment:

Model the facility using the bioretention element within a Washington State Department of Ecology approved continuous simulation model, assuming a 15-minute timestep. Size the facility to treat or infiltrate the water quality design volume which is 91% of the total runoff volume as predicted by an Ecology approved continuous simulation model. Alternatively, size the facility to treat 100% of the water quality design volume. The surface pool drawdown time shall be 24 hours or less.

For facilities sized to meet Minimum Requirement #7: Flow Control:

Model the facility using the bioretention element within a Washington State Department of Ecology approved continuous simulation model, assuming a 15-minute timestep. Size the facility to meet the flow control requirements. The surface pool drawdown time shall be 24 hours or less.

Table 4 - 15: WWHM Modeling Assumptions for Bioretention

Variable	Assumptions
Computational Time Step	15 minutes
Inflows to Facility	Surface flow and interflow from contributing area routed to facility
Precipitation and Evaporation applied to Facility	Yes
Bioretention Soil Infiltration Rates	Default and Custom Bioretention Soil Media: WWHM assumes a default infiltration rate of 12 inches per hour. Choose the soil layer SMMWW - 12 in/hr and the appropriate factor of safety below.
Safety Factor for Saturated Hydraulic Conductivity (K_{SAT})	Enter a K_{SAT} Safety Factor of 4 if the contributing area to the facility equals or exceeds any of the following: • 5,000 square feet of pollution-generating impervious surface; • 10,000 square feet of impervious surface; • ¾ acres of lawn and landscaped. If the contributing area is less than all of the above or if the design includes a pretreatment device for solids removal, enter a K_{SAT} Safety Factor of 2.
Bioretention Soil Depths	18 inches for the Default and Custom Mixes. The soil depths for HPBSM depend on the type of treatment.
Native Soil Infiltration Rate	Design Infiltration Rate of the Native Soil
Infiltration Across Wetted Surface Area	Only if sides slopes are 3:1 or flatter
Overflow	Dependent on Design.
Underdrain	If underdrain is proposed, click underdrain is used box.
Underdrain Aggregate	Use Gravel as the Material Layer for the Underdrain Aggregate Layer. Only the void volume of the aggregate below the underdrain invert and above the bottom of the bioretention facility can be used for flow control benefits.

The above table has specific guidance for WWHM. If other Ecology approved models are used, the same variables and assumptions must be made though they may have different names/ choices within that model.

11.2.8 General Construction Criteria

- Do not install media or excavate bioretention facility during soil saturation periods.
- Excavation and soil placement should be done from equipment operating adjacent to the facility or by conveyor – no heavy equipment should be operated in the facility.
- If equipment must be operated within the facility, use lightweight, low ground pressure equipment and scarify the base at least 12" to reduce compaction upon completion.
- Clogged soil and silt shall be removed during excavation to finished bottom grade prior to installing bioretention cell profile.

- Scarify sides and bottom a minimum of 3 inches to roughen before BSM placement.
- Ensure the bioretention facility is protected from erosion and sedimentation until all contributory areas are fully stabilized.
- If sedimentation occurs within the bioretention facility, excavate the area as necessary in minimum 6-inch lifts to remove sediment.
- Subgrade infiltration rates shall be field tested per Appendix A - Determining the Design Infiltration Rate and compared to design rates. Failure to meet or exceed the design infiltration rate will require revised engineering design to verify achievement of treatment and flow control benefits that were estimated in the design.
- Prior to placement of the BSM, the subgrade shall be inspected by a Washington State Licensed Professional Engineer or Washington State Professional Geologist to verify condition.
- Do not mix or place soil if the BSM or subgrade is saturated.
- Place the BSM in horizontal layers not to exceed 12 inches per lift.
- Compact the BSM to a relative compaction of 85% of modified maximum dry density. Compaction can be achieved by boot packing and applying 0.2 inches of water per 1 inch of BSM depth. Water for settling shall be sprayed or sprinkled.
- Do not use bioretention facilities as temporary sediment control facilities. Construction of the bioretention area should not begin until contributing areas are stabilized. Inlets should be blocked until BSM has been placed and bioretention facility has been planted. All inlet protection shall be in place before inlets are unblocked.

11.2.9 Verification Testing

- If using the default bioretention soil media, laboratory analysis for saturated hydraulic conductivity of the bioretention soil media is not required. The applicant shall provide verification of the mineral aggregate gradation, compliance with the compost specifications, and the mix ratio before soil placement.
- If using a custom bioretention soil media, verification of compliance with the minimum design criteria cited above for such custom mixes must be provided. This will require laboratory testing of the material that will be used in the installation. Testing shall be performed by a Seal of Testing Assurance, AASHTO, ASTM or other standards organization accredited laboratory with current and maintained certification. Samples for testing must be supplied from the BSM that will be placed in the bioretention areas.
- If testing infiltration rates is necessary for post-construction verification, use the Pilot Infiltration Test (PIT) method or a double ring infiltrometer test. If using the PIT method, do not excavate Bioretention Soil Mix (conduct test at level of finished Bioretention Soil Mix elevation), use a maximum of 6 inch ponding depth and conduct test before plants are installed. The City of Tacoma will determine the need for post construction verification on a case-by-case basis.

Chapter 12 Permeable Pavement

12.1 BMP L633: Permeable Pavements

12.1.1 Purpose

This Chapter provides infeasibility criteria, design criteria, and maintenance criteria for permeable pavements.

Permeable paving surfaces are an important integrated management practice within the LID approach and can be designed to accommodate pedestrian, bicycle and auto traffic while allowing infiltration, treatment and storage of stormwater.

The general categories of permeable paving systems include:

- Porous hot or warm-mix asphalt pavement is a flexible pavement similar to standard asphalt that uses a bituminous binder to adhere aggregate together. However, the fine material (sand and finer) is reduced or eliminated and, as a result, voids form between the aggregate in the pavement surface and allow water to infiltrate.
- Pervious Portland cement concrete is a rigid pavement similar to conventional concrete that uses a cementitious material to bind aggregate together. However, the fine aggregate (sand) component is reduced or eliminated in the gradation and, as a result, voids form between the aggregate in the pavement surface and allow water to infiltrate.
- Permeable interlocking concrete pavements (PICP) and aggregate pavers. PICPs are solid, precast, manufactured modular units. The solid pavers are (impervious) high-strength Portland cement concrete manufactured with specialized production equipment. Pavements constructed with these units create joints that are filled with permeable aggregates and installed on an open-graded aggregate bedding course. Aggregate pavers (sometime called pervious pavers) are a different class of pavers from PICP. These include modular precast paving units made with similar sized aggregates bound together with Portland cement concrete with high-strength epoxy or other adhesives. Like PICP, the joints or openings in the units are filled with open-graded aggregate and placed on an open-graded aggregate bedding course. Aggregate pavers are intended for pedestrian use only.
- Grid systems include those made of concrete or plastic. Concrete units are precast in a manufacturing facility, packaged and shipped to the site for installation. Plastic grids typically are delivered to the site in rolls or sections. The openings in both grid types are filled with topsoil and grass or permeable aggregate. Plastic grid sections connect together and are pinned into a dense-graded base, or are eventually held in place by the grass root structure. Both systems can be installed on an open-graded aggregate base as well as a dense-graded aggregate base.
- The City of Tacoma has developed Standard Plans for permeable pavement sections that can be used for both public and private projects within the City of Tacoma. These plans are available at tacoma.gov/government/departments/public-works/engineering/right-of-way-design-manual/

12.1.2 Applications

- Permeable paving systems can generally be used where traditional paving surfaces are used.
- Limit run-on from pervious surfaces to permeable pavement surfaces to the maximum extent practicable. Run-on shall only be allowed from fully stabilized areas.

- Unless the pavement, base course, and subgrade have been designed to accept runoff from adjacent impervious surfaces, slope impervious runoff away from the permeable pavement to the maximum extent practicable. Sheet flow from up-gradient impervious areas is not recommended, but permissible if the permeable pavement area is greater than the impervious pavement area.
- This BMP can be utilized to ensure compliance with Minimum Requirement #5: Onsite Stormwater Management.
    - The BMP can be used solely to mitigate for other hard surfaces if utilizing the List Approach or may be used in combination with other BMPs to satisfy the LID Performance Standard.
- This BMP may also be used to help ensure compliance with Minimum Requirement #6: Stormwater Treatment, Minimum Requirement #7: Flow Control and Minimum Requirement #8: Wetlands Protection.
- Where compliance with Minimum Requirements is not required, where feasible, this BMP is recommended to be used to help protect receiving waterbodies from the effects of stormwater.

12.1.3 Infeasibility Criteria

The following infeasibility criteria describe conditions that make permeable pavement infeasible when applying The List Approach for compliance with Minimum Requirement #5: Onsite Stormwater Management.

The infeasibility criteria shall also be used to determine the appropriateness of installing permeable pavement. Project proponents may be allowed to install permeable pavement even if considered infeasible, unless otherwise stated within the specific infeasibility criteria, provided documentation is included that substantiates the design. Documentation may be required by a Washington State Licensed Professional Engineer or other appropriate professional depending upon the project conditions.

These criteria also apply to impervious pavements that would employ stormwater collection from the surface of the impervious pavement with redistribution below the pavement.

Setback distances are measures from the edge of the pavement section.

A site characterization study must be completed in order to determine if the following infeasibility criteria apply.

The following infeasibility criteria require evaluation of site specific conditions and a written recommendation from an appropriate Washington State Licensed Professional (e.g., Professional Engineer, Professional Geologist, Professional Hydrogeologist)

- Where professional geotechnical evaluation recommends infiltration not be used due to reasonable concerns about erosion, slope failure, or down gradient flooding.
- Within an area whose groundwater flows into an erosion hazard or landslide hazard area.
- Where infiltrating and ponded water below new permeable pavement would compromise existing adjacent impervious pavements.
- Where infiltrating and ponded water below new permeable pavement would threaten existing below grade basements.
- Where infiltrating water would threaten shoreline structures such as bulkheads.
- Downslope of steep, erosion prone areas that are likely to erode sediment.

- Where fill soils are used that can become unstable when saturated.
- Excessively steep slopes where water within the aggregate base layer or at the subgrade surface cannot be controlled by detention structures and may cause erosion and structural failure, or where surface runoff velocities may preclude adequate infiltration at the pavement surface.
- Where permeable pavements cannot provide sufficient strength to support the anticipated loads.
- Where underlying soils are unsuitable for supporting traffic loads when saturated.
- Where installation of permeable pavement would threaten the safety or reliability of preexisting underground utilities, preexisting underground storage tanks, preexisting structures, or preexisting road or parking lot surfaces.

The following infeasibility criteria are based upon subsurface characteristics and require a soils report to determine infeasibility. See Appendix B: Soils Reports for Soils Report Requirements.

- Where the minimum vertical separation between the elevation of the lowest layer designed to be part of the permeable pavement section and the seasonal high groundwater elevation, bedrock or other impermeable layer is 1 foot or less.
- Where the field testing indicates potential permeable pavement locations have a measured (initial) native soil saturated hydraulic conductivity less than 0.3 inches/hour.
    - Permeable pavement installed for the purposes of Minimum Requirement #5: Onsite Stormwater Management shall only be constructed where infiltration is feasible.
    - If the measured soil infiltration rate is less than 0.30 inches/hour, permeable pavement cannot be used to meet The List Approach.
- Where replacing existing impervious surfaces unless the existing surface is a non-pollution generating surface over an outwash soil with a saturated hydraulic conductivity of 4 inches/hour or greater.

The following infeasibility criteria are based on conditions such as topography and distances to predetermined boundaries. Citation of the following do not need site-specific written recommendations from a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist though some criteria may require professional services to determine if the infeasibility criteria apply.

- Within an area designated as an erosion hazard or landslide hazard.
- For properties with known soil or groundwater contamination:
    - Within 100 feet of an area known to have deep soil contamination;
    - Where groundwater modeling indicates infiltration will likely increase or change the direction of the migration of pollutants in the groundwater;
    - Wherever surface soils can be found to be contaminated unless those soils are removed within 10 horizontal feet from the infiltration area;
    - Any area where these facilities are prohibited by an approved cleanup plan under the state Model Toxics Control Act or Federal Superfund Law, or an environmental covenant under Chapter 64.70 RCW.
    - Within 100 feet of a closed or active landfill.

- Within 100 feet of a drinking water well, or a spring used for drinking water supply if the permeable pavement is (or has run-on from) a pollution-generating hard surface
- Within 10 feet of small on-site sewage disposal drainfield, including reserve areas, and greywater reuse systems. For setbacks from a “large on-site sewage disposal system”, see WAC Chapter 246-272B.
- Within 10 feet of an underground storage tank and connecting underground pipes, regardless of tank size. As used in this criteria, an underground storage tank means any tank used to store petroleum products, chemicals, or liquid hazardous wastes of which 10% or more of the storage volume (including volume in the connecting piping system) is beneath the ground surface.
- At multi-level parking garages, and over culverts and bridges.
- Where the subgrade slope exceeds the maximum recommended design slope after reasonable efforts to grade.
- Where the permeable pavement wearing course slope exceeds 6% after reasonable efforts to design grade.
- Where the road receives more than very low traffic volumes. Roads with a projected average daily traffic volume of 400 vehicles or less are very low volume roads (AASHTO, 2001), (USDOT, 2013). This infeasibility criterion does not extend to sidewalks and other non-traffic bearing surfaces.
- Where the area receives more than very low truck traffic. Areas with very low truck traffic are roads or other areas not subject to through truck traffic but may receive up to weekly use by utility trucks (e.g., garbage, recycling), daily school bus use, and multiple daily use by pick-up trucks, mail/parcel delivery trucks, and maintenance vehicles. This infeasibility criterion does not extend to sidewalks and other non-traffic bearing surfaces.
- In areas that typically generate high concentrations of oil due to high traffic turnover or the frequent transfer of oil. These include:
    - Areas of a commercial or industrial site subject to an average daily traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area, or 300 total trip ends per day.
    - Areas of commercial or industrial sites subject to petroleum storage and transfer in excess of 1,500 gallons per year, not including routinely delivered heating oil. This petroleum storage and transfer criterion is intended to address regular transfer operations such as gasoline service stations, not occasional filling of heating oil tanks.
    - Areas of a commercial or industrial site subject to parking, storage or maintenance of 25 or more vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.). In general, all-day parking areas are not included in this criteria.
    - Road intersections with a measured ADT count of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primary pedestrian or bicycle use improvements.
- In areas with “industrial activity” as identified in 40 CFR 122.26(b)(14).
- Where the risk of concentrated pollutant spills is more likely such as gas stations, truck stops, and industrial chemical storage sites.
- Where routine, heavy applications of sand occur in frequent snow zones to maintain traction during weeks of snow and ice accumulation. Most lowland western Washington areas do not fit this criterion.

- If there are any conflicts with any of the following competing needs criteria:
  - Requirements of the following federal or state laws, rules, and standards:
    - Historic Preservation Laws and Archaeology Laws as listed at: https://dahp.wa.gov/project-review/preservation-laws
    - Federal Superfund or Washington State Model Toxics Control Act
    - Federal Aviation Administration requirements for airports
    - American with Disabilities Act
  - When found to be in conflict with special zoning district design criteria adopted and being implemented pursuant to a community planning process.
  - Public health and safety standards
  - Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.
  - City of Tacoma Critical Area Ordinances that provides protection of tree species or other critical areas.
- Within 10 feet of a building structure.
- Within 5 feet of any other structure or property line.
- Within 50 feet from the top of any slope greater than 20% and from geologically hazardous areas. The permeable pavement may be sited within 50 feet of a slope greater than 20% and/or geologically hazardous area if a geotechnical analysis performed by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist determines that there will be no negative impacts to the slopes and/or geologically hazardous areas caused by the permeable pavement.
- Where the project design cannot avoid putting pavement in areas likely to have long-term excessive sediment deposition after construction.

12.1.4 Subsurface Characteristics

A soils report is required to design permeable pavement. A soils report is also required if citing that permeable pavement is not feasible due to subsurface characteristics. See Appendix B: Soils Reports requirements.

12.1.5 Design Criteria

Pavement sections in the City Right-of-Way and/or that are required to comply with the City of Tacoma Design Manual shall meet requirements of the City of Tacoma Design Manual - tacoma.gov/government/departments/public-works/engineering/right-of-way-design-manual/.

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

At a minimum, comply with the design criteria in the sections below. The City of Tacoma Design Manual, Chapter 4 contains additional requirements for permeable pavement sections that are placed in the ROW. The Low Impact Development Technical Guidance Manual for Puget Sound is also a good guide for general guidance when designing permeable pavements.

12.1.5.1 Infiltration Rate/Drawdown

Infiltration Rates

Refer to Volume 4 – Appendix D: Determining the Design Infiltration Rate for the allowable methods for determining infiltration rates.

The design (long-term) infiltration rate shall be used for design calculations. If a sand layer or engineered soils are used for treatment below the permeable pavement, the smaller of the two design infiltration rates shall be used in design.

If permeable pavements are used for stormwater treatment, the measured (initial) soil infiltration rate shall be 12 inches or less. Design (long-term) infiltration rates up to 3 inches per hour can be considered if the infiltration receptor is not a sole-source aquifer and the treatment soil has characteristics comparable to those specified in Section 12.1.5.10 – Treatment Layer below.

Drawdown Time

Document that the maximum ponded depth from the infiltration BMP can infiltrate through the infiltration BMP surface within 48 hours.

This drawdown requirement is intended to restore hydraulic capacity between storms and maintain infiltration rates. This can be calculated by multiplying the horizontal projection of the infiltration BMP (this would be the rock reservoir not including any pavement section) by the estimated design infiltration rate and multiplying the result by 48 hours.

Note: the drawdown time is a check procedure not a method for designing the facility.

12.1.5.2 Depth to Bedrock, Water Table, or Impermeable Layer

The base of the permeable pavement section (including any treatment layer) shall be greater than or equal to 1 foot above the seasonal high-water mark, bedrock (or hardpan) or other low permeability layer.

12.1.5.3 Subgrade

Subgrade shall be a maximum 3% slope. If roadway surface exceeds 3%, subsurface detention structures per Section may be required.

Compact the subgrade to the minimum necessary for structural stability and at a minimum be "firm and unyielding" and be 90-92% Standard Proctor. See the City of Tacoma Right of Way Design Manual for additional subgrade preparation for applications within the City ROW. The exposed subgrade shall maintain preconstruction infiltration rates. The subgrade shall be protected during construction including minimizing traffic to the subgrade.

To prevent compaction when installing the aggregate base, the following steps are recommended:

- Dump aggregate onto subgrade from the edge of the installation.
- Dump subsequent aggregate base from on top of the aggregate base.

12.1.5.4 Separation or Bottom Filter Layer

A layer of sand or crushed stone (0.5 inches or smaller) is recommended to promote infiltration across the surface, stabilize the base layer, protect underlying soils from compaction, and serve as a transition between the base course and the underlying geotextile material or subgrade.

12.1.5.5 Geotextile, Geogrids, and Sidewall Barriers

Geotextiles between the subgrade and aggregate base are not required or necessary for many soil types. Geotextile is recommended on the side slopes of the open graded base perimeter next to the soil subgrade if concrete curbs or impermeable liners are not provided that extend the full depth of the base. Geotextile is required between the permeable ballast and sand layer used for treatment (if proposed). Geotextile shall conform to WSDOT Standard Specification 9-33.2(1) - Table 3 - Geotextile for Separation - Nonwoven. Geotextile shall be installed per WSDOT Standard Specification 2-12.3(1).

Geotextiles or geogrids may be needed for soils with poor structural stability to prevent the downward movement of the aggregate base into the subgrade.

Membrane liners on sidewalks of permeable pavement are recommended to:

- Reduce sidewall movement and degradation of subgrade infiltration capability; and
- Protect adjacent density graded subgrade material from migrating into the more open graded aggregate base of the permeable pavement.

30 mil PVC membranes are commonly used and should be placed vertically in the soils extending from the top of the aggregate base to the bottom of the subgrade.

12.1.5.6 Permeable Ballast Base Course (Aggregate/Storage Layer)

The open-graded aggregate base provides the following:

1. A stable base that distributes vehicle loads from the pavement to the subgrade
2. A highly permeable layer to disperse water downward and laterally to the underlying soil
3. A temporary reservoir that stores water prior to infiltration into the underlying soil or collection in underdrains for conveyance (WSDOT, 2003)

The depth of the aggregate layer shall be based on the depth needed for structural support and depth required to ensure compliance with the Minimum Requirements. The applicant shall submit modeling with an Ecology approved continuous simulation model, assuming a 15-minute timestep, showing the proposed ballast thickness is sufficient as a reservoir layer to manage stormwater based on the design criteria applicable to the project. Projects required to comply with Minimum Requirements #6, #7, or #8 and Minimum Requirement #5: Onsite Stormwater Management - Low Impact Development (LID) Performance Standard shall submit modeling results from an Ecology approved continuous simulation model. The City of Tacoma may require other projects, such as installations that receive run-on to submit calculations.

Aggregate base depths of 6 to 36 inches are common depending on pavement type, structural design, storage needs, and environmental factors such as cold weather. The minimum standards are shown below. See the City of Tacoma Design Manual for pavement sections that must be designed per the City of Tacoma Design Manual.

Flexible pavements (e.g. porous asphalt and permeable pavers) require properly designed aggregate base material for structural stability. Rigid pavements (pervious concrete) do not rely as much on the aggregate base for structural stability; however, however minimum depths are necessary for stormwater storage and providing a uniform surface for applying pervious concrete.

Increasing aggregate base depth for stormwater storage provides the additional benefit of increasing the strength of the overall pavement section by isolating underlying soil movement and imperfections that may otherwise be transmitted to the wearing course (Cahill et al., 2003).

12.1.5.6.1 Aggregate Base / Storage Layer Guidance Specific to Permeable Pavement Types

12.1.5.6.1.1 Porous Hot-Mix Asphalt and Portland Cement Pervious Concrete Aggregate Base / Storage Layer Guidance

- The following are minimum depths needed for porous HMA:
  - Refer to the City of Tacoma Standard Plan PD-01 for the minimum permeable ballast thickness necessary for structural integrity of permeable pavement roadways, accessways, and trails.
  - For private onsite permeable pavement, the minimum ballast thickness shall be 6 inches.
- Permeable ballast base course shall meet the requirements of WSDOT Standard Specification Section 9-03.9(2) – Permeable Ballast with the following modifications:
  - The permeable ballast base course shall be seated or compacted until no visible movement of aggregate is observed. Immediately following spreading and final shaping each layer of surfacing shall be lightly compacted in one lift to a firm and unyielding condition.
  - Permeable ballast base course shall not be manufactured from recycled concrete. The materials shall be uniform in quality and substantially free from wood, roots, bark, and other extraneous material and shall meet the following quality test requirements:

Table 4 - 16: Quality Test Requirements

Los Angeles Wear, 500 Rev	30% maximum, WSDOT Test Method T 96
Degradation Factor	30 minimum, WSDOT Test Method T113
Minimum Void Ratio Content	30% as determined by AASHTO T19 or ASTM

- Gradation shall be per Table 4-17: Porous Hot Mix Asphalt and Portland Cement Pervious Concrete Permeable Ballast Grading Requirements

Table 4 - 17: Porous Hot Mix Asphalt and Portland Cement Pervious Concrete Permeable Ballast Grading Requirements

Sieve Size	Percent Passing (by weight)
2.5”	100
2”	90-100
1.5”	35-70
1”	0-15
0.5”	0-5
No. 100	0-3
No. 120	0
% Fracture	95

- The fracture requirement shall be at least two fractured faces and will apply to the combined aggregate retained on the No. 4 sieve in accordance with FOP for AASHTO T335. Permeable ballast base course shall meet the requirements for grading and quality when placed in hauling vehicles for delivery to the site, after placement in temporary location, when in stockpiles on site, during installation, and after installation and in place after compacted to project specifications.

12.1.5.6.1.2 Permeable Interlocking Concrete Pavers Aggregate Base / Storage Layer Guidance

- ICPI recommends base/subbase thicknesses for pavements up to a lifetime of 1 million equivalent single-axle loads (ESALs) that are 18,000 pounds each. For example, at lifetime ESALs of 500,000 with a CBR of 5%, the subbase (ASTM No. 2 rock) should be 18 inches, and the base (ASTM No. 57 rock) thickness should be 4 inches. Increased aggregate subbase thicknesses can be applied for increased stormwater volume storage. See ICPI guidelines for details on base thickness and design (Smith, 2011).
- Minimum subbase depth for pedestrian applications should be 6 inches (Smith, 2011).
- The subbase and base aggregate should be hard, durable, crushed rock with 90% fractured faces, a Los Angeles (LA) Abrasion of < 40 (ASTM C131-06 and C535-12) and a design CBR of 80% (Smith, 2011).

12.1.5.6.1.3 Plastic or Concrete Grid Systems Aggregate Base / Storage Layer Guidance

- Minimum depth is 4 to 6 inches for driveways, alleys, and parking lots (less base course depth is required for trails) (personal communication between C. Hinman and A. Gersen, 2004). Increased depths can be applied for additional storage capacity if needed to meet flow control goals.
- Typical base aggregate is a sandy gravel material typical for road base construction.
- Aggregate should have grading per table below:

Table 4 - 18: Plastic or Concrete Grid Systems Permeable Ballast Grading Requirements

U.S. Standard Sieve	Percent Passing
1 inch	100
3/4 inch	90 to 100
3/8 inch	70 to 80
No. 4	55 to 70
No. 10	45 to 55
No. 40	25 to 35
No. 200	3 to 8

12.1.5.7 Subsurface Detention Structures

For permeable pavements on slopes ≥3%, provide subsurface detention structures or terrace subgrade to increase infiltration, improve flow attenuation, and reduce structural issues with subgrade erosion on slopes. See the “Low Impact Technical Guidance Manual for Puget Sound” for examples and design recommendations.

12.1.5.8 Wearing Course (Surface Layer)

The wearing course provides support (in conjunction with the aggregate base) for the designed traffic loads while maintaining adequate porosity for infiltration.

Permeable pavement systems allow infiltration of stormwater; however, to prevent freeze-thaw damage and retain infiltration capability, the wearing course should not become saturated from excessive water volume stored in the aggregate base layer.

12.1.5.8.1 Wearing Course Guidance Specific to Permeable Pavement Types

12.1.5.8.1.1 Porous Hot-Mix Asphalt Wearing Course / Surface Layer Guidance

- The minimum infiltration rate shall be 20 inches per hour.
- Products shall have adequate void space for infiltration – typically 16-25%.
- The maximum slope shall be 5%.
- Refer to the City of Tacoma Standard Plan PD-01 for the minimum porous HMA thickness necessary for structural integrity of permeable pavement roadways, accessways, and trails.
- For private onsite permeable pavement, the wearing course thickness shall be 2 inches though 3” is recommended.
- Pavement material shall conform to the latest version of the WSDOT General Special Provisions for Porous Hot Mix Asphalt.

12.1.5.8.1.2 Portland Cement Pervious Concrete Wearing Course / Surface Layer Guidance

- The minimum infiltration rate shall be 20 inches per hour.
- Products shall have adequate void space for infiltration – typically 15-35%

- The maximum slope shall be 12%.
- Refer to the City of Tacoma Standard Plan PD-01 for the minimum pervious concrete thickness necessary for structural integrity of permeable pavement roadways, accessways, and trails.
- For private onsite permeable pavement, the wearing course thickness shall be 5 to 9 inches depending on the traffic loads.
- Pavement material shall conform to the latest version of the WSDOT General Special Provisions for Pervious Concrete Pavement

12.1.5.8.1.3 Permeable Interlocking Concrete Pavers Aggregate Base / Storage Layer Guidance

- The minimum infiltration rate shall be 20 inches per hour.
- Pavement joints should be filled with No. 8, 89, or 9 stone. Consult with pavement manufacturer specifications to determine the appropriate material type and size.
- The maximum slope shall be 12%.
- Pavement thickness and material shall be per manufacturer specifications.

12.1.5.8.1.4 Plastic or Concrete Grid Systems Wearing Course / Surface Layer Guidance

- The minimum infiltration rate shall be 20 inches per hour.
- Fill material shall be a minimum of 2 inches of sand, gravel, or soil.
- The maximum slope varies by manufacturer and generally range from 6% to 12% (primarily based upon traction opposed to infiltration capability). Consult the manufacturer for maximum slope recommendations.
- Pavement thickness and material shall be per manufacturer specifications.
- Fill material depends on if the system is an aggregate system or grass system.
    - For aggregate systems:
        - Aggregate should be clean, washed, and hard angular rock typically 3⁄16- to 1/2-inch.
    - For grass systems:
        - For plastic grids, sand (usually with a soil polymer or conditioner), sandy loam or loamy sand are typical fill materials.
        - For concrete grids, fill the openings with topsoil.

12.1.5.9 Permeable Pavement - Underdrain

Underdrains are not recommended. Underdrains placed at or near the bottom of the aggregate base should not be used and if used, the permeable pavement is not considered a low impact development technique and cannot be used to satisfy List Approach of Minimum Requirement #5: Onsite Stormwater Management and cannot be used to satisfy flow control requirements. Elevated underdrains that are placed within the aggregate base course to protect the pavement wearing course from saturation can be used to satisfy the List Approach of Minimum Requirement #5: Onsite Stormwater Management though an underdrain is not required and not recommended. The underdrain perforations or slots shall only be located on the lower half of the pipe.

12.1.5.10 Treatment Layer

Permeable pavement can be used to meet Minimum Requirement #6 – Stormwater Treatment if a treatment layer beneath the pavement and ballast section is provided. The permeable pavement wearing course and/or aggregate layer do not provide treatment.

Additional pretreatment is not required as it is assumed that the wearing course provides sufficient removal of larger sediments.

Any of the following treatment layer types can be used to provide treatment:

- Native Soils - The native soils below the permeable pavement meet the following criteria or engineered soils are imported that meet the following criteria:
    - Cation exchange capacity (CEC) of the treatment soil must be greater than or equal to 5 milliequivalents CEC/100 g dry soil (USEPA Method 9081). Consider empirical testing of soil sorption capacity, if practicable. Ensure that soil CEC is sufficient for expected pollutant loadings, particularly heavy metals. CEC values of greater than 5 meq/100g are expected in loamy sands, according to Rawls, et al.
    - Depth of soil used for infiltration treatment must be a minimum of 18 inches.
        - If permeable pavement does not accept any run-on, the depth of treatment soil may be reduced to 12 inches.
        - Organic content shall be a minimum of 1%. Organic content shall be measured on a dry weight basis using ASTM D2974.
        - Waste fill materials should not be used as infiltration soil media nor should such media be placed over uncontrolled or non-engineered fill soils.
        - Measured (initial) saturated hydraulic conductivity must be 12 inches or less.
- 6” Sand Layer - A 6” layer of sand meeting the gradation in Table 4-19 Treatment Sand Layer Specification is provided. This would meet the requirements for basic treatment.
- 12” Sand Layer - A 12” layer of sand meeting the gradation in Table 4-19 Treatment Sand Layer Specification is provided. This would meet the requirements for basic, metals, and phosphorus treatment.

Table 4 - 19: Treatment Sand Layer Specification

U.S. Sieve Number	Percent Passing
4	95-100
8	70-100
16	40-90
30	25-75
50	2-25
100	<4
200	<2

Note: Treatment layers as well as the aggregate layer must be considered part of the BMP when determining the separation from the bottom of the BMP to the seasonal high groundwater layer or other restrictive layer.

12.1.5.11 Flow Entrance

When designed to take runoff from other areas, permeable pavement must be protected from sedimentation. Flow entrance methods include sheet flow to the permeable pavement surface or subsurface delivery to the storage reservoir via pipes (for example from roof downspout systems). Informal pretreatment options like filter strips for sheet flow or catch basins for subsurface delivery should be considered for any run-on to the permeable pavement section.

12.1.5.12 Drainage Conveyance

Permeable roads should be designed to ensure safe driving conditions in the event of an intense storm event and to account for potential clogging.

Backup infiltration areas may also be considered to account for more intense storms and pavement clogging. This may include additional aggregate areas placed along the roadway section or within medians and perimeter areas.

12.1.6 Acceptance Test

- For driveways or small permeable pavement sections (1000 square feet or less), test by pouring a bucket of water on the permeable surface. Additional testing prior to acceptance will be needed if there is runoff from the surface.

For permeable pavement sections greater than 1000 square feet, test the initial infiltration rate using ASTM C1701 or ASTM C1781. Test to determine if the minimum infiltration rate of 20 inches per hour is met. The number of test locations is specified in ASTM C1701 or ASTM C1781.

12.1.7 Permeable Pavement Modeling

Use the permeable pavement element of an Ecology approved continuous simulation model, assuming a 15-minute timestep.

The models allow for specifying pavement thickness and porosity, aggregate base material thickness and porosity, maximum allowed ponding depth, and native soil infiltration rate.

- Use a value of zero for the pavement thickness and pavement porosity. The design shall not depend on water storage in the pore space of the permeable pavement section itself but should rely on the reservoir layer.
- For grades less than 2% no adjustments to the below grade volumes are necessary.
- For grades greater than 2% without internal dams within the base materials, the below ground storage volume must be adjusted as follows:
    1. Permeable pavement surfaces that are below the surrounding grade and that are on a slope can be modeled as permeable pavement with an infiltration rate and a nominal depth.
    2. The dimensions of the permeable pavement are:
        - the length (parallel to and beneath the road) of the base materials that are below grade
        - the width of the below grade base materials
        - an Effective Total Depth of 1 inch.
        - If the continuous simulation model required the permeable pavement to have an overflow riser for the model run, enter 0.04 ft (0.5") for the riser height and 1000 inches for the riser diameter. This will ensure no head build-up.
    3. If an underdrain is elevated in the below grade base materials, the pipe should only have perforations or slots on the lower half (below the spring line) or near the invert. Pipe volume and trench volume above the pipe invert cannot be assumed as available storage space. If a underdrain is placed at the bottom of the base material, model the pavement as an impervious area.
- For roads on a slope with internal dams within the base materials that are below grade, the below ground storage volume must be adjusted as follows:
    1. Each stretch of permeable pavement (cell) that is separated by barriers can be modeled separately. For each cell, determine the average depth of water within the cell at which the barrier at the lower end will be overtopped.
    2. Specify the dimensions of each cell of the below-grade base materials using the permeable pavement dimension fields for:
        - the pavement length (length of the cell parallel to the road)
        - the width of the bottom of the base material
        - an Effective Total Depth
    3. Each cell should have its own contributing area within the permeable pavement element that includes the road above it, any areas whose stormwater drains onto and through the road and any offsite areas. Represent each contributing area with a permeable pavement icon and a lateral flow basin icon (if there is run-on).
- In the runoff modeling, similar designs throughout the project can be summed and represented as one facility. For example, all walkways can be summed into one facility. In these instances, a weighted average of the design infiltration rate (only if they are within a factor of 2) can be used. The averages shall be weighted by the contributing area.

- In WWHM, in the Permeable Pavement Element, the Use Wetted Surface Area should be set to No if the below grade base material trench has sidewalls steeper than 2H:1V - which is typical of roadway design.

12.1.8 Maintenance

- Sweep non-planted surfaces with a high-efficiency sweeper twice per year, once in autumn and once in early spring. Sweeping frequency can be reduced if infiltration rate testing indicates that a rate of 10 inches/hour or greater is being maintained.
- The design engineer should consider the turning radius of the sweeper when designing permeable pavement surfaces to ensure the facility can be properly maintained

Chapter 13 Biofiltration BMPs

13.1 BMP T1010: Basic Biofiltration Swale

13.1.1 Description

- Basic biofiltration swales are vegetation-lined channels designed to remove suspended solids from stormwater. The shallow, concentrated flow allows for filtration of stormwater by the vegetation.

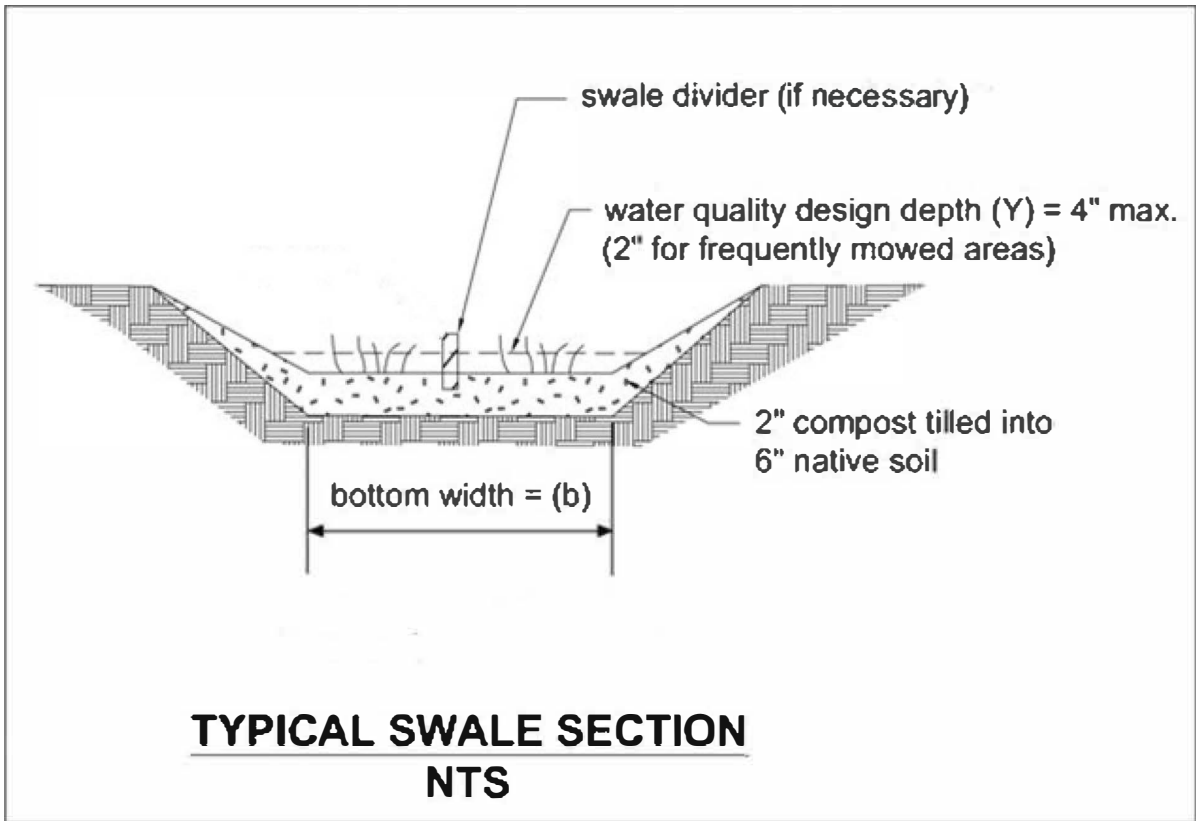


Figure 4 - 14 Typical Swale Section

13.1.2 Applications and Limitations

- Basic biofiltration swales can be used to help ensure compliance with Minimum Requirement #6: Stormwater Treatment.
- The performance of biofiltration swales is variable between storm events and is therefore not a consistent treatment BMP - it is recommended to consider other BMPs before biofiltration swales.

13.1.3 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as

applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

Basic biofiltration swales may be located upstream or downstream of detention facilities. If placed downstream from detention, prolonged flows may reduce grass survival and a wet biofiltration swale or other BMP may be more appropriate.

Basic biofiltration swales shall be designed using the design criteria in Table 4 - 20: Design Criteria for Basic Biofiltration Swale and design criteria within this section.

Table 4 - 20: Design Criteria for Basic Biofiltration Swale

Design Parameter	BMP T1010 - Basic Biofiltration Swale	
Longitudinal Slope	0.015 - 0.025 (feet per foot)	
Maximum Velocity at Q_{biofil}	1 ft / sec	
Maximum water depth	2”- if mowed frequently; 4” if mowed infrequently	
Manning Coefficient	Soil and Cover	Manning's Coefficient
	Grass-legume mix on compacted native soil	0.20
	Grass-legume mix on lightly compacted soil	0.22
	Grass-legume mix on lightly compacted amended soil	0.35
Bed width (bottom)	2 - 10 ft (swale widths up to 16 feet may allowed with a swale dividing berm per Figure 4 - 16: Swale Dividing Berm).	
Freeboard height	1.0 ft	
Minimum hydraulic residence time at Q_{biofil}	9 minutes	
Minimum length	100 ft	
Maximum sideslope (Z)	3 H:1V 4H:1V preferred	

13.1.4 Sizing Procedure for Biofiltration Swales

Design Steps

These calculations below assume the biofiltration swale will be constructed as a trapezoid. If an alternate biofiltration swale shape is proposed, alter the equations for the proposed shape as necessary. See Figure 4 - 15: Geometric Formulas for Common Swale Shapes.

D.1. Determine the water quality design flowrate (Q_{wq}) using an Ecology approved continuous simulation model, assuming a 15-minute timestep.

D.2. Determine the biofiltration design flowrate (Q_{biofil}) using the equation below.

$$Q_{biofil} = kQ_{wq}$$

Where

k = 2.0 for online systems

k = 3.5 for offline systems

D.3. Establish the longitudinal slope of the proposed biofiltration swale. Longitudinal slope shall be between 0.015-0.025 feet per foot.

D.4. Select the type of vegetation and depth of flow (based on frequency of mowing and type of vegetation).

D.5. Select a value of Manning's n (see Table 4 - 20: Design Criteria for Basic Biofiltration Swale based on vegetation type and frequency of mowing)

D.6. Use Manning's equation and first approximations relating hydraulic radius and dimensions for the selected swale shape to obtain a working value of a biofiltration swale bottom and top width dimension:

D.7. $$Q_{biofil} = \frac{1.49AR^{0.67}s^{0.5}}{n}$$

Where:

Q_{biofil} = Biofiltration design flowrate, calculated in D2.

n = Manning's n (dimensionless)

s = Longitudinal slope as a ratio of vertical rise/horizontal run (dimensionless)

A = cross-sectional area (ft^2)

R = hydraulic radius (ft)

Because the depth of flow in most biofiltration swales is shallow relative to the bottom width, channel side slopes can be ignored in the calculation of bottom width. Use the following equation to estimate the swale bottom width for a trapezoidal swale.

$$b \approx \frac{(Q_{biofil}) \times n}{1.49y^{1.67}s^{0.5}} - Zy$$

Where:

b = Bottom width (ft)

Q_{biofil} = Biofiltration design flowrate calculated in D2.

n = Manning's n (see Table 4 - 20: Design Criteria for Basic Biofiltration Swale)

y = Design flow depth (see Table 4 - 20: Design Criteria for Basic Biofiltration Swale)

s = Longitudinal slope (see Table 4 - 20: Design Criteria for Basic Biofiltration Swale)

Z = Side slope (for trapezoid select 3)

A minimum 2-foot bottom width is required. If the calculated bottom width is less than 2 feet, use 2 for design for the remainder of the equations.

D.8. Compute A

$$A_{trapezoid} = by + Zy2$$

Where:

$A_{trapezoid}$ = cross-sectional area (ft²)

y = depth of flow (ft)

b = bottom width of trapezoid (ft)

Z = side slope

D.9. Compute the flow velocity (V_{biofil}) at Q_{biofil}:

$$V_{biofil} = \left(\frac{Q_{biofil}}{A}\right)$$

Where:

A = cross-sectional area (ft^2)

$Q_{biofill}$ = Biofiltration design flowrate, calculated in D.2.

D.10. If V >1.0 ft/sec, alter design and repeat calculations until the condition is met. A velocity greater than 1.0 ft/sec was found to flatten grasses, thus reducing filtration. A velocity lower than this maximum value will allow a 9-minute hydraulic residence time criterion in a shorter biofilter.

$$L = V_{biofil} t(60sec/min)$$ Where:

t = hydraulic residence time (min). See Table 4 - 20: Design Criteria for Basic Biofiltration Swale.

V_{biofil} = velocity at Q_{biofil} (ft/sec)

$Q_{biolfil}$ = biofiltration design flowrate as calculated in D.2.

If a biofilter length is greater than the space permits, follow the advice in D.11.

If a length less than 100 feet results from this analysis, increase it to 100 feet, the minimum allowed. In this case, it may be possible to save some space in width and still meet all criteria. This possibility can be checked by computing V in the 100 ft biofiltration swale for t = 9 minutes, recalculating A (if V < 1.0 ft/sec) and recalculating T.

D.11. If there are space constraints, the local government and the project proponent should consider the following solutions (listed in order of preference):

1. Divide the contributing area into multiple biofiltration swales.
2. Use infiltration or other low impact development techniques to provide lower discharge rates to the biofiltration swale (only if the Site Suitability Criteria are met).

3. Increase vegetation height and design depth of flow (note: the design must ensure that vegetation remains standing during design flow).
4. Reduce the developed surface area to gain space for biofiltration.
5. Increase the longitudinal slope.
6. Increase the side slopes.
7. Nest the biofiltration swales within or around another BMP.

D.12. Note the Final Calculated Biofiltration Swale Dimensions.

D.13. Calculate the total final swale depth (yswale)

For offline facilities:

$$y_{swale} = y + 1$$

Where:

y was chosen in D.4.

For online facilities:

Complete the Freeboard Check to Obtain the Total Required Swale Depth.

Freeboard Check

The freeboard check must be performed for the combination of highest expected flow and least vegetation coverage and height. A check is not required for biofiltration swales that are located offline from the primary conveyance/detention system. Maintain the same units as in the biofiltration capacity analysis.

The maximum permissible velocity for erosion prevention (V_{max}) is 3 feet per second.

F.1. Determine Q_{convey} which is the 100-year, return frequency flow using an Ecology approved continuous simulation model and assuming a 15-minute timestep.

F.2. Calculate the flow depth at Q_{convey}

$$y_{convey} = \frac{Q_{convey} \times n}{1.49 s^{0.5} b}$$

Where:

y = flow depth (ft)

Q_{convey} = 100-year, return frequency flow from F.1.

n = 0.03

s = longitudinal slope as determined from Design Steps

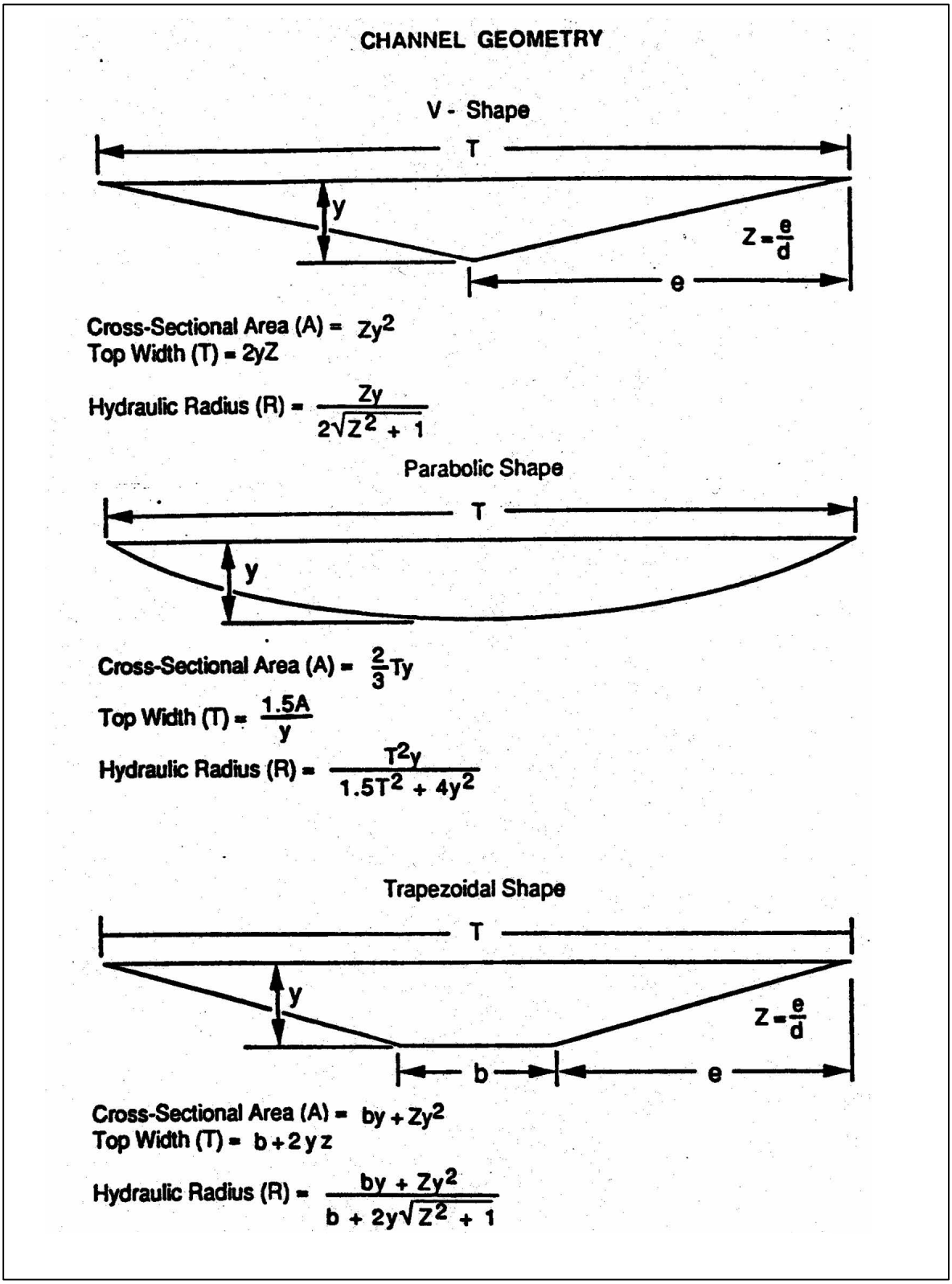
b = biofiltration swale width as calculated from Design Steps

F.3. Calculate total required swale depth (y_{swale})

$$y_{swale} = y_{convey} + 1$$

Completion Step

Review all of the criteria and guidelines for biofilter planning, design, installation, and operation above and specify all of the appropriate features for the application.



Source: Livingston, et al, 1984

Figure 4 - 15: Geometric Formulas for Common Swale Shapes

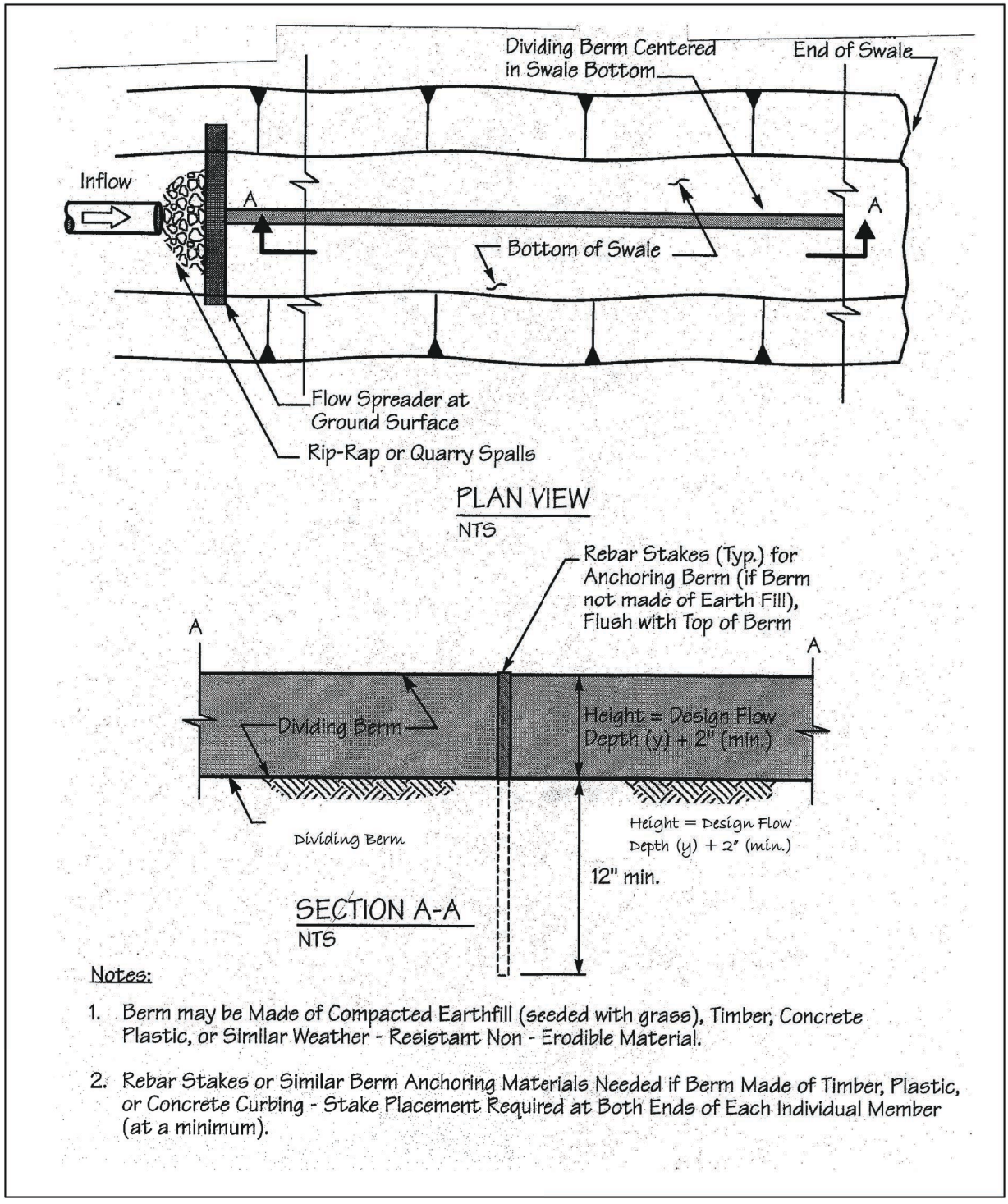


Figure 4 - 16: Swale Dividing Berm

13.1.5 Level Spreaders and Energy Dissipators

- Construct level spreaders and swale dividers of plastic boards, concrete, or other materials that will not leach contaminants. Stake level spreaders with nongalvanized metal pins at 4 feet on center minimum.
- Install level spreaders at the head of all swales, and every 50 feet in swales greater than or equal to 4 feet width. Install level spreaders at the head of the biofiltration swale if a swale divider is used. Include sediment cleanouts (weir, settling basin, or equivalent) at the head of the biofiltration swale as needed
- Use energy dissipaters (such as check dams) for swales on longitudinal slopes exceeding 2.5%. Energy dissipaters may take the place of level spreaders if they are designed and installed to maintain level flow in the swale.

13.1.6 Soil Criteria

Soils shall have the following mix and be tilled to a depth of at least 8 inches:

- Sandy Loam: 60-90%
- Clay: 0-10%
- Composted Material: 10-30%
  - Compost shall comply with A900: Compost
- If groundwater contamination is a concern, seal the bed with clay or a geomembrane liner - see A100: Liners.

13.1.7 Vegetation Criteria

- See A1000: Vegetation for recommended grasses, wetland plants, and groundcovers.
- Select fine, turf-forming, water-resistant grasses where vegetative growth and moisture will be adequate for growth.
- Irrigate if moisture is insufficient during dry weather season.
- Use sod with low clay content and where needed to initiate adequate vegetative growth. Preferably sod should be laid to a minimum of one-foot vertical depth above the swale bottom.
- Consider sun/shade conditions for adequate vegetative growth and avoid prolonged shading of any portion not planted with shade tolerant vegetation.
- Stabilize soil areas upslope of the biofilter to prevent erosion.
- Fertilizing a biofilter shall not be allowed.

13.1.8 Construction Criteria

- Do not put swale into operation until exposed soil in contributing area is stabilized.
- Keep erosion and sediment control measures in place until swale vegetation is established.
- Avoid compaction during construction.
- Grade biofiltration swales to ensure longitudinal and lateral slopes are uniform.
- Below the design water depth install an erosion control blanket, at least 4" of topsoil, and the selected biofiltration seed mix. Provide vegetation above the water line.

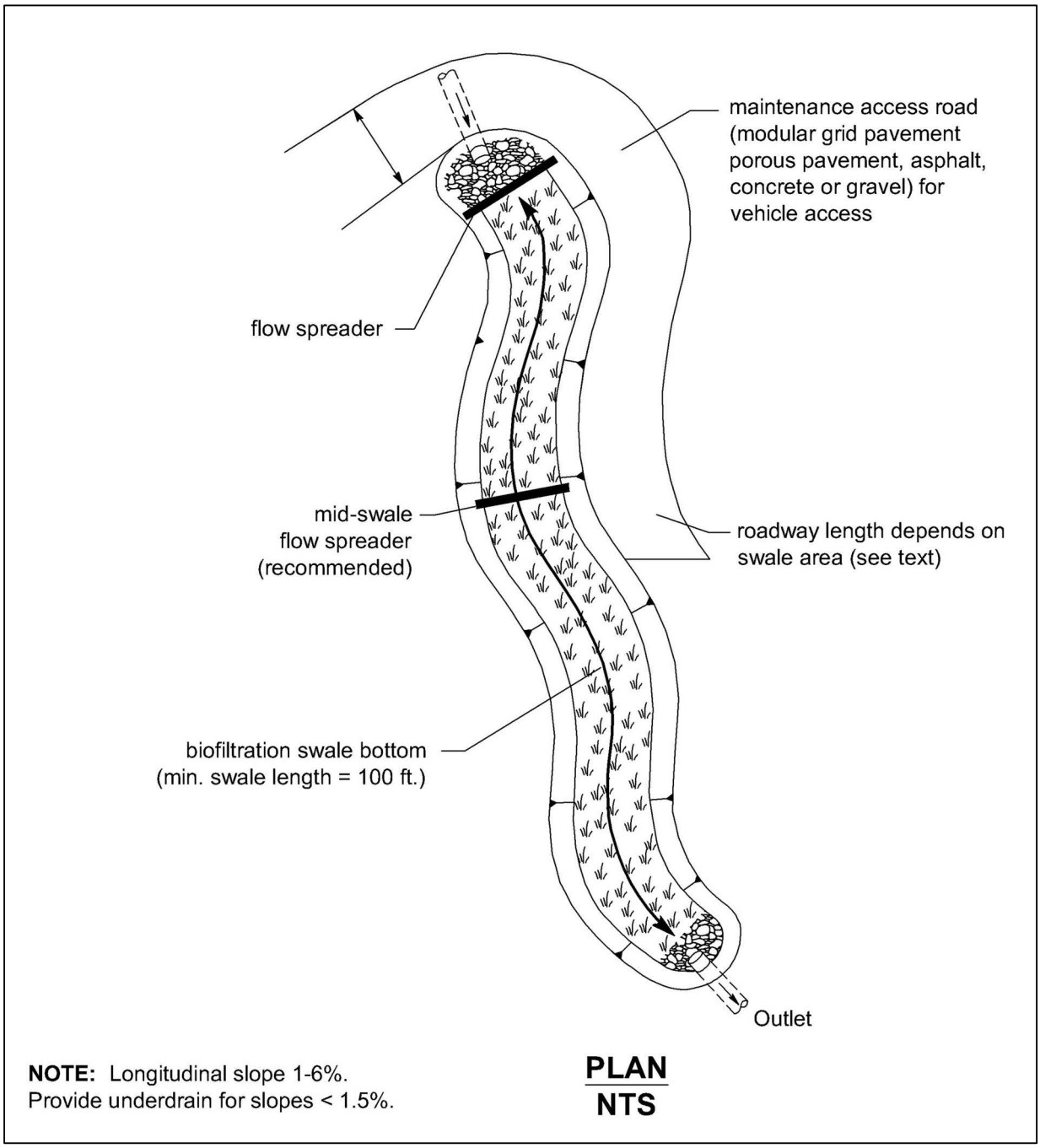


Figure 4 - 17: Biofiltration Swale Access Features

13.2 BMP T1020: Wet Biofiltration Swale

13.2.1 Description

A *wet biofiltration swale* is a variation of a basic biofiltration swale for use where the longitudinal slope is slight, water tables are high, or continuous low base flow is likely to result in saturated soil conditions. Where saturation exceeds about 2 weeks, typical grasses will die. Thus, vegetation specifically adapted to saturated soil conditions is needed. Different vegetation in turn requires modification of several of the design parameters for the basic biofiltration swale.

13.2.2 Applications

- Wet biofiltration swales can be used to help ensure compliance with Minimum Requirement #6: Stormwater Treatment.
- The performance of wet biofiltration swales is variable between storm events and is therefore not a consistent treatment BMP - it is recommended to consider other BMPs before biofiltration swales.
- Wet biofiltration swales are applied where a basic biofiltration swale is desired but not allowed or advisable because one or more of the following conditions exist:
  - The swale is located on glacial till soils and is downstream of a detention pond providing flow control.
  - Saturated soil conditions are likely because of seeps or base flows on the site.
  - Longitudinal slopes shall be less than 2 percent.

13.2.3 Design Criteria

Wet biofiltration swales may be located upstream or downstream of detention facilities.

Use the same design and sizing criteria as for basic biofiltration swales except as noted below and shown in Table 4 - 20: Design Criteria for Basic Biofiltration Swale.

Table 4 - 21: Design Criteria for Wet Biofiltration Swales

Design Parameter	BMP T1020: Wet Biofiltration Swale	
Longitudinal Slope	0.020 feet per foot or less	
Maximum Velocity at Q_{biofil}	1 ft / sec	
Maximum water depth	4 inches	
Manning Coefficient	Soil and Cover	Manning's Coefficient
	Grass-legume mix on compacted native soil	0.20
	Grass-legume mix on lightly compacted soil	0.22
	Grass-legume mix on lightly compacted amended soil	0.35

Table 4 - 21: Design Criteria for Wet Biofiltration Swales

Design Parameter	BMP T1020: Wet Biofiltration Swale
Bed width (bottom)	2 - 25 ft
Freeboard height	1.0 ft
Minimum hydraulic residence time at Q_{biofil}	9 minutes
Minimum length	100 ft
Maximum sideslope (Z)	3 H:1 V 4H:1V preferred

Wet biofiltration swales shall only be designed as offline facilities.

1. Adjust for extended wet season flow.
    - If the swale will be downstream of a detention pond or vault providing flow control, multiply the treatment area (bottom width times length) of the swale by 2, and readjust the swale length, as necessary. Maintain a 5:1 length to width ratio.
    - The increase in treatment area is needed to ensure pollutant removal can be achieved during extended flow conditions.
2. Swale geometry.
    - The bottom width may be increased to 25 feet maximum, but a length-to-width ratio of 5:1 must be provided. No longitudinal dividing berm is needed.

      The minimum swale length is 100 feet.
    - If longitudinal slopes are greater than 2 percent, the wet swale must be stepped so that the slope within the stepped sections averages 2 percent. Steps may be made of retaining walls, log check dams, or short riprap sections.
3. High-flow bypass
    - A high-flow bypass (i.e., an offline design) is required for flows greater than the Q_{biofil}. The bypass may be an open channel parallel to the wet biofiltration swale.
4. Water Depth and Base Flow
    - Design water depth shall be 4 inches for all wetland vegetation selections.
5. Flow Velocity, Energy Dissipation, and Flow Spreading
    - No flow spreader is required.
6. Access

- Access is only required to the inflow and outflow of the swale. Access along the swale is not required.
- Wheel strips may not be used for access.

7. Planting Requirements
   - A list of acceptable plants is shown in A1000: Vegetation.
   - A wetland seed mix may be applied by hydroseeding, but if coverage is poor, planting of rootstock or nursery stock is required. Poor coverage is considered to be more than 30 percent bare area through the upper ⅔ of the swale after four weeks.

13.3 BMP T1030: Continuous Inflow Biofiltration Swale

13.3.1 Description

In situations where water enters a biofiltration swale continuously along the side slope rather than discretely at the head, a different design approach–the continuous inflow biofiltration swale–is needed. The basic swale design is modified by increasing swale length to achieve an equivalent average residence time.

13.3.2 Applications

Continuous inflow biofiltration swales can be used to ensure compliance with Minimum Requirement #6: Stormwater Treatment.

A continuous inflow biofiltration swale is to be used when inflows are not concentrated, such as locations along the shoulder of a road without curbs. This design may also be used where frequent, small point flows enter a swale, such as through curb inlet ports spaced at intervals along a road, or from a parking lot with frequent curb cuts. In general, no inlet port shall carry more than about 10 percent of the flow.

A continuous inflow swale is not appropriate for a situation in which significant lateral flows enter a swale at some point downstream from the head of the swale. In this situation, the swale width and length must be recalculated from the point of confluence to the discharge location in order to provide adequate treatment for the increased flows.

13.3.3 Design Criteria

Same as specified for BMP T1010: Basic Biofiltration Swale except as noted below and shown in Table 4 - 22: Design Criteria for Continuous Inflow Biofiltration Swales.

Table 4 - 22: Design Criteria for Continuous Inflow Biofiltration Swales

Design Parameter	BMP T1030: Continuous Inflow Biofiltration Swale	
Longitudinal Slope	0.015 - 0.025 (feet per foot)	
Maximum Velocity at Q_{biofil}	1 ft / sec	
Maximum water depth	2”- if mowed frequently; 4” if mowed infrequently	
Manning Coefficient	Soil and Cover	Manning's Coefficient
	Grass-legume mix on compacted native soil	0.20
	Grass-legume mix on lightly compacted soil	0.22
	Grass-legume mix on lightly compacted amended soil	0.35

Table 4 - 22: Design Criteria for Continuous Inflow Biofiltration Swales

Design Parameter	BMP T1030: Continuous Inflow Biofiltration Swale
Bed width (bottom)	2 - 10 ft
Freeboard height	1.0 ft
Minimum hydraulic residence time at Q_{biofil}	18 minutes (initial assumed for design - see notes in BMP T1030)
Minimum length	100 ft
Maximum sideslope (Z)	3 H:1 V 4H:1V preferred

- The design flow for continuous inflow swales must include runoff from the pervious side slopes draining to the swale along the entire swale length. Therefore, they must be online facilities.
- If only a single design flow is used, the flowrate at the outlet should be used. The goal is to achieve an average residence time through the swale of 9 minutes as calculated using the online water quality design flowrate multiplied by the ratio, K. Assuming an even distribution of inflow into the side of the swale double the hydraulic residence time to a minimum of 18 minutes.
- Interior side slopes above the water quality design treatment elevation shall be planted in grass. A typical lawn seed mix or the biofiltration seed mixes are acceptable. Landscape plants or groundcovers other than grass may not be used anywhere between the runoff inflow elevation and the bottom of the swale.

13.4 BMP T1040: Vegetated Filter Strip

13.4.1 Description

A vegetated filter strip is flat with no side slopes (Figure 4 - 18: Typical Filter Strip). Untreated stormwater is distributed as sheet flow across the inlet width of a biofilter strip.

13.4.2 Applications/Limitations

The vegetated filter strip is typically used online and adjacent and parallel to a paved area such as parking lots, driveways, and roadways.

13.4.3 Design Criteria for Vegetated Filter Strips

- Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.
- Vegetated filter strips shall not be located downstream of detention facilities.
- Filter strips shall only receive sheet flow.
- Use curb cuts ≥ 12-inch wide and 1-inch above the filter strip inlet.
- Along roadways, vegetated filter strip BMPs should include a gravel flow spreader that is at least 1 foot wide, and preferably 3 to 4 feet wide. Water should sheet flow from the paved area, through the (vegetation free) gravel flow spreader, and over the vegetated filter strip.
- The flow from the roadway must enter the vegetated filter strip as sheet flow.
- Vegetated filter strips must not receive concentrated flow discharges.
- Contributing area flow path length:
  - The contributing area to the vegetated filter strip can have a maximum flow path length of 30 feet, if using the Design Procedure (Method 1) below.
  - The contributing area to the vegetated filter strip can have a maximum flow path length of 150 feet, if using the Design Procedure (Method 2) below.
- Vegetated filter strips should be used where the average daily traffic (ADT) on the roadway is < 30,000.
- Vegetated filter strips should not be used on roadways with longitudinal slopes > 5% because of the difficulty in maintaining the necessary sheet flow conditions.
- Vegetated filter strips should be constructed after other portions of the project are completed.
- Vegetated filter strip beds should have a final organic content of 5% for grass and 10% for shrub areas.
- Vegetated filter strips should be constructed outside the natural stream buffer area whenever possible to maintain a more natural buffer along the streambank.

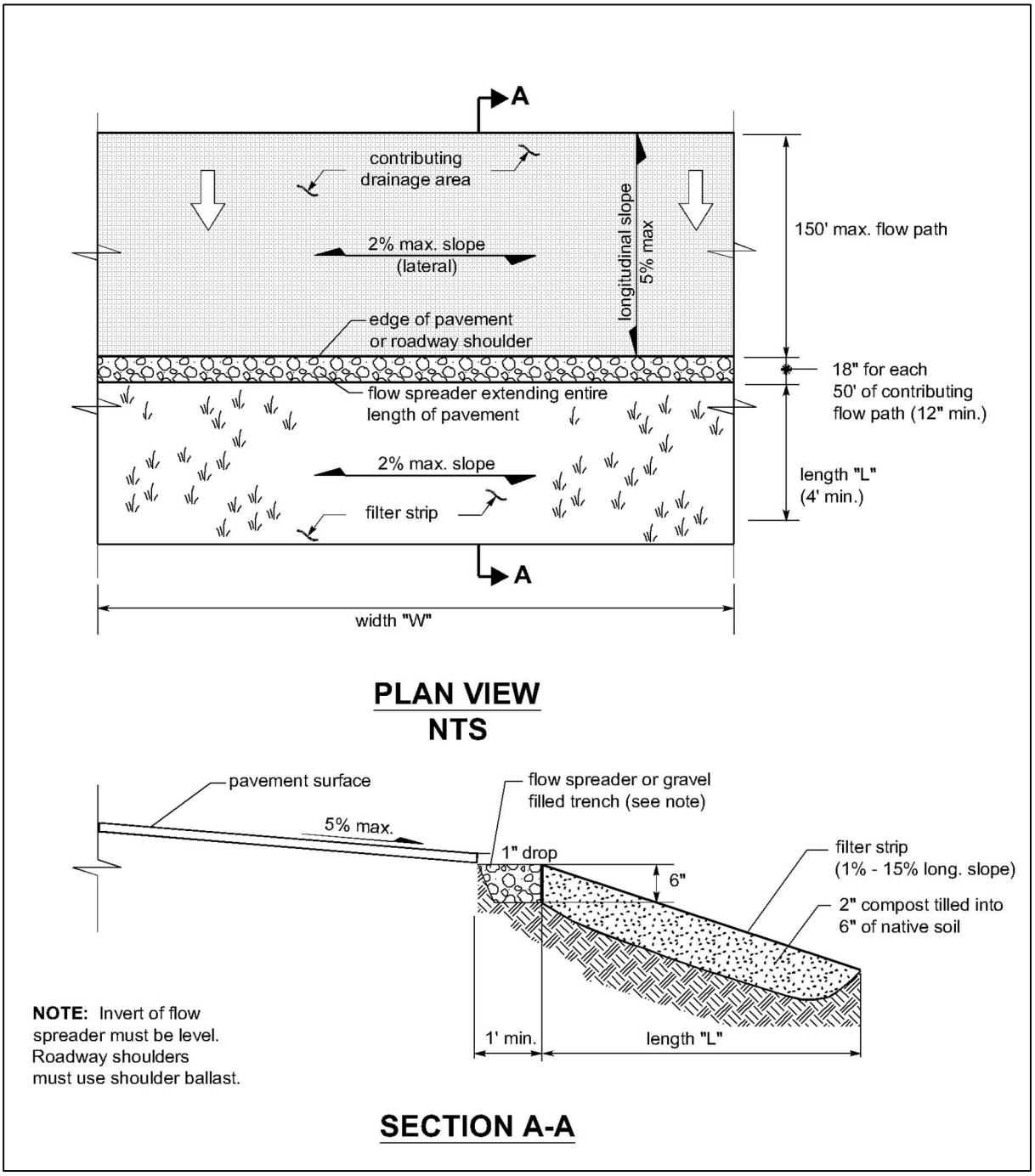


Figure 4 - 18: Typical Filter Strip

13.4.4 Sizing Procedure for Vegetated Filter Strips

Use sizing Method #1 or Method #2 depending upon the contributing area flowpath. See Section 13.4.3.

13.4.4.1 Design Procedures - Method #1

This method may be used when the contributing area to the vegetated filter strip has a maximum flow path length of 30 feet.

The sizing of the vegetated filter strip is based on a 3-step procedure:

1. Determine the length of the flow path from the contributing area (FL), defined as the length of the flow path from the upstream to the downstream edge of the area draining to the BMP.
2. Calculate the average longitudinal or cross slope (S) of the filter strip (along the direction of sheet flow), averaged over the total width of the filter strip.
3. Determine the required length of the filter strip (L, along the direction of sheet flow over the vegetated filter strip). The width of the vegetated filter strip should equal the width of the area draining to it.

Table 4 - 23 Design Criteria for Vegetated Filter Strips - Method 1 summarizes the methods and assumptions for the above steps for sizing vegetated filter strips.

Table 4 - 23: Design Criteria for Vegetated Filter Strips - Method 1

Step	Variable	Methods and Assumptions
1	Length of the Flowpath from the contributing area (FL)	Defined as the length of the flowpath from the upstream to the downstream edge of the area draining to the BMP.
2	Longitudinal or cross slope (S) of the Vegetated Filter Strip	• S must be between 2% and 20% • The vegetated filter strip can be stepped down so that the S ≤ 20% criterion is not exceeded. ◦ Drop sections must be provided with erosion protection at the base and flow spreaders to re-spread flows. ◦ Drops must be less than 12” in height

Step	Variable	Methods and Assumptions
3	Length of Filter Strip	• Use Figure 4-19: Vegetated Filter Strip Design Graph to determine the required length of the vegetated filter strip. ◦ Find the curve representing the appropriate length of the flowpath (FL). ◦ Interpolate between curves as necessary. ◦ Find the point along the curve where the design longitudinal or cross slope (S) of the filter strip is directly below and read the filter strip length (L) to the left on the y axis. • Minimum required filter strip length (L): ◦ 4 feet for FL ≤ 10 feet ◦ 4.5 feet for FL = 25 feet ◦ 5.5 feet for FL = 30 feet • Provide the minimum required length or more along the entire stretch of pavement draining to it.

13.4.4.2 Design Procedures - Method #2

Use the Design Criteria in Table 4 - 24: Design Criteria for Vegetated Filter Strips - Method 2.

Table 4 - 24: Design Criteria for Vegetated Filter Strips - Method 2

Design Parameter	BMP T1040: Vegetated Filter Strip
Longitudinal Slope	0.01 - 0.33 (feet per foot)
Maximum velocity at Q_{veg}	0.5 ft / sec
Maximum water depth	1-inch
Manning coefficient	0.35
Minimum hydraulic residence time at Q_{veg}	9 minutes
Minimum length	Sufficient to achieve hydraulic residence time in the filter strip
Maximum Side Slope (Z)	Inlet edge ≥ 1” lower than contributing paved area
Maximum Contributing Flowpath	150 feet
Max. longitudinal slope of contributing area	0.05 (steeper than 0.05 need upslope flow spreading and energy dissipation)
Max lateral slope of contributing area	0.02 (at the edge of the strip inlet)
Note: 1. Below the design water depth install an erosion control blanket, at least 4” of topsoil, and the selected seed mix. Above the water line use straw mulch or sod.	

Project proponents may utilize the Vegetated Filter Strip spreadsheet available at tacoma.org/stormwatermanual to calculate the appropriate vegetated filter strip size for a project. The spreadsheet uses the procedure below.

D.1. Determine the water quality design flowrate (Q_{wq}) using an Ecology approved continuous simulation model, assuming a 15-minute timestep.

D.2. Determine the vegetated filter strip design flowrate (Q_{veg}) using the equation below.

$$Q_{veg} = kQ_{wq}$$

Where

k=2.0 for online systems

D.3. Calculate the design flow depth using Manning’s equation as follows:

$$Q_{veg} = \frac{1.49AR^{0.67}s^{0.5}}{n}$$

Substituting for AR:

$$Q_{veg} = \frac{1.49 Ty^{1.67} s^{0.5}}{n}$$

Where:

Ty = $A_{rectangle}$, ft^2

y = $R_{rectangle}$, design depth of flow, ft. (1 inch maximum)

n = Manning's roughness coefficient = 0.35

s = Longitudinal slope of filter strip parallel to direction of flow, feet per foot

T = Width of filter strip perpendicular to the direction of flow, ft.

A = Filter strip inlet cross-sectional flow area (rectangular), ft^2

R = hydraulic radius, ft.

Rearranging for y:

$$y = \left(\frac{Q_{veg} \times n}{1.49 Ts^{0.5}} \right)^{0.6}$$

D.4. Calculate the design flow velocity V, ft./sec., through the vegetated filter strip:

$$V = \frac{Q_{veg}}{Ty}$$

V must not exceed 0.5 ft./sec

D.5. Calculate required length, ft., of the filter strip at the minimum hydraulic residence time, t, of 9 minutes:

$$L = tV = 540V$$

13.5 BMP T1050: Compost-Amended Vegetated Filter Strip (CAVFS)

13.5.1 Description

CAVFS are a variation of the vegetated filter strip that includes soil amendments. The soil amendments improve infiltration characteristics, increase surface roughness, and improve plant sustainability.

13.5.2 Applications

CAVFS can be used to help ensure compliance with Minimum Requirement #5: Onsite Stormwater Management and Minimum Requirement #6: Stormwater Treatment. CAVFS provide basic and metals treatment.

13.5.3 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

See Figure 4 - 20: Compost Amended Vegetated Filter Strip (CAVFS)

CAVFS shall only receive sheet flow.

Use curb cuts ≥ 12 inch wide and 1 inch above the filter strip inlet.

CAVFS shall be designed to treat 91% of the influent runoff file through the soil profile. Use the CAVFS element of an Ecology approved continuous simulation model, assuming a 15-minute timestep, to ensure this requirement is met.

The following apply to the required compost-amended soil section:

- The soil mix shall:
  - Have an initial saturated hydraulic conductivity less than 12 inches/hour.
  - Have a minimum long-term hydraulic conductivity less than 1.0 inches/hour per ASTM D2434 (Standard Test Method for Permeability of Granular Soils) at 85% compaction per ASTM D1557 (Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort).
  - Have a minimum organic contact of 5% by dry weight per ASTM Designation D2974 (Standard Test Method for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils).
  - Have a clay content less than 5%.
  - Have a pH between 5.5 and 7.0.
  - Be uniform and free of stones, stumps, roots, or material larger than 2 inches.
- The compost component shall comply with A900: Compost.
- The soil component shall be loamy sand (USDA Soil Textural Classification).

- The final soil mixture should be tested prior to installation for fertility, micronutrient analysis and organic material content.
- Choose one of the following methods in order to obtain a soil mix that meets the criteria above:
  - Presumptive Approach: Place and rototill 1.75 inches of composted material into 6.25 inches of soil to achieve a total amended depth of 9.5 inches, for a settled depth of 8 inches. Water or roll compact soil to 85% maximum. Plant the CAVFS.
  - Custom Approach: Place and rototill the calculated amount of composted material into a depth of soil needed to achieve 8 inches of settled soil at 5% organic content. Water or roll to compact soil to 85% maximum. Plant the CAVFS.
  - Generally, the required soil mix can be achieved with 60-65% loamy sand mixed with 25-30% compost or a 30% sandy loam, 30% coarse sand, 30% compost blend.

13.5.4 Compost Amended Vegetated Filter Strips for Minimum Requirement #5: Onsite Stormwater Management

13.5.4.1 Applications

CAVFS may be used to help meet the mitigation requirements of Minimum Requirement #5: Onsite Stormwater Management for both the List Approach and LID Performance Standard Approach for pedestrian and multi-use sidewalks, trails, and walkways. CAVFS are not an approved option for other surface types.

13.5.4.2 Infeasibility Criteria

The following infeasibility criteria describe conditions that make CAVFS infeasible when applying The List Approach for compliance with Minimum Requirement #5: Onsite Stormwater Management.

The infeasibility criteria shall also be used to determine the appropriateness of installing CAVFS.

Project proponents may be allowed to install CAVFS even if considered infeasible, unless otherwise stated within the specific infeasibility criteria, provided documentation is included that substantiates the design. Documentation may be required by a Washington State Licensed Professional Engineer or other appropriate professional depending on the project conditions.

Setback distances are measured from the edge of the CAVFS.

A site characterization study must be completed in order to determine if the following infeasibility criteria apply.

The following infeasibility criteria require evaluation of site-specific conditions and a written recommendation from an appropriate Washington State Licensed Professional (e.g., Professional Engineer, Professional Geologist, Professional Hydrogeologist).

- If the design criteria cannot be met.
- If the use of the CAVFS is likely to create flooding or erosion problems.

The following infeasibility criteria are based on conditions such as topography and distances to predetermined boundaries. Citation of the following do not need site-specific written recommendations from a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist though some criteria may require professional services to determine if the infeasibility criteria apply.

- If the setback criteria cannot be met. Setback criteria are generally required by Tacoma Municipal Code, Uniform Building Code, the Tacoma Pierce County Health Department, or other state regulations. Where a conflict between setback requirements occurs, the City shall require compliance with the most stringent of the setback requirements from the various codes and regulations. The following are the minimum setback requirements required by this manual.
  - The CAVFS shall be at least 10 feet from any building structure and at least 5 feet from any other structure or property line. If necessary, setbacks shall be increased from the minimum 10 feet in order to maintain a 1H:1V side slope for future excavation and maintenance.
  - The CAVFS shall not be located in critical areas, critical area buffers, streams, or lakes.
  - The CAVFS shall be setback a minimum of 50 feet from the top of any slope greater than 15% and from geologically hazardous areas. The dispersion area may be sited within 50 feet of a slope greater than 15% and/or geologically hazardous area if a geotechnical analysis performed by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist determines that there will be no negative impacts to the slopes and/or geologically hazardous area caused by the location of the dispersion area.
  - Setbacks from Onsite Sewage Systems shall conform to WAC 246-272A-0210.
- If there are any conflicts with any of the following competing needs criteria:
  - Requirements of the following federal or state laws, rules, and standards:
    - Historic Preservation Laws and Archaeology Laws as listed at: https://dahp.wa.gov/project-review/preservation-laws
    - Federal Superfund or Washington State Model Toxics Control Act
    - Federal Aviation Administration requirements for airports
    - American with Disabilities Act
  - When found to be in conflict with special zoning district design criteria adopted and being implemented pursuant to a community planning process.
  - Public health and safety standards
  - Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.
  - City of Tacoma Critical Area Ordinances that provides protection of tree species or other critical areas.
- Where the sidewalk, walkway, or trail exceeds a lateral slope of 5% or a longitudinal slope of 8%.

The following infeasibility criteria are based upon subsurface characteristics and require a soils report to determine infeasibility. See Appendix B: Soils Reports for Soils Report Requirements.

- Where the field testing indicates potential CAVFS locations have a measured (initial) native soil saturated hydraulic conductivity less than 0.3 inches/hour.
  - CAVFS installed for the purposes of Minimum Requirement #5 shall only be constructed where infiltration is feasible.

- If the measured soil infiltration rate is less than 0.3 inches/hour, CAVFS cannot be used to meet The List Approach or Low Impact Development (LID) Performance Standard.

- Where the minimum vertical separation between the lowest elevation of the CAVFS and the seasonal high groundwater elevation, bedrock, or other impermeable layer is 1 foot or less.

13.5.4.3 Subsurface Characterization

A soils report is required to design a CAVFS. A soils report is also required if citing that a CAVFS is not feasible due to subsurface characteristics. See Appendix B: Soils Reports requirements.

13.5.4.4 Sizing Criteria for Meeting Minimum Requirement #5: Onsite Stormwater Management – The List Approach

- For sidewalks, walkways, and trails less than 10 feet and where the measured soil infiltration rate is 0.3 inches/hour or greater:

Table 4 - 25 CAVFS Width Based on Surface Width of Sidewalk, Walkway, and/or Trail

Sidewalk, walkway, trail hard surface width	CAVFS Minimum Width
Less than 6 feet	2 Feet
6 feet to 8 feet	2.5 Feet
8 feet to less than 10 feet.	3 Feet

- Sidewalks, walkways, and trails greater than 10 feet or where the measured soil infiltration rate is less than 0.3 inches/hour:
  - Size the CAVFS utilizing the Sizing Criteria for meeting Minimum Requirements #5: Onsite Stormwater Management - Low Impact Development (LID) Performance Standard.

13.5.4.5 Sizing Criteria for Meeting Minimum Requirement #5: Onsite Stormwater Management – Low Impact Development (LID) Performance Standard

Utilize the CAVFS Element of an Ecology approved continuous simulation model, assuming a 15-minute timestep, to ensure the LID Performance Standard is met.

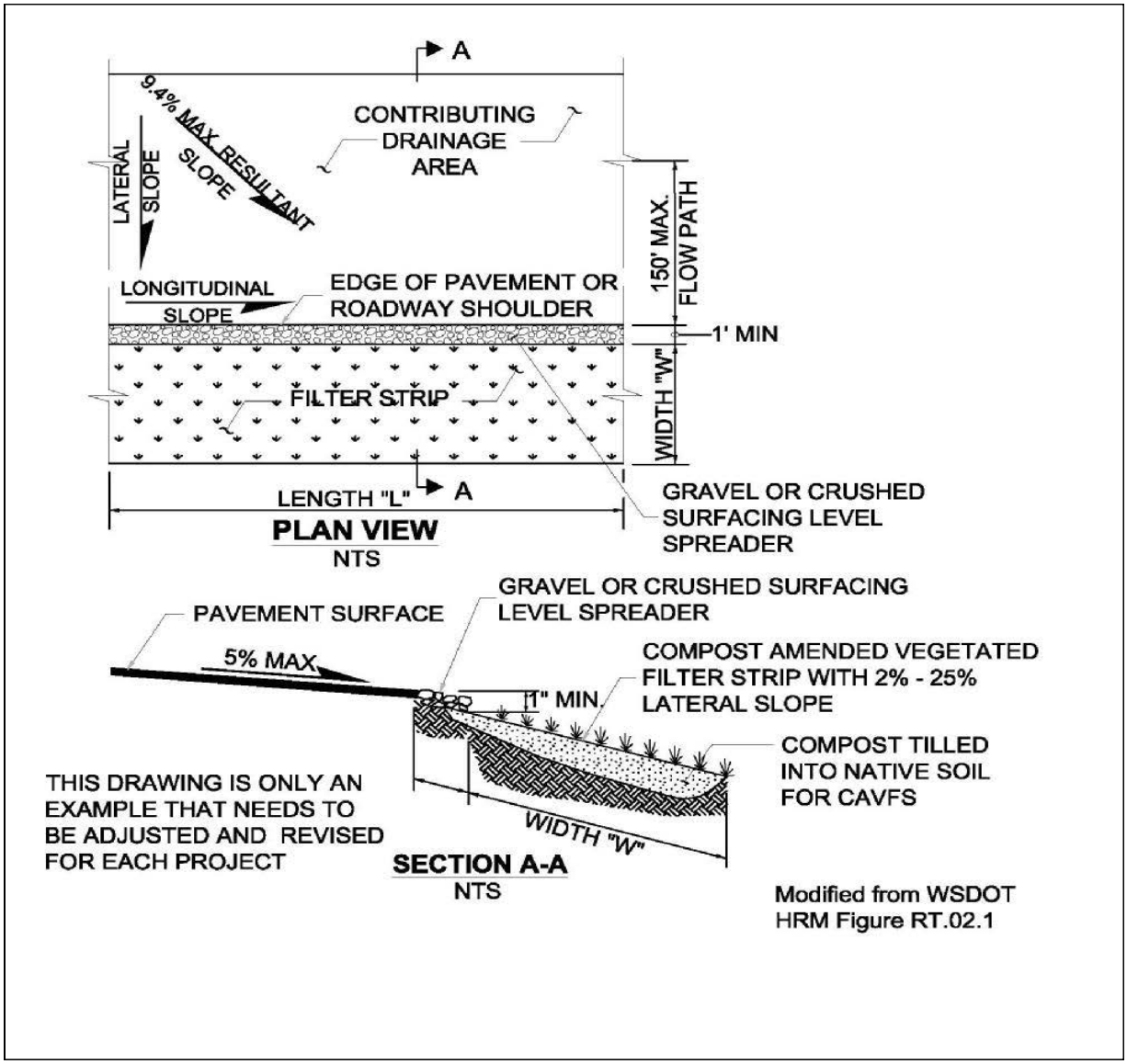
13.5.4.6 Additional Design Criteria when Utilizing CAVFS for Minimum Requirement #5: Onsite Stormwater Management

In addition to meeting the design criteria in Section 13.5.3 - Design Criteria, the following criteria apply to CAVFS that will be used to meet Minimum Requirement #5: Onsite Stormwater Management:

- The sidewalk, walkway, or trail shall have a lateral slope greater than 1% and less than 5%.
- The sidewalk, walkway, or trail shall have a longitudinal slope less than 8%.
- The CAVFS shall have a minimum slope of 2%.
- The CAVFS shall have a maximum slope of 25%.

Note: A report from a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist is required for slopes over 15%.

Figure 4 - 20: Compost Amended Vegetated Filter Strip (CAVFS)



13.6 BMP T900: Media Filter Drain

13.6.1 General Description

The media filter drain (MFD), previously referred to as the ecology embankment, is a linear flow-through stormwater treatment device that can be sited along road side slopes (conventional design) and medians (dual media filter drains), borrow ditches, or other linear depressions. Cut-slope applications may also be considered. The MFD can also be used in an end-of-pipe application where surface runoff is collected and conveyed to a location where flows can be redispersed to the MFD.

MFD configurations are separated into seven typical installations. MFD Type 1 though Type 5 have the option of placing a 3-inch medium compost layer with grass over the MFD mix area. If the 3-inch compost layer with grass is used on the MFD mix area, the BMP does not qualify for phosphorous treatment. MFD Types 1 through 7 are shown in Figure 4- 21: Media Filter Drain Type 1: Side Slope Application With Underdrain through Figure 4 - 27: Media Filter Drain Type 7: End-of-pipe Application Without Underdrain

The different MFD types are briefly described below:

- MFD Type 1 - V Sheet flow application with underdrain.
- MFD Type 2 - V Sheet flow applications; flows are from both sides of the median.
- MFD Type 3 - V Sheet flow application without underdrain; drains to slope.
- MFD Type 4* - V End-of-pipe application, redispersed to MFD with underdrain.
- MFD Type 5* - V End-of-pipe application, redispersed to MFD without underdrain.
- MFD Type 6* - V End-of-pipe application that is downstream of a detention BMP, redispersed to MFD with underdrain. MFD Type 6 doesn’t have the no-vegetation zone or grass strip because of the sediment storage in the upstream detention BMP. MFD Type 6 must have a 3-inch medium compost blanket with grass over MFD mix area. MFD Type 6 must have 8-inch-diameter compost socks, spaced at a minimum of 4-foot intervals, along the bottom of the MFD media mix.
- MFD Type 7* - V Same as Type 6, except MFD doesn’t have an underdrain; it drains to the adjacent side slope.

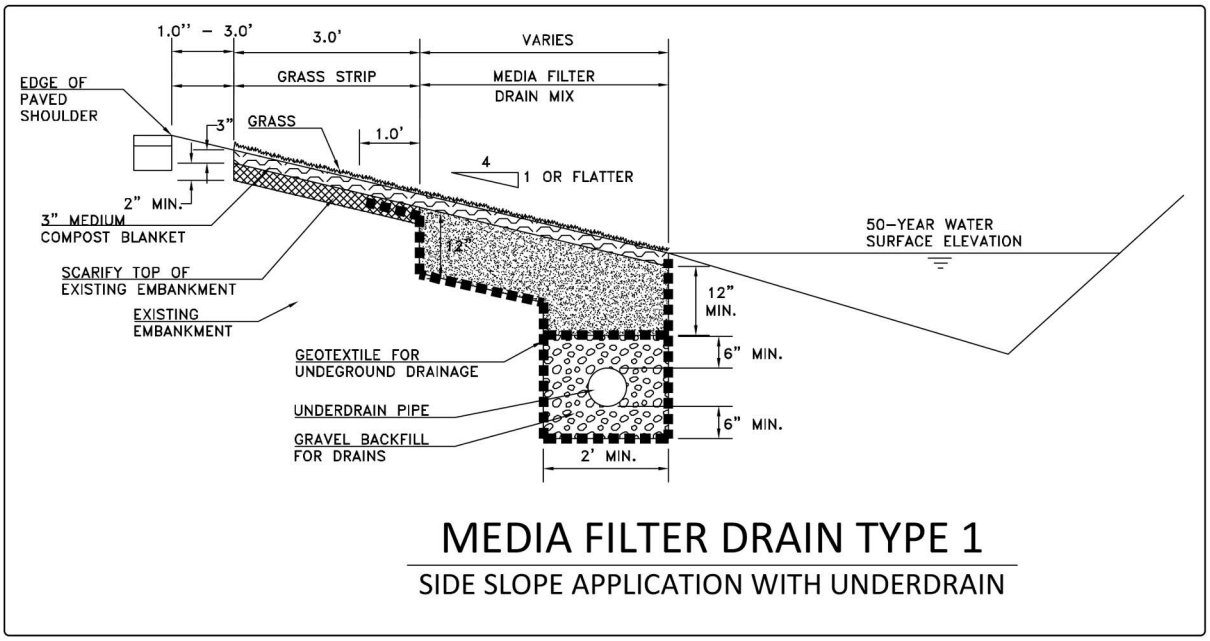


Figure 4 - 21: Media Filter Drain Type 1: Side Slope Application With Underdrain

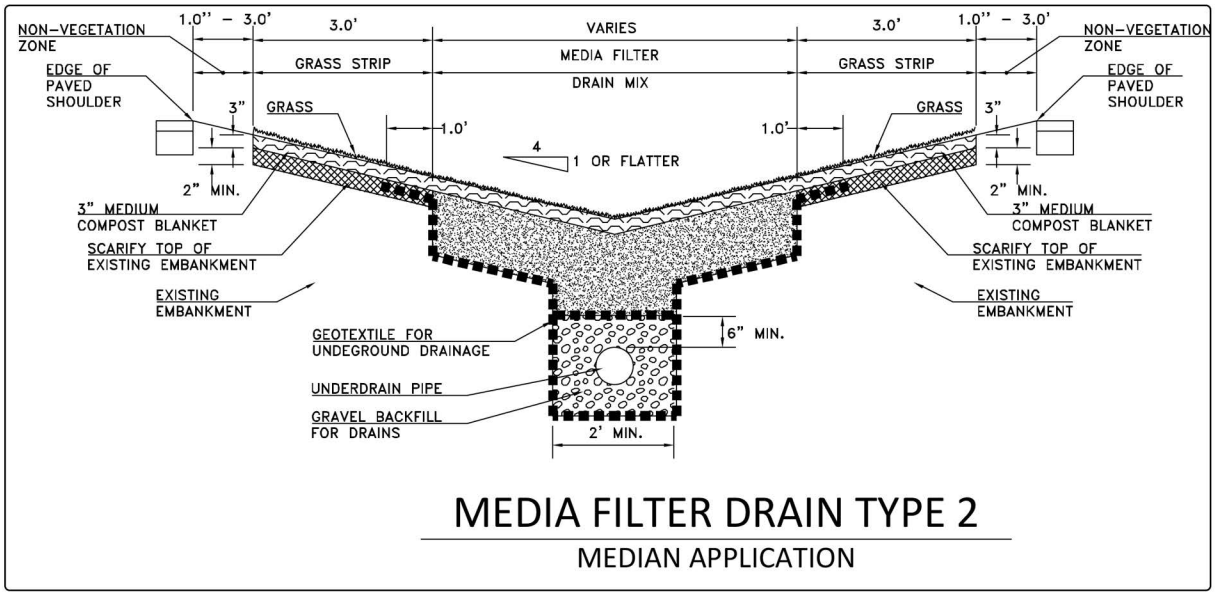


Figure 4 - 22: Dual Media Filter Drain Type 2: Median Application

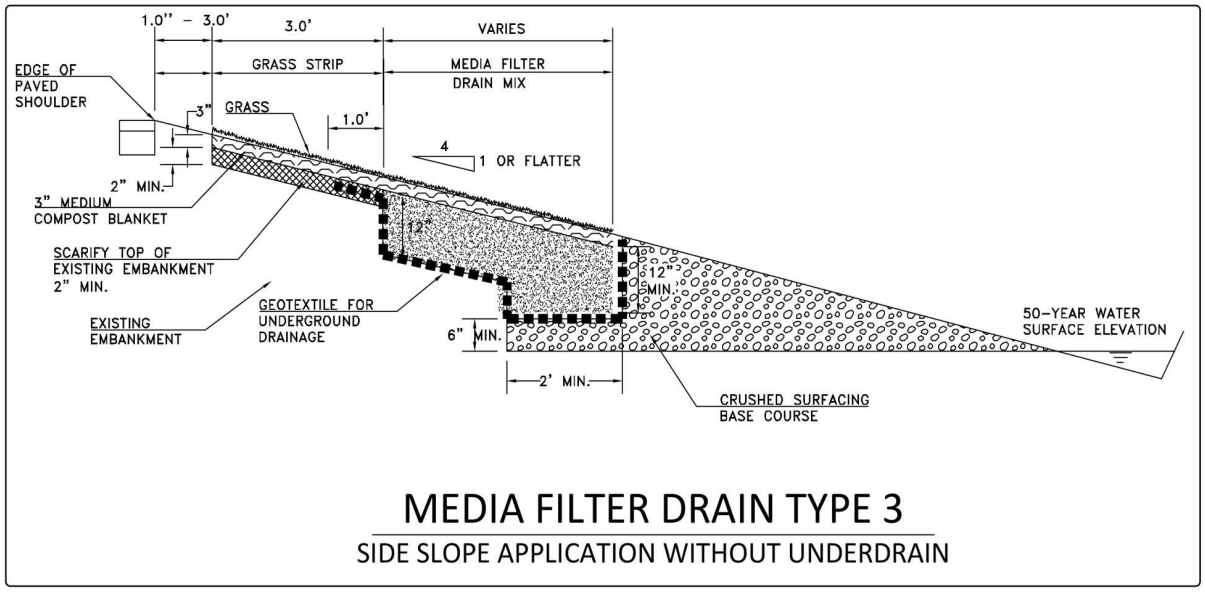


Figure 4 -23: Media Filter Drain Type 3: Side Slope Application Without Underdrain

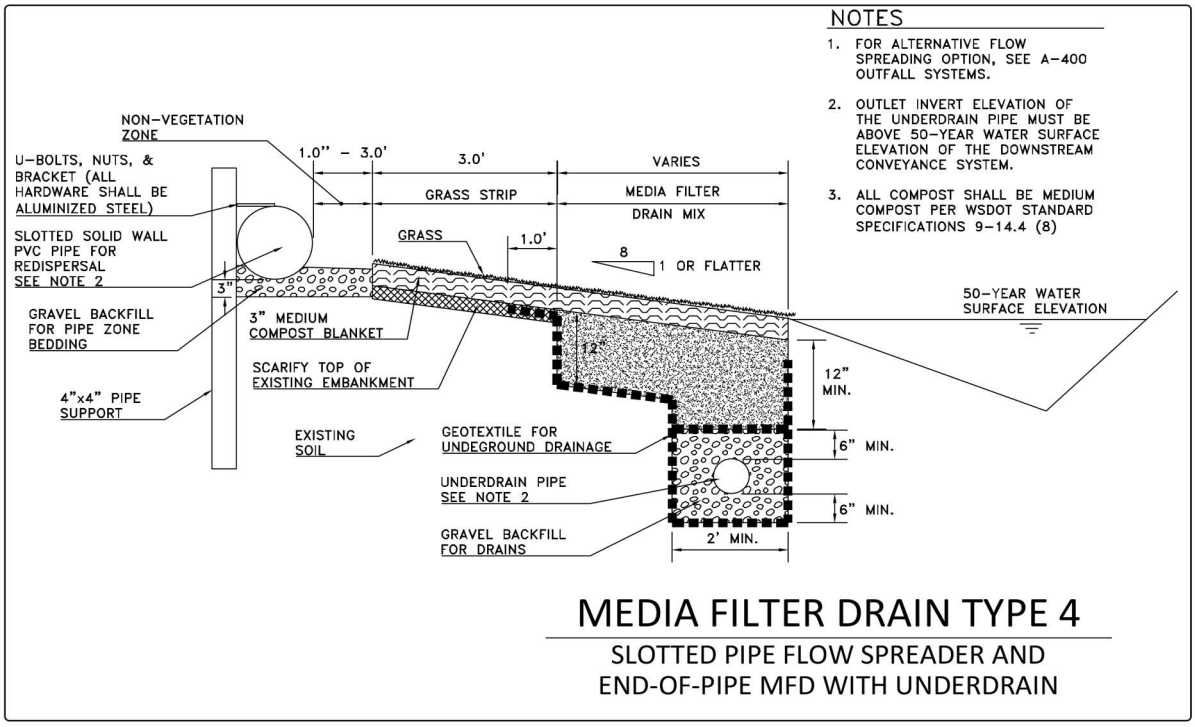


Figure 4 - 24: Media Filter Drain Type 4: End-of-pipe Application With Underdrain

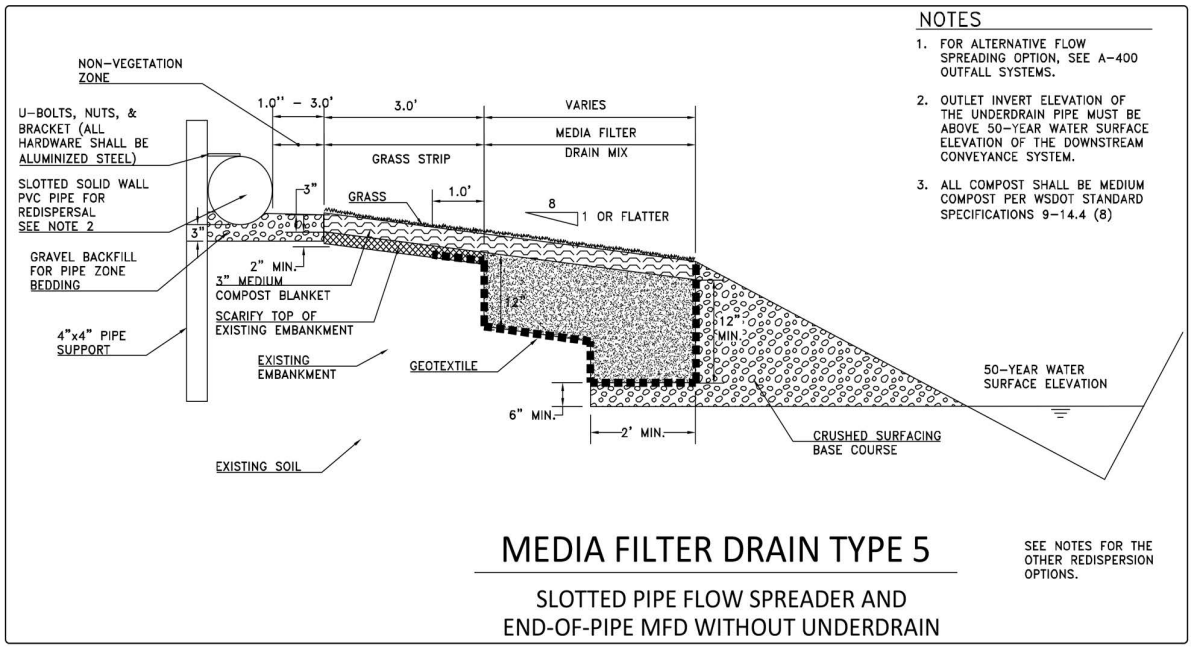


Figure 4 - 25: Media Filter Drain Type 5: End-of-pipe Application Without Underdrain

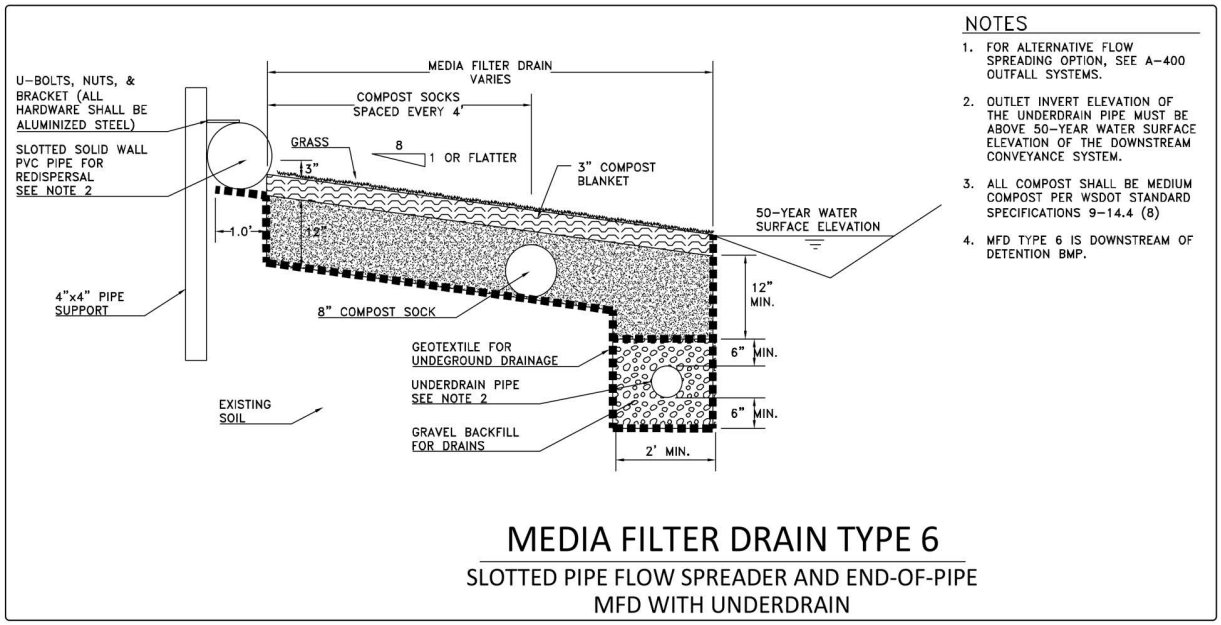


Figure 4 - 26: Media Filter Drain Type 6: End-of-pipe Application With Underdrain

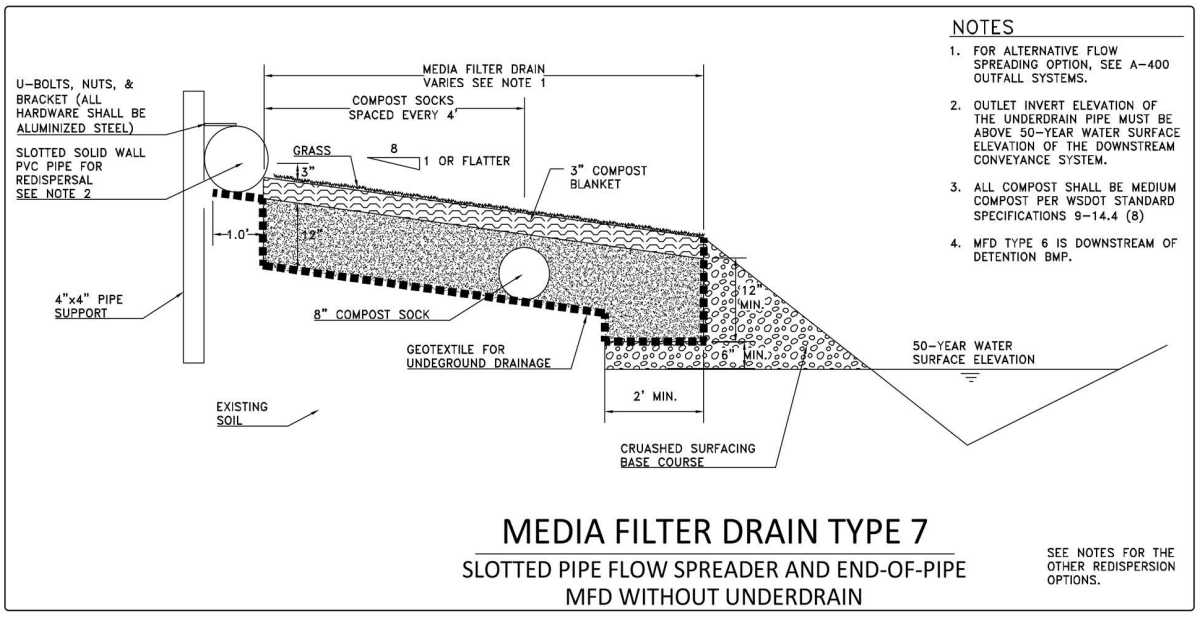


Figure 4 - 27: Media Filter Drain Type 7: End-of-pipe Application Without Underdrain

13.6.2 Functional Description

The MFD removes suspended solids, phosphorus (MFD without 3-inch medium compost blanket), and metals from highway runoff through physical straining, ion exchange, carbonate precipitation, and biofiltration

Stormwater is conveyed to the MFD via sheet flow or is redispersed to a vegetation-free gravel zone (MFD Type 1 – Type 5) to ensure dispersion and provide some pollutant trapping. Next, a grass strip provides pretreatment, further enhancing filtration and extending the life of the system. The runoff is then filtered through a bed of porous, alkalinity-generating granular medium—the media filter drain mix. Treated stormwater and surface water flows away from the MFD mix bed into a downstream conveyance system. Geotextile lines the underside of the MFD mix bed and the underdrain pipe and trench (if applicable).

The underdrain trench is an option for hydraulic conveyance of treated stormwater to a desired location, such as a downstream flow control facility, discharge location, or stormwater outfall. The trench's perforated underdrain pipe is a protective measure to ensure free flow through the MFD mix. It may be possible to omit the underdrain pipe if it can be demonstrated that the pipe is not necessary to maintain free flow through the MFD mix and underdrain trench.

It is critical to note that water should sheet flow across or be redispersed to the MFD. To ensure sediment accumulation does not restrict sheet flow, edge of pavement installations should include a 1-inch drop between the pavement surface and nonvegetation zone where there is no guardrail or include a 1-inch drop where there is guardrail. Note that MFD Types 4 through Type 7 include a 3-inch drop between the flow spreader and the MFD mix bed to ensure sheet flow continues over time.

13.6.3 Applications and Limitations

- Media filter drains can be used to ensure compliance with Minimum Requirement #6: Stormwater Treatment. Depending on the configurations, MFD can provide basic,

phosphorus (MFD without 3-inch medium compost blanket on MFD mix area), and metals stormwater treatment.

- MFD Type 1 and Type 3 - Ideal along highway side slopes, when adjacent to wetlands, and in narrow right of way locations.
- Dual MFD for Highway Medians (MFD Type 2) - Prime locations for the MFD Type 2 are in highway medians, roadside conveyance ditches, or other linear depressions. It is especially critical for water to sheet flow across the MFD Type 2. Channelized flows or ditch flows running down the middle of the MFD Type 2 (continuous off-site inflow) should be minimized.
- MFD Type 4 and Type 5 - Ideal where stormwater needs to be or already is captured and conveyed to a discharge location that can accommodate this BMP. These options provide maximum flexibility for placement where sheet flow off the edge of pavement is not feasible. Catch basins and pipes are used to convey stormwater to the MFD Type 4 and Type 5.
- MFD Type 6 and Type 7 - Ideal where stormwater needs to be collected and conveyed for both stormwater treatment and flow control. The MFD is downstream of the detention BMP.
- Ensure lateral MFD side slopes adjacent to the roadway pavement (MFD Type 1 - Type 3) are less than 4H:1V. As side slopes approach 3H:1V, without design modifications, sloughing may become a problem due to friction limitations between the separation geotextile and underlying soils.
- Where the MFD is built away from the roadway (MFD Type 4 - Type 7), ensure the lateral MFD side slope is less than 8H:1V.
- Ensure longitudinal MFD slopes are no steeper than 5%.
- Ensure the longest flow path from the contributing area delivering sheet flow to the MFD (Type 1 - Type 3) does not exceed 150 feet.
- Do not construct in wetlands and wetland buffers.
- Shallow groundwater - Determine seasonal high groundwater table levels to ensure the MFD mix bed and the underdrain (if applicable) will not become saturated by shallow groundwater. The hydraulic and stormwater treatment performance of the MFD may be compromised due to backwater effects and lack of sufficient hydraulic gradient due to shallow groundwater or pooling at the discharge location.
- Unstable slopes - In areas where slope stability may be problematic, consult a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist.
- Narrow roadway shoulders - In areas where there is a narrow roadway shoulder (width less than 10 feet), consider placing the MFD farther down the embankment slope. This will reduce the amount of rutting in the MFD and decrease overall maintenance repairs. Also, consider using a MFD Type 5 or Type 6.
- Ensure the upstream conveyance system to a MFD Type 4 - Type 7 has adequate hydraulic head to push flows through the redispersal structure and not create upstream flooding problems.

13.6.4 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best

Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

13.6.4.1 Facility Geometry

13.6.4.1.1 Components

- ***No-Vegetation Zone*** - The no-vegetation zone (vegetation-free zone) is a shallow gravel zone located directly adjacent to the highway pavement. The no-vegetation zone is a crucial element in a properly functioning MFD or other BMPs that use sheet flow to convey runoff from the highway surface to the BMP. The no-vegetation zone functions as a level spreader to promote sheet flow and a deposition area for coarse sediments. Make sure the no-vegetation zone is between 1 foot and 3 feet wide. Depth will be a function of how the roadway section is built from subgrade to finish grade; the resultant cross section will typically be triangular to trapezoidal.
- ***Grass Strip*** - The width of the grass strip is dependent on the availability of space within the highway side slope and MFD type. The grass strip is required on MFD Type 1 - Type 5. The minimum grass strip width is 3 feet, but wider grass strips are recommended if the additional space is available. At a minimum, the existing embankment will be scarified 2 inches and covered with a 3-inch blanket of medium compost and seeded. Consider adding aggregate to the soil mix to help minimize rutting problems from errant vehicles. The soil mix should ensure grass growth for the design life of the MFD.
- ***Media Filter Drain Mix Bed*** - The MFD mix is a mixture of crushed rock (sized by screening), dolomite, gypsum, and perlite. The crushed rock provides the support matrix of the medium; the dolomite and gypsum add alkalinity and ion exchange capacity to promote the precipitation and exchange of heavy metals; and the perlite improves moisture retention to promote the formation of biomass within the MFD mix. The combination of physical filtering, precipitation, ion exchange, and biofiltration enhances the water treatment capacity of the mix. The MFD mix has an estimated initial filtration rate of 50 inches per hour and a long-term filtration rate of 28 inches per hour due to siltation. With an additional safety factor, the rate used to size the length of the MFD should be 10 inches per hour. Internal 8-inch-diameter medium compost socks are required along the bottom of the MFD Type 6 and Type 7 installations at even 4-foot spacings. Make sure there is a minimum of one row of compost socks for each MFD Type 6 or Type 7 installation.
- ***3-Inch Medium Compost Blanket and Grass*** - Place a 3-inch medium compost blanket with grass over the media filter drain bed area to reduce noxious weeds and unwanted vegetation. Compost shall be medium compost and conform to WSDOT Standard Specification 9-14.5(8). Do not use this compost blanket in phosphorous-sensitive areas or phosphorous total maximum daily load (TMDL) areas. If this option is used, the MFD will not be considered as a phosphorous treatment BMP. Do not use MFD Type 6 and Type 7 in phosphorous-sensitive areas since the 3-inch compost blanket is required.
- ***Conveyance System Below Media Filter Drain Mix*** - The gravel underdrain trench (MFD Type 1, Type 4, and Type 6) provides hydraulic conveyance when treated runoff needs to be conveyed to a desired location such as a downstream flow control facility, discharge location, or stormwater outfall. In Group C and D soils, an underdrain pipe helps ensure free flow of the treated runoff through the MFD mix bed. In some Group A and B soils, an underdrain pipe may not be necessary if most water percolates into subsoil from the underdrain trench. Evaluate the need for underdrain pipe in all cases. The PEO may eliminate the gravel underdrain trench if flows can be conveyed laterally to an adjacent ditch or onto a fill slope that is properly vegetated to protect against erosion

(MFD Type 3 and Type 5). Keep the MFD mix free draining up to the 50-year storm event water surface elevation represented in the downstream ditch.

13.6.4.1.2 Length

- The length of the MFD (Type 1 - Type 3) is the same as the length of the contributing pavement.
- The length of the MFD (Type 4 - Type 7) depends on the sizing procedures. (See the Design Method section below.)

13.6.4.1.3 Cross Section

- The surface of the MFD (Type 1 - Type 3) should have a lateral slope less than 4H:1V (<25%). On steeper terrain, it may be possible to construct terraces to create a 4H:1V slope, or other engineering may be employed to ensure slope stability up to 3H:1V.
- The surface of the MFD (Type 4 - Type 7) should have a lateral slope less than 8H:1V (<12.5%).

13.6.4.1.4 Contributing Area

For MFD (Type 1 - Type 3), the resultant slope from the contributing area should be less than or equal to 9.4%, calculated using the equation below:

$$S_{CFS} \leq (G^2 + e^2)^{0.5}$$

Where:

S_{CFS} = resultant slope of the lateral and longitudinal slopes (%)

e = lateral slope (superelevation) (%)

G = longitudinal slope (grade) (%)

13.6.4.2 Materials

The MFD mix consists of the amendments listed in Table 4 - 27: Media Filter Drain Mix. Mixing and transportation must occur in a manner that ensures the materials are thoroughly mixed prior to placement and that separation does not occur during transportation or construction operations.

These materials should be used in accordance with the following WSDOT Standard Specifications:

- Gravel Backfill for Drains - 9-03.12(4)
- Underdrain Pipe - 7-01.3(2)
- Construction Geotextile for Underground Drainage, Moderate survivability, drainage class A, nonwoven - 9-33.1
- Crushed Surfacing Base Course (CSBC) - 9-03.9(3)

If the MFD is configured to allow the treated runoff to flow laterally into a ditch (MFD Type 3 and MFD Type 5), the crushed surfacing base course below the MFD should conform to WSDOT Standard Specification 9-03.9(3).

13.6.4.3 Sizing

13.6.4.3.1 Media Filter Drain Mix Bed Sizing Procedure for MFD Type 1 - Type 3

The width of the MFD mix bed is determined by the amount of contributing pavement routed to the embankment. The surface area of the MFD mix bed needs to be sufficiently large to fully infiltrate and filter the stormwater treatment design flowrate using the long-term filtration rate of the MFD mix. For design purposes, incorporate a 50% safety factor into the long-term MFD mix filtration rate to accommodate variations in slope, resulting in a design filtration rate of 10 inches per hour. The MFD mix bed should have a bottom width of at least 2 feet in contact with the conveyance system below the MFD mix.

The MFD mix bed should be a minimum of 12 inches deep, including the section on top of the underdrain trench.

For stormwater treatment, base the sizing of the MFD mix bed on the requirement that the stormwater treatment flowrate from the pavement area, $Q_{Highway}$, cannot exceed the long-term infiltration capacity of the MFD, $Q_{Infiltration}$:

$$Q_{Highway} \leq Q_{Infiltration}$$

For western Washington, $Q_{Highway}$ is the water quality design flowrate calculated by an Ecology approved continuous simulation model, assuming a 15-minute timestep.

Base the long-term infiltration capacity of the MFD on the following equation:

$$\frac{LTIR \times L \times W}{C \times SF} = Q_{Infiltration}$$

Where:

LTIR = Long-term infiltration rate of the media filter drain mix
(use 10 inches per hour for design) (in/hr)

L = Length of media filter drain (parallel to roadway) (ft)

W = Width of the media filter drain mix bed (ft)

C = Conversion factor of 43200 ((in/hr)/(ft/sec))

SF = Safety Factor (equal to 1.0, unless unusually heavy sediment loading is expected)

Assuming that the length of the MFD is the same as the length of the contributing pavement, solve for the width of the media filter drain:

$$W \geq \frac{Q_{Highway} \times C \times SF}{LTIR \times L}$$

Western Washington project applications of this design procedure have shown that, in almost every case, the calculated widths of the MFD Type 1 and Type 3 do not exceed 1.0 foot.

Therefore, Table 4 - 26:Western Washington Design Widths for Media Filter Drains (Type 1 and Type 3) was developed to simplify the design steps; use it to establish an appropriate width.

Table 4 - 26: Western Washington Design Widths for Media Filter Drains (Type 1 and Type 3)

Pavement width that contributes runoff to the media filter drain	Minimum media filter drain width*
≤ 20 feet	2 feet
≥ 20 and ≤ 35 feet	3 feet
> 35 feet	4 feet
*Width does not include the required 1 to 3 foot gravel vegetation-free zone or the 3-foot grass strip width.	

13.6.4.3.2 Media Filter Drain Mix Bed Sizing Procedure for MFD Type 4 and Type 5

The length (perpendicular to the direction of flow) and width (parallel to the direction of flow) of the MFD mix bed (Type 4 and Type 5) is determined by many factors. The design procedure is outlined below:

1. Determine the total tributary pervious and impervious area (ft^2) and flowrate (cfs) that will be sent to the MFD.
2. For MFD Type 4 and Type 5, divide the tributary area determined in Step 1 above by the “pavement area to MFD media area” ratio of 19.5. This determines the area of MFD needed, and applies to on-line and off-line Type 4 and Type 5 MFDs.
3. From A300: Flow Spreading Devices, choose Option F (slotted flow dispersal pipe) or Option G (perforated pipe in a gravel-backfilled trench with notched grade board) as the redispersal/flow spreader structure type to be used upstream of the MFD. For on-line Type 4 and Type 5 MFDs, the number of flow spreaders and the flow spreader mounding analysis (Option F) is based on the full 100-year rate from the tributary area coming to the MFD. For off-line Type 4 and Type 5 MFDs, the number of flow spreaders and the flow spreader mounding analysis (Option F) is based on the water quality design flowrate.
4. Determine the length (perpendicular to the direction of flow) and width (parallel to the direction of flow) of the MFD mix bed by the following:
    - The flow spreader length shall be between 50 feet and 200 feet. The number of flow spreaders and their lengths are calculated based on the criteria in Step 3 above.
    - The width of the MFD mix bed = (flow spreader length)/5 for flow spreader lengths of 50 feet to 100 feet.
    - The width of the MFD mix bed = 20 feet for flow spreader lengths of 101 feet to 200 feet.
    - Check to make sure the total area of MFD mix bed(s) calculated in (4) is greater than or equal to the area determined in (2) above.

13.6.4.3.3 Media Filter Drain Mix Bed Sizing Procedure for MFD Type 6 and Type 7

MFD Type 6 and Type 7 are designed as on-line BMPs only. The design procedure is outlined below:

1. From A300: Flow Spreading Devices, choose Option F (slotted flow dispersal pipe) or Option G (perforated pipe in a gravel-backfilled trench with notched grade board) as the redispersal/flow spreader structure type to be used upstream of the MFD. The number of flow spreaders and the flow spreader mounding analysis (if using Option F) shall be based on the 100-year release rate from the detention BMP (MGSFlood, 15-minute time steps). Determine the length of each flow spreader.

2. Determine the MFD mix bed area (L x W) using the equation below:

$$\frac{LITR \times L \times W}{C \times SF} = Q_{2year}$$

   Where:

   LTIR = Long-term infiltration rate of the media filter drain mix (use 10 inches per hour for design) (in/hr)

   L = Length of media filter drain (parallel to spreader) (ft)

   W = Width of the media filter drain mix bed (ft) measured parallel to the flow

   C = Conversion factor of 43200 ((in/hr)/(ft/sec))

   SF = Safety Factor (equal to 2.0)

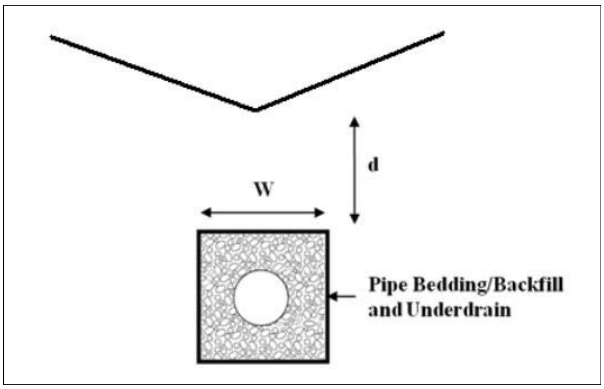
   Q_{2year} = 2-year release rate (determined from an Ecology approved continuous simulation model, assuming 15-minute time steps) from the detention facility (ft^3/sec)

3. The number of flow spreaders and length of each flow spreader was determined in Step 1. The length of the flow spreader(s) is equal to the length of the MFD. The width of the MFD follows the same ratios stated in Steps 4b and 4c of the MFD Type 4 and Type 5 design. Determine the total MFD mix bed length (L) and width (W). Check to make sure the calculated MFD mix bed area (L x W) is greater than or equal to the MFD mix bed area calculated in Step 2.

13.6.4.4 Underdrain Design

Underdrain pipe can provide a protective measure to ensure free flow through the MFD mix and is sized similar to stormwater conveyance systems. For MFD underdrain sizing, an additional step is required to determine the flowrate that can reach the underdrain pipe. This is done by comparing the contributing basin flowrate to the infiltration flowrate through the MFD mix and then using the smaller of the two to size the underdrain. The analysis described below considers the flowrate per foot of MFD, which allows the flexibility of incrementally increasing the underdrain diameter where long lengths of underdrain are required. When underdrain pipe connects to a stormwater conveyance system, place the invert of the underdrain pipe above the 25-year water surface elevation in the stormwater conveyance system to prevent backflow into the underdrain system.

Figure 4 - 28: Media Filter Drain Underdrain Installation



The following describes the procedure for sizing underdrains in a MFD Type 1, 2, 4, and 6.

1. Calculate the flowrate per foot from the contributing basin to the MFD.

$$\frac{Q_{highway}}{ft} = \frac{Q_{highway}}{L_{MFD}}$$

Where:

$\frac{Q_{highway}}{ft}$ = contributing flowrate per foot (cfs/ft)

LMFD = length of MFD contributing runoff to the underdrain (ft)

2. Calculate the MFD flowrate of runoff per foot given an infiltration rate of 10 in/hr through the MFD mix

$$\frac{Q_{MFD}}{ft} = \frac{f \times W \times 1ft}{ft} \times \frac{1ft}{12in} \times \frac{1hr}{3600sec}$$

Where:

$\frac{Q_{MFD}}{ft}$ = flowrate of runoff through MFD mix layer (cfs/ft)

W = width of underdrain trench (ft); the minimum width is 2 ft

f = infiltration rate though the MFD mix (in/hr) = 10 in/hr

3. Size the underdrain pipe to convey the runoff that can reach the underdrain trench. This is taken to be the smaller of the contributing basin flowrate or the flowrate through the MFD mix layer.

$$\frac{Q_{UD}}{ft} = \text{smaller}\left\{\frac{Q_{highway}}{ft} \text{ or } \frac{Q_{MFD}}{ft}\right\}$$

Where:

$\frac{Q_{UD}}{ft}$ = underdrain design flowrate per foot (cfs/ft)

4. Determine the underdrain design flowrate using the length of the MFD and a factor of safety of 1.2.

$$Q_{UD} = 1.2 \times \frac{Q_{UD}}{ft} \times W \times L_{MFD}$$

Where:

Q_{UD} = estimated flowrate to the underdrain (cfs)

W = width of the underdrain trench (ft); the minimum width is 2 ft

LMFD = length of MFD contributing runoff to the underdrain (ft)

5. Given the underdrain design flowrate, determine the underdrain diameter. Round pipe diameters to the nearest standard pipe size and have a minimum diameter of 6 inches.

$$D = 16\left(\frac{Q_{UD} \times n}{s^{0.5}}\right)^{\frac{3}{8}}$$

Where:

D = underdrain pipe diameter (inches)

n = Manning's coefficient

s = slope of pipe (ft/ft)

Table 4 - 27: Media Filter Drain Mix

Amendment	Quantity
Mineral aggregate shall meet all requirements for the WSDOT Standard Specifications 9-03.4 Aggregate for Bituminous Surface Treatment - Crushed screenings 3/8-inch to No.4 with the exception of: The fracture requirement shall be at least two fractured faces and will apply to material retained on the U.S. No. 4 sieve in accordance with FOP for AASHTO T 335.	3 cubic yards
Perlite: • WSDOT Standard Specifications 9-14.5(9) Horticultural grade	1 cubic yard per 3 cubic yards of mineral aggregate
Dolomite: • WSDOT Standard Specifications 9-14.5(5) Agricultural grade	40 pounds per cubic yard of perlite
Gypsum: • WSDOT Standard Specifications 9-14.5(6) Agricultural grade	12 pounds per cubic yard of perlite

13.6.4.5 Landscaping

Landscape the grass strip the same as BMP T1010: Basic Biofiltration Swale.

13.6.4.6 Construction Criteria

Keep effective erosion and sediment control measures in place until grass strip is established. Do not allow vehicles or traffic on the MFD, to minimize rutting and maintenance repairs.

13.6.4.7 Signage

If MFD is in a critical aquifer recharge area for drinking water supplies, provide signage prohibiting the use of pesticides.

Provide a stormwater facility sign. Sign shall conform to A800: Signage.

Chapter 14 Sand Filtration BMPs

14.1 Purpose

This chapter presents criteria for the design, construction and maintenance of stormwater treatment sand filters. Treatment sand filters are used to collect, treat and remove TSS, phosphorous, and insoluble organics (including oils) from stormwater.

Sand filtration options discussed in this Chapter are:

BMP T810: Sand Filter Vault
BMP T820: Linear Sand Filter
BMP T808: Basic Sand Filter
BMP T809: Large Sand Filter

14.2 Description

A typical sand filtration system consists of a pretreatment facility, flow spreader(s), a sand bed, and the underdrain piping. The sand filter bed includes a geotextile fabric between the sand bed and the bottom underdrain system.

An impermeable liner under the facility may also be needed if the filtered runoff requires additional treatment to remove soluble groundwater pollutants, or in cases where additional groundwater protection is mandated - see A100: Liners. The variations of a sand filter include a basic or large sand filter, sand filter with level spreader, sand filter vault, and linear sand filter.

Figure 4 - 29: Sand Filtration Basin Preceded by Presettling Basin (Varation of a Basic Sand Filter) through Figure 4 - 36: Linear Sand Filter provide examples of various sand filter configurations.

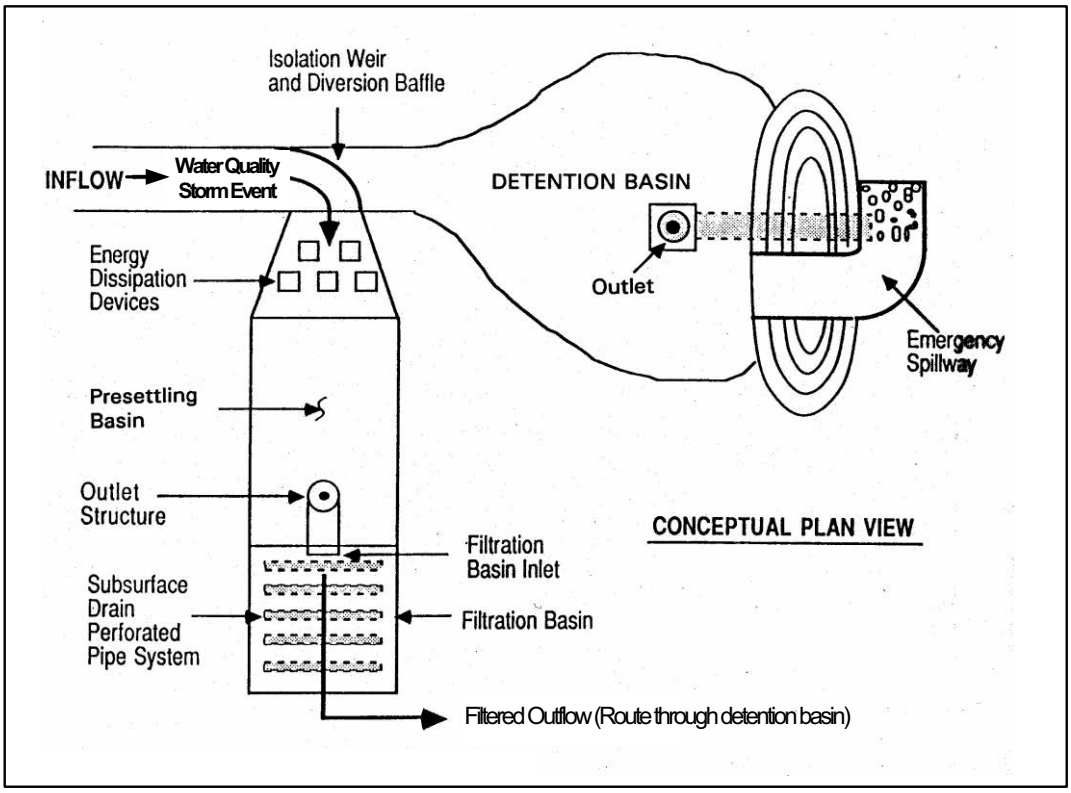


Figure 4 - 29: Sand Filtration Basin Preceded by Presettling Basin (Variation of a Basic Sand Filter)

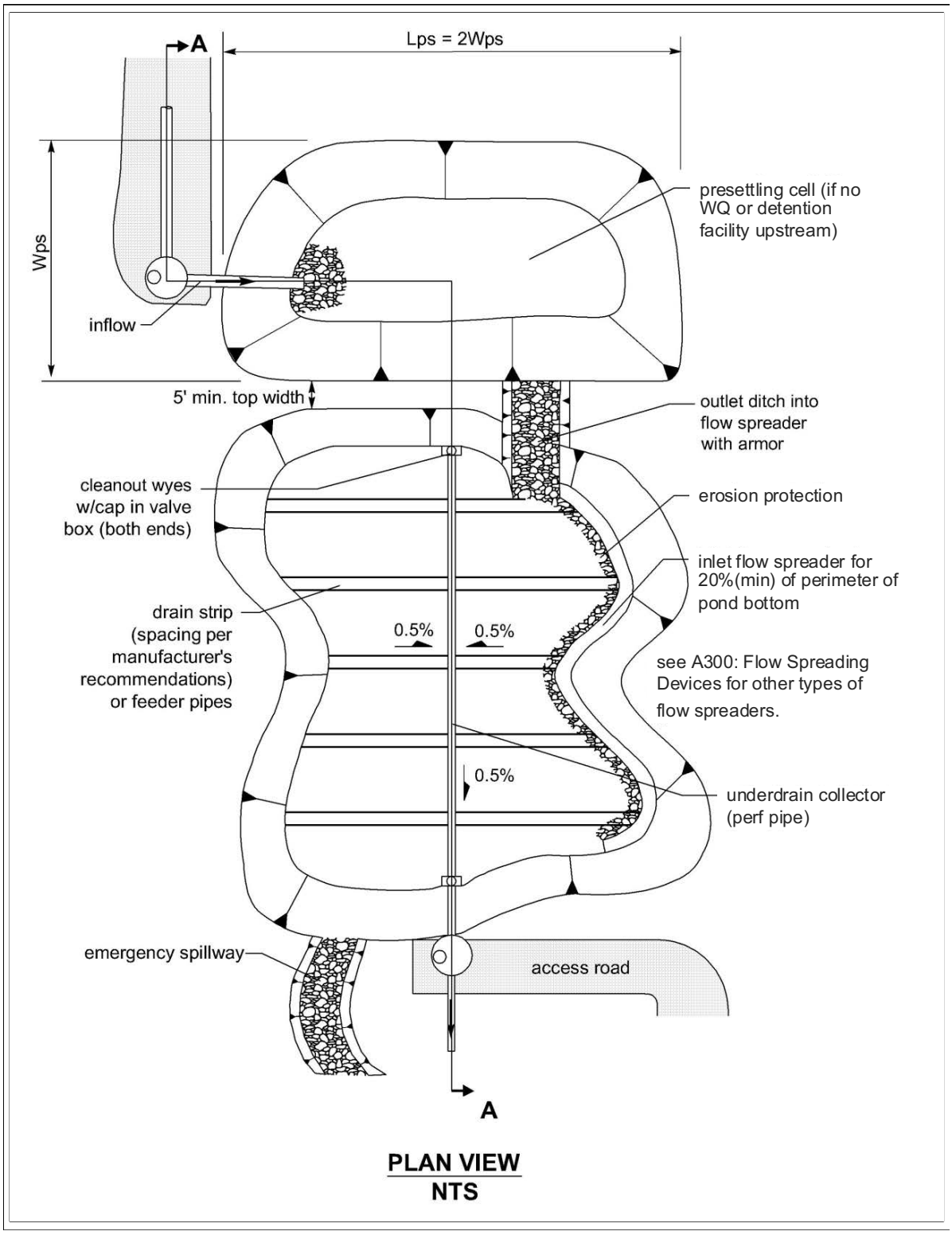


Figure 4 - 30: Sand Filter with a Pretreatment Cell (top view)

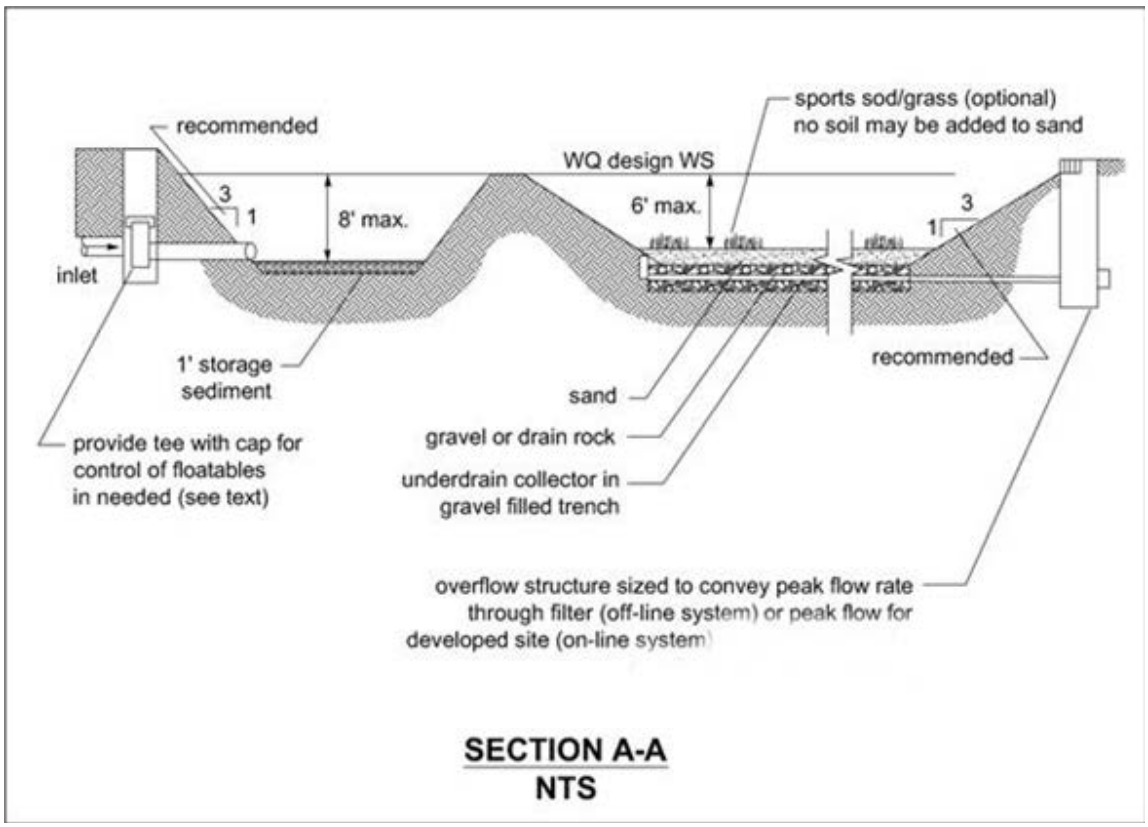


Figure 4 - 31: Sand Filter with a Pretreatment Cell (side view)

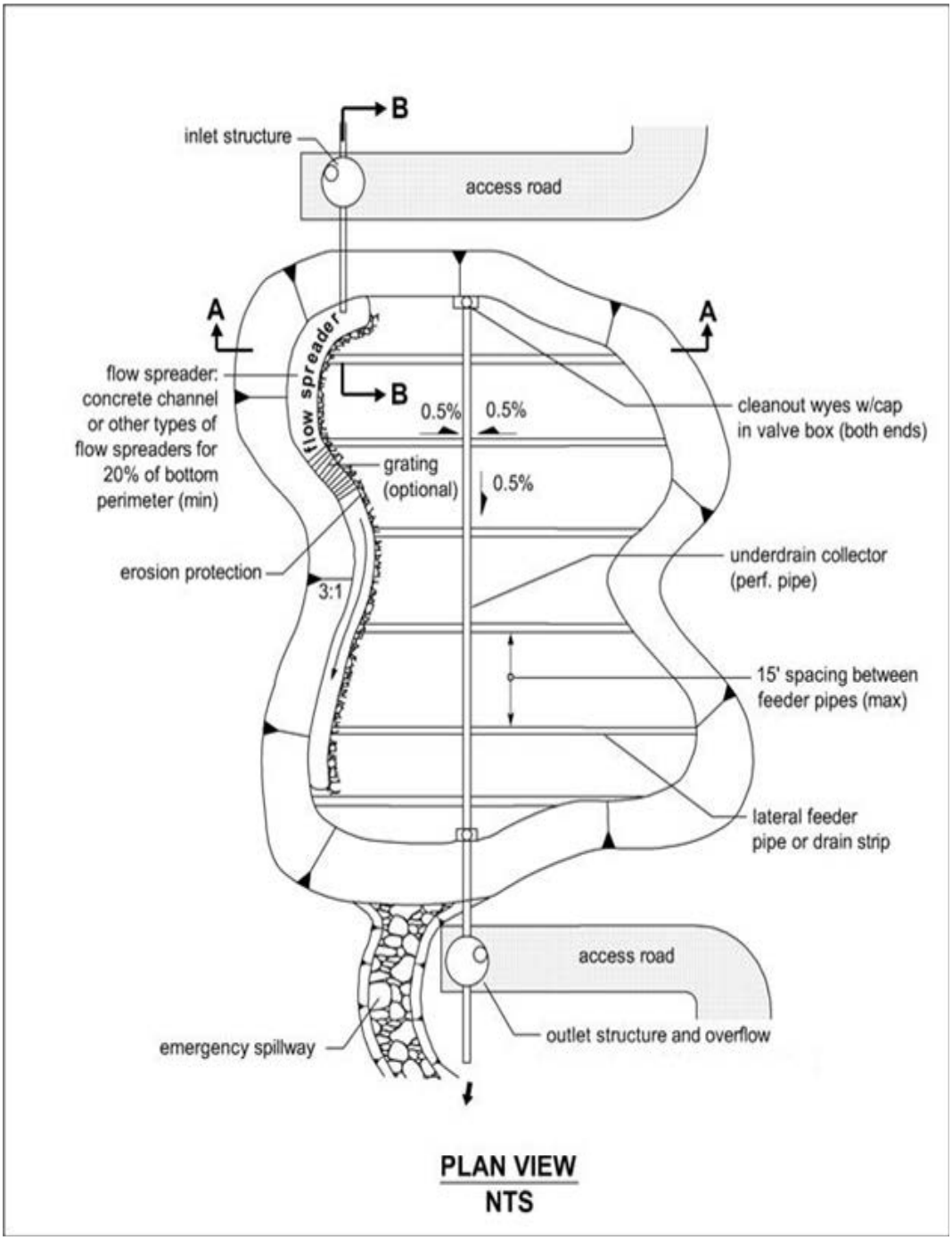


Figure 4 - 32: Sand Filter with Level Spreader (top view)

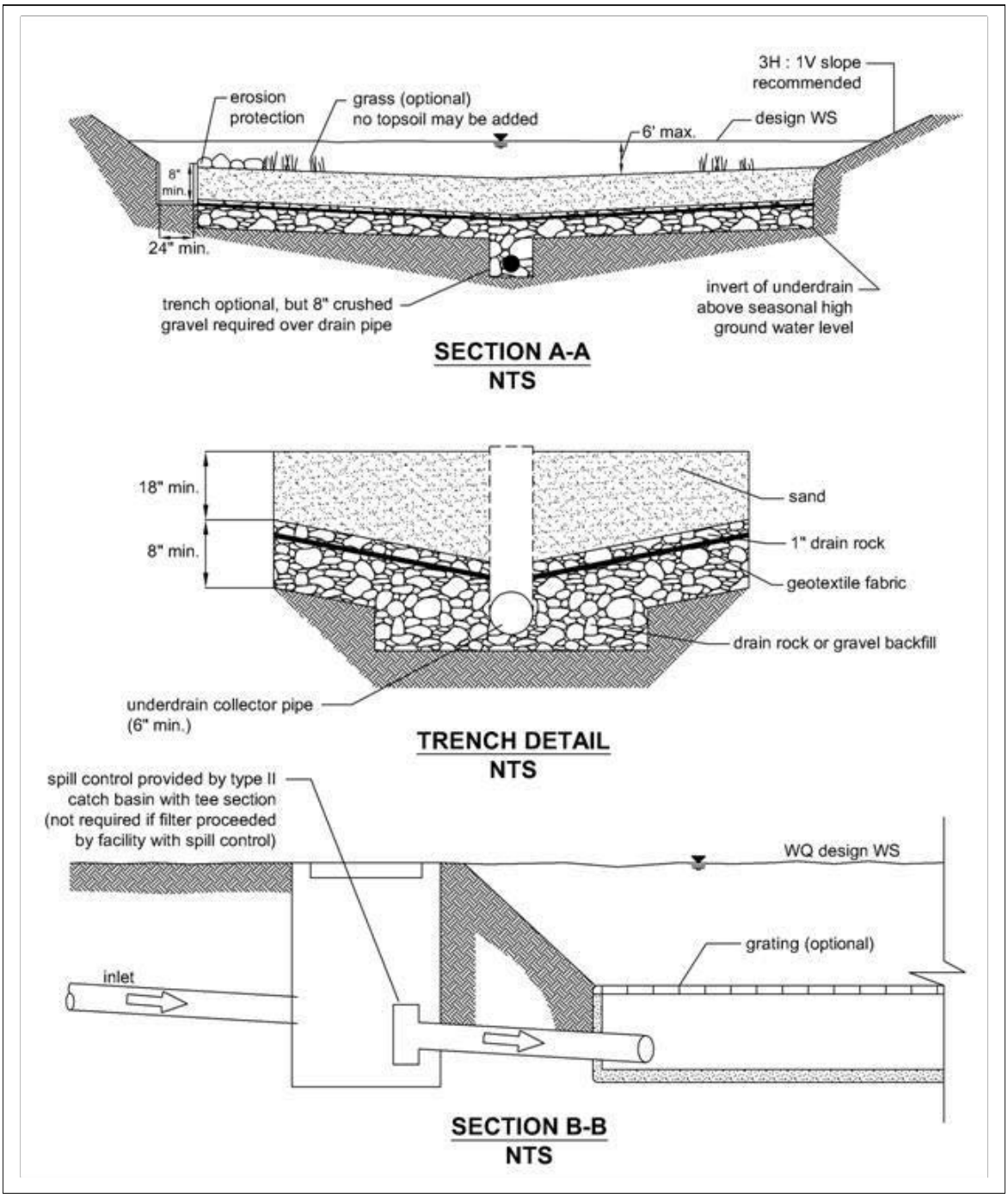


Figure 4 - 33: Sand Filter with Level Spreader (side view)

14.3 Applications

- Sand filters can be used to ensure compliance with Minimum Requirement #6: Stormwater Treatment.
- Pretreatment is required for BMP T808: Basic Sand Filter, BMP T809: Large Sand Filter, and BMP T810: Sand Filter Vault.

14.4 Design Criteria for All Sand Filtration BMPs

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

Sand filter design criteria are as follows:

1. Hydraulic head of 4 feet from inlet to outlet is required for BMP T808: Basic Sand Filter, BMP T809: Large Sand Filter, and BMP T810: Sand Filter Vault.
2. Sand filters shall be sized to capture and treat the water quality design volume, which is 91% of the total runoff volume as predicted by an Ecology approved continuous simulation model, assuming a 15-minute timestep.
3. The design hydraulic conductivity shall be 1 in/hr.
4. ***Online*** sand filters must be placed ***downstream*** of a detention facility. This is to prevent exposure of the sand filter surface to high flow rates that could cause loss of media and previously removed pollutants.
5. ***Online*** sand filters placed ***downstream*** of a detention facility must be sized using an Ecology approved continuous simulation model, assuming a 15-minute timestep, to filter the on-line water quality design flowrate. This ensures the sand filter is treating 91% of the total runoff volume.
6. ***Offline*** sand filters placed ***upstream*** of a detention facility must have a flow splitter designed to send all flows at or below the 15-minute water quality flowrate, as predicted by an Ecology approved continuous simulation model, assuming a 15-minute timestep, to the sand filter. The sand filter must be sized to filter all the runoff sent to it (no overflows from the treatment facility should occur).
7. ***Offline*** sand filters placed ***downstream*** of a detention facility must have a flow splitter designed to send all flows at or below the 2-year return period flowrate as estimated by an Ecology approved continuous simulation model, assuming a 15-minute timestep, from the detention facility to the treatment facility. The treatment facility must be sized to filter all the runoff sent to it (no overflows from the treatment facility should occur).
8. For online sand filters include an overflow in the design. The overflow height shall be at the maximum hydraulic head of the water above the sand bed. Online sand filters shall provide overflow structures designed in accordance with BMP F110: Detention Ponds.
9. Pretreat runoff to be treated by the sand filter (e.g., presettling basin, etc. depending on pollutants) to remove debris and other solids, and oil from high use sites.

10. Design inlet bypass and flow spreading structures (e.g., flow spreaders, weirs or multiple orifice openings) to capture the applicable design flowrate, minimize turbulence and to spread the flow uniformly across the surface of the sand filter. Install stone riprap or other energy dissipation devices to prevent gouging of the sand medium and to promote uniform flow. Include emergency spillway or overflow structures (see A400: End of Pipe Discharge Protection and A300: Flow Spreading Devices).
    - If the sand filter is curved or an irregular shape, provide a flow spreader for a minimum of 20% of the filter perimeter.
    - If the length-to-width ratio of the filter is 2:1 or greater, locate a flow spreader on the longer side of the filter and for a minimum length of 20% of the facility perimeter.
    - Provide erosion protection along the first foot of the sand bed adjacent to the flow spreader. Methods for this include geotextile weighted with sand bags at 15-foot intervals and quarry spalls. The geotextile shall conform to A2000: Geotextile Specifications, Geotextile for Underground Drainage - Moderate Survivability, Class A.
11. Include underdrain piping in sand filter design. Types of underdrains include a central collector pipe with lateral feeder pipes; or a geotextile drain strip in an 8-inch gravel backfill or drain rock bed; or longitudinal pipes in an 8-inch gravel backfill or drain rock with a collector pipe at the outlet end.
    - Size the underdrain piping for the two-year return frequency flow indicated by an Ecology approved continuous simulation model, assuming a 15-minute timestep. Provide at least 1 foot of hydraulic head above the invert of the upstream end of the collector pipe.
    - Internal diameters of underdrain pipes shall be a minimum of six inches having two rows of ½-inch holes spaced 6 inches apart longitudinally (maximum), with rows 120 degrees apart (laid with holes downward). Maximum perpendicular distance between two feeder pipes or the edge of the filter and a feeder pipe, must be 15 feet. All piping is to be schedule 40 PVC or greater wall thickness.
    - Main collector underdrain pipe shall be at a slope of 0.5 percent minimum.
    - A geotextile fabric must be used between the sand layer and drain rock or gravel and placed so that 1-inch of drain rock/gravel is above the fabric. The geotextile shall conform to A2000: Geotextile Specifications, Geotextile for Underground Drainage - Low Survivability, Class C. Drain rock shall be 0.75-1.5 inch rock or gravel backfill, washed free of clay and organic material.

12. Provide cleanout wyes with caps or junction boxes at both ends of the collector pipes. Extend cleanouts to the surface of the filter. Provide a valve box for access to the cleanouts. Provide access for cleaning all underdrain piping. This may consist of installing cleanout ports that tee into the underdrain system and surface above the top of the sand bed. To facilitate maintenance of the sand filter an inlet shutoff/bypass valve is recommended.Sand specification: The sand in a filter shall be a minimum 18” in depth and must meet the size gradation (by weight) given in Table 4 - 28: sand Specifications. The contractor must obtain a grain size analysis from the supplier to certify that the sieve requirements are met.

Table 4 - 28: Sand Specifications[1]

U.S. Sieve Number	Percent Passing
4	95-100
8	70-100
16	40-90
30	25-75
50	2-25
100	<4
200	<2

1. Source: King County Stormwater Design Manual, September 1998

13. Impermeable Liners for Sand Bed Bottom: Impermeable liners are generally required for soluble pollutants such as metals and toxic organics and where the underflow could cause problems with structures. Impermeable liners may be made of clay, concrete or geomembrane. Clay liners shall have a minimum thickness of 12 inches and meet the specifications given in Table 4 - 29: Clay Liner Specifications.

Table 4 - 29: Clay Liner Specifications[1]

Property	Test Method	Unit	Specification
Permeability	ASTM D-2434	cm/sec	1×10^{-6} max.
Plasticity Index of Clay	ASTM D-423 & D-424	percent	Not less than 15
Liquid Limit of Clay	ASTM D-2216	percent	Not less than 30
Clay Particles Passing	ASTM D-422	percent	Not less than 30
Clay Compaction	ASTM D-2216	percent	95% of Standard Proctor Density

1. Source: City of Austin, 1988

- If a geomembrane liner is used it shall have a minimum thickness of 30 mils and be ultraviolet light resistant. The geomembrane liner shall be protected from puncture, tearing, and abrasion by installing geotextile fabric on the top and bottom of the geomembrane. The non-woven geotextile shall conform to A2000: Geotextile Specifications, Geotextile Strength Properties for Impermeable Liner Protection.
- Concrete liners may also be used for sedimentation chambers and for sedimentation and sand filtration basins less than 1,000 square feet in area. Concrete shall be 5 inches thick Class A or better and shall be reinforced by steel wire mesh. The steel wire mesh shall be 6 gauge wire or larger and 6-inch by 6-inch mesh or smaller. An "Ordinary Surface Finish" is required. When the underlying soil is clay or has an unconfined compressive strength of 0.25 ton per square foot or less, the concrete shall have a minimum 6-inch compacted aggregate base. This base must consist of coarse sand and river stone, crushed stone or equivalent with diameter of 0.75- to 1-inch.
- If an impermeable liner is not required then a geotextile fabric liner shall be installed that retains the sand. The non-woven geotextile shall conform to A2000: Geotextile Specifications, Geotextile for Underground Drainage - Low Survivability, Class C.
- If an impermeable liner is not provided, then an analysis shall be made of possible adverse effects of seepage zones on groundwater, and near building foundations, basements, roads, parking lots and sloping sites. Sand filters without impermeable liners shall not be built on fill sites and shall be located at least 20-feet downslope and 100-feet upslope from building foundations.

14. Include an access ramp with a slope not to exceed 7H:1V, or equivalent, for maintenance purposes at the inlet and the outlet of a surface filter. Access ramp shall conform to A3000: Access Ramps and Roads.
15. Side slopes for earthen/grass embankments shall not exceed 3H:1V to facilitate mowing.
16. There shall be at least 2 feet clearance between the seasonal high groundwater level and the bottom of the sand filter.

14.5 Construction Criteria for All Sand Filtration BMPs

- The sand filter shall not be placed into service until site construction is complete and the site is stabilized.
- Place sand in a uniform thickness and compact using a water settling method. Settling shall be accomplished by flooding the sand with 10-15 gallons of water per cubic foot of sand. After flooding, the sand shall be smoothed and leveled.

14.6 BMP T808: Basic Sand Filter

14.6.1 Design Criteria for Basic Sand Filters

- Comply with Section 14.4 Design Criteria for All Sand Filtration BMPs and Section 14.5 Construction Criteria for All Sand Filtration BMPs. No additional design criteria apply.

14.7 BMP T809: Large Sand Filter

14.7.1 Design Criteria for Large Sand Filters

Comply with Section 14.4 Design Criteria for All Sand Filtration BMPs and Section 14.5 Construction Criteria for All Sand Filtration BMPs except:

- Large sand filters shall be sized to capture and treat 95% of the total runoff volume.
- Large sand filter underdrains and overflows shall be designed by increasing the 2-year return period flowrate by the ratio of the 95% runoff volume and the 91% runoff volume.

$$\text{Design flowrate for overflow or underdrain} = \frac{\text{95\% runoff volume}}{\text{91\% runoff volume}} \times \text{2 year return period flowrate}$$

14.8 BMP T810: Sand Filter Vault

14.8.1 Description

A sand filter vault is similar to an open sand filter except that the sand layer and underdrains are installed below grade in a vault. It consists of presettling and sand filtration cells.

14.8.2 Design Criteria for Sand Filter Vaults

- Comply with Section 14.4 Design Criteria for All Sand Filtration BMPs and Section 14.5 Construction Criteria for All Sand Filtration BMPs, in addition to the criteria below.
- Sand filter vaults may be designed offline or online.
- The sand filter bed shall consist of a sand top layer, a geotextile second layer and an underdrain.
- Optimize sand inlet flow distribution with minimal sand bed disturbance. A maximum 8-inch distance between the top of the spreader and the top of the sand bed is required. Flows may enter the sand bed by spilling over the top of the wall into a flow spreader pad or alternatively a pipe and manifold system may be used. Any pipe and manifold system must retain the required dead storage volume in the first cell, minimize turbulence, and be readily maintainable.
- If an inlet pipe and manifold system is used, the minimum pipe size shall be 8 inches. Multiple inlets are required to minimize turbulence and reduce local flow velocities.
- Provide erosion protection along the first foot of the sand bed adjacent to the spreader. Geotextile fabric secured on the surface of the sand bed, or equivalent method, may be used. The non-woven geotextile shall conform to A2000: Geotextile Specifications,, Geotextile for Underground Drainage - Moderate Survivability, Class A.
- Design the presettling cell for sediment collection and removal. Use a V-shaped bottom, removable bottom panels, or equivalent sludge handling system. Provide one-foot of sediment storage in the presettling cell.
- Seal the pre-settling chamber to trap oil and trash. This chamber is usually connected to the sand filtration chamber using a pipe with an inverted elbow to protect the filter surface from oil and trash.
- If a retaining baffle is necessary for oil/floatables in the presettling cell, it must extend at least one foot above to one foot below the design flow water level. Provide provision for the passage of flows in the event of plugging. Provide access opening and ladder on both sides of the baffle.
- To prevent anoxic conditions, provide a minimum of 24 square feet of ventilation grate for each 250 square feet of sand bed surface area. For sufficient distribution of airflow across the sand bed, grates may be located in one area if the sand filter is small, but placement at each end is preferred. Small grates may also be dispersed over the entire sand bed area.
- Sand filter vaults must conform to the materials, structural suitability, and access criteria specified for wetvaults in BMP T1120: Wetvaults.
- Provide a sand filter inlet shutoff/bypass valve for maintenance
- A geotextile fabric over the entire sand bed may be installed that is flexible, highly permeable, three-dimensional matrix, and adequately secured. This is useful in trapping trash and litter. A geotextile may be used though may not be the best product. A polyethylene or polypropylene geonet might be better. The geonet should have high UV

resistance (90% or more strength retained after 500 hours in the weatherometer, ASTM D4355), and high permittivity (ASTM D4491, 0.8/sec or more) and percent open area (CWO-22125, 10% ore more). Tensile strength should be on the order of 200 lbs grab (ASTM D4632) or more.

- Access shall be provided for inspection and maintenance.
  - Access openings shall be provided a maximum of 50 feet from any location within the vault.
  - Access openings shall be provided over the inlet to the presettling cell.
  - Access openings shall be provided over each cell and situated over the V in the vault floor.
  - Access openings (except the removable panel) may be round, solid lids or 3' square diamond plate covers.
  - A removable panel shall be placed over the entire sand bed area.
  - Vaults that are less than 10 feet wide shall have removable lids.
  - Vaults shall comply with OSHA confined space requirements including clearly marking entrances to confined areas.
  - Provide ventilation pipes in all corners of the presettling cell. Alternatively, provide a removable panel over the entire presettling cell. If access manholes are installed at 12 foot or less spacing, ventilation pipes are not needed.
  - Locate removable panels outside traveled lanes.
- The maximum depth from finished grade to the vault invert is 20 feet.
- The minimum internal height shall be 7 feet and the minimum width shall be 4 feet.

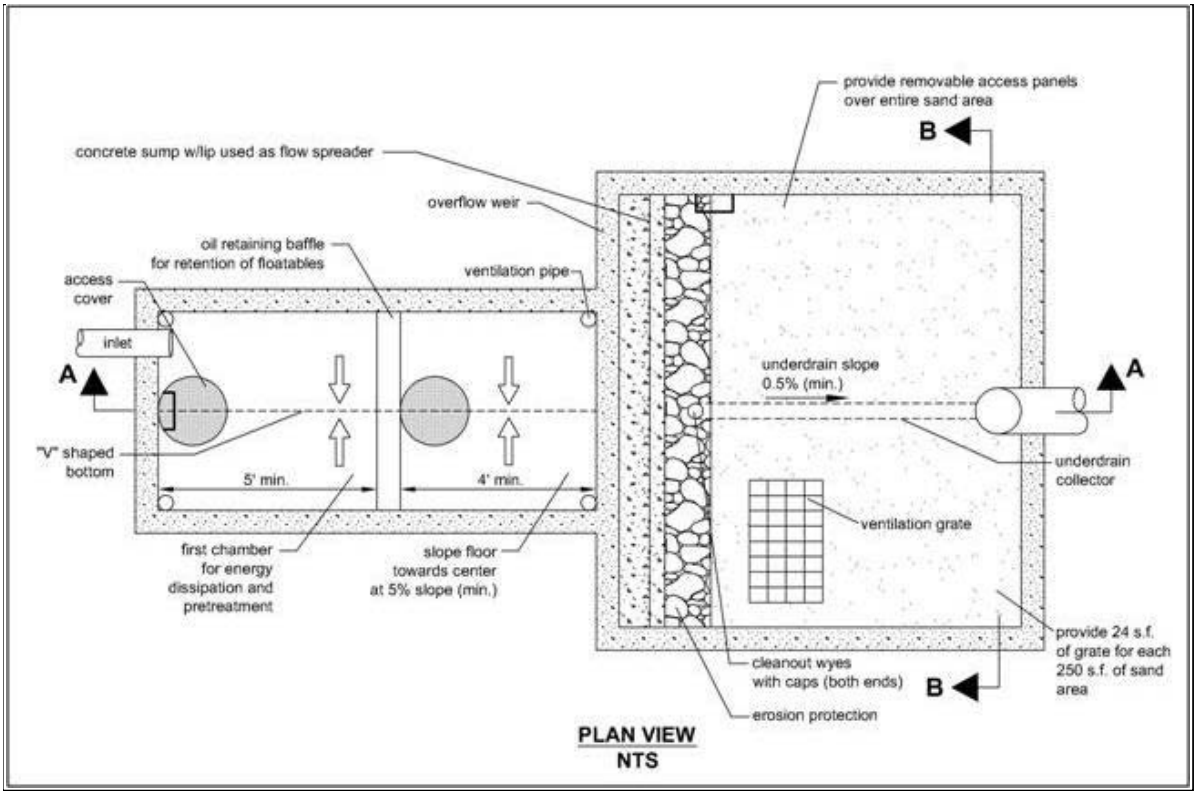


Figure 4 - 34: Sand Filter Vault (top view)

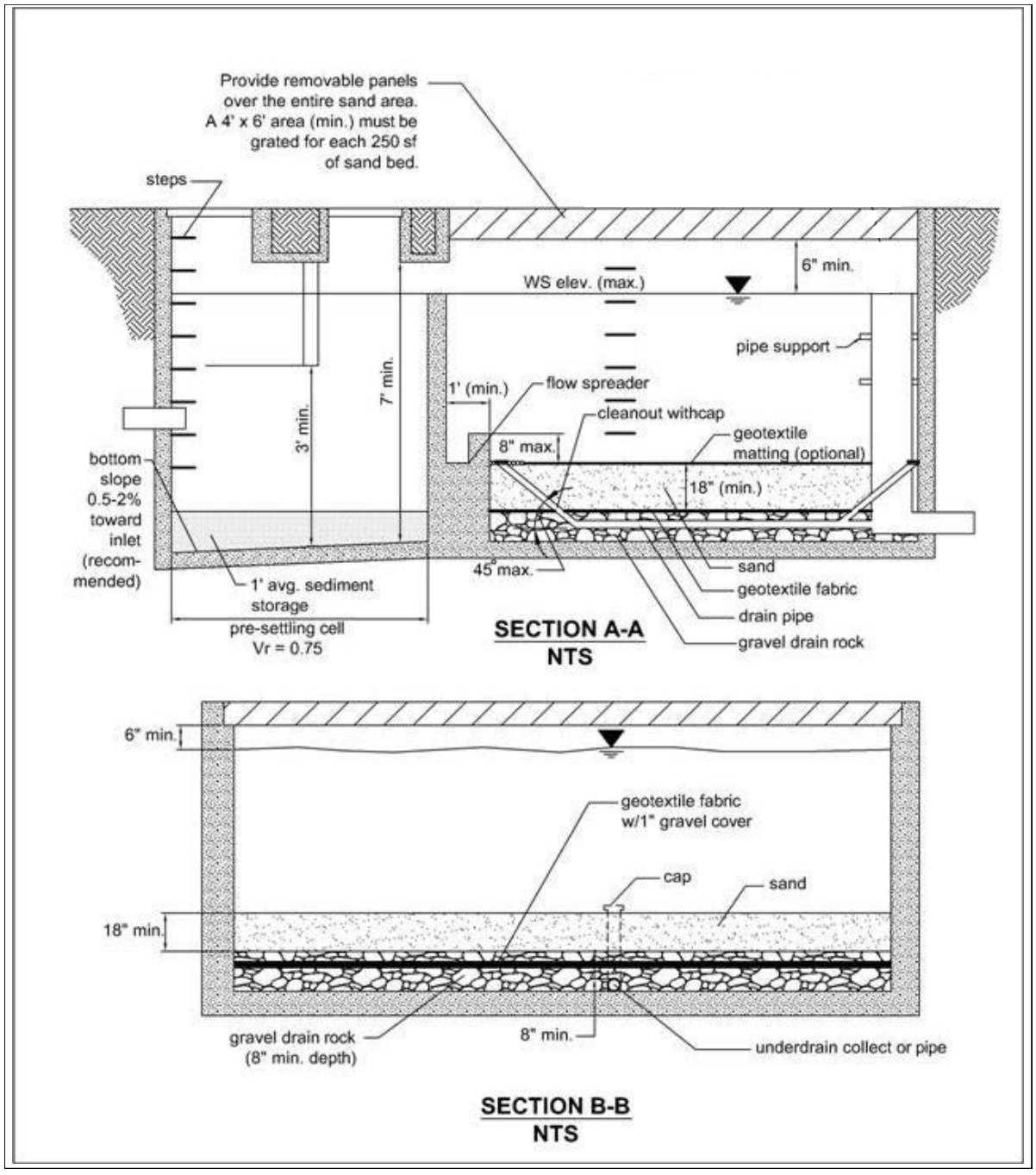


Figure 4 - 35: Sand Filter Vault (side view)

14.9 BMP T820: Linear Sand Filter

14.9.1 Description

Linear sand filters are typically long, shallow, two-celled, rectangular vaults. The first cell is designed for settling coarse particles, and the second cell contains the sand bed. Stormwater enters the second cell via a weir section that also functions as a flow spreader.

Figure 4 - 36: Linear Sand Filter illustrates a linear sand filter.

14.9.2 Design Criteria for Linear Sand Filters

Comply with Section 14.4 Design Criteria for All Sand Filtration BMPs and Section 14.5 Construction Criteria for All Sand Filtration BMPs in addition to the criteria below.

- Divide the two cells by a divider wall that is level and extends a minimum of 12 inches above the sand bed.
- Stormwater may enter the sediment cell by sheet flow or a piped inlet.
- The width of the sand cell must be 1-foot minimum to 15 feet maximum.
- The sand filter bed must be a minimum of 12 inches deep and have an 8-inch layer of drain rock with perforated drainpipe beneath the sand layer.
- The drainpipe must be 6-inch diameter minimum and be wrapped in geotextile and sloped a minimum of 0.5 percent to promote positive drainage. The non-woven geotextile shall conform to A2000: Geotextile Specifications, Geotextile for Underground Drainage - Low Survivability, Class C.
- Maximum sand bed ponding depth: 12 inches.
- Must be vented as described above for sand filter vaults.
- Linear sand filters must conform to the materials and structural suitability criteria specified for wetvaults in BMP T1120: Wetvaults.
- Sediment cell width shallbe selected based on sand filter width as follows:

Table 4 - 30: Linear Sand Filter Cell Widths

Sand filter width, (w) inches	12-24	24-48	48-72	72+
Sediment cell width, inches	12	18	24	w/3

- Linear sand filters shall only be used if the contributing area is 2 acres or less.

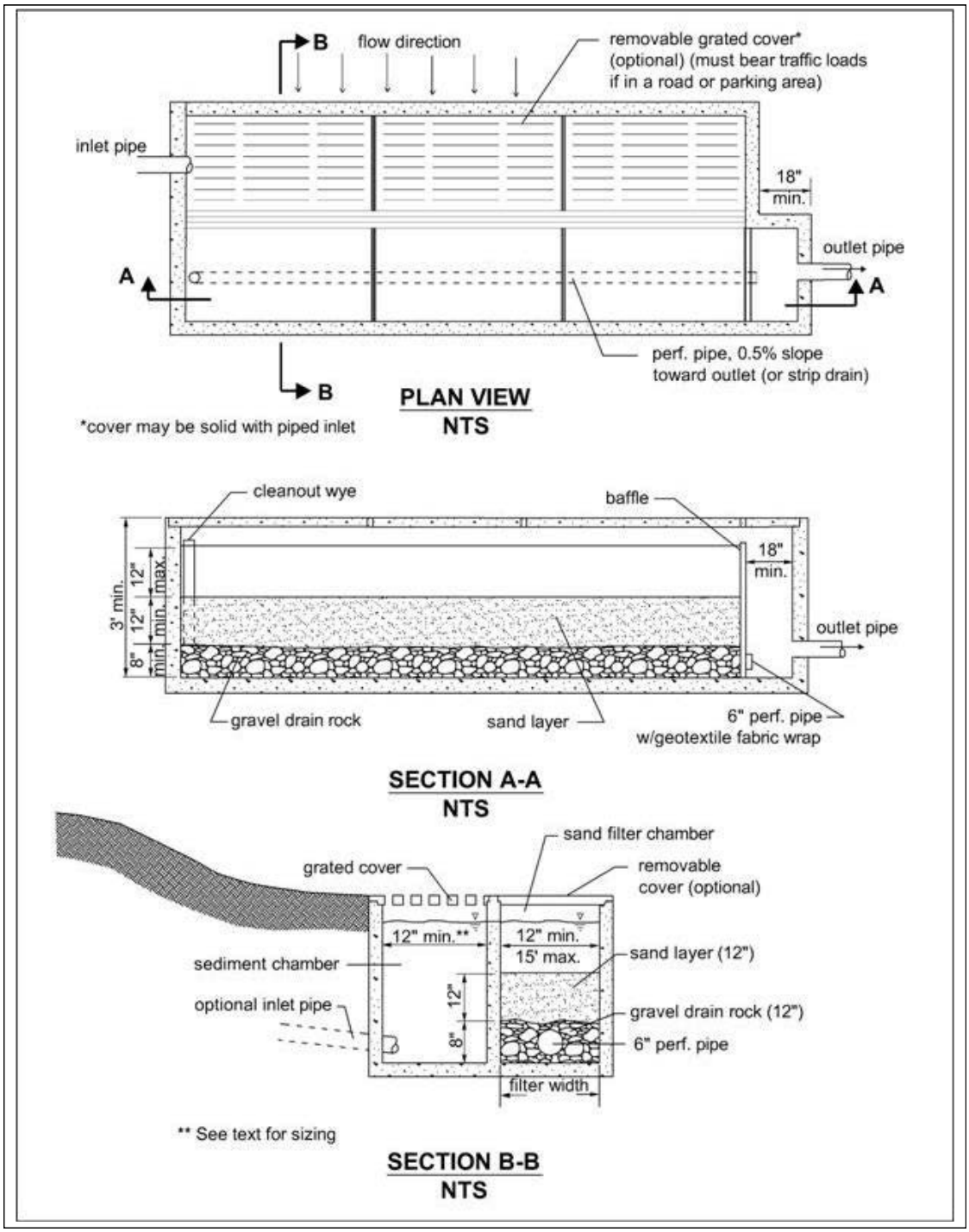


Figure 4 - 36: Linear Sand Filter

Chapter 15 Wetpool BMPs

15.1 BMP T1110: Wetponds - Basic and Large

15.1.1 Description

A wetpond is a constructed stormwater pond that retains a permanent pool of water ("wetpool") at least during the wet season. The volume of the wetpool is related to the effectiveness of the pond in settling particulate pollutants. As an option, a shallow marsh area can be created within the permanent pool volume to provide additional treatment for nutrient removal. Flow control can be provided in the "live storage" area above the permanent pool. Figure 4 - 37: Wetpond (top view) and Figure 4 - 38: Wetpond (side view) and illustrate a typical wetpond.

15.1.2 Application

- Basic wetponds and large wetponds can be used to help ensure compliance with Minimum Requirement #6: Stormwater Treatment.
- Basic and large wetponds provide Basic Treatment.
- Large wetponds provide Phosphorus Treatment.
- When used as part of a treatment train, basic and large wetponds provide Metals Treatment.

15.1.3 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

Basic and large wetponds may be located upstream or downstream of detention facilities. When located downstream of detention, performance and aesthetics may be increased.

General wetpond design criteria and concepts are shown in Figure 4 - 37: Wetpond (top view) and Figure 4 - 38: Wetpond (side view).

- A small amount of base flow is desirable to maintain circulation and reduce the potential for low oxygen conditions during late summer.

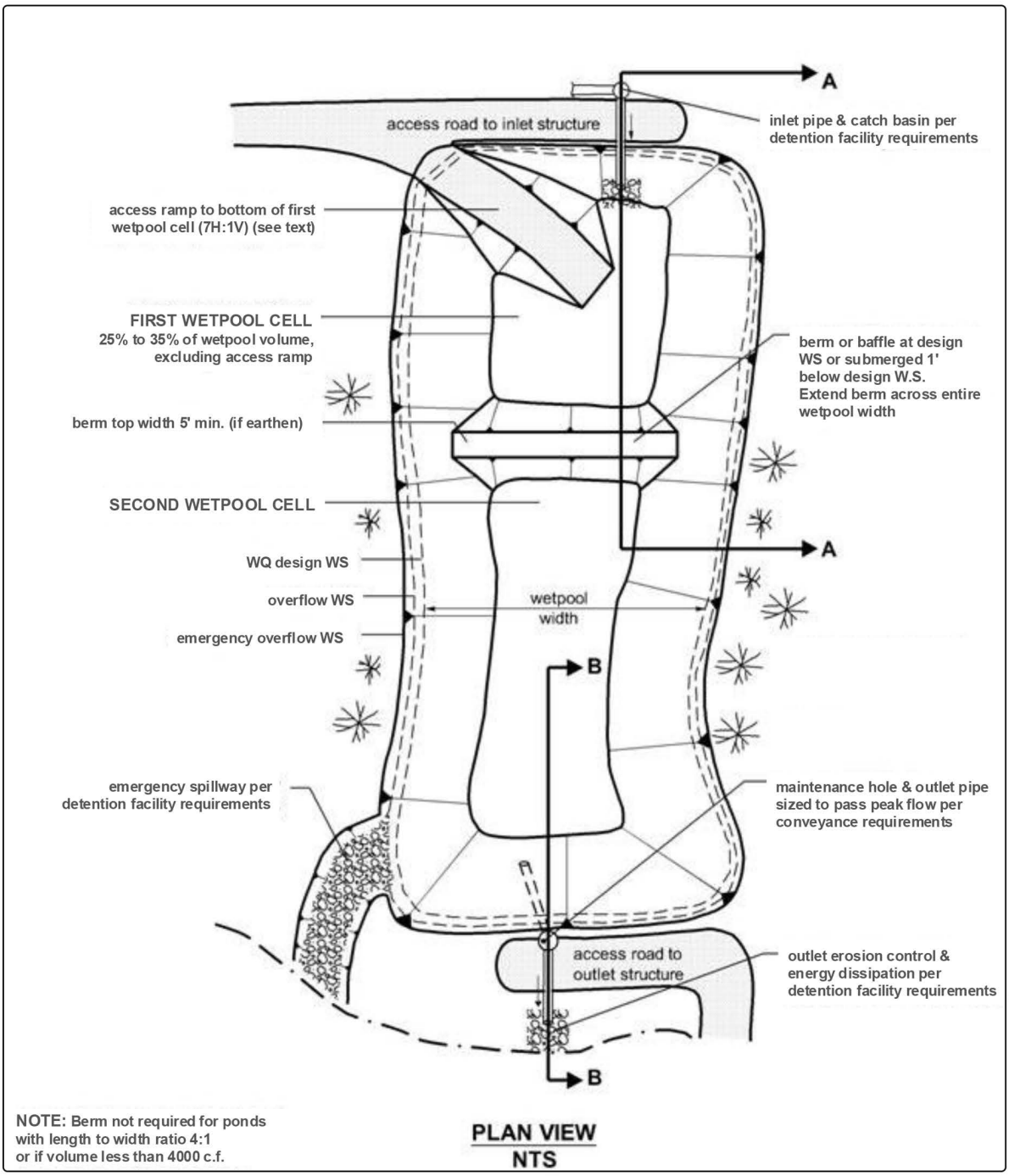


Figure 4 - 37: Wetpond (top view)

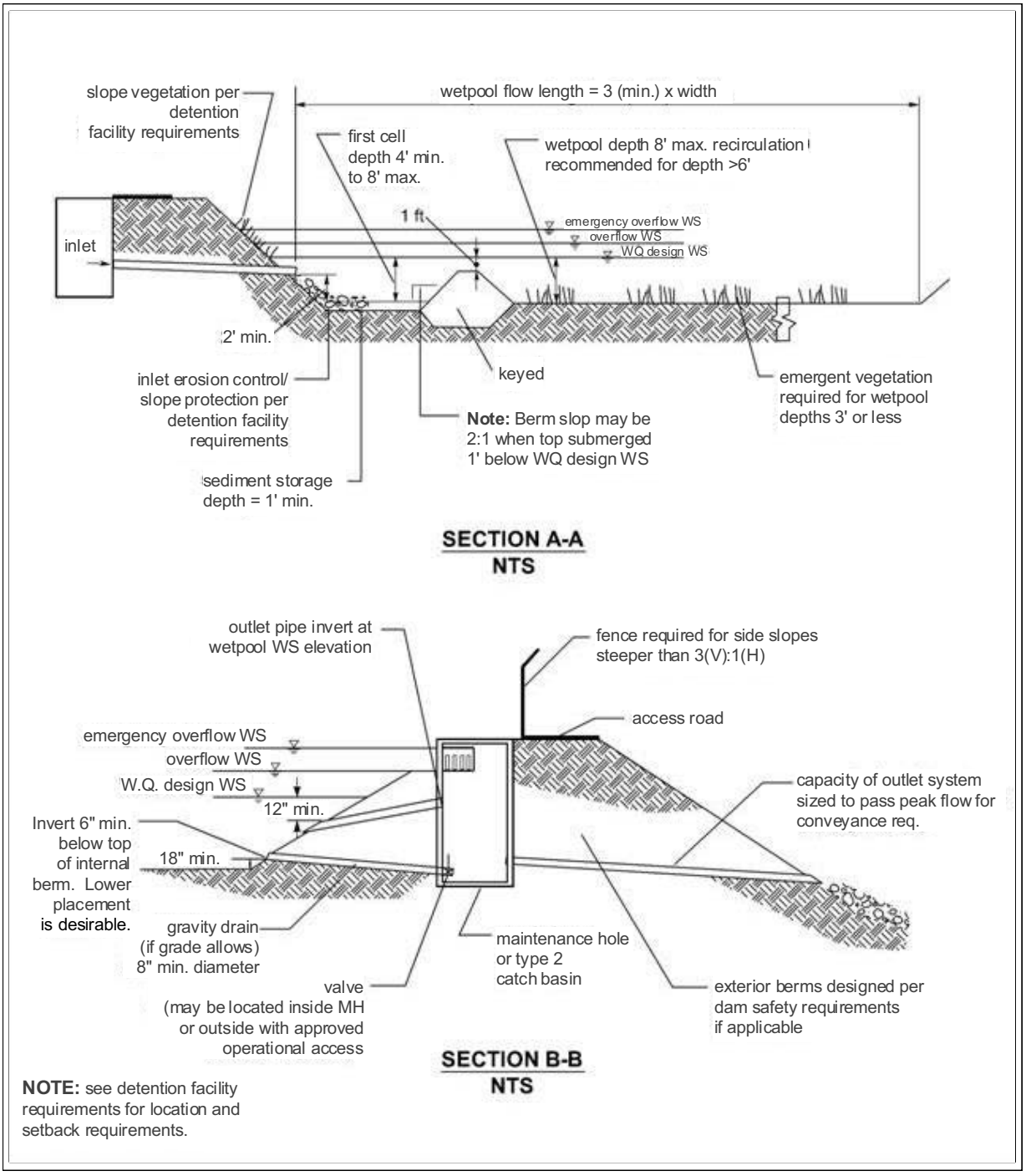


Figure 4 - 38: Wetpond (side view)

15.1.3.1 Sizing Procedure

Procedures for determining a wetpond's dimensions and volume are outlined below.

1. The wetpool volume shall be equal to or greater than the water quality design storm volume. Calculate the required wetpool volume (V) using an Ecology approved continuous simulation model, assuming a 15-minute timestep, to obtain the water quality design volume.
2. For large wetponds only. Calculate the wetpool volume required for a large wetpond (V_{large}).

   $$V_{large} = 1.5V$$

3. Determine wetpool dimensions. Determine the wetpool dimensions satisfying the design criteria outlined below and illustrated in Figure 4 - 37: Wetpond (top view) and Figure 4 - 38: Wetpond (Side view). A simple way to check the volume of each wetpool cell is to use the following equation:

   $$V = \frac{h(A_1 + A_2)}{2}$$

   or for Large Wetponds

   $$V_{large} = \frac{h(A_1 + A_2)}{2}$$

   Where:

   V = wetpool volume (ft^3)

   h = wetpool average depth (ft)

   A_1 = water quality design surface area of wetpool (sf)

   A_2 = bottom area of wetpool (sf)

4. Design pond outlet pipe and determine primary overflow water surface. The pond outlet pipe shall be placed on a reverse grade from the pond's wetpool to the outlet structure. Provide documentation on how the outlet pipe was sized. Volume 5 contains guidance for conveyance system design. Pipe sizing shall be based on backwater effects.
5. Determine wetpond dimensions.

15.1.3.2 Efficiency

The primary design factor that determines a wetpond's efficiency is the wetpool volume. The larger the wetpool volume, the greater the potential for pollutant removal.

Also important are the avoidance of short-circuiting and promotion of plug flow. To prevent short-circuiting and promote plug flow, the pond should be designed to force water to flow to all potentially available routes avoiding dead zones and maximizing the time water stays in the pond during a storm event.

Design features that encourage plug flow and avoid dead zones are:

- Dissipating energy at the inlet.
- Providing a large length-to-width ratio.
- Providing a broad surface for water exchange using a berm designed as a broad-crested weir to divide the wetpond into two cells rather than a constricted area such as a pipe.
- Maximizing the flowpath between inlet and outlet, including the vertical path, enhances treatment by increasing residence time.
- A small amount of base flow is desirable to maintain circulation and reduce the potential for low oxygen conditions during late summer.

15.1.3.3 Wetpool Geometry

- Divide the wetpool into two cells separated by a baffle or berm. The first cell shall contain between 25 to 35 percent of the total wetpool volume. The baffle or berm volume shall not count as part of the total wetpool volume.
- Provide sediment storage in the first cell. The sediment storage shall have a minimum depth of 1-foot. Install a fixed sediment depth monitor in the first cell to gauge sediment accumulation unless an alternative gauging method is proposed.
- The minimum depth of the first cell shall be 4 feet, exclusive of sediment storage requirements. The depth of the first cell may be greater than the depth of the second cell.
- The maximum depth of each cell shall not exceed 8 feet (exclusive of sediment storage in the first cell). Plant pool depths of 3 feet or shallower (second cell) with emergent wetland vegetation (see planting requirements).
- Place inlets and outlets to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet shall be at least 3:1. The ***flowpath length*** is defined as the distance from the inlet to the outlet, as measured at mid-depth. The ***width*** at mid-depth can be found as follows: width = (average top width + average bottom width)/2.
- Wetponds with wetpool volumes less than or equal to 4,000 cubic feet may be single celled (i.e., no baffle or berm is required). However, it is especially important in this case that the flowpath length be maximized. The ratio of flowpath length to width shall be at least 4:1 in single celled wetponds, but should preferably be 5:1.
- All inlets shall enter the first cell. For multiple inlets, the length-to-width ratio shall be based on the average flowpath length for all inlets.
- Line the first cell in accordance with the liner requirements contained in 21.1 A100: Liners.
- For wetpool depths in excess of 6 feet, it is recommended that some form of recirculation be provided in the summer, such as a fountain or aerator, to prevent stagnation and low dissolved oxygen conditions.
- A tear-drop shape, with the inlet at the narrow end, rather than a rectangular pond is preferred since it minimizes dead zones caused by corners.

15.1.3.4 Berms, Baffles, and Slopes

- A berm or baffle shall extend across the full width of the wetpool, and tie into the wetpond side slopes. If the berm embankments are greater than 4 feet in height, the berm must be constructed by excavating a key with dimensions equal to 50 percent of the embankment cross-sectional height and width. This requirement may be waived if recommended by a

Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist for specific site conditions. The geotechnical analysis shall address situations in which one of the two cells is empty while the other remains full of water.

- The top of the berm may extend to the WQ design water surface or be 1-foot below the WQ design water surface. If at the WQ design water surface, berm side slopes shall be 3H:1V. Berm side slopes may be steeper (up to 2H:1V) if the berm is submerged 1-foot.
- If good vegetation cover is not established on the berm, erosion control measures shall be used to prevent erosion of the berm back-slope when the pond is initially filled.
- The interior berm or baffle may be a retaining wall provided that the design is prepared and stamped by a Washington State Licensed Professional Engineer. If a baffle or retaining wall is used, it shall be submerged one foot below the design water surface to discourage access by pedestrians.
- Side slopes shall not exceed a slope of 3H:1V. Moderately undulating slopes are acceptable and can provide a more natural setting for the facility. In general, gentle side slopes improve the aesthetic attributes of the facility and enhance safety.
- Interior side slopes may be retaining walls. Retaining walls require design and stamp by a Washington State Licensed Professional Engineer.

15.1.3.5 Inlet and Outlet

See Figure 4 - 38: Wetpond (side view) for details on the following requirements:

- Submerge the inlet to the wetpond with the inlet pipe invert a minimum of two feet from the pond bottom (not including sediment storage). The top of the inlet pipe shall be submerged at least 1-foot, if possible.
- Provide an outlet structure. Either a Type 2 catch basin with a grated opening or a manhole with a beehive grate may be used (see Figure 4 - 74: OverflowStructure for an illustration). A sump is not required in the outlet structure for wetponds that do not provide detention storage.
- The pond outlet pipe (as opposed to the manhole or type 2 catch basin outlet pipe) shall be back-sloped or have a down-turned elbow, and extend 1 foot below the WQ design water surface.
- Size the pond outlet pipe, at a minimum, to pass the online WQ design flow. The highest invert of the outlet pipe sets the WQ design water surface elevation.
- The overflow criteria for single-purpose (treatment only, not combined with flow control) wetponds are as follows:
  - The requirement for primary overflow is satisfied by either the grated inlet to the outlet structure or by a beehive grate above the pond outlet structure.
  - The bottom of the grate opening in the outlet structure shall be set at or above the height needed to pass the WQ design flow through the pond outlet pipe. The grate invert elevation sets the overflow water surface elevation.
  - The grated opening and downstream conveyance shall be sized to pass the 100-year design flow. The capacity of the outlet system shall be sized to pass the peak volumetric flowrate for the conveyance requirements.
- In addition to the primary overflow, ponds must have an emergency overflow spillway. Design the Emergency Overflow Spillway per A600: Emergency Overflow Spillway.

- The City may require a bypass/shutoff valve to enable the pond to be taken offline for maintenance purposes.
- A gravity drain for maintenance is recommended if grade allows.
  - The drain invert shall be at least 6 inches below the top elevation of the dividing berm or baffle. Deeper drains are encouraged where feasible, but must be no deeper than 18 inches above the pond bottom.
  - The drain shall be at least 8 inches (minimum) diameter and shall be controlled by a valve. Use of a shear gate is allowed only at the inlet end of a pipe located within an approved structure.
  - Provide operational access to the valve at the finished ground surface.
  - The valve location shall be accessible and well marked with 1-foot of paving placed around the box. It must also be protected from damage and unauthorized operation.
  - A valve box is allowed to a maximum depth of 5 feet without an access manhole. If over 5 feet deep, an access manhole or vault is required.
- Acceptable materials for other parts of the wetpond include thermoplastics, iron, steel, aluminum, and concrete. Steel and iron shall be aluminum coated (aluminized Type 2). Zinc coated (galvanized) materials are prohibited. Painted metal parts shall not be used because of poor longevity.
- The number of inlets to the facility should be limited; ideally there should be only one inlet. The flowpath length should be maximized from inlet to outlet for all inlets to the facility.

15.1.3.6 Access and Setbacks

- All facilities shall be a minimum of 20 feet from any structure or property line.
- Provide maintenance access road(s) to the inlet and outlet. Access roads and ramps shall conform to A3000: Access Ramps and Roads.
- An access ramp is required for removal of sediment. For small, shallow ponds, an access ramp may not be required if the trackhoe can load a truck parked at the pond edge. Extend the access ramp to the bottom of the first cell unless all portions of the cell can be reached and sediment loaded from the top of the pond.
- The internal berm may be used as access only if all the following apply:
  - The internal berm is no more than 4' above the first wetpool cell.
  - The first wetpool cell is less than 1,500 square feet (measured without the ramp)
  - The internal berm is designed to support a loaded truck, 80,000 pounds minimum, considering the berm is normally submerged and saturated.

15.1.3.7 Planting Requirements

Planting requirements for Wetponds are the same as Detention Ponds with additional considerations for planting as noted below. See BMP F100: Detention Facilities.

- Large wetponds intended for phosphorus control shall not be planted within the cells, as the plants will release phosphorus in the winter when they die off. The bottom and side slopes shall be stabilized to prevent erosion.
- If the second cell of a basic wetpond is 3 feet deep or shallower, the bottom area shall be planted with emergent wetland vegetation. See A1000: Vegetation for recommended emergent wetland plant species for wetponds. The recommendations in A1000:

Vegetation for recommended plant species for wetponds are for all of western Washington. Local knowledge should be used to tailor this information to Tacoma as appropriate.

- Cattails (Typha latifolia) shall not be used because they tend to crowd out other species.
- If the wetpond discharges to a phosphorus-sensitive lake or wetland, shrubs that form a dense cover should be planted on slopes above the WQ design water surface on at least three sides. Native vegetation species shall be used in all cases. No planting on berms or banks is allowed if the wetpond is regulated as a dam.
- Provide a planting plan that shows mature plant coverage and species type.
- Evergreen or columnar deciduous trees along the west and south sides of ponds are recommended to reduce thermal heating, except that no trees or shrubs may be planted on berms meeting the criteria of dams regulated for safety. In addition to shade, trees and shrubs also discourage waterfowl use and the phosphorus enrichment problems they cause. Trees should be set back so that the branches will not extend over the pond.

15.1.3.8 Landscaping

Landscaping considerations are the same as BMP F110: Detention Ponds.

15.1.3.9 Signage

Provide a stormwater facility sign. Sign shall conform to A800: Signage.

15.1.3.10 Aesthetics

- The following design features should be incorporated to enhance aesthetics where possible:
  - Provide pedestrian access to shallow pool areas enhanced with emergent wetland vegetation. This allows the pond to be more accessible without incurring safety risks.
  - Provide side slopes that are sufficiently gentle to avoid the need for fencing (3H:1V or flatter).
  - Create flat areas overlooking or adjoining the pond for picnic tables or seating that can be used by residents. Walking or jogging trails around the pond are easily integrated into site design.
  - Include fountains or integrated waterfall features for privately maintained facilities.
  - Provide visual enhancement with clusters of trees and shrubs. On most pond sites, it is important to amend the soil before planting since ponds are typically placed well below the native soil horizon in very poor soils. Make sure dam safety restrictions against planting do not apply.
  - Orient the pond length along the direction of prevailing summer winds (typically west or southwest) to enhance wind mixing.

15.1.4 Construction Criteria

- Remove sediment that has accumulated in the pond after construction is complete (unless used for a liner - see below).
- Sediment that has accumulated in the pond at the end of construction may be used as a liner in high permeability soils if the sediment meets the criteria for low permeability or treatment liners in keeping with guidance given in Chapter 3. Sediment used for a soil liner must be graded to provide uniform coverage and must meet the thickness specifications in Chapter 3. The sediment must not reduce the design volume of the pond. The pond must be over-excavated initially to provide sufficient room for the sediments to serve as a liner.

15.2 BMP T1120: Wetvaults

15.2.1 Description

A wetvault is an underground structure similar in appearance to a detention vault, except that a wetvault has a permanent pool of water (wetpool) which dissipates energy and improves the settling of particulate pollutants (see the wetvault details in Figure 4 - 39: Wetvault). Being underground, the wetvault lacks the biological pollutant removal mechanisms, such as algae uptake, present in surface wetponds.

15.2.2 Applications and Limitations

Wetvaults can be used to help ensure compliance with Minimum Requirement #6: Stormwater Treatment. A wetvault may be used for commercial, industrial, or roadway projects if there are space limitations precluding the use of other treatment BMPs. The use of wetvaults for residential development is highly discouraged. Combined detention and wetpools are allowed; see BMP T1040: Vegetated Filter Strip.

If oil control is required for a project, a wetvault may be combined with an API oil/water separator.

Below-ground structures like wetvaults are more difficult to inspect and maintain.

15.2.3 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

Wetvaults may be located upstream or downstream of detention facilities.

15.2.3.1 Sizing

The wetpool volume shall be equal to or greater than the water quality design storm volume. The wetpool volume shall be calculated using an Ecology approved continuous simulation model, assuming a 15-minute timestep to obtain the water quality design volume.

Typical design details and concepts for the wetvault are shown in Figure 4 - 39: Wetvault.

15.2.3.2 Wetpool Geometry

Same as specified for wetponds (see BMP T1010: Basic Biofiltration Swale) except for the following two modifications:

- The sediment storage in the first cell shall be an average of 1-foot. Because of the v-shaped bottom, the depth of sediment storage needed above the bottom of the side wall is roughly proportional to vault width according to the schedule below:

Table 4 - 31: Depth of Sediment Storage Needed Based on Vault Width

Vault Width	Sediment Depth (from bottom of side wall)
15’	10”
20’	9”
40’	6”
60’	4”

- The second cell shall be a minimum of 3 feet deep since planting cannot be used to prevent re-suspension of sediment in shallow water as it can in open ponds.

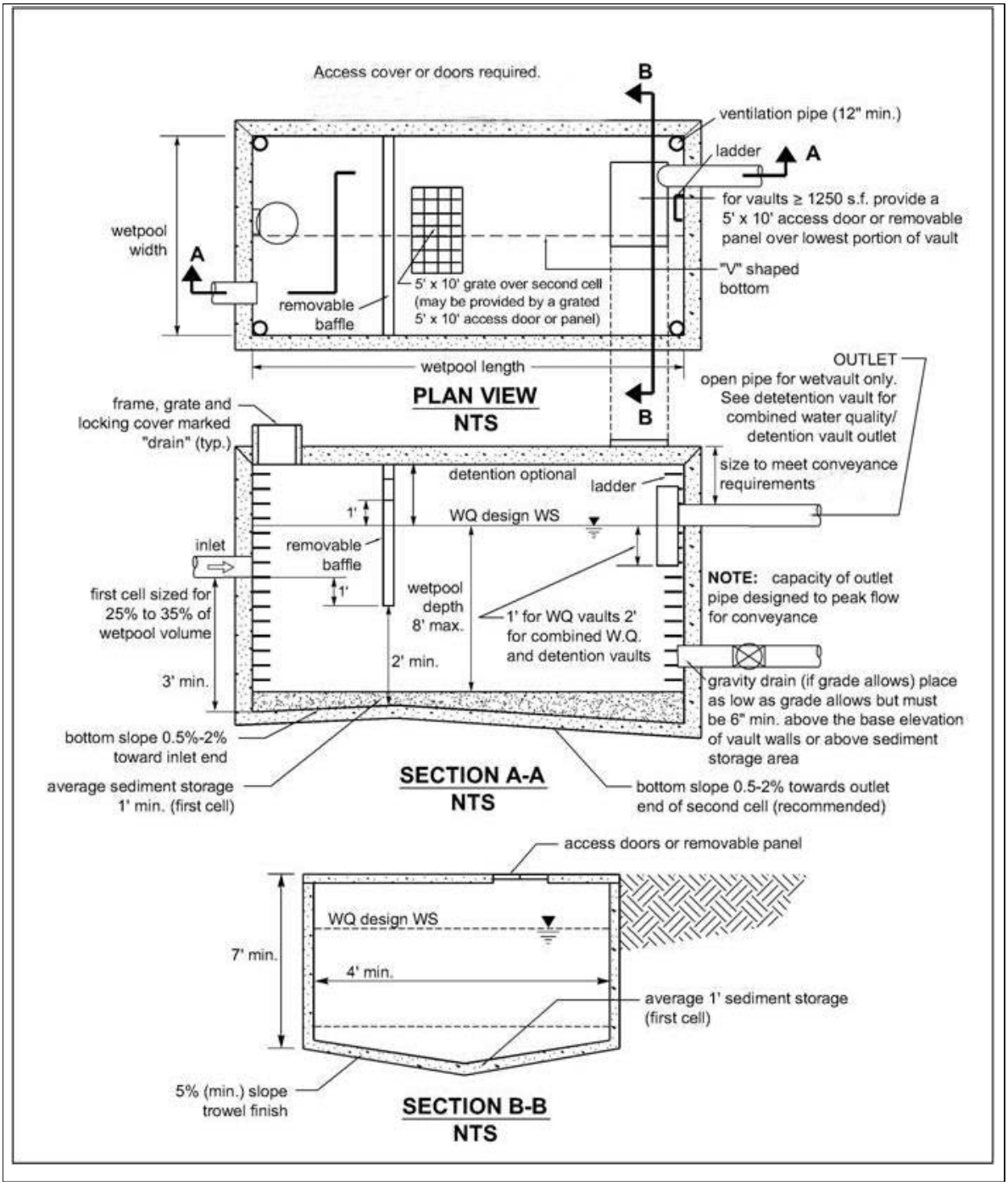


Figure 4 - 39: Wetvault

15.2.3.3 Vault Structure

- Separate the vault into two cells by a wall or a removable baffle. If a wall is used, provide a 5-foot by 10-foot removable maintenance access for both cells. If a removable baffle is used, the following criteria apply:
  - The baffle shall extend from a minimum of 1-foot above the WQ design water surface to a minimum of 1-foot below the invert elevation of the inlet pipe.
  - The lowest point of the baffle shall be a minimum of 2 feet from the bottom of the vault, and greater if feasible.
- If the vault is less than 2,000 cubic feet (inside dimensions), or if the length-to-width ratio of the vault pool is 5:1 or greater, the baffle or wall may be omitted and the vault may be one-celled.
- Do not divide the two cells of a wetvault into additional subcells by internal walls. If internal structural support is needed, it is preferred that post and pier construction be used to support the vault lid rather than walls. Any walls used within cells must be positioned so as to lengthen, rather than divide, the flowpath.
- Slope the bottom of the first cell toward the access opening. Slope shall be between 0.5 percent (minimum) and 2 percent (maximum). The second cell may be level (longitudinally) sloped toward the outlet, with a high point between the first and second cells. Sloping the second cell towards the access opening for the first cell is also acceptable. Alternatively, access openings shall be positioned a maximum of 10 feet from any location within the vault.
- Slope the vault bottom laterally a minimum of 5 percent from each side towards the center, forming a broad "v" to facilitate sediment removal.

  Note: More than one "v" may be used to minimize vault depth.
- The City may allow the vault bottom to be flat if removable panels are provided over the entire vault. Removable panels shall be at grade, have stainless steel lifting eyes, and weigh no more than 5 tons per panel.
- The highest point of a vault bottom must be at least 6 inches below the outlet elevation to provide for sediment storage over the entire bottom.
- Evaluate buoyancy of the vault and include results in the Stormwater Site Plan.
- Wetvaults may be constructed using arch culvert sections provided the top area at the WQ design water surface is, at a minimum, equal to that of a vault with vertical walls designed with an average depth of 6 feet.
- Wetvault structures shall be watertight.

15.2.3.4 Inlet and Outlet

- Submerge the inlet to the wetvault. The inlet pipe invert shall be a minimum of 3 feet from the vault bottom. Submerge the top of the inlet pipe at least 1-foot, if possible.
- Unless designed as an offline facility, the capacity of the outlet pipe and available head above the outlet pipe shall be designed to convey the 100-year design flow for developed site conditions without overtopping the vault. The available head above the outlet pipe must be a minimum of 6 inches.
- The outlet pipe shall be back-sloped or have tee section, the lower arm of which shall extend 1 foot below the WQ design water surface to provide for trapping of oils and floatables in the vault.

- Center the inlet and outlet pipes over the “V” portion of the vault.
- The inlet and outlet should be at opposing corners of the vault.
- The number of inlets to the wetvault should be limited, and the flowpath length should be maximized from inlet to outlet for all inlets to the vault.

15.2.3.5 Materials

- Minimum 3,000 psi structural reinforced concrete may be used for wetvaults. Provide all construction joints with water stops.

15.2.3.6 Structural Stability

- All vaults must meet structural requirements for overburden support and H20 traffic loading. Vaults located under roadways must meet City of Tacoma live load requirements.
- Design cast in place wall sections as retaining walls.
- Structural design for cast in place vaults must be stamped by a Washington State Licensed Professional Engineer with structural engineering expertise.
- Place vaults on stable, well consolidated native material with suitable bedding. Do not place vaults in fill slopes, unless analyzed by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist for stability.

15.2.3.7 Access and Setback Requirements

Access

- Provide access opening over the inlet and outlet pipes.
- Position access opening a maximum of 50' from any location within the vault. Provide access to each "v" if more than one "v" is provided in the vault floor.
- For vaults greater than 1,250 ft^2 of floor area, provide a 5' by 10' removable panel over the inlet.
- For vaults under roadways, locate the removal panel outside the travel lanes when possible.
- All access openings, except those covered by removable panels, may have round, solid locking lids or 3 ft^2 locking diamond plate covers.
- Vaults with widths 10 feet or less must have removable lids.
- The maximum depth from finished grade to the vault invert should be 20 feet.
- Provide internal structural walls of large vaults with openings sufficient for maintenance access between cells. Size and situate the openings to allow access to the maintenance "v" in the vault floor.
- The minimum internal height should be 7 feet from the highest point of the vault floor (not sump) and the minimum width should be 4 feet. Concrete vaults may be a minimum 3 feet in height and width if used as tanks with access manholes at each end, and if the width is no larger than the height. Also, the minimum internal height requirements may not be needed for any areas covered by removable panels.
- Vaults must comply with the OSHA confined space requirements, which includes clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.

- Provide ventilation pipes (minimum 12 inch diameter or equivalent) in all four corners of vaults to allow for artificial ventilation prior to entry of maintenance personnel into the vault. Or, provide removable panels over the entire vault. Vaults providing manhole access at 12 foot spacing need not provide corner ventilation pipes.
- Provide a minimum of 50 square feet of grate over the second cell. For vaults in which the surface area of the second cell is greater than 1,250 square feet, grate 4 percent of the top. This requirement may be met by one grate or by many smaller grates distributed over the second cell area.

  A grated access door can be used to meet this requirement.

- Lockable grates instead of manhole covers are recommended to increase air contact with the wetpool.

Setbacks

- Wetvaults shall be a minimum of 20 feet from any structure or property line.

15.2.4 Modifications for Combining with a Baffle Oil/Water Separator

If the project site is a high-use site and a wetvault is proposed, the vault may be combined with a API oil/water separator to meet the stormwater treatment requirements with one facility rather than two.

- The sizing procedures for BMP T1200a: API (Baffle Type) Separators shall be run as a check to ensure the vault is large enough. If the oil/water separator sizing procedures result in a larger vault size, increase the wetvault size to match.
- An oil retaining baffle shall be provided in the second cell near the vault outlet. The baffle shall not contain a high-flow overflow, or else the retained oil will be washed out of the vault during large storms.
- The vault shall have a minimum length-to-width ratio of 5:1.
- The vault shall have a design water depth-to-width ratio of between 1:3 to 1:2.
- The vault shall be watertight and shall be coated to protect from corrosion.
- Separator vaults shall have a shutoff mechanism on the outlet pipe to prevent oil discharges during maintenance and to provide emergency shut-off capability in case of a spill. Also, provide a valve box and riser.
- Wetvaults used as oil/water separators must be offline and must bypass flows greater than the offline WQ design flow multiplied by 3.5. This will minimize the entrainment and/ or emulsification of previously captured oil during very high flow events.

15.3 BMP T1130: Stormwater Treatment Wetlands

15.3.1 Description

Stormwater treatment wetlands are shallow artificial ponds that are designed to treat stormwater through the biological processes associated with emergent aquatic plants (see the stormwater wetland details in Figure 4 - 40: Stormwater Wetland - Option 1 and Figure 4 - 41: Stormwater Wetland - Option 2).

Wetlands created to mitigate disturbance impacts, such as filling of wetlands, shall not be used as stormwater treatment facilities.

15.3.2 Applications and Limitations

- Stormwater treatment wetlands can be used to ensure compliance with Minimum Requirement #6: Stormwater Treatment.
- Stormwater treatment wetlands can be used alone to meet Metals Treatment and Basic Treatment. When used as part of a treatment train with either a Basic Sand Filter Basin or Sand Filter Vault, stormwater treatment wetlands can provide Phosphorus Treatment.

The most critical factor for a successful design is the provision of an adequate supply of water for most of the year. Since water depths are shallower than in wetponds, water loss by evaporation is an important concern. Stormwater wetlands are a good facility choose for ensuring compliance with Minimum Requirement #6: Stormwater Treatment in areas with high winter groundwater levels.

15.3.3 Design Criteria

Stormwater wetlands use most of the same design criteria as wetponds. However, instead of gravity settling being the dominant treatment process, pollutant removal mediated by aquatic vegetation and the microbiological community associated with that vegetation becomes the dominant treatment process. Thus when designing wetlands, water volume is not the dominant design criteria. Rather, factors which affect plant vigor and biomass are the primary concerns.

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

Stormwater treatment wetlands may be located upstream or downstream of detention facilities. Stormwater treatment wetlands located downstream from detention may have better plant diversity.

15.3.3.1 Sizing Procedure

1. Calculate the design volume (V). The stormwater treatment wetland design volume shall be equal to or greater than the water quality design storm volume. The wetpool volume shall be calculated using an Ecology approved continuous simulation model, assuming a 15-minute timestep, to obtain the water quality design volume.
2. Calculate the surface area (A) of the stormwater wetland using the equation below:

$$A_{total} = \frac{V_{total}}{D_{avg}}$$

Where:

A_{total} - Surface Area of the Stormwater Wetland (ft^2)

V_{total} - Design Volume (ft^3)

D_{avg} - Average Water Depth (ft) = 3

3. Determine the surface area of the presettling cell (first cell) of the stormwater treatment wetland using the equations below.

$$v_{pre} = 0.33V_{total}$$

Where:

V_{pre} = Volume of the Presettling Cell (ft^3)

V_{total}=Design Volume (ft^3) as calculated in Step 1.

$$A_{pre} = \frac{V_{pre}}{D_{pre}}$$

Where:

A_{pre} - Surface Area of the Presettling Cell (ft^2)

V_{pre} - Volume of the Presettling Cell (ft^3)

D_{pre} - Depth of Presettling cell (ft) = between 4 and 8 feet.

4. Determine the surface area of the wetland cell (second cell).

$$A_{wetland} = A_{total} - A_{pre}$$

5. Determine water depth distribution in the second cell. Decide if the top of the dividing berm will be at the surface or submerged (designer's choice). Adjust the distribution of water depths in the second cell according to Step 8 in below in Section 15.3.3.2 Wetland Geometry. This will result in a facility that holds less volume than that determined in Step 1 above. This is acceptable.
6. Choose plants. See A1000: Vegetation for a list of plants recommended for wetpond water depth zones, or consult a wetland scientist.

15.3.3.2 Wetland Geometry

1. Stormwater wetlands shall consist of two cells, a presettling cell and a wetland cell.
2. The presettling cell shall contain approximately 33 percent of the total wetland volume.

3. The depth of the presettling cell shall be between 4 feet (minimum) and 8 feet (maximum), excluding sediment storage.
4. Provide one-foot of sediment storage in the presettling cell.
5. The wetland cell shall have an average water depth of about 1.5 feet (plus or minus 3 inches). The average water depth required for the total storage volume is typically 3 feet.
6. Shape the "berm" separating the two cells such that its downstream side gradually slopes to form the second shallow wetland cell (see the section view in Figure 4 - 40: Stormwater Wetland - Option 1). Alternatively, the second cell may be graded naturalistically from the top of the dividing berm (see 8 below).
7. The top of the berm shall be either at the WQ design water surface or submerged 1-foot below the WQ design water surface. Correspondingly, the side slopes of the berm must meet the following criteria:
    a If the top of berm is at the WQ design water surface, the berm side slopes shall be no steeper than 3H:1V.
    b If the top of berm is submerged 1-foot, the upstream side slope may be up to 2H:1V.
8. Grade the bottom of the wetland cell in one of two ways:
    a Shallow evenly graded slope from the upstream to the downstream edge of the wetland cell (see Figure 4 - 40: Stormwater Wetland - Option 1).
    b A "naturalistic" alternative, with the specified range of depths intermixed throughout the second cell (see Figure 4 - 41: Stormwater Wetland - Option 2). A distribution of depths shall be provided in the wetland cell depending on whether the dividing berm is at the water surface or submerged.

The maximum depth shall be 2.5 feet in either configuration.

Table 4 - 32: Distribution of Depths in Wetland Cell

Dividing Berm at WQ Design Water Surface		Dividing Berm Submerged 1-Foot	
Depth Range (feet)	**Percent**	**Depth Range (feet)**	**Percent**
0.1 to 1	25	1 to 1.5	40
1 to 2	55	1.5 to 2	40
2 to 2.5	20	2 to 2.5	20

15.3.3.3 Lining Requirements

Stormwater treatment wetlands are not intended to infiltrate. In infiltrative soils, line both cells of the stormwater wetland. To determine whether a low-permeability liner or a treatment liner is required, determine whether the following conditions will be met. If soil permeability will allow sufficient water retention, lining may be waived.

1. The second cell must retain water for at least 10 months of the year.

2. The first cell must retain at least three feet of water year-round.
3. Use a complete precipitation record when establishing these conditions. Take into account evapotranspiration losses as well as infiltration losses. Many wetland plants can adapt to periods of summer drought, so a limited drought period is allowed in the second cell. This may allow a treatment liner rather than a low permeability liner to be used for the second cell. The first cell must retain water year-round in order for the presettling function to be effective.
4. If a low permeability liner is used, place a minimum of 18 inches of native soil amended with good topsoil or compost (one part compost mixed with 3 parts native soil) over the liner. For geomembrane liners, a soil depth of 3 feet is recommended to prevent damage to the liner during planting. Hydric soils are not required.

See A100: Liners for additional information.

15.3.3.4 Inlet and Outlet

See Figure 4 - 40: Stormwater Wetland - Option 1 and Figure 4 - 41: Stormwater Wetland - Option 2 for details on the following requirements:

- Submerge the inlet to the stormwater treatment wetland with the inlet pipe invert a minimum of two feet from the stormwater treatment wetland bottom (not including sediment storage). The top of the inlet pipe shall be submerged at least 1-foot, if possible.
- Provide an outlet structure. Either a Type 2 catch basin with a grated opening or a manhole with a beehive grate may be used (see Figure 4 - 74: Overflow Structure for an illustration). A sump is not required in the outlet structure.
- The stormwater treatment wetland outlet pipe (as opposed to the manhole or type 2 catch basin outlet pipe) shall be back-sloped or have a down-turned elbow, and extend 1 foot below the WQ design water surface.
- Size the stormwater treatment wetland outlet pipe, at a minimum, to pass the online WQ design flow. The highest invert of the outlet pipe sets the WQ design water surface elevation.
- The overflow criteria for single-purpose (treatment only, not combined with flow control) stormwater treatment wetlands are as follows:
  - The requirement for primary overflow is satisfied by either the grated inlet to the outlet structure or by a beehive grate above the stormwater treatment wetland outlet structure.
  - The bottom of the grate opening in the outlet structure shall be set at or above the height needed to pass the WQ design flow through the stormwater treatment wetland outlet pipe. The grate invert elevation sets the overflow water surface elevation.
  - The grated opening and downstream conveyance shall be sized to pass the 100-year design flow. The capacity of the outlet system shall be sized to pass the peak flow for the conveyance requirements.
- In addition to the primary overflow, stormwater treatment wetlands must have an emergency overflow spillway. Design the Emergency Overflow Spillway per A600: Emergency Overflow Spillway.
- The City may require a bypass/shutoff valve to enable the pond to be taken offline for maintenance purposes.
- A gravity drain for maintenance is recommended if grade allows.

- The drain invert shall be at least 6 inches below the top elevation of the dividing berm or baffle. Deeper drains are encouraged where feasible, but must be no deeper than 18 inches above the pond bottom.
- The drain shall be at least 8 inches (minimum) diameter and shall be controlled by a valve. Use of a shear gate is allowed only at the inlet end of a pipe located within an approved structure.
- Provide operational access to the valve to the finished ground surface.
- The valve location shall be accessible and well marked with 1-foot of paving placed around the box. It must also be protected from damage and unauthorized operation.
- A valve box is allowed to a maximum depth of 5 feet without an access manhole. If over 5 feet deep, an access manhole or vault is required.

- Acceptable materials for other parts of the wetpond include thermoplastics, iron, steel, aluminum, and concrete. Steel and iron shall be aluminum coated (aluminized Type 2). Zinc coated (galvanized) materials are prohibited. Painted metal parts shall not be used because of poor longevity.
- The number of inlets to the facility should be limited; ideally there should be only one inlet. The flowpath length should be maximized from inlet to outlet for all inlets to the facility.

15.3.3.5 Access and Setbacks

- All facilities shall be a minimum of 20 feet from any structure or property line.
- Provide maintenance access road(s) to the inlet and outlet. Access roads and ramps shall conform to A3000: Access Ramps and Roads.
- Place manhole lids in or at the edge of the access road when possible.
- An access ramp is required for removal of sediment. For small, shallow ponds, an access ramp may not be required if the trackhoe can load a truck parked at the pond edge. Extend the access ramp to the bottom of the first cell unless all portions of the cell can be reached and sediment loaded from the top of the pond.
- The internal berm may be used as access only if all the following apply:
  - The internal berm is no more than 4' above the first wetpool cell.
  - The first wetpool cell is less than 1,500 square feet (measured without the ramp)
  - The internal berm is designed to support a loaded truck, 80,000 pounds minimum, considering the berm is normally submerged and saturated.

15.3.3.6 Planting Requirements

Plant the wetland cell with emergent wetland plants following the recommendations given in A1000: Vegetation for stormwater treatment wetlands or the recommendations of a wetland specialist. Cattails (Typha latifolia) are not allowed. Provide a planting plan showing mature plant coverage and species type.

15.3.3.7 Signage

Provide a stormwater facility sign. Sign shall conform to A800: Signage.

15.3.3.8 Construction Criteria

- Remove sediment that has accumulated in the pond after construction is complete (unless used for a liner - see below).

- Sediment that has accumulated in the pond at the end of construction may be used as a liner in high permeability soils if the sediment meets the criteria for low permeability or treatment liners in keeping with guidance given in BMP A100: Liners. Sediment used for a soil liner must be graded to provide uniform coverage and must meet the thickness specifications in BMP A100: Liners. The sediment must not reduce the design volume of the pond. The pond must be over-excavated initially to provide sufficient room for the sediments to serve as a liner.
- Construction of the naturalistic alternative (Option 2) can be accomplished by first excavating the entire area to the 1.5-foot average depth. Then soil subsequently excavated to form deeper areas can be deposited to raise other areas until the distribution of depths indicated in the design is achieved.

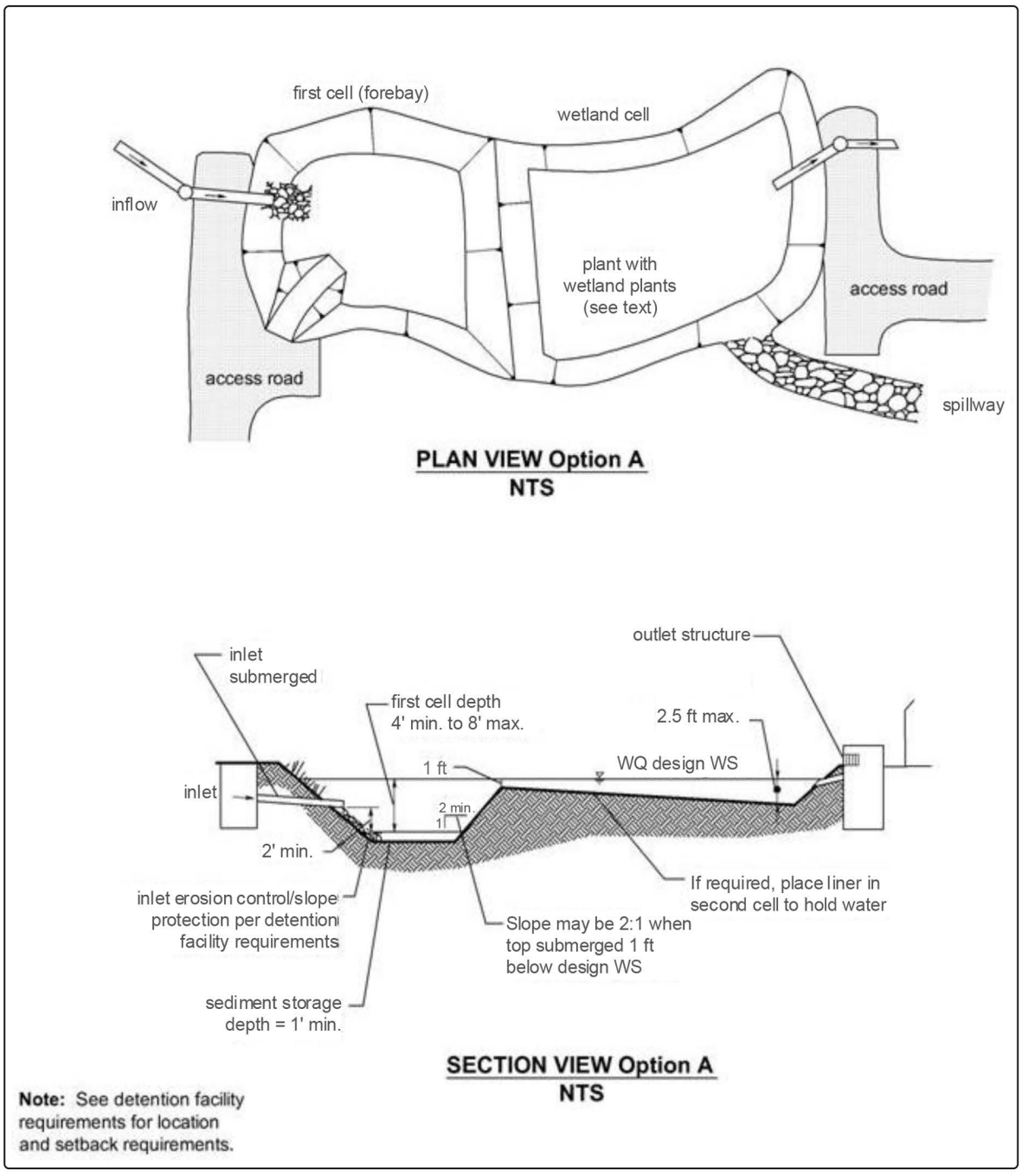


Figure 4 - 40: Stormwater Wetland – Option 1

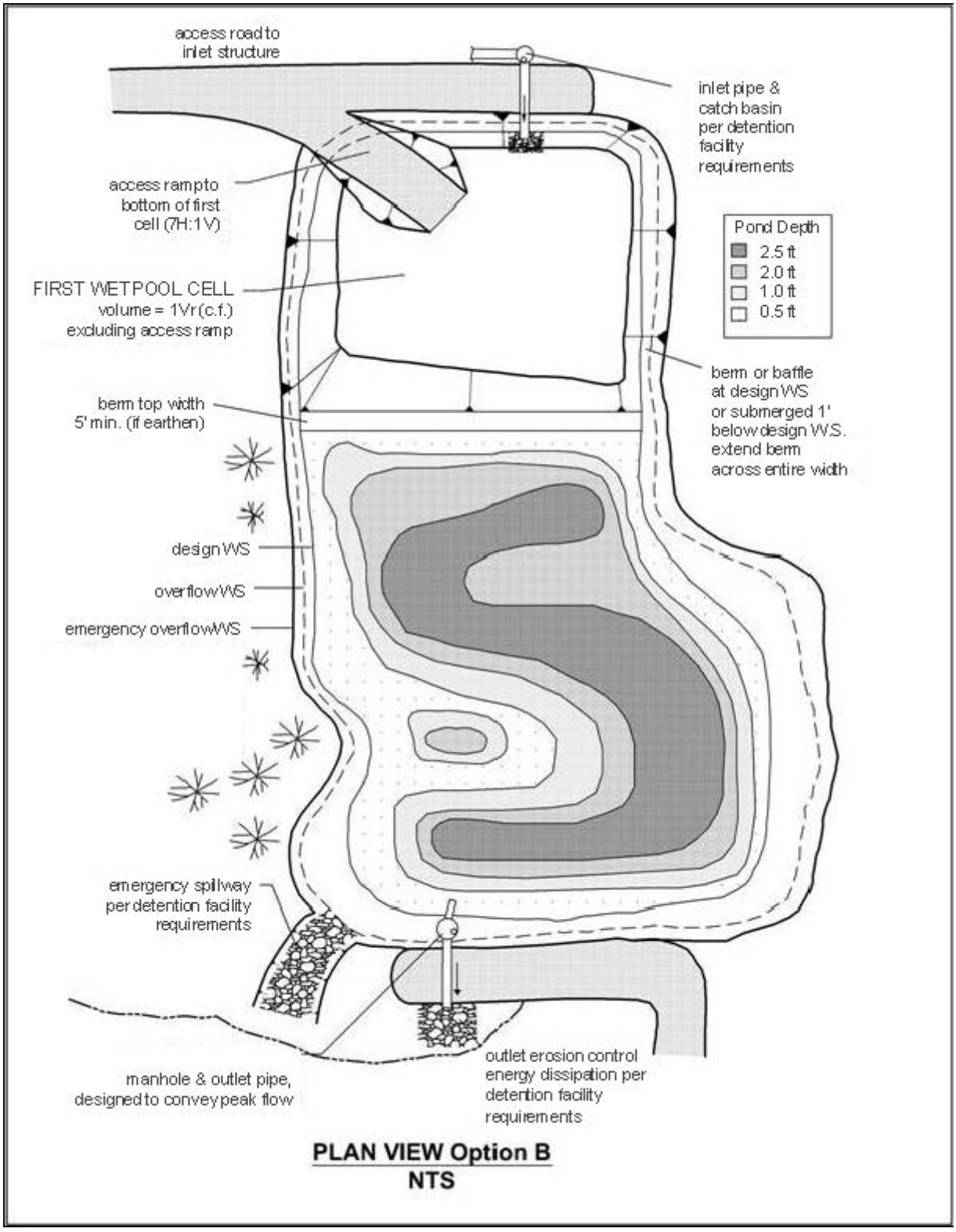


Figure 4 - 41: Stormwater Wetland – Option 2

15.4 BMP T1140: Combined Detention and Wetpool Facilities

15.4.1 Description

Combined detention and stormwater treatment wetpool facilities have the appearance of a detention facility but contain a permanent pool of water as well. The following design procedures, requirements, and recommendations cover differences in the design of the stand-alone stormwater treatment facility when combined with detention storage. The following combined facilities are addressed:

- Detention/wetpond (basic and large)
- Detention/wetvault
- Detention/stormwater wetland.

There are two sizes of the combined wetpond, a basic and a large, but only a basic size for the combined wetvault and combined stormwater wetland. The facility sizes (basic and large) are related to the pollutant removal goals.

15.4.2 Applications and Limitations:

Combined detention and wetpool facilities can be used to help ensure compliance with Minimum Requirement #5: Onsite Stormwater Management for Meeting the LID Performance Standard Only, Minimum Requirement #6: Stormwater Treatment, Minimum Requirement #7: Flow Control, and Minimum Requirement #8: Wetlands Protection.

Combined detention and stormwater treatment facilities are efficient for sites that also have detention requirements. The stormwater treatment facility may often be placed beneath the detention facility without increasing the facility surface area. However, the fluctuating water surface of the live storage will create unique challenges for plant growth and for aesthetics alike.

The live storage component of the facility shall be provided above the seasonal high water table.

15.4.3 BMP T1140a: Combined Detention and Wetponds

15.4.3.1 Design Criteria

Typical design details and concepts for a combined detention and wetpond are shown in Figure 4 - 42: Combined Detention and Wetpond (top view) and Figure 4 - 43: Combined Detention and Wetland (side view). The detention portion of the facility shall meet the design criteria and sizing procedures set forth in BMP F110: Detention Ponds.

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

15.4.3.1.1 Sizing

The sizing for combined detention and wetponds are identical to those for wetponds and for detention facilities. Refer to Guidance in BMP T1110: Wetponds - Basic and Large for sizing the wetpond portion and BMP F100: Detention Facilities for sizing the detention portion.

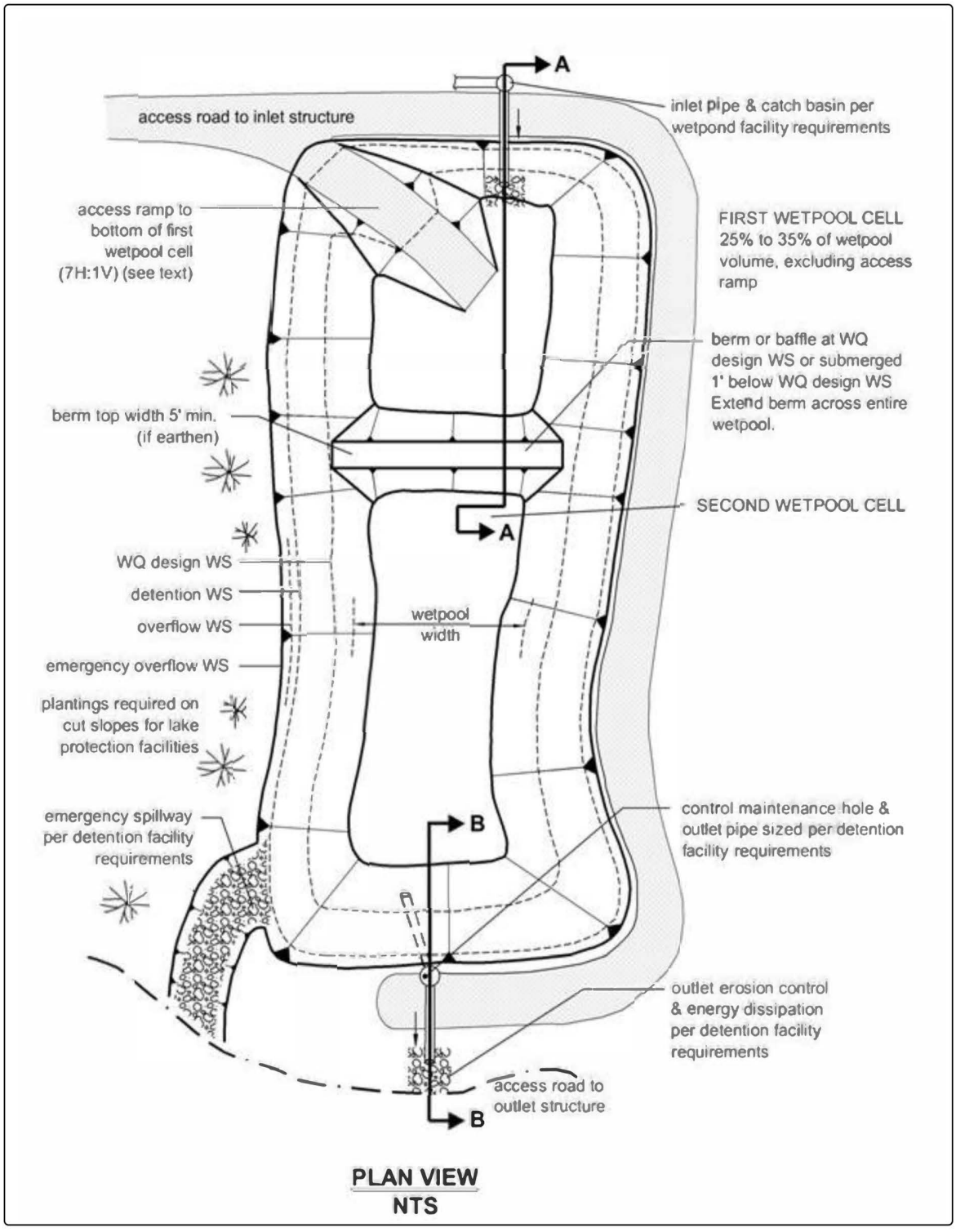


Figure 4 - 42: Combined Detention and Wetpond (top view)

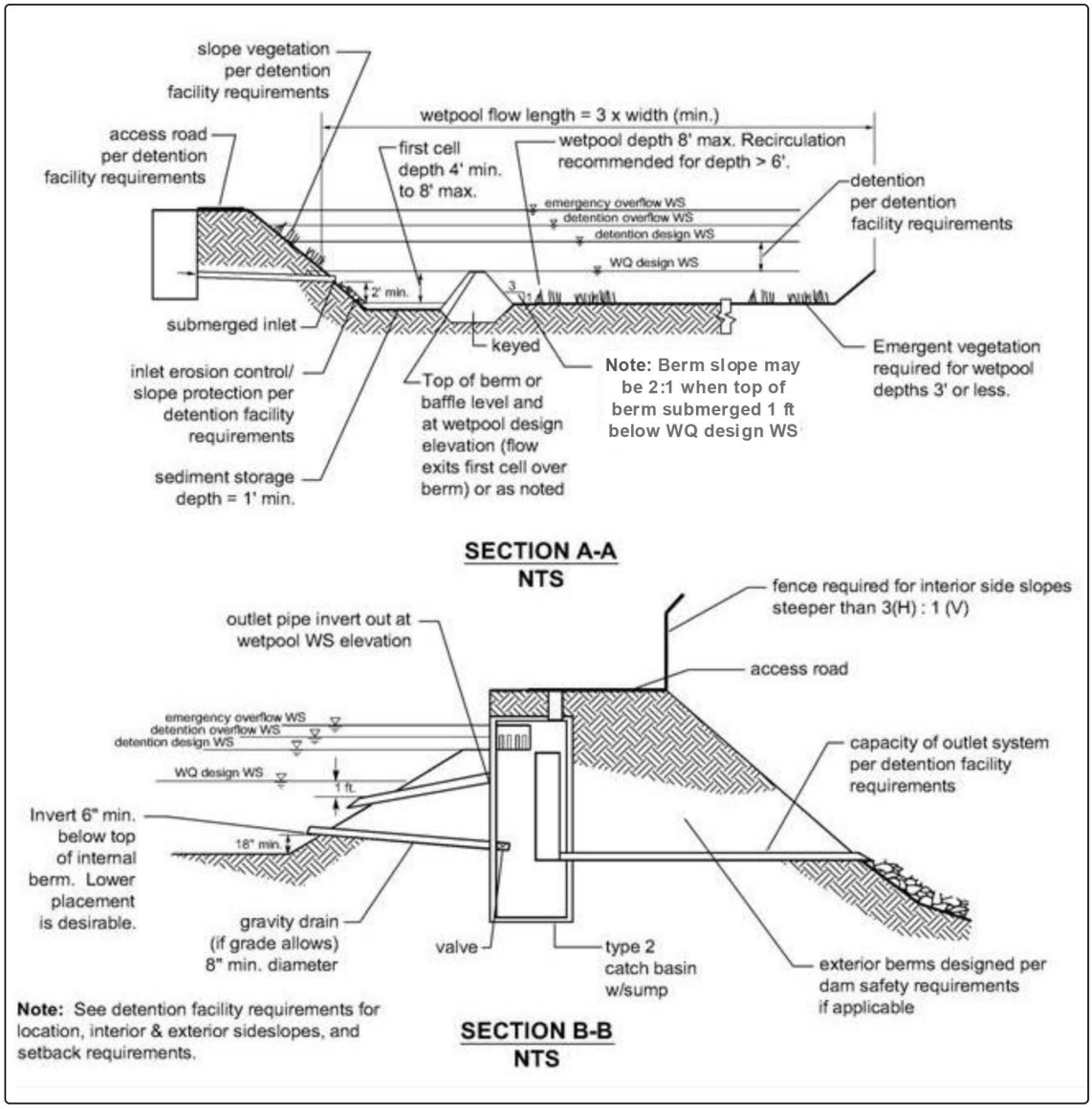


Figure 4 - 43: Combined Detention and Wetpond (side view)

15.4.3.1.2 Detention and Wetpool Geometry

- Do not include the wetpool and sediment storage volumes in the required detention volume.
- The "Wetpool Geometry" criteria for wetponds (see BMP T1010: Basic Biofiltration Swale) shall apply with the following modifications/clarifications:
  - The permanent pool may be shallower to comprise most of the pond bottom, or deeper positioned to comprise a limited portion of the bottom. Note, having the first wetpool cell at the inlet allows for more efficient sediment management than if the cellis moved away from the inlet. Wetpond criteria governing water depth must still be met. See Figure 4 - 44: Alternative Configurations of Detention and Wetpool Areas for two possibilities for wetpool cell placement.

- The minimum sediment storage depth in the first cell is 1-foot. The 6 inches of sediment storage required for a detention pond does not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with the detention sediment storage requirement.

15.4.3.1.3 Berms, Baffles and Slopes

Same as for wetponds (see BMP T1110: Wetponds - Basic and Large)

15.4.3.1.4 Inlet and Outlet

The Inlet and Outlet criteria for wetponds (BMP T1110: Wetponds - Basic and Large) shall apply with the following modifications:

- Provide a sump in the outlet structure of combined ponds.
- Design the detention flow restrictor and its outlet pipe according to the requirements for detention ponds.

15.4.3.1.5 Access and Setbacks

The same as for wetponds (BMP T1110: Wetponds - Basic and Large).

15.4.3.1.6 Planting Requirements

The same as for wetponds (BMP T1110: Wetponds - Basic and Large).

15.4.3.1.7 Embankments

The same as for wetponds (BMP T1110: Wetponds - Basic and Large).

15.4.3.1.8 Signage

Provide a stormwater facility sign. Sign shall conform to A800: Signage.

15.4.3.2 Construction

The same as for wetponds (BMP T1110: Wetponds - Basic and Large).

15.4.4 BMP T1140b: Combined Detention and Wetvault

The sizing procedure for combined detention and wetvaults is identical to those outlined for wetvaults and for detention vaults.

15.4.4.1 Design Criteria

The design criteria for BMP F100: Detention Facilities and BMP T1120: Wetvaults must both be met, except for the following modifications or clarifications:

- The minimum sediment storage depth in the first cell shall average 1-foot. The 6 inches of sediment storage required for detention vaults do not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with detention vault sediment storage requirements.
- The oil retaining baffle shall extend a minimum of 2 feet below the WQ design water surface.
- If a vault is used for detention as well as stormwater treatment, the facility may not be modified to function as a baffle oil/water separator as allowed for wetvaults in BMP T1020: Wet Biofiltration Swale.

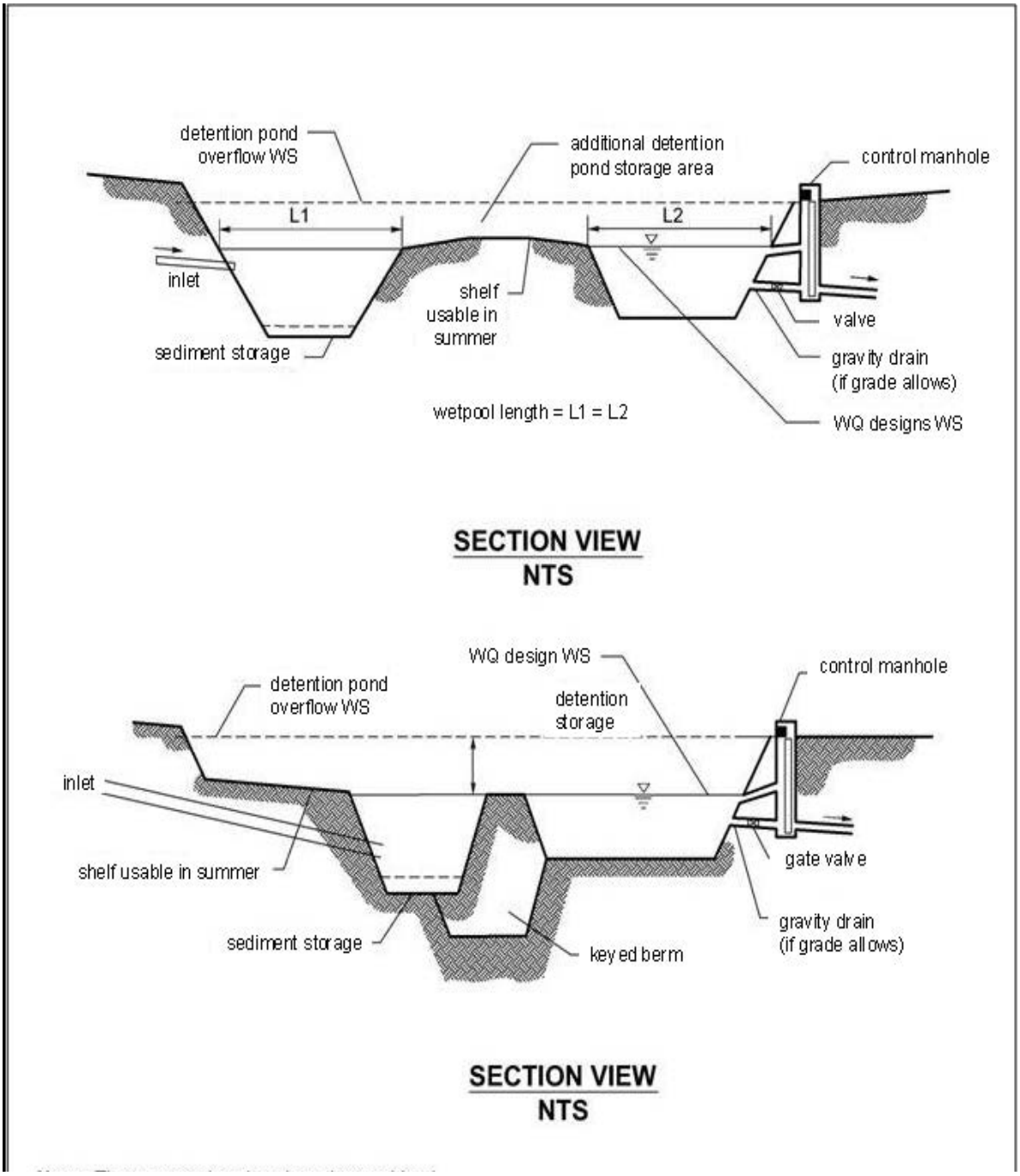


Figure 4 - 44: Alternative Configurations of Detention and Wetpool Areas

15.4.5 BMP T1140c: Combined Detention and Stormwater Treatment Wetland

15.4.5.1 Design Criteria

The design criteria for BMP F110: Detention Ponds and BMP T1130: Stormwater Treatment Wetlands must both be met, except for the following modifications or clarifications The Wetland Geometry criteria for stormwater wetlands (see BMP T1130: Stormwater Treatment Wetlands) shall be modified as follows:

The minimum sediment storage depth in the first cell is 1-foot. The 6 inches of sediment storage required for detention ponds does not need to be added to this, nor does the 6 inches of sediment storage in the second cell of detention ponds need to be added.

15.4.5.1.1 Sizing

The sizing procedure for combined detention and stormwater wetlands is identical to those outlined for stormwater wetlands and for detention facilities. Follow the procedure specified in BMP T1030: Continuous Inflow Biofiltration Swale to determine the stormwater wetland size. Follow the standard procedure specified in BMP F110: Detention Ponds to size the detention portion of the wetland.

Water Level Fluctuation Restrictions: The difference between the WQ design water surface and the maximum water surface associated with the 2-year runoff shall not be greater than 3 feet. If this restriction cannot be met, the size of the stormwater wetland must be increased. The additional area may be placed in the first cell, second cell, or both. If placed in the second cell, the additional area need not be planted with wetland vegetation or counted in calculating the average depth.

15.4.5.1.2 Inlet and Outlet

The Inlet and Outlet criteria for wetponds (BMP T1110: Wetponds - Basic and Large) shall apply with the following modifications:

- Provide a sump in the outlet structure of combined facilities.
- Design the detention flow restrictor and its outlet pipe according to the requirements for BMP F110: Detention Ponds.

15.4.5.1.3 Planting Requirements

See A1000: Vegetation for appropriate plant options for Combined Detention and Stormwater Treatment Wetlands.

Chapter 16 Pretreatment BMPs

16.1 BMP T610: Presettling Basin

16.1.1 Purpose

A presettling basin provides pretreatment of runoff in order to remove suspended solids, which can impact other stormwater treatment BMPs.

16.1.2 Application

- Pretreatment basins, when used with other stormwater treatment BMPs, can be used to ensure compliance with Minimum Requirement #6: Stormwater Treatment when Pretreatment is required.
- Pretreatment basins may also be used for ensuring compliance with Minimum Requirement #3: Source Control for areas where sediment may impact the stormwater system.

16.1.3 Design Criteria

- Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.
- Presettling basins shall be installed upstream of other stormwater treatment or flow control BMPs.
- The presettling basin shall be designed as a wetpool facility. The wetpool volume shall be at least 30% of the total water quality volume. The water quality volume shall be calculated using an Ecology approved continuous simulation model, assuming a 15-minute timestep.
- If the runoff in the presettling basin will be in direct contact with the soil, it must be lined per A100: Liners.
- The presettling basin shall conform to the following:
    - The length-to-width ratio shall be at least 3:1. Berms or baffles may be used to lengthen the flowpath.
    - The minimum depth shall be 4 feet; the maximum depth shall be 6 feet.
- Inlets and outlets shall be designed to minimize velocity and reduce turbulence. Inlet and outlet structures should be located at extreme ends of the basin in order to maximize particle-settling opportunities.

Chapter 17 Emerging Technologies

17.1 BMP T1300: Emerging Technologies

17.1.1 Background

Traditional best management practices (BMPs) such as wetponds and filtration swales may not be appropriate in many situations due to size and space restraints or their inability to remove target pollutants. Because of this, the stormwater treatment industry emerged and new stormwater treatment devices are currently in development.

Emerging technologies are those new stormwater treatment devices that are continually being added to the stormwater treatment marketplace. These devices include both permanent and construction site treatment technologies. Many of these devices have not undergone complete performance testing so their performance claims cannot be verified.

17.1.2 Emerging Technology Use in the City of Tacoma

- All emerging technologies must be designed and maintained in accordance with the most up to date Use Level Designation and with the Design Criteria for All Stormwater Facilities. Use Level Designations can be found: https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies.
- Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.
- For privately maintained facilities:
  - The City of Tacoma allows the use of any technology that has received a Use Level Designation from the Washington State Department of Ecology as part of the TAPE Program.
- For publically maintained facilities:
  - The City of Tacoma allows emerging technologies on a case by case basis.

17.1.3 Ecology Role in Evaluating Emerging Technologies

To aid local governments in selecting new stormwater treatment technologies Ecology developed the Technology Assessment Protocol – Ecology (TAPE) and Chemical Technology Assessment Protocol Ecology (CTAPE) protocols. These protocols provide manufacturers with guidance on stormwater monitoring so they may verify their performance claims.

As a part of this process Ecology:

- Posts information on emerging technologies at the emerging technologies website: http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html.
- Participates in all Technical Review Committee (TRC) and Chemical Technical Review Committee (CTRC) activities which include reviewing manufacturer performance data and providing recommendations on use level designations.

- Grants use level designations based on performance and other pertinent data submitted by the manufacturers and vendors.
- Provides oversight and analysis of all submittals to ensure consistency with this manual.

17.1.4 Use Level Designations

Ecology developed use level designations to assess levels of development for emerging technologies. The use level designations are based upon the quantity, quality, and type of performance data. There are three use level designations: pilot use level designation, conditional use level designation, and general use level designation.

Pilot Use Level Designation (PULD)

For technologies that have limited performance data, the pilot use level designation allows limited use to enable field testing to be conducted. Pilot use level designations may be given based solely on laboratory performance data. Pilot use level designations apply for a specified time period only. During this time period, the proponent must complete all field testing and submit a technology evaluation report (TER) to Ecology and the TRC. Ecology will limit the number of installations to five during the pilot use level period.

Local governments may allow PULD technologies to be installed if the manufacturer agrees to conduct additional field testing based on the TAPE at all sites to obtain a general use level designation. Local governments covered by a municipal stormwater NPDES permit must notify Ecology in writing when a PULD technology is proposed. The form can be found: https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies

Conditional Use Level Designation (CULD)

For emerging technologies that have considerable performance data that was not collected per the TAPE protocol, the CULD was established. Conditional use level designations may be given if field data has been collected by a protocol that is reasonably consistent but does not necessarily fully meet the TAPE protocol. The field data must meet the statistical goals set out in the TAPE guidelines (Appendix D). Laboratory data may be used to supplement field data. Technologies that are granted a CULD will be allowed continued use for a specified time period, during which the field testing necessary to obtain a general use level designation (GULD) must be completed and a TER must be submitted to Ecology and the TRC. Ecology will limit the number of installations to ten during the CULD period.

General Use Level Designation (GULD)

The general use level designation (GULD) confers a general acceptance for the specified applications (land uses). Technologies with a GULD may be used anywhere in Washington, subject to Ecology conditions.

Chapter 18 Oil Water Separators

18.1 Purpose

Oil water separators remove oil and other water-insoluble hydrocarbons and settleable solids from stormwater.

18.2 Description

This section provides design criteria for two common types of oil water separators. Both separators rely on gravity separation to remove floating and dispersed oil from the stormwater. The oil will rise to the surface where it remains until skimmed or cleaned. Oil water separators do not remove dissolved or emulsified oils. Oil water separators rely on consistent inspection and maintenance to perform effectively.

- The American Petroleum Institute (API) Oil Water Separator
  - API Separators are vault structures composed of three bays (the forebay, separator bay, and afterbay) separated by baffles.
- The Coalescing Plate (CP) Oil Water Separator
  - Coalescing plate separators add a series of plates in the separator bay which improve removal efficiency by providing additional surface area. CP separators can be smaller due to the addition of the plates.

18.3 Applications

- Oil water separators can be used to ensure compliance with Minimum Requirement #6: Stormwater Treatment when Oil Control is required.
- Oil water separators may also be used for ensuring compliance with Minimum Requirement #3: Source Control for areas where additional oil control may be necessary.
- API and CP separators shall not be used to remove dissolved or emulsified oils such as may be present in coolants, soluble lubricants, glycols, and alcohols.
- Oil water separators perform best when located in areas where the contributing area is mostly impervious surface and the stormwater is likely to contain a higher load of petroleum. Because oil water separators do not perform well at low concentrations, it is not recommended to install them where dilute concentrations are likely.

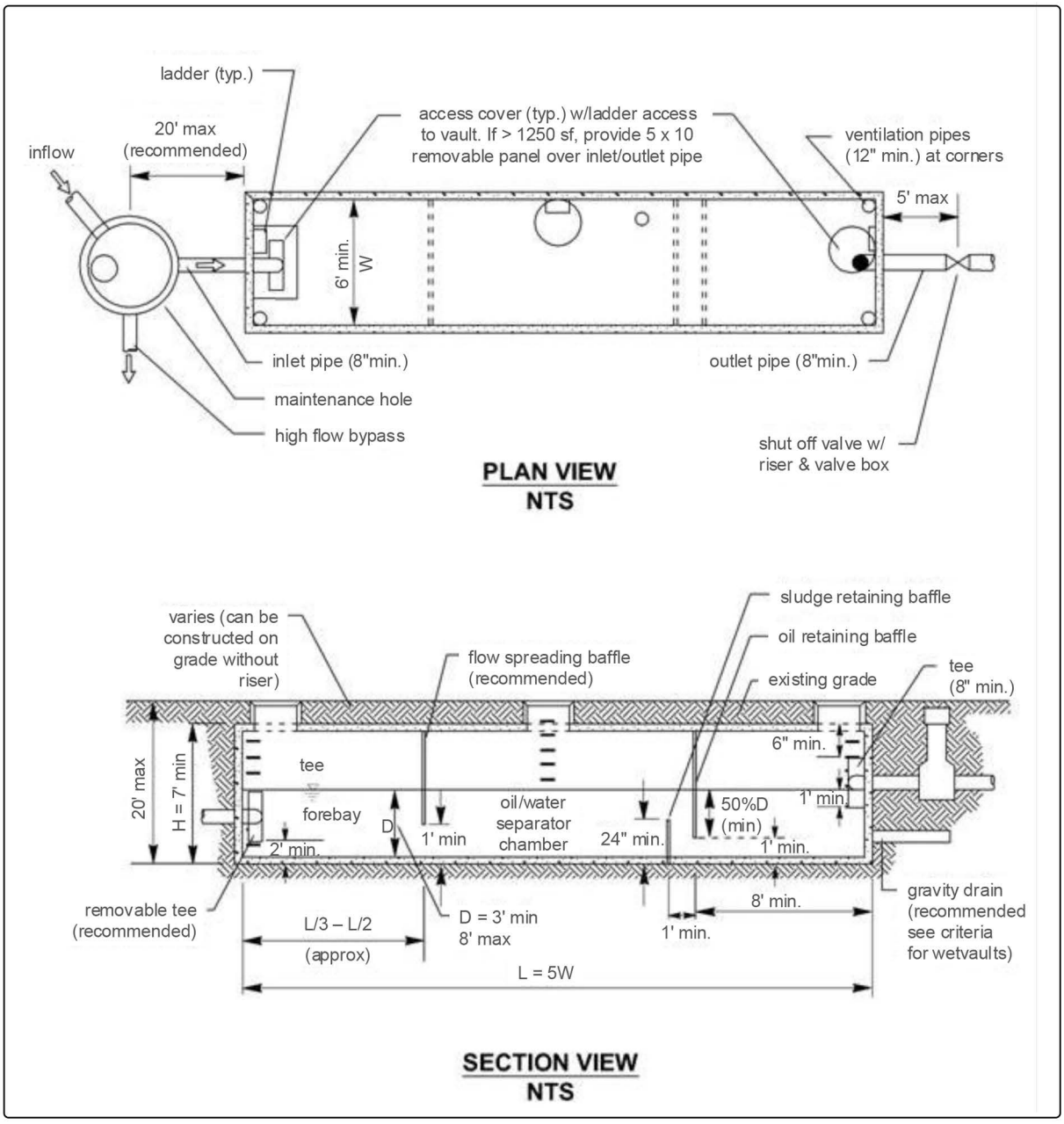


Figure 4 - 45: API (Baffle Type) Separator

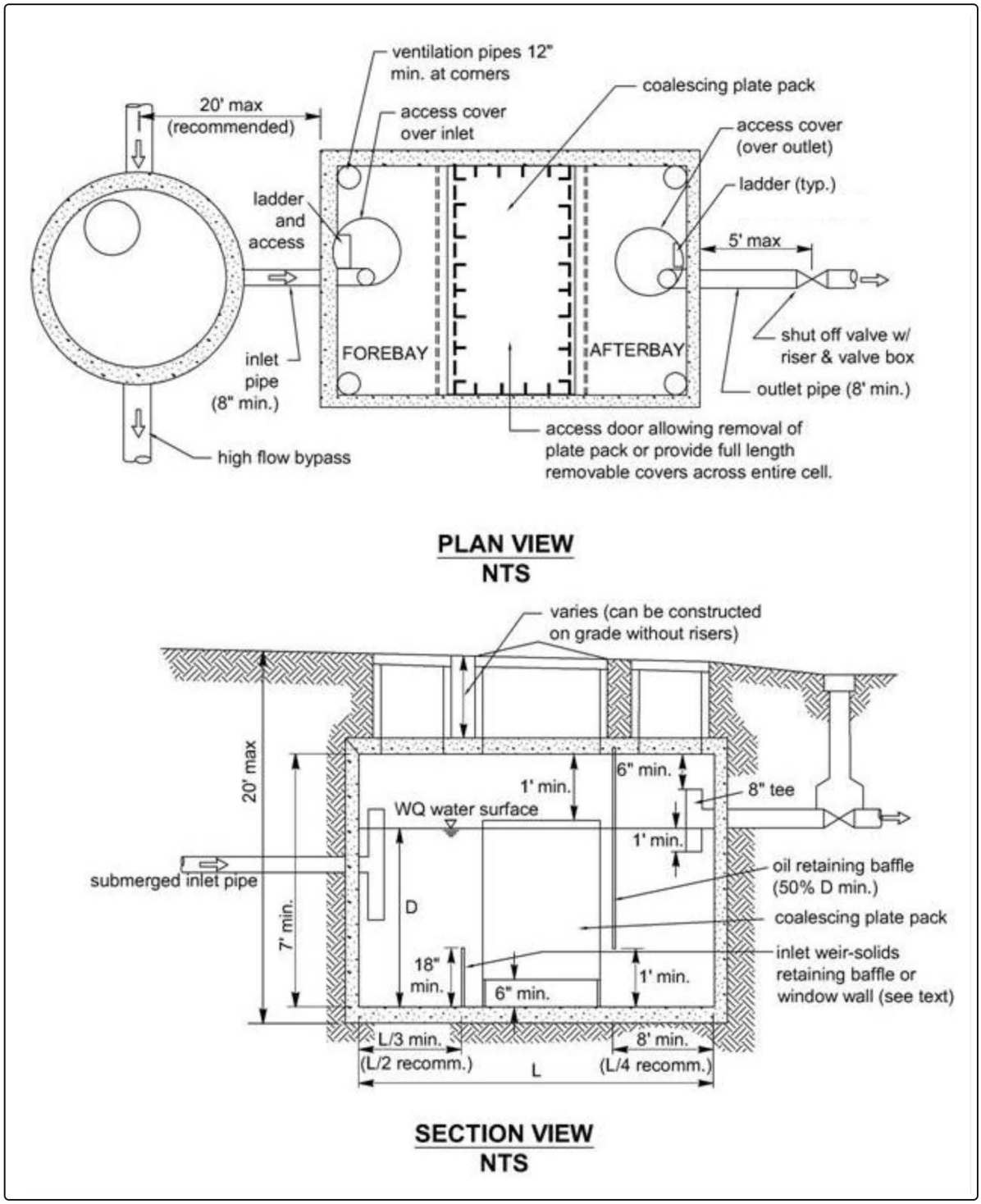


Figure 4 - 46: Coalescing Plate Separator

18.4 Design Criteria Applicable to Both API and CP Separators

The following are design criteria applicable to API and CP oil/water separators:

- Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

18.4.1 Siting

- Locate the separator offline and bypass the incremental portion of flows that exceed the adjusted water quality design flowrate.
- The separator shall be installed upstream of any other stormwater treatment facility.
- The separator shall be installed upstream of any pumps to prevent oil from emulsifying.
- Separators may be installed upstream or downstream of flow control facilities.

18.4.2 Vault Structure

- Separator vaults shall be watertight. Pipes entering and exiting a vault below the water quality design water surface shall be sealed using a non-porous, non-shrinking vault.
- Separator vaults shall have a shutoff mechanism on the outlet pipe to prevent oil discharges during maintenance and to provide emergency shutoff capability in the event of a spill.

18.4.3 Inlet and Outlet

- The inlet shall be submerged at least 2 feet from the vault bottom.
  - The submerged inlet helps to dissipate flows. The minimum distance from the bottom helps to minimize resuspension of sediments.
- The inlet shall be extended above the water quality design water surface.
  - Extending the tee to the surface allows air to escape reducing turbulence.
- The inlet and outlet pipe shall be a minimum 8" installed with a tee.
- The outlet shall be sized to pass the modified water quality design flow.
- The outlet shall be a tee extending 1 foot below the outlet the water quality design water surface.
- The outlet tee shall extend above the water quality design water surface.

18.4.4 Materials

- Vault baffles shall be concrete or stainless steel and be securely attached to the vault.

18.4.5 Access

- Provide access to each separator bay. If the length of width of a bay exceeds 50 feet, additional access points are necessary.

- Access points for the forebay and afterbay shall be positioned over the inlet and outlet tee to allow for visual inspection and access.

18.4.6 Recommended Criteria

- Use absorbents in the afterbay if necessary.
- For areas likely to produce larger amounts of oil, install a bleed-off pipe which discharges to a separate waste oil tank.

18.4.7 Sizing - Stoke's Law

Gravity oil water separators are designed using Stoke's law principles. The principles define the rise velocity of an oil droplet based upon the density of the oil, the size of the oil droplet, and properties of the water. Stoke's Law relies on laminar flow and spherical oil droplets.

Stokes Law equation for rise rate, Vt (cm/sec):

$$Vt = \frac{\left[(g)(\rho_w - \rho_o)(d^2)\right]}{[(18 \times \mu w)]}$$

Where:

Vt = the rise rate of the oil droplet (cm/s or ft/s)

g = acceleration due to gravity (cm/s² or ft/s^2)

ρ_w = density of water at the design temperature (g/cm³ or lbm/ft^3)

ρ_o = density of oil at the design temperature (g/cm³ or lbm/ft^3)

d = oil droplet diameter (cm or ft)

μ_w = absolute viscosity of the water (g/cm*s or lbm/(ft*s))

18.5 BMP T1200a: API (Baffle Type) Separators

18.5.1 Design Criteria for API Separators

The design criteria below are in addition to design criteria provided in the previous section.

- API separators shall be divided into three compartments: a forebay, an oil separation cell and an afterbay.
  - The forebay is designed primarily to trap and collect sediment, support plug flow conditions and reduce turbulence.
  - The oil separation cell traps and holds oil as it rises from the water column, and it serves as a secondary sediment collection area.
  - The afterbay provides a relatively oil-free cell before the outlet and provides a secondary oil separation area.
- The length of the forebay shall be approximately 1/3 to 1/2 the length of the vault. In addition, the surface area of the forebay must be at least 20 square feet per 10,000 square feet of impervious area draining to the separator.
- A removable flow spreading baffle is required.
  - Extend baffle from the surface to a depth of up to ½ the vault depth.
  - Baffle height to water depth ratio shall be 0.85.
- A removable sediment retaining baffle is required.
  - Extend baffle from the vault floor.
  - Baffle shall be a minimum 24" from the vault floor.
  - Baffle height to water depth ratio shall be 0.15.
  - Locate the baffle 1' from the oil retaining baffle (on the inlet side)
  - A window wall baffle may be used provided the area of the window opening is at least 3 times greater than the area of the inflow pipe.
- A removable oil retaining baffle is required.
  - Locate approximately the distance equal to ¼ the total vault length from the outlet wall, or a minimum of 8 feet, whichever is greater.
    - The minimum length provides for maintenance.
  - Extend baffle down to a depth of at least 50% of the design water depth.
    - Baffle height to water depth ratio shall be 0.85.
    - The configuration shall be designed to minimize turbulence and entrainment of sediment.
- Baffles may be fixed rather than removable if additional entry ports and ladders are provided so that both sides of the baffle are accessible to maintenance crews.
- API separator vaults shall have a minimum length-to-width ratio of 5:1.
- The design water depth (D) shall be a minimum of 3 feet deep and a maximum of 8 feet deep unless otherwise approved by the City of Tacoma.

- API separator vaults shall have a design water depth-to-width ratio of between 0.3 and 0.5.

18.5.2 Sizing Criteria for API separators

18.5.2.1 Sizing Criteria for Contributing Areas Less than 2 Acres

The Washington State Department of Ecology modified the API Sizing Criteria for smaller drainage areas by using the design hydraulic horizontal velocity, Vh for the design Vh/Vt rather than using the API minimum of Vh/Vt=15. The API Sizing Criteria is applicable for drainage areas 2 acres or greater. Use the following steps for sizing and API Separator when the contributing area is less than 2 acres.

1. Calculate the Water Quality Design Flowrate (Q_{wq})

Use an Ecology approved continuous simulation model, assuming 15-minute timesteps, to determine the 15-minute offline water quality flowrate.

Convert the calculated Water Quality Design Flowrate to ft^3/min.

2. Calculate the Adjusted Water Quality Design Flowrate (Q_{adj})

$$Q_{adj} = (3.5) \times Q_{wq}$$

Q_{adj} should be in ft^3/min.

3. Calculate V_t using Sizing - Stoke's Law

4. Select depth and width based upon allowed maximum water depths and allowed depth-to-width ratios.

5. Calculate the horizontal velocity of the bulk fluid (V_h).

$$V_h = \frac{Q_{adj}}{d \times w}$$

Where:
V_h = Horizontal Velocity (ft/min)

Q_{adj} calculated in Step 2. (ft^3/min)

d = separator water depth (ft)

w = separator width (ft)

The maximum V_h allowed is 2 ft/min.

6. Calculate V_h/V_t

V_h as calculated in Step 5

V_t as calculated in Step 3.

7. Determine F - the turbulence and short-circuiting factor.

Use Figure 4 - 47: Turbulence and Short-Circuiting Factor to determine F.

8. Calculate the Minimum Separator Length ls.

$$l_s = F \times \left(\frac{V_h}{V_t} \right) \times d$$

$$l_t = l_f + l_s + l_a$$

$$l_t = \frac{l_t}{3} + l_s + \frac{l_t}{4}$$

Where:

l_t = total length of 3 bays (ft)

l_f = length of forebay (ft)

l_a - length of afterbay (ft)

9. Calculate the Minimum Hydraulic Design Volume (V)

$$V = l_s \times w \times d$$

Where:

V = minimum hydraulic design volume (ft^3)

l_s = separator Length as calculated in Step 8

w = width (ft) - chosen in Step 4

d = separator water depth (ft) - chosen in Step 4

10. Calculate the Minimum Horizontal Area of the Separator A_h

$$A_h = w \times l_s$$

Where:

A_h = minimum horizontal area of the separator (ft^2)

l_s = separator length - calculated in Step 8

w = width (ft) - chosen in Step 4

11. Compute and Check that the Horizontal Surface Area of the Vault Forebay Criterion is Satisfied

This surface area of the forebay must be at least 20 ft^2 per 10,000 ft^2 of impervious area draining to the separator.

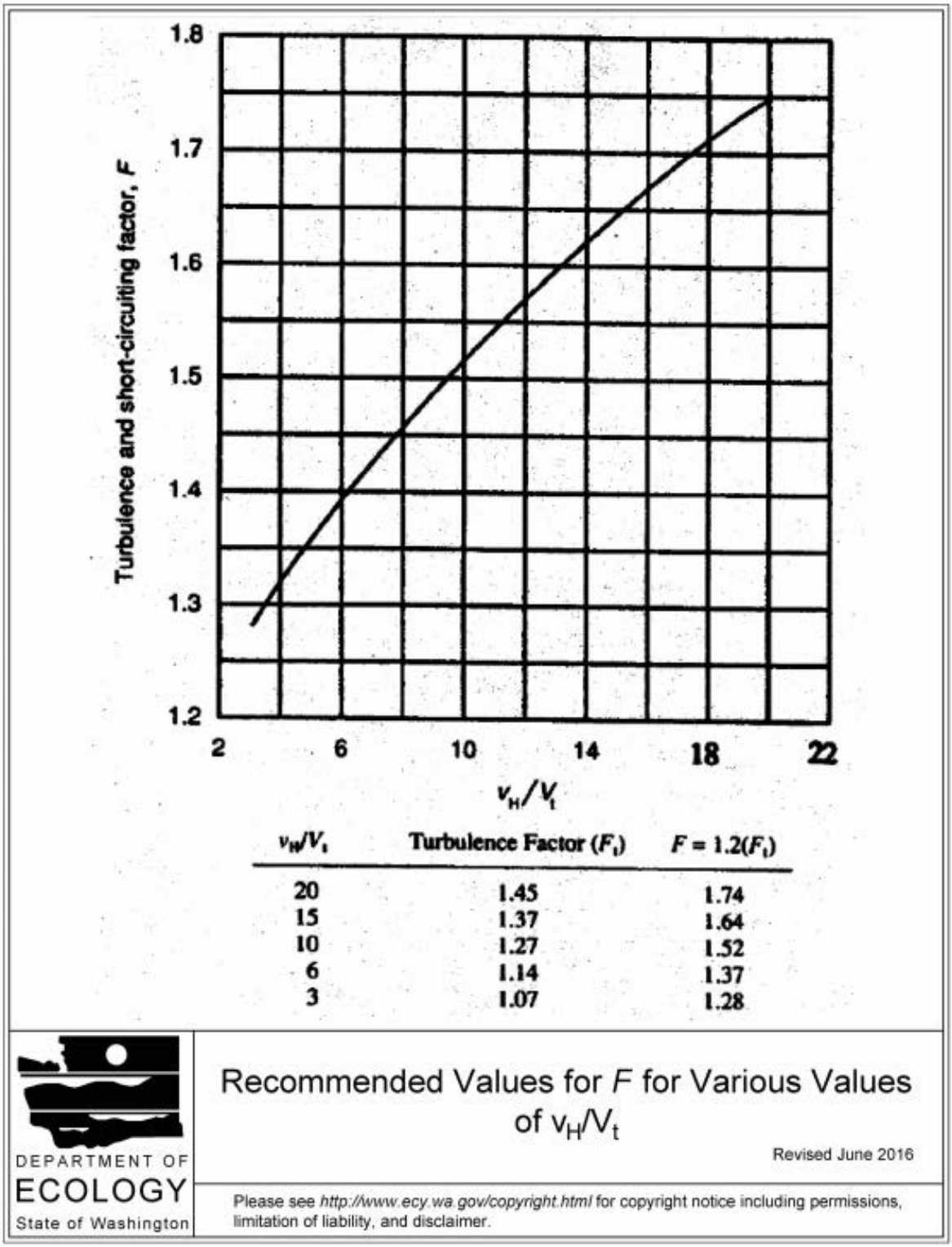
The length of the forebay (L/3) may be increased to meet the criterion without having to increase the overall length of the vault.

12. Design the flow splitter and high-flow bypass.

See A200: Flow Splitters for design information.

18.5.2.2 Sizing Criteria for Contributing Areas 2 Acres and Greater

Use $V_h = 15 \times V_t$ and repeat Steps 7 to 12 above.



v_H/V_t	Turbulence Factor (F_t)	$F = 1.2(F_t)$
20	1.45	1.74
15	1.37	1.64
10	1.27	1.52
6	1.14	1.37
3	1.07	1.28

DEPARTMENT OF ECOLOGY
State of Washington

Recommended Values for *F* for Various Values of v_H/V_t

Revised June 2016

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Figure 4 - 47: Turbulence and Short-Circuiting Factor

18.6 BMP T1200b: Coalescing Plate (CP) Separators

18.6.1 Design Criteria for CP Separators

- Coalescing plate separators shall be divided by baffles or berms into three compartments: a forebay, an oil separation cell which houses the plate pack, and an afterbay. The forebay controls turbulence and traps and collects debris. The oil separation call captures and holds oil. The afterbay provides a relatively oil-free exit cell before the outlet.
- The length of the forebay shall be a minimum of ⅓ the length of the vault, L (though ½ L is recommended). In addition, it is recommended that the surface area of the forebay be at least 20 square feet per 10,000 square feet of tributary impervious area draining to the separator. In lieu of an attached forebay, a separate grit chamber, sized to be a least 20 square feet per 10,000 square feet of tributary impervious area, may precede the oil/ water separator.
- An oil-retaining baffle shall be provided. For large units, a baffle position of 0.25 L from the outlet wall is recommended. The distance from the outlet shall consider the ability to inspect and maintain the separator. The oil-retaining baffle shall extend from the water surface to a depth of at least 50 percent of the design water depth. Various configurations are possible, but the baffle shall be designed to minimize turbulence and entrainment of sediment.
- A bottom sediment-retaining baffle shall be provided upstream of the plate pack. The minimum height of the sediment-retaining baffle shall be 18 inches. Window walls may be used, but the window opening must be a minimum of three times greater than the area of the inflow pipe.
- It is recommended that entire space between the sides of the plate pack and the vault wall be filled with a solid but lightweight removable material such as a plastic or polyethylene foam to reduce short-circuiting around the plate pack. Rubber flaps are not effective for this purpose.
- The Reynolds Number through the separator bay shall be <500 (laminar flow).
- The separator plates shall meet the following criteria:
    - Plates shall be inclined at 45º to 60º from the horizontal. This range of angles exceeds the angle of repose of many solids and therefore provides more effective droplet separation while minimizing the accumulation of solids on the individual plates.
    - Plates shall have a minimum plate spacing of ½ inch (perpendicular distance between plates) and have corrugations.
    - Locate plate pack at least 6 inches from the bottom of the separator for sediment storage.
    - Locate plate pack such that there is 12 inches minimum from the top of the plate pack and the bottom of the vault cover.
    - Design plates for ease of removal (by bundling securely) and cleaning with high-pressure rinse or equivalent.
    - Plate packs shall be stainless steel or polypropylene.

18.6.2 Sizing Criteria for CP Separators

Coalescing plate separators are designed using similar principles as API separators. For API separators, horizontal separation is related only to the water surface area. For CP separators, horizontal separation is related to the plate surface area therefore increasing the treatment area.

Use the following steps for sizing an API Separator:

1. Calculate the Water Quality Design Flowrate (Q_{WQ})

Use an Ecology approved continuous simulation model, assuming a 15-minute timestep, to determine the 15-minute offline water quality flowrate.

Convert the calculated Water Quality Design Flowrate to ft^3/min.

2. Calculate the Adjusted Water Quality Design Flowrate (Q_{adj})

$$Q_{adj} = (3.5) \times (Q_{WQ})$$

Q_{adj} should be in ft^3/min.

3. Calculate the plate minimum effective separation area (A_h)

$$A_h = \frac{Q_{adj}}{V_t}$$

Where:

A_h = horizontal surface area of the plates (ft^2)

Q_{adj} = adjusted water quality flowrate from Step 2 (ft^3/min)

V_t = rise rate of the oil droplet per Sizing - Stoke's Law.

4. Calculate the collective projected surface area (A_p)

Use the following equation to solve for A_p

$$A_h = A_p = A_a(\cos H)$$

Where

A_a = actual collective plate area of the plate configuration (ft^2)

H = angle of the plates to the horizontal (degree)

The oil water separator shall be sized using the projected surface area rather than the actual plate area.

5. Choose a Separator

Choose a separator that provides the required actual collective plate area and meets all the design criteria.

6. Design the flow splitter and high-flow bypass.

See A200: Flow Splitters for design information.

Chapter 19 Other Low Impact Development Best Management Practices

19.1 BMP L613: Post-Construction Soil Quality and Depth

19.1.1 Purpose

Naturally occurring (undisturbed) soil and vegetation provide important stormwater functions including: water infiltration; nutrient, sediment, and pollutant adsorption; sediment and pollutant biofiltration; water interflow storage and transmission; and pollutant decomposition. These functions are largely lost when development strips away native soil and vegetation and replaces it with minimal topsoil and sod. Not only are these important stormwater functions lost, but such landscapes themselves become pollution generating pervious surfaces due to increased use of pesticides, fertilizers and other landscaping and household/industrial chemicals, the concentration of pet wastes, and pollutants that accompany roadside litter.

19.1.2 Applications

- Soil amendments are required for the disturbed areas of sites subject to Minimum Requirement #5: Onsite Stormwater Management that will not be covered by an impervious surface, incorporated into a stormwater facility, or engineered as structural fill or slope.
- Where Minimum Requirement #5: Onsite Stormwater Management does not apply, it is recommended to incorporate soil amendments into all disturbed areas of the site.

19.1.3 Infeasibility Criteria for Soil Quality BMPs

- Post-Construction soil quality and depth is considered infeasible on slopes greater than 33%. Citation of this infeasibility criterion requires evaluation of site specific conditions.
- This BMP is considered infeasible if there are any conflicts with any of the following competing needs criteria:
    - Requirements of the following federal or state laws, rules, and standards:
        - Historic Preservation Laws and Archaeology Laws as listed at: https://dahp.wa.gov/project-review/preservation-laws
        - Federal Superfund or Washington State Model Toxics Control Act
        - Federal Aviation Administration requirements for airports
        - American with Disabilities Act
    - When found to be in conflict with special zoning district design criteria adopted and being implemented pursuant to a community planning process.
    - Public health and safety standards
    - Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.
    - City of Tacoma Critical Area Ordinances that provides protection of tree species or other critical areas.

19.1.4 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

19.1.4.1 Soil Retention

- Retain the duff layer and native topsoil in an undisturbed state to the maximum extent practicable. In any areas requiring grading, remove and stockpile the duff layer and topsoil onsite in a designated, controlled area, not adjacent to public resources and critical areas, to be reapplied to other portions of the site where feasible. Use appropriate BMPs to ensure retained soil does not enter the stormwater system.

19.1.4.2 Soil Quality

- All areas subject to clearing and grading that will not be covered by impervious surface, incorporated into a stormwater facility or engineered as structural fill or slope shall, at project completion:
  - Have a topsoil layer that is a minimum depth of eight inches except where tree roots limit the depth of incorporation of amendments needed to meet the criteria. Subsoils below the topsoil layer should be scarified at least 4 inches with some incorporation of the upper material to avoid stratified layers, where feasible.
    - The topsoil layer shall have a minimum organic matter content of 10% dry weight in planting beds, and minimum 5% organic matter content in turf areas, and a pH from 6.0 to 8.0 or matching the pH of the original undisturbed soil.
  - Planting beds have been mulched with 2 inches of organic material
- To meet the organic content requirements above use one of the following options:
  1. Compost applied at the Preapproved Rate (see Table 4 - 33: Amendment Options). Compost shall meet the compost specifications in A900: Compost.
  2. Compost applied at a Calculated Rate (see Table 4 - 34: Calculated Amendment Rate). Compost shall meet the compost specifications in A900: Compost.
  3. Other organic matter applied at a Calculated Rate (see Table 4 - 34: Calculated Amendment Rate). Other organic matter shall:
     - Have a carbon to nitrogen ratio below 25:1. Carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.
     - Not exceed contaminant limits identified in Table 220-B, Testing Parameters, in WAC 173-350-220.
- The resulting soil shall be conducive to the type of vegetation to be established.

City of Tacoma Standard Plan GSI-01 provides a graphical representation of BMP L613. The Standard Plan is available at tacoma.gov/government/departments/public-works/engineering/right-of-way-design-manual/.

19.1.4.3 Implementation Options:

Use one of the following options to meet the post construction soil quality and depth requirements. Use the information in this BMP and the most recent version of "Guidelines for Resources for Implementing Soil Quality and Depth BMP T5.13" to meet the requirements of this BMP. This guidance can be found online at: https://www.soilsforsalmon.org/.

Option 1. Leave native vegetation and soil undisturbed, and protect from compaction during construction.

Option 2. Amend existing site topsoil or subsoil either at default Preapproved Rates (see Table 4 -33: Amendment Options), or at Calculated Rate (see Table 4 - 34: Calculated Amendment Rate) based on tests of the soil and amendment.

Option 3. Stockpile existing topsoil during grading, and replace it prior to planting. Stockpiled topsoil must also be amended if needed to meet the organic matter or depth requirements, either at a default Preapproved Rates (see Table 4 - 33: Amendment Options) or at a Calculated Rate (see Table 4 - 34: Calculated Amendment Rate).

Option 4. Import topsoil mix of sufficient organic content and depth to meet the requirements.

More than one method may be used on different portions of the same site. Soil that already meets the depth and organic matter quality standards, and is not compacted, does not need to be amended.
There is a soils management plan worksheet available at tacoma.org/stormwatermanual that can be used to help determine the amount of amendments needed for a given area.

Table 4 - 33: Amendment Options

<table>
<tr><td colspan="2">OPTION 1: Leave native vegetation and soil undisturbed, and protect from compaction during construction
Identify areas of the site that will not be stripped, logged, graded or driven on, and fence off those areas to prevent impacts during construction. If neither soils nor vegetation are disturbed these areas do not require amendments.</td></tr>
<tr><td colspan="2">OPTION 2: Amend existing site topsoil or subsoil either at Preapproved Rate or at Calculated Rate based on the tests of the soil and amendments</td></tr>
<tr><td colspan="2">Scarification
• Scarify or till subgrade to 8 inches depth (or to depth needed to achieve a total depth of 12 inches of uncompacted soil after calculated amount of amendment is added).
• Entire surface should be disturbed by scarification.
• Do not scarify within drip line of existing trees to be retained.
• Amend soil to meet required organic content.</td></tr>
<tr><td>A. Planting Beds
1. PREAPPROVED RATE: Place 3 inches of composted material and rototill into 5 inches of existing site soil (a total amended depth of about 9.5 inches, for a settled depth of 8 inches).
2. CALCULATED RATE: Place calculated amount of composted material or approved organic material and rototill into depth of soil needed to achieve 8 inches of settled soil at 10% organic content.
• Rake beds to smooth and remove surface rocks larger than 2 inches diameter.
• Mulch planting beds with 2 inches of organic mulch</td><td>B. Turf Areas
1. PREAPPROVED RATE: Place 1.75 inches of composted material and rototill into 6.25 inches of existing site soil (a total amended depth of about 9.5 inches, for a settled depth of 8 inches).
2. CALCULATED RATE: Place calculated amount of composted material or approved organic material and rototill into depth of soil needed to achieve 8 inches of settled soil at 5% organic content.
• Water or roll to compact soil to 85% of maximum dry density.
• Rake to level, and remove surface rocks larger than 1 inch diameter.</td></tr>
</table>

Table 4 - 33: Amendment Options

<table>
<tr><td colspan="2">OPTION 3:Stockpile existing topsoil during grading, and replace it prior to planting. Stockpiled topsoil must also be amended if needed to meet the organic matter or depth requirements, either at a default Preapproved Rate or at a Calculated Rate.</td></tr>
<tr><td colspan="2">Scarification.
• If placed topsoil plus compost or other organic material will amount to less than 12 inches: Scarify or till subgrade to depth needed to achieve 12 inches of loosened soil after topsoil and amendment are placed.
• Entire surface should be disturbed by scarification.
• Do not scarify within drip line of existing trees to be retained.
• Stockpile and cover soil with weed barrier material that sheds moisture yet allows air transmission, in approved location, prior to grading.
• Replace stockpiled topsoil prior to planting. Amend if needed to meet required organic content.</td></tr>
<tr><td>A. Planting Beds
1. PREAPPROVED RATE: Place 3 inches of composted material and rototill into 5 inches of replaced soil (a total amended depth of about 9.5 inches, for a settled depth of 8 inches).
2. CALCULATED RATE: Place calculated amount of composted material or approved organic material and rototill into depth of replaced soil needed to achieve 8 inches of settled soil at 10% organic content.
• Rake beds to smooth and remove surface rocks larger than 2 inches diameter.
• Mulch planting beds with 2 inches of organic mulch or stockpiled duff.</td><td>B. Turf Areas
1. PREAPPROVED RATE: Place 1.75 inches of composted material and rototill into 6.25 inches of replaced soil (a total amended depth of about 9.5 inches, for a settled depth of 8 inches).
2. CALCULATED RATE: Place calculated amount of composted material or approved organic material and rototill into depth of replaced soil needed to achieve 8 inches of settled soil at 5% organic content.
• Water or roll to compact soil to 85% of maximum dry density.
• Rake to level, and remove surface rocks larger than 1 inch diameter.</td></tr>
<tr><td colspan="2">OPTION 4: Import topsoil mix of sufficient organic content and depth to meet the requirements.</td></tr>
<tr><td colspan="2">Scarification.
• Scarify or till subgrade in two directions to 6 inches depth.
• Entire surface should be disturbed by scarification.
• Do not scarify within drip line of existing trees to be retained</td></tr>
</table>

Table 4 - 33: Amendment Options

A. Planting Beds	B. Turf Areas
• Use imported topsoil mix containing 10% organic matter (typically around 40% compost). Soil portion must be sand or sandy loam as defined by the USDA. • Place 3 inches of imported topsoil mix on surface and till into 2 inches of soil. • Place second lift of 3 inches topsoil mix on surface. • Rake beds to smooth, and remove surface rocks over 2 inches diameter. • Mulch planting beds with 2 inches of organic mulch.	• Use imported topsoil mix containing 5% organic matter (typically around 25% compost). Soil portion must be sand or sandy loam as defined by the USDA. • Place 3 inches of imported topsoil mix on surface and till into 2 inches of soil. • Place second lift of 3 inches topsoil mix on surface. • Water or roll to compact soil to 85% of maximum. • Rake to level, and remove surface rocks larger than 1 inch diameter

Table 4 - 34: Calculated Amendment Rate

CALCULATING CUSTOM AMENDMENT RATES TO ACHIEVE A TARGET SOIL ORGANIC MATTER CONTENT

Where soils already have some organic content, it is often cost-effective to calculate the amount of compost amendment needed to achieve the target 10% soil organic matter for landscape beds or 5% for turf areas, rather than using the preapproved rates.

Custom amendment rates can be calculated using either the equation below, or the Compost Amendment Rate Calculator available as an Excel spreadsheet online at www.SoilsforSalmon.org.

EQUATION FOR CALCULATING COMPOST APPLICATION RATES:

Use this equation to calculate compost application rates to achieve the target final soil organic matter content (10% for landscape beds or 5% for turf areas) for a soil with a given bulk density and initial soil organic matter.

$$CR = D \times \frac{SBD\% \times FOM\%}{SBD \times (SOM\% - FOM\%) - CBD \times (COM\% - FOM\%)}$$

Where:

CR = Compost application rate (inches) calculated needed to achieve the target final organic matter (FOM)

D = Depth of finished incorporation (inches)

SBD = Soil bulk density (lb/cubic yard dry weight)*

SOM% = Initial soil organic matter (%)***

FOM% = Final target soil organic matter (%)***

CBD = Compost bulk density (lb/cubic yard dry weight)**

COM% = Compost organic matter (%)***

Assumption: This equation calculates compost rate using an additive approach. For example, a 3-inch compost rate incorporated to an 8-inch depth will be a final mix containing 3/8 compost and 5/8 soil by volume.

* To convert Soil Bulk Density in g/cm3 units to lb/cubic yard, multiply by 1697.

** To convert Compost Bulk Density from lb/cubic yard “as is” to lb/cubic yard dry weight, multiply by solids content.

*** All Organic Matter measurements are based on the commonly used “loss-on-combustion” method.

19.1.4.4 Maintenance

- Establish soil quality and depth toward the end of construction and once established, protect from compaction, such as from large machinery use, and from erosion.
- Plant vegetation and mulch the amended soil area after installation.
- Leave plant debris or its equivalent on the soil surface to replenish organic matter.
- Reduce and adjust, where possible, the use of irrigation, fertilizers, herbicides and pesticides, rather than continuing to implement formerly established practices. Follow Integrated Pest Management (IPM) techniques.

19.1.5 Post Construction Soil Quality and Depth Modeling

All areas meeting the soil quality and depth design criteria may be entered into approved runoff models as "Pasture" rather than "Lawn/Landscaping".

19.2 BMP L615: Trees

19.2.1 Purpose

Trees provide flow control via interception, transpiration, and increased infiltration. Additional environmental benefits include improved air quality, carbon sequestration, reduced heat island effect, pollutant removal, and habitat preservation or formation.

When implemented in accordance with the criteria outlined below, retained in place and newly planted or moved trees (transplanted trees) receive credits toward meeting flow control requirements. The degree of flow control provided by a tree depends on the tree type (i.e., evergreen or deciduous), crown area, and whether or not the tree crown overhangs impervious surfaces.

19.2.2 Applications, Limitations, and Site Considerations/Infeasibility Criteria

This BMP can be used to help ensure compliance with Minimum Requirement #5: Onsite Stormwater Management, Minimum Requirement #7: Flow Control and/or Minimum Requirement #8: Wetlands Protection.

The degree of flow control is dependent on tree type and tree location.

Site Considerations/Infeasibility Criteria

Because each tree has different growth patterns and needs, general infeasibility criteria is not appropriate when considering if trees can be retained or transplanted. The applicant shall take into consideration the following when determining if the use of this BMP is feasible for a project. The applicant must describe why tree retention and transplanting is not feasible for a project in the SSP when applying the List Approach for compliance with Minimum Requirement #5: Onsite Stormwater Management. The Urban Forest Manual provides additional guidance related to tree retention and transplanting – www.cityoftacoma.org/urbanforestmanual.

Planting and retaining healthy trees requires space and investment. The designer/engineer should be engaged from planning through construction phases, whether new construction or a retrofit, to conduct site assessment to inform soil strategies and species selection for healthy tree growth. The initial site assessment for location and type of tree should include the following:

- Available aboveground growing space
- Available belowground root space and ground-level planting area relative to existing or planned pavement, buildings, and utilities
    - See below for ways to increase soil and rooting volume, create root paths, and increase soil volume. These techniques must be considered.
- Type of soil and availability of water, including subgrade soils, groundwater levels, and site drainage patterns
- Overhead obstructions
- Vehicle and pedestrian sight lines
- Proximity to paved areas and underground structures
- Proximity to property lines, buildings, and other vegetation
- Prevailing wind direction and sun exposure

- Maintenance
- Slope and topographic features
- Proximity to snow storage areas
- Lists of required and prohibited local trees

Ways to Increase Soil and Rooting Volume:

- Structural Soil Cells are modular frames that support pavement above and create large spaces for uncompacted soil and tree roots. Follow manufacturer recommendations. Soil cells have benefits over structural soils that help ensure tree success including increased void space and the ability to choose soils more conducive for tree success.
- Structural Soils can be used under all or part of the paved surfaces adjacent to trees to provide the necessary soil volume. Where structural soil is placed adjacent to open graded base aggregate, geotextile should be used to prevent migration of fine aggregate in the structural soil to the more open graded material. Structural soils should have the following specifications.
    - Soil depth shall be 24” minimum.
    - Compaction shall be 95% Proctor
    - Tree Pit Opening: At least 5’ x 5’.
    - Available soil: the structural aggregate uses about 80% of the available space, therefore about 20% of the total planting volume is available soil to support tree growth.
    - Soil Volume: 2 cubic feet for each 1 cubic foot of crown projection shall be used.
    - Drain Down: Structural soil reservoir should drain down within 48 hours to encourage root distribution.
- Creating Root Paths
    - Root paths trenches are typically 4” wide by 12” deep filled with a strip drain board and topsoil.
    - Root paths are placed approximately 4 feet on center and extend into the tree planting pit a minimum of 1 foot and preferably within a few inches of the root ball.
- Connecting to Adjacent Soil Volume – Soil Trenches
    - Soil trenches are typically 5 feet wide with slopes sides for structural integrity and filled with topsoil or other designed soil mix. Sidewalk placed over soil trenches may be reinforced with rebar and thickened to span the soil trench. The thickened portion should extend a minimum of 18” onto the adjacent compacted area.

Soil analysis for trees should include: understanding historical uses, extent and result of disturbances, soil texture, compaction, permeability, barriers and interfaces in the soil profile, and chemical characteristics (Urban, 2008). Urban soils are often degraded from construction activities. If the existing soil or structural soils are used as the planting material, particular attention should be given to soil pH, which is often high due to concrete/construction debris and can cause nutrient deficiency and other problems. The ideal soil pH for most trees is 5 to 6.5 (Day and Dickinson, 2008).

Water availability and the site drainage pattern are also important. In general, the tree planting pit or reservoir in the tree rooting zone (18 to 24 inches) and above the underdrain (if installed) should drain down within 48 hours to encourage aerobic conditions and good root distribution through planting pit for many tree species (Bartens et al., 2009). If there is potential for extended ponding, consult a qualified professional for appropriate drainage strategies and a landscape architect or arborist for appropriate tree species for more saturated conditions.

Additional environmental, economic, and aesthetic functions, such as shade (reduced heat island effect), windbreak, privacy screening, air quality, and increased property value can also be considered when determining the use, type, and placement of trees.

19.2.3 Retained Trees

19.2.3.1 Site Considerations

Setbacks of proposed infrastructure from existing trees are a critical consideration. Tree protection requirements limit grading and other disturbances in proximity to the tree.

19.2.3.2 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

The following provides requirements and recommendations associated with tree retention for flow control credit. Review submittal shall include the existing tree species, trunk diameter, crown area (and dripline delineation), and location (relative to existing ground level impervious surfaces and proposed development, including clearing and grading) on the plan set.

19.2.3.2.1 Certified Arborist Report

Documentation that clearly shows that the tree is healthy, not topped, and has no structural defects must be submitted to the City for review in order to obtain credits for stormwater mitigation. Based upon the information received, the City may require a certified arborist report.

A certified arborist report may be required to obtain credits for stormwater mitigation. The arborist report must include the following information at a minimum:

- Species of the tree(s) that are proposed for retention
- Condition of the tree(s) that are proposed for retention
- Verification that the proposed project will not negatively impact the tree(s)

19.2.3.2.2 Tree Species and Condition

Retained trees shall be chosen from the Stormwater Credits for Trees table available at tacoma.org/stormwatermanual. The City of Tacoma may approve trees not contained on this list on a case-by-case basis. The applicant must submit growth characteristics for the proposed tree to the City. The growth characteristics must be obtained from a reputable source and must include information on mature height and width. The City of Tacoma reserves the right to make the final determination of the flow credit for a given tree.

- Existing tree species and location must be clearly shown on submittal drawings.

- Trees must be viable for long-term retention (i.e., in good health and compatible with proposed construction).

19.2.3.2.3 Tree Size

To receive flow control credit, retained trees shall have a minimum 6 inches diameter at breast height (DBH). DBH is defined as the outside bark diameter at 4.5 feet above the ground on the uphill side of a tree (see Figure 4 - 48: Standard Tree Measurement). For existing trees smaller than this, the newly planted tree credit may be applied.

The retained tree crown area shall be measured as the area within the tree drip line. A drip line is the line encircling the base of a tree, which is delineated by a vertical line extending from the outer limit of a tree's branch tips down to the ground (see Figure 4 - 49: Tree Protection During Construction (City of Tacoma Standard Plan LS-08)).

If trees are clustered, overlapping crowns are not double counted.

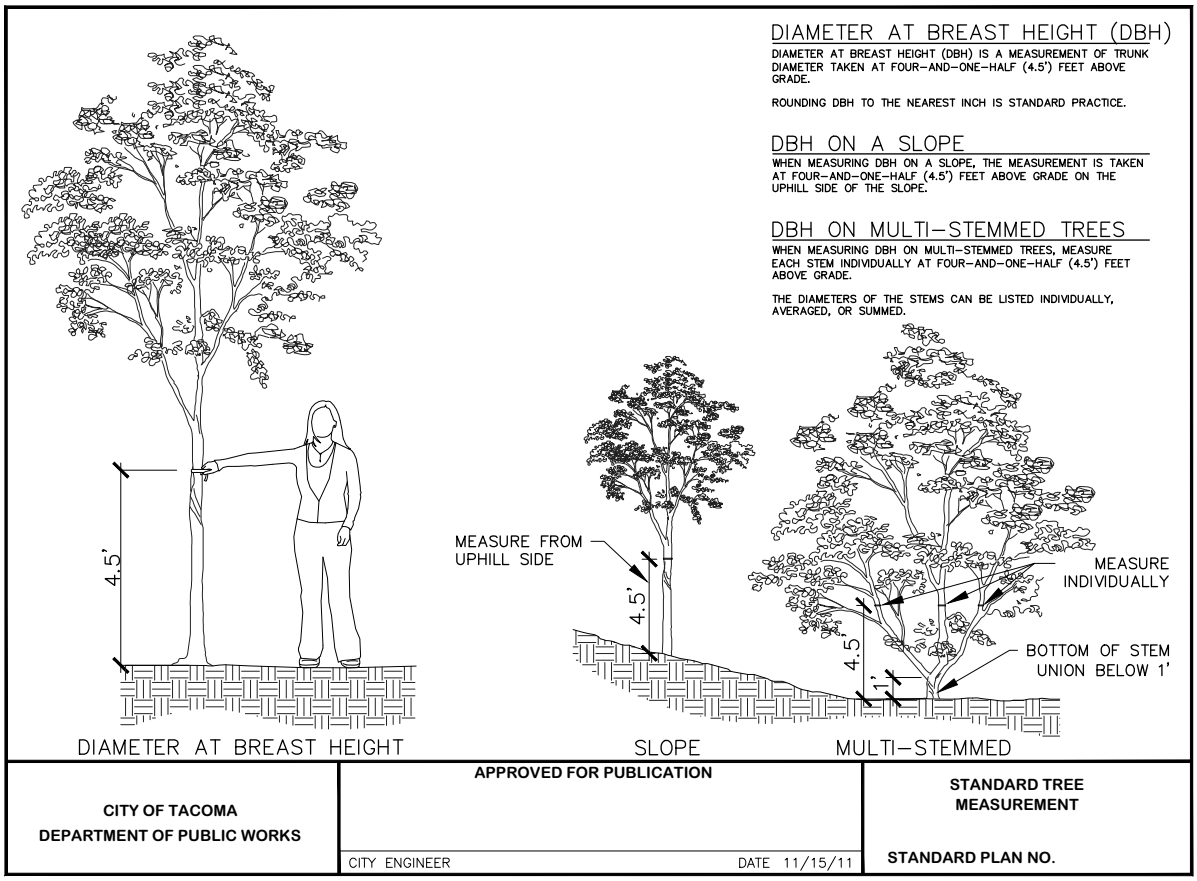


Figure 4 -48: Standard Tree Measurement

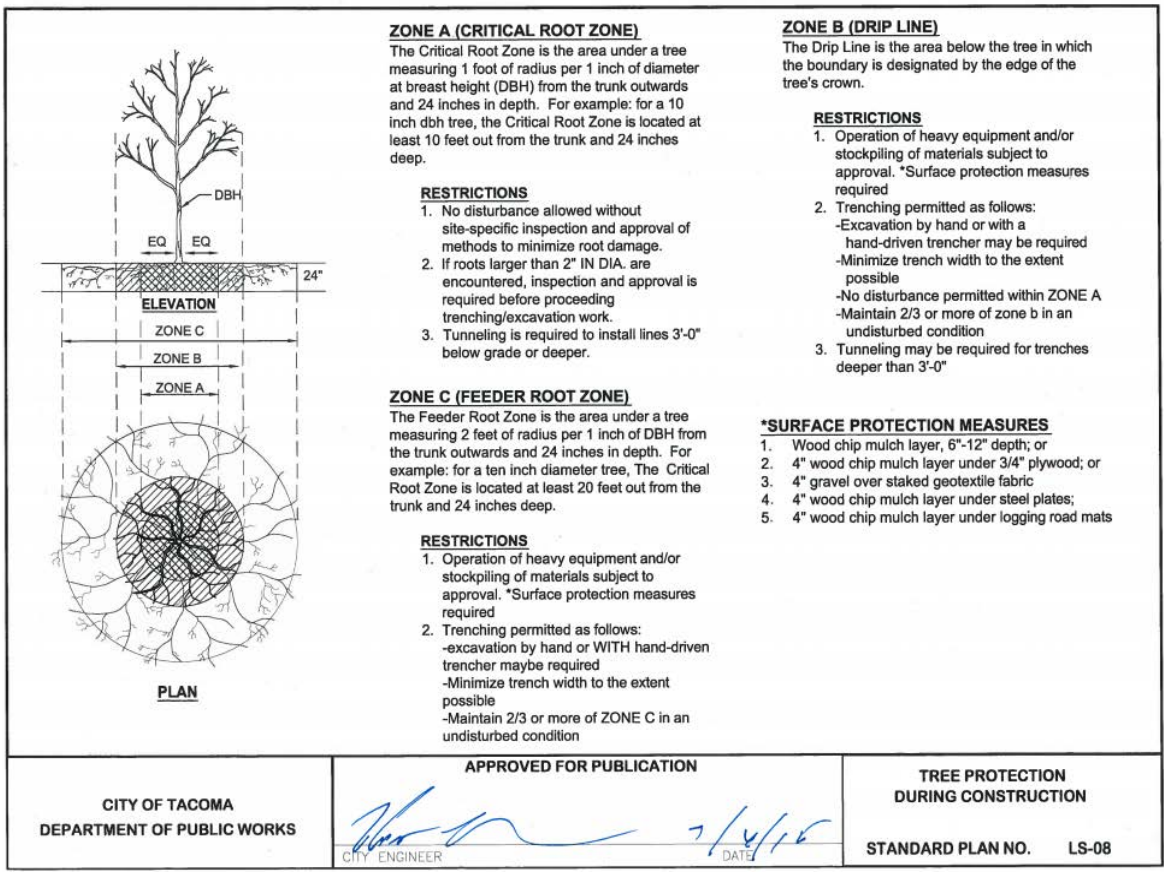


Figure 4 - 49:Tree Protection During Construction

19.2.3.2.4 Tree Location

Flow control credit for retained trees depends upon proximity to ground level impervious or other hard surfaces. To receive a credit, the existing tree must be on the development site or abutting right-of-way. Higher credit is given for tree trunks that are 20 feet or less from existing ground level impervious surfaces. Distance from impervious surfaces is measured from the tree trunk center.

If the arborist report concludes that impervious surface should not be placed within 20 feet of the tree and the crown overlap with impervious surface is still anticipated given a longer setback, higher tree flow control credit may be approved. Trees planted in planter boxes are not eligible for flow control credit.

19.2.3.3 Tree Protection Measures during Construction

The existing tree roots, trunk, and crown shall be fenced and protected during construction activities per Tacoma Municipal Code 9.18.030, according to industry standards (ANSI A300 Part 5) and the International Society of Arboriculture's Best Management Practices-Managing Trees During Construction.

19.2.3.4 Long-term Tree Retention and Protection

Trees shall be retained, maintained and protected until redevelopment of the site necessitates alternative stormwater mitigation or if alternative stormwater mitigation is proposed to replace the

trees. Trees that are removed or die shall be replaced with like species during the next planting window (see Planting Window). Trees shall be pruned according to industry standards, ANSI A300 Part 1 and the International Society of Arboriculture's Best Management Practices-Tree Pruning.

19.2.3.5 Tree Retention Modeling

Flow control credits for retained trees are provided in the table below:

Table 4 - 35: Flow Credits for Retained Trees

Tree Type	Credit	Minimum Square Footage Per Tree[a]
Evergreen	20% of Canopy Area	100 ft^2
Deciduous	10% of Canopy Area	50 ft^2

a. Only trees that produce the minimum square footage per tree can be used for credits

The total credits for retained and newly transplanted trees shall not exceed 25 percent of the total project impervious surface requiring mitigation. The total impervious or hard surface entered into the model may be reduced by the square footage mitigated but shall not exceed 25% of the total project impervious surface requiring mitigation.

The applicant will be required to enter into a covenant and easement agreement with the City to ensure the trees are properly maintained and will remain in place during their safe and useful life.

Flow credits only apply to flow control thresholds. Flow credits do not apply to stormwater treatment thresholds. Credits are given as a percentage of the existing tree canopy area.

To use these credits, the retained tree and protection measures must meet the requirements outlined in this section.

Tree credits are not applicable to trees in native vegetation areas used for flow dispersion or other flow control credit. Credits are also not applicable to trees in planter boxes. The total tree credit for retained and newly transplanted trees shall not exceed 25 percent of the total project impervious surface requiring mitigation.

19.2.4 Newly Transplanted Trees

19.2.4.1 Site Considerations

Mature tree height, size, and rooting depth must be considered to ensure that the tree location is appropriate given adjacent and above- and below-ground infrastructure. Setback requirements are presented below. Setbacks are measured from the tree trunk center.

- Minimum 5 foot setback from structures
- Minimum 5 foot setback from underground utility lines
- Minimum 5 foot setback from property lines
- Minimum 2 foot setback from edge of any paved surface

19.2.4.2 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

The following provides requirements and recommendations associated with tree transplanting for flow control credit. Submittal for review shall include the tree species, tree size (caliper or height), and tree location (with setbacks from ground level impervious surfaces structures and belowground utilities) on the plan set.

19.2.4.2.1 Tree Species

Only trees contained in Appendix 7 of the Urban Forest Manual - The Approved Tree List - will be considered for tree credits. The Urban Forest Manual is available online at tacoma.gov/UFM. The City of Tacoma may approve trees not contained on this list on a case-by-case basis. The applicant must submit growth characteristics (mature height and crown spread at maturity) for the proposed tree to the City. The growth characteristics must be obtained from a reputable source and must include information on mature height and width. The City of Tacoma reserves the right to make the final determination of the flow credit for a given tree.

19.2.4.2.2 Tree Size

To receive flow control credit, new deciduous trees shall be at least 1.5 inches in caliper measured 6 inches above the ground at the time of planting. New evergreen trees shall be at least 4 feet tall at the time of planting.

19.2.4.2.3 Tree Location

Trees shall be sited according to sun, soil, moisture, and species culture preference. Transplanting locations shall be selected to ensure that sight distances and appropriate setbacks are maintained given mature height, size, and rooting depths. Similar to retained trees, flow control credit for newly transplanted trees varies upon proximity to ground level impervious surfaces. To receive a credit, the newly transplanted tree must be on the project site and located within 20 feet of the ground level impervious or hard surface. Distance from impervious surfaces is measured from the edge of the surface to the center of the tree at ground level.

To help ensure tree survival and canopy coverage, the minimum tree spacing for newly transplanted trees shall accommodate mature tree spread. In no circumstance shall flow control credit be given for new trees transplanted less than 15 feet on center spacing for evergreen trees and 25 feet on center spacing for deciduous trees. Trees transplanted in above-ground structures (e.g. pots, planter boxes, etc.) are not eligible for flow control credit.

19.2.4.2.4 Planting Window

Trees shall be planted between October 1 and March 1. If it is predicted to be a dry or wet planting season, the planting window may be reduced or extended as necessary to help ensure survivability. Information must be provided describing why an altered planting window is appropriate.

19.2.4.2.5 Irrigation

Provisions shall be made for supplemental irrigation during the first three growing seasons after installation to help ensure tree survival.

19.2.4.3 Long-term Tree Retention and Protection

Trees shall be retained, maintained and protected until redevelopment of the site necessitates alternative stormwater mitigation or if alternative stormwater mitigation is proposed to replace the trees. Trees that are removed or die shall be replaced with like species during the next planting window. Trees shall be pruned according to industry standards, ANSI A300 Part 1 and International Society of Arboriculture's Best Management Practices - Tree Planting.

19.2.4.4 Tree Transplanting Modeling

Flow control credits for newly transplanted trees are provided in the table below:

Table 4 - 36: Flow Credits for Newly Transplanted Trees

Tree Type	Credit
Evergreen	50 ft^2 per tree
Deciduous	20 ft^2 per tree

The credits provided in the table are square footage of impervious surface available for flow credit per tree. The total credits for retained and newly transplanted trees shall not exceed 25 percent of the total project impervious surface requiring mitigation. The total impervious or hard surface entered into the model may be reduced by the square footage mitigated but shall not exceed 25% of the total project impervious surface requiring mitigation.

The applicant will be required to enter into a covenant and easement agreement with the City to ensure the trees are properly maintained and will remain in place.

Flow credits only apply to flow control thresholds. Flow credits do not apply to stormwater treatment thresholds.

Tree credits are not applicable to trees in native vegetation areas used for flow dispersion or other flow control credit. Credits are also not applicable to trees in planter boxes. The total tree credit for retained and newly planted trees shall not exceed 25 percent of impervious surface requiring mitigation.

19.3 BMP L631: Vegetated Rooftops (Green Roofs)

19.3.1 Purpose and Definition

A vegetated rooftop, also known as a green roof, is a rooftop that is partially or completely covered with vegetation and a growing medium planted over a waterproofing membrane. The green roof will also contain a root repelling membrane and stormwater system.

19.3.2 Applications and Limitations

Vegetated rooftops can be used to help ensure compliance with Minimum Requirement #5: Onsite Stormwater Management, Minimum Requirement #7: Flow Control and Minimum Requirement #8: Wetlands Protection.

It is unlikely that the use of this BMP alone will meet the Minimum Requirement compliance goals.

Vegetated rooftops offer a practical method of managing runoff in densely developed urban neighborhoods and can be engineered to achieve specific stormwater runoff control objectives.

19.3.3 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

See the “Low Impact Development Technical Guidance for Puget Sound” for design criteria.

City of Tacoma Typical Detail GSI-010 shows a conceptual plan for a vegetated roof section.

19.3.4 Vegetated Rooftop Modeling

Use the Green Roof element in an Ecology approved continuous simulation model, assuming a 15-minute timestep, to model vegetated roofs.

19.4 BMP L632: Rainwater Harvesting

19.4.1 Purpose and Definition

Rainwater harvesting systems are designed to collect stormwater and use the collected water.

19.4.2 Applications and Limitations

Rainwater harvesting can be used to help ensure compliance with Minimum Requirement #5: Onsite Stormwater Management, Minimum Requirement #7: Flow Control, and Minimum Requirement #8: Wetlands Protection.

It is unlikely that the use of this BMP alone will meet the Minimum Requirement compliance goals.

19.4.3 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

- If a rainwater re-use system holds more than 6 inches depth of water, it should not be accessible except for maintenance purposes.
- Design and maintain the system to minimize clogging by leaves and other debris.
- Restrict use to 4 homes/acre when captured water is solely used for outdoor use.

See the "Low Impact Development Technical Guidance for Puget Sound" for additional design considerations.

19.4.4 Rainwater Harvesting Modeling

The contributing area to the rainfall re-use system does not need to be entered into the runoff model when:

- 100% of the annual average runoff volume (predicated by an Ecology approved continuous simulation model, assuming a 15-minute timestep) is re-used, or
- Interior uses have a monthly water balance that demonstrates adequate capacity for each month and re-use of all stored water annually.

19.5 BMP L634: Minimal Excavation Foundations

19.5.1 Purpose and Definition

Minimal excavation foundation systems are those techniques that engage intact existing soil strength with minimal or no excavation, and do not disturb or significantly compact the native soil profile. This preserves most of the hydrologic properties of the native soil. Pin pile, screw pile, and cluster pile foundations are an example of a minimal excavation foundation.

19.5.2 Applications and Limitations

- Minimal excavation foundations can be used to help ensure compliance with Minimum Requirement #5: Onsite Stormwater Management, Minimum Requirement #7: Flow Control, and/or Minimum Requirement #8: Wetlands Protection.
- It is unlikely that the use of this BMP alone will meet the Minimum Requirement compliance goals.
- Heavy equipment cannot be used within or immediately surrounding the building. Terracing of the foundation area may be accomplished by tracked, blading equipment not exceeding 650 psf.

19.5.3 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

See the most recent version of “Low Impact Development: Technical Guidance Manual for Puget Sound” for design information.

19.5.4 Minimal Excavation Foundation Modeling

- Modeling using an Ecology approved continuous simulation model, assuming a 15-minute timestep, is required.
- Where stormwater from roofs is dispersed on the up gradient side of a structure in accordance with the design criteria in BMP L603: Downspout Dispersion, model the contributing roof area as pasture on the native soil. If the stormwater is cut off by an embedded grade beam, wall, or skirt structure that inhibits stormwater from reaching the full flowpath, modeling for flow control purposes is not allowed.
- If stormwater from roofs is dispersed down gradient of the structure in accordance with the design criteria and guidelines in BMP L603: Downspout Dispersion, and there is at least 50 feet of vegetated flowpath through native material or lawn/landscaped area that meets the guidelines in BMP L613: Post-Construction Soil Quality and Depth, model the contributing roof areas as lawn/landscaped areas.
- Where terracing on a slope below the building or vegetated flowpath is necessary for construction, the square footage of the roof that can be modeled as pasture or lawn/ landscape area must be reduced to account for lost permeable soils. The roof area modeled as pasture or lawn/landscape shall be reduced by the same percentage as that of the intact permeable soils in the slope below the structure or within the down gradient flow path that are removed by the terracing.

19.6 BMP L635: Reverse Slope Sidewalks

19.6.1 Definition and Purpose

Reverse slope sidewalks are sloped to flow away from the road and onto adjacent vegetated areas.

19.6.2 Applications and Limitations

Reverse Slope Sidewalks can be used to help ensure compliance with Minimum Requirement #5: Onsite Stormwater Management, Minimum Requirement #7: Flow Control, and/or Minimum Requirement #8: Wetlands Protection.

It is unlikely that the use of this BMP alone will meet the Minimum Requirement compliance goals.

19.6.3 Design Criteria for Reverse Slope Sidewalks

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

- There must be greater than 10 feet of vegetated surface downslope that is not directly connected into the stormwater system.
- Vegetated area receiving flow from sidewalk must be native soil or meet the guidelines in BMP L613: Post-Construction Soil Quality and Depth.

19.6.4 Reverse Slope Sidewalk Modeling

- Modeling in an Ecology approved continuous simulation model, assuming a 15-minute timestep, is required to obtain flow credits. Model the facility using the Lateral Flow Element to send impervious areas onto lawn/landscaped areas for dispersion. Where multiple reverse slope sidewalks are proposed, the impervious area may be modeled as lawn/landscaped area so that the project schematic is manageable.

Chapter 20 Detention Facilities

20.1 BMP F100: Detention Facilities

20.1.1 Purpose

Detention facilities include detention ponds (BMP F110), detention tanks (BMP F120), and detention vaults (BMP F130) that are used to capture stormwater, store it, and slowly release the flows to help mimic predeveloped or existing conditions. Detention facilities use flow control structures to allow for slow release of the stormwater - see A500: Control Structures.

20.1.2 Application

BMP F110: Detention Ponds, BMP F120: Detention Tanks, and BMP F130: Detention Vaults can be used to help ensure compliance with Minimum Requirement #5: Onsite Stormwater Management for Meeting the LID Performance Standard Only, Minimum Requirement #7: Flow Control, and Minimum Requirement #8: Wetlands Protection.

20.1.3 Design Criteria for All Detention Facilities

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

20.1.3.1 Sizing

The volume and outflow design for detention ponds, detention tanks, and detention vaults must be sized using an Ecology approved continuous simulation model, assuming a 15-minute timestep, using the design criteria in A500: Control Structures, and using the criteria in Modeling Your Best Management Practices. The design shall be based upon the applicable Minimum Requirement that is required to be met:

- Minimum Requirement #5: Onsite Stormwater Management: See Volume 1, Section 1.3.5.2 - Compliance Methods - Low Impact Development (LID) Performance Standard.
- Minimum Requirement #7: Flow Control: See Volume 1, Section 1.3.7.4 - Flow Control Mitigation.
- Minimum Requirement #8: Wetlands Protection is specific to the individual wetland needs. Mitigation may require detention facilities in order to maintain wetland hydrology.

20.1.3.2 Detention Facility Overflow

In all ponds, tanks, and vaults, a primary overflow (usually a riser pipe within the control structure; see A500: Control Structures) shall be provided to bypass the developed peak volumetric flowrate calculated using a 10-minute timestep from a Type 1A, 100-year, 24-hour frequency storm using a single event model or the 100-year return period flowrate as estimated by an Ecology approved continuous simulation model, assuming a 15-minute timestep, over or around the restrictor system. The design must provide controlled discharge directly into the downstream conveyance system.

20.2 BMP F110: Detention Ponds

Detention ponds are depressions where stormwater is collected, stored, and slowly released.

20.2.1 Design Criteria Specific for Detention Ponds

Standard details for detention ponds are provided in Figure 4 - 50: Typical Detention Pond and Control structure discussion and details are provided in A500: Control Structures.

The Design Criteria below is in addition to the Design Criteria for All Detention Facilities.

20.2.1.1 General

- Ponds must be designed as flow-through systems (however, parking lot storage may utilize a back-up system; see BMP F150: Roofs for Detention). Developed flows must enter through a conveyance system separate from the control structure and outflow conveyance system. Maximizing distance between the inlet and outlet is encouraged to promote sedimentation.
- Pond bottoms shall be level and be located a minimum of 0.5 feet below the inlet and outlet to provide sediment storage. This sediment storage area is modeled by setting the bottom orifice 0.5 feet (or whatever sediment storage is chosen) above the bottom of the detention pond.
- Design criteria for outflow control structures are specified in A500: Control Structures.

20.2.1.2 Setbacks

The following setback requirements shall be met, along with those stipulated in Design Criteria for All Flow Control BMPs.

- The 100-year water surface elevation shall be at least 10 feet from any building structure and at least 5 feet from any other structure or property line. If necessary, setbacks shall be increased from the minimum 10 feet in order to maintain a 1H:1V side slope for future excavation and maintenance. Vertical pond walls may necessitate an increase in setbacks.

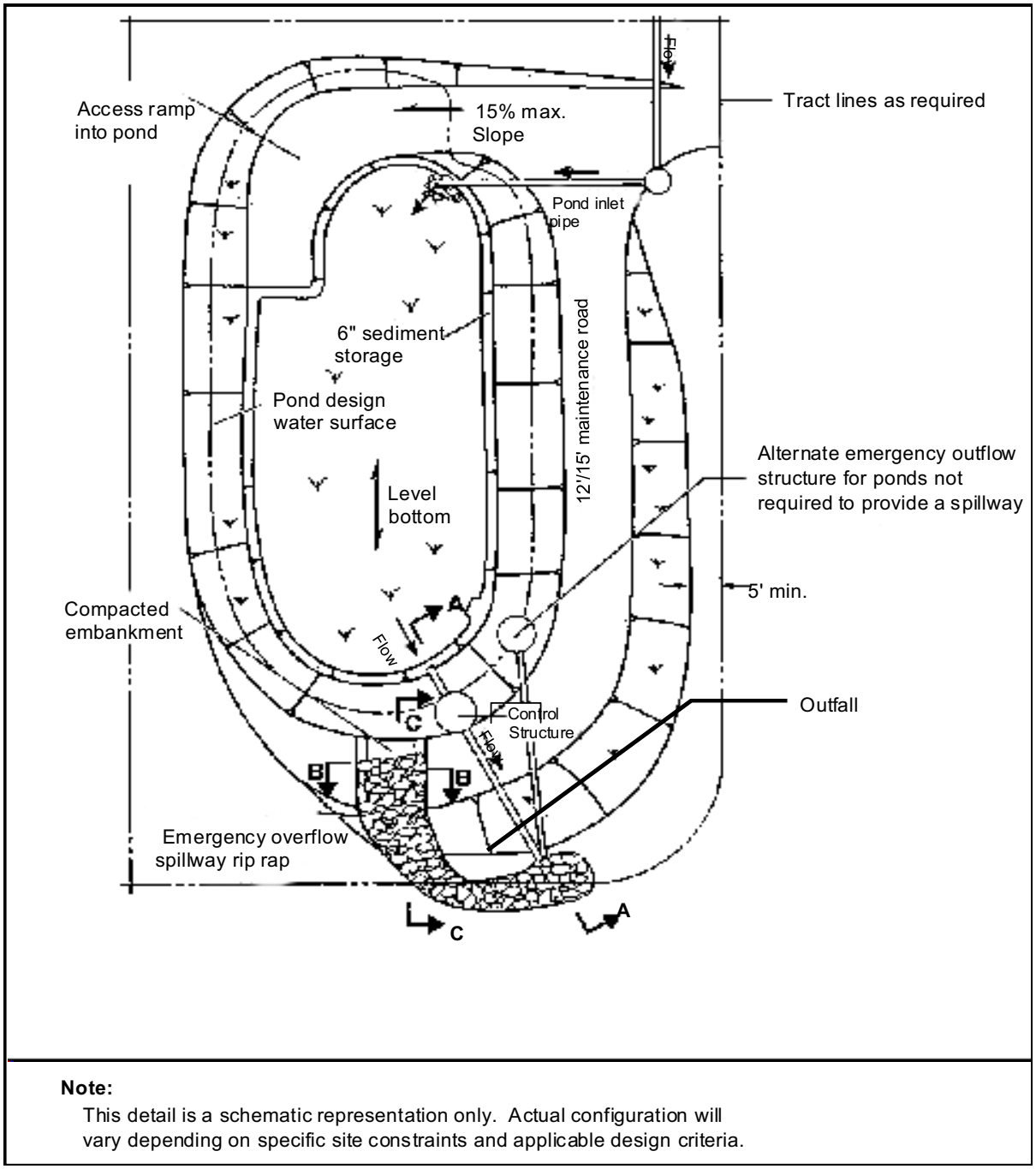
20.2.1.3 Side Slopes

- Interior side slopes up to the emergency overflow water surface shall not be steeper than 3H:1V unless a fence is provided (see A700: Fencing).
- Exterior side slopes must not be steeper than 2H:1V unless analyzed for stability by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist.
- Pond walls may be vertical retaining walls, provided:
  - They are constructed of minimum 3,000 psi structural reinforced concrete.
  - A fence is provided along the top of the wall.
  - Access for maintenance per this section shall be provided.
  - The design is stamped by a licensed Washington State Licensed Professional Engineer.
  - Ladders shall be provided on the walls for safety reason if all walls are vertical retaining walls.

Other retaining walls such as rockeries, concrete, masonry unit walls, and keystone type walls may be used if designed and stamped by a Washington State Licensed Professional Engineer.

20.2.1.4 Embankments

- Pond berm embankments higher than 6 feet must be designed by a Washington State Licensed Professional Engineer.
- For berm embankments 6 feet or less in height, the minimum top width shall be 6 feet or as recommended by a Washington State Licensed Professional Engineer.
- Pond berm embankments must be constructed on native consolidated soil (or adequately compacted and stable fill soils analyzed by a Washington State Licensed Professional Engineer) free of loose surface soil materials, roots, and other organic debris.
- Pond berm embankments greater than 4 feet in height must be constructed by excavating a key equal to 50 percent of the berm embankment cross-sectional height and width unless specified otherwise by a Washington State Licensed Professional Engineer.
- Embankment compaction should be accomplished in such a manner as to produce a dense, low permeability engineered fill that can tolerate post-construction settlements with a minimum of cracking. The embankment fill shall be placed on a stable subgrade and compacted to a minimum of 95% of the Standard Proctor Maximum Density, ASTM Procedure D698. Placement moisture content should lie within 1% dry to 3% wet of the optimum moisture content.
- The berm embankment shall be constructed of soils with the following minimum characteristics per the United States Department of Agriculture's Textural Triangle: a minimum of 20% silt and clay, a maximum of 60% sand, a maximum of 60% silt, with nominal gravel and cobble content. Soils outside this range may be used by stamped recommendation of a Washington State Licensed Professional Engineer.
- Anti-seepage filter-drain diaphragms must be placed on all pipes in berm embankments impounding water with depths greater than 8 feet at the design water surface. See Dam Safety Guidelines, Part IV, Section 3.3.B. An electronic version of Dam Safety Guidelines is available in PDF format at https://ecology.wa.gov/Water-Shorelines/Water-supply/Dams.



Note:
This detail is a schematic representation only. Actual configuration will vary depending on specific site constraints and applicable design criteria.

Figure 4 - 50: Typical Detention Pond

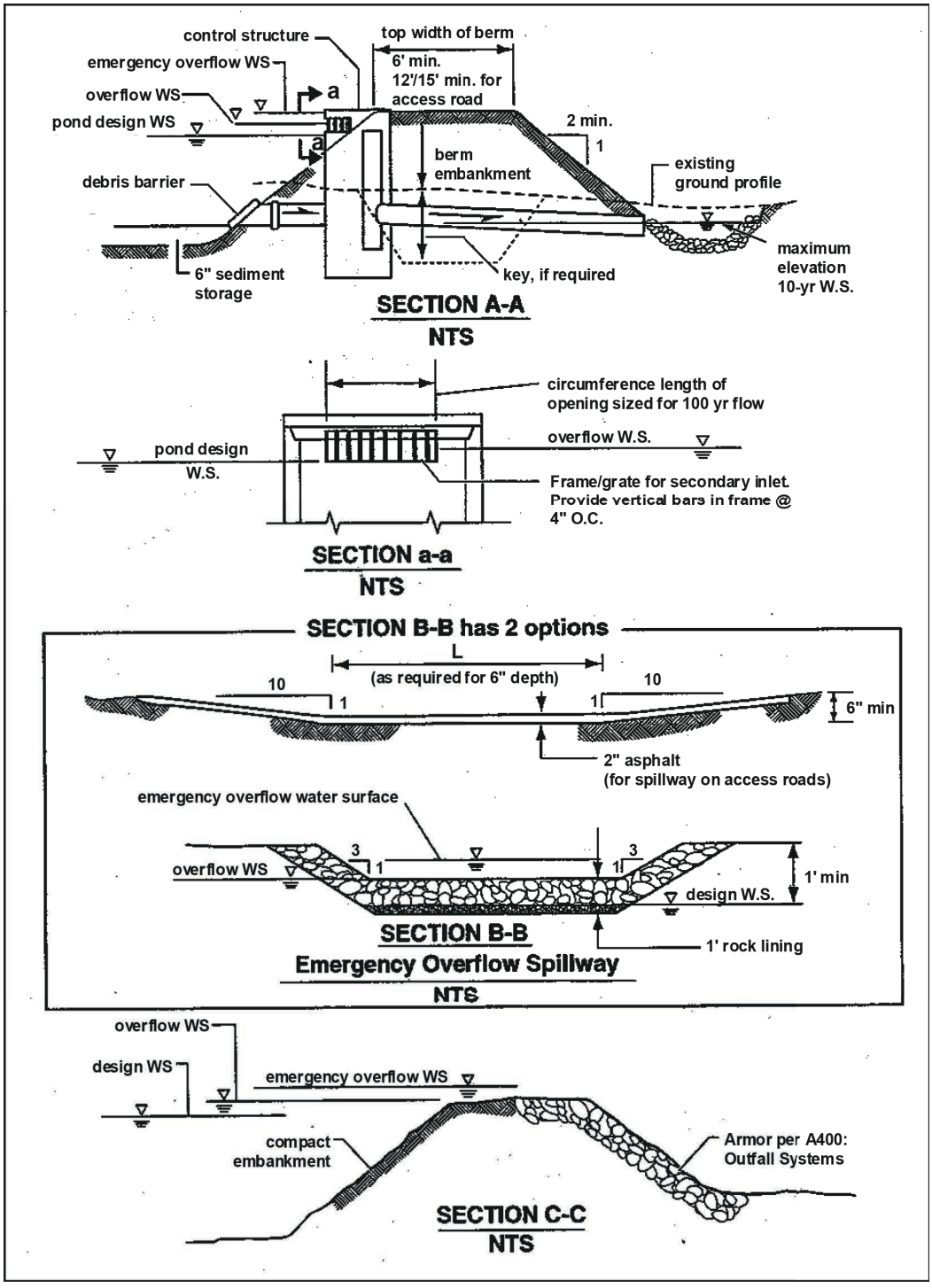


Figure 4 - 51: Typical Detention Pond Sections

20.2.1.5 Overflow

The following overflow requirements shall be met along with those stipulated in Section 20.1.3.2 - Detention Facility Overflow.

- A secondary inlet to the control structure shall be provided in ponds as additional protection against overtopping should the inlet pipe to the control structure become plugged. A grated opening in the control structure manhole functions as a weir (see) when used as a secondary inlet.
- The maximum circumferential length of this opening must not exceed one-half the control structure circumference.
- The beehive grate overflow structure as shown in Figure 4 - 74: Overflow Structure may also be used as a secondary inlet.
- In addition to the above overflow provisions, ponds shall have an emergency overflow spillway. Design the Emergency Overflow Spillway per A600: Emergency Overflow Spillway.

20.2.1.6 Access

Access shall be provided to the inlet, outlet, and control structure. Access roads and ramps shall conform to A3000: Access Ramps and Roads

20.2.1.7 Signage

Provide a stormwater facility sign. Sign shall conform to A800: Signage.

20.2.1.8 Planting Requirements

Exposed earth on the pond bottom and interior side slopes shall be sodded or seeded with an appropriate seed mixture or landscaped. See A1000: Vegetation for seed mixes and plant selection recommendations. All remaining areas of the tract shall be planted with grass or be landscaped and mulched with a 4-inch cover of hog fuel or shredded wood mulch. Shredded wood mulch is made from shredded tree trimmings, usually from trees cleared on site. The mulch should be free of garbage and weeds and should not contain excessive resin, tannin, or other material detrimental to plant growth. Do not use construction materials, wood debris, or wood treated with preservatives for producing shredded wood mulch. The seed mix and coverage shall be specified on the plan set.

20.2.1.9 Landscaping

Landscaping is encouraged for most stormwater tract areas (see below for areas not to be landscaped). However, if provided, landscaping should adhere to the criteria that follow so as not to hinder maintenance operations. Landscaped stormwater tracts may, in some instances, provide a recreational space. In other instances, “naturalistic” stormwater facilities may be placed in open space tracts.

The following guidelines shall be followed if landscaping is proposed for facilities.

- Provide a planting plan that clearly shows the species of plants and the spacing for each plant species.
- No trees or shrubs shall be planted on berms meeting the criteria for dams regulated for safety.
- No trees or shrubs shall be planted within 10 feet of inlet or outlet pipes or artificial stormwater and surface water structures such as spillways or flow spreaders.

- Species of trees with roots that seek water shall be avoided within 50 feet of pipes or artificial structures.
- Planting shall be restricted on berms that impound water either permanently or temporarily during storms. This restriction does not apply to cut slopes that form pond banks, only to berms.
    - Trees or shrubs may not be planted on portions of water-impounding berms taller than four feet high. Only grasses may be planted on berms taller than four feet.
    - Trees planted on portions of water-impounding berms less than 4 feet high must be small, not higher than 20 feet mature height, and must have a fibrous root system. A1000: Vegetation gives some examples of trees with these characteristics developed for the Central Puget Sound.

    Note: The internal berm in a detention pond is not subject to this planting restriction since the failure of an internal berm would be unlikely to create a safety problem.
- All landscape material, including grass, shall be planted in topsoil. Topsoil shall be tilled in or otherwise integrated into the detention pond bottom or sides to ensure proper plant growth. If a liner is present, this may require additional consideration to ensure liner depth is maintained. Native underlying soils may be made suitable for planting if amended with 4 inches of compost tilled into the subgrade. Compost shall comply with A900: Compost.
- For a naturalistic effect as well as ease of maintenance, trees or shrubs shall be planted in clumps to form "*landscape islands*" rather than planting evenly spaced.
    - The landscaped islands shall be a minimum of six feet apart, and if set back from fences or other barriers, the setback distance should also be a minimum of 6 feet. Where tree foliage extends low to the ground, the 6 feet setback should be counted from the outer drip line of the trees (estimated at maturity).
    - This setback allows a 6-foot wide mower to pass around and between clumps.
- Evergreen or columnar deciduous trees along the west and south sides of ponds are recommended to reduce thermal heating. Evergreen trees and trees which produce relatively little leaf-fall are preferred in areas contributing to the pond.
- Trees should be set back so that branches do not extend over the pond (to prevent deposition of leaves into the pond).
- Drought tolerant species are recommended.
- The method of construction of soil/landscape systems can cause natural selection of specific plant species. Use soils that encourage desired species and discourage undesired species.

20.2.1.10 Detention Ponds and Infiltration

Detention ponds may occasionally be sited on soils that allow for infiltration. These detention ponds have a surface discharge and may also utilize infiltration as a second pond outflow. Detention ponds sized with infiltration as a second outflow must meet all the requirements of BMP 710: Infiltration Ponds, including a soils report, testing, groundwater protection, pre-settling, and construction techniques.

20.3 BMP F120: Detention Tanks

20.3.1 Description

Detention tanks are underground storage facilities typically constructed using large diameter pipe. Standard detention tank details are shown in Figure 4 - 52: Typical Detention Tank and Figure 4 - 53: Detention Tank Access Detail. Control structure details are shown in A500: Control Structures.

Certain of these requirements and design criteria shall also apply to other types of detention facilities, for example arch pipe detention facilities. The City of Tacoma shall determine which requirements and design criteria are appropriate for various types of detention facilities.

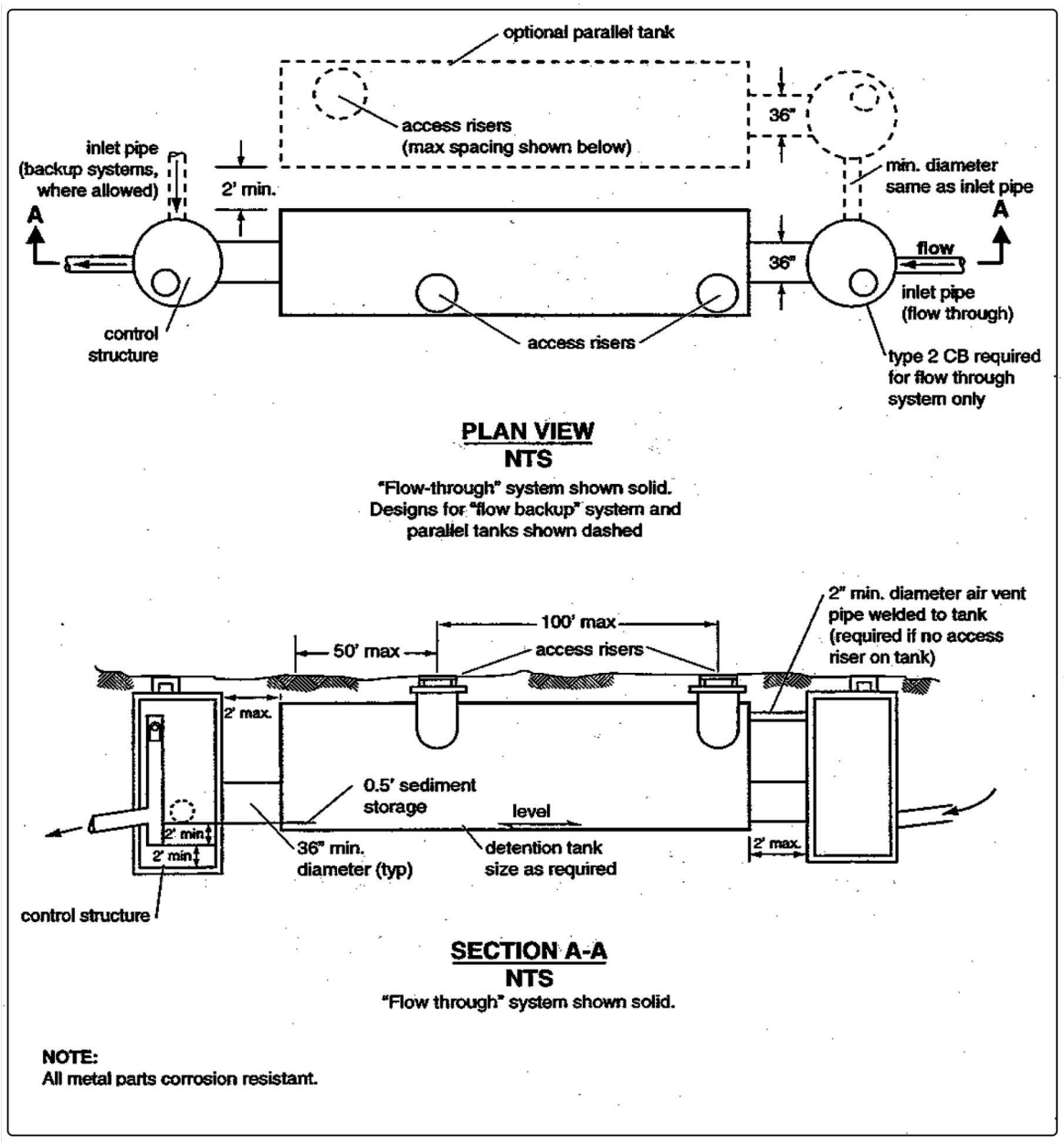


Figure 4 -52: Typical Detention Tank

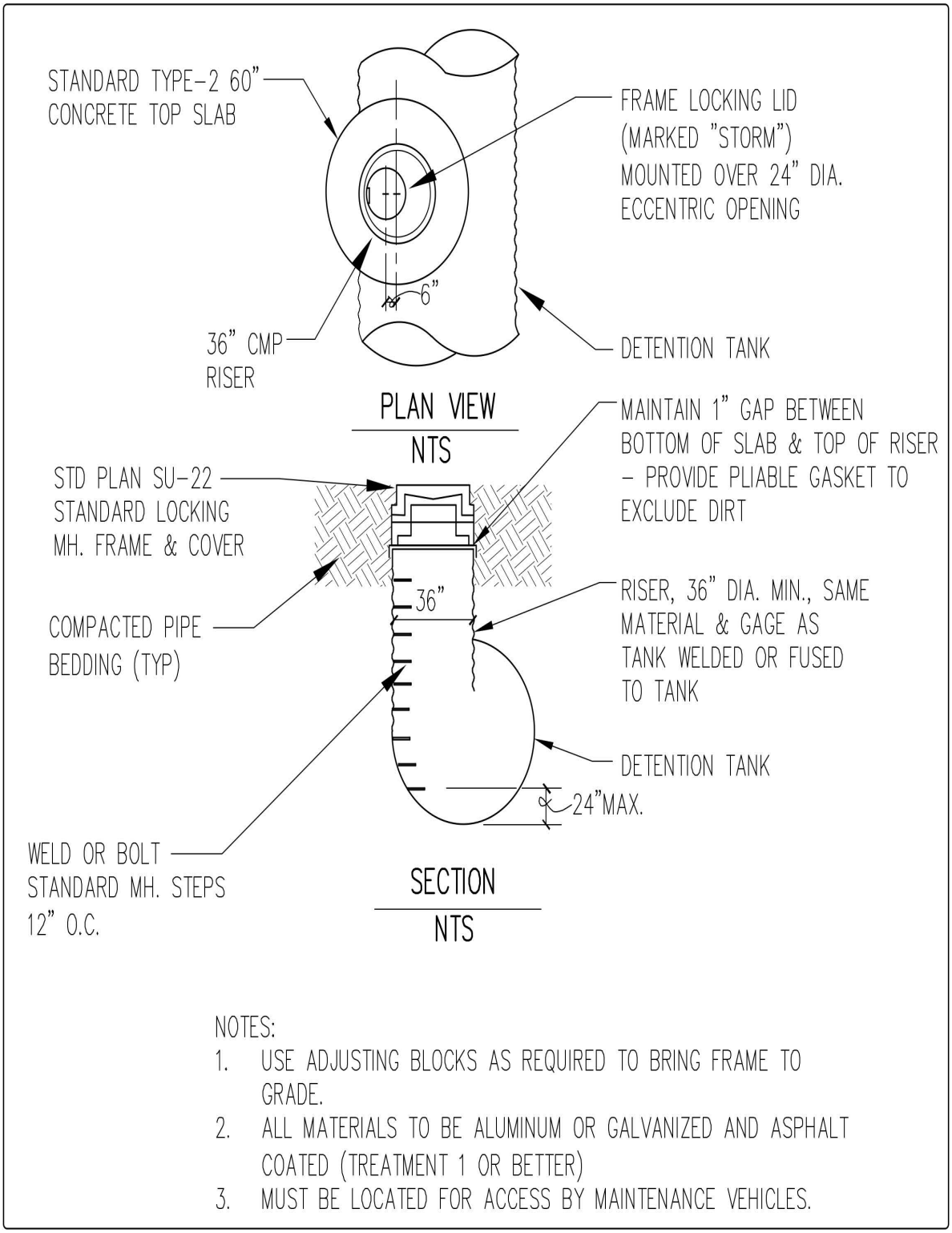


Figure 4 - 53: Detention Tank Access Detail

20.3.2 Design Criteria

20.3.2.1 General

Comply with Design Criteria for All Detention Facilities in addition to the design criteria below.

- Tanks shall be designed as flow-through systems with manholes in line (see Figure 4 - 52: Typical Detention Tank) to promote sediment removal and facilitate maintenance. Detention facilities may be designed as back up systems if preceded by a Stormwater Treatment BMP.
- The detention tank bottom shall be located 6 inches below the inlet and outlet to provide dead storage for sediment.
- The minimum pipe diameter for a detention tank is 36 inches.
- The minimum thickness for CMP shall be as follows:
  - 16 gage for pipe diameters up to 84”
  - 14 gage for pipe diameters 96” - 120”
  - 12 gage for pipe diameters 126” - 138”
  - 10 gage for pipe diameter 144”
- Tanks with a diameter larger than 36 inches may be connected to each adjoining structure with a short section (2-foot maximum length) of 36-inch minimum diameter pipe. These sections shall not be considered as access when determining required access points.
- Details of outflow control structures are given in A500: Control Structures.
- Parallel tanks shall be placed a minimum of two feet from each other measured from the edge of tank or pipe.

20.3.2.2 Structural Stability

- All tanks must meet structural requirements for overburden support and H20 traffic loading. Tanks located under roadways must meet City of Tacoma live load requirements.
- Place tanks on stable, well consolidated native material with suitable bedding. Do not place tanks in fill slopes, unless analyzed by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist for stability.

20.3.2.3 Access

- The maximum depth from finished grade to tank invert shall be 20 feet.
- Access openings shall be positioned a maximum of 50 feet from any location within the tank. A minimum of one access opening per tank shall be provided.
- The maximum distance between access risers shall be 100 feet.
- All tank access openings shall have round, solid locking lids (usually 1/2 to 5/8-inch diameter Allen-head cap screws).
- Thirty-six inch minimum diameter riser-type manholes (see Figure 4 - 53: Detention Tank Access Detail) of the same gauge or thickness as the tank material may be used for access along the length of the tank and at the upstream terminus of the tank in a backup system. The top slab is separated (1-inch minimum gap) from the top of the riser to allow for deflections from vehicle loadings without damaging the riser tank.

- All tank access openings must be readily accessible to maintenance vehicles.
- Tanks must comply with the OSHA confined space requirements, which include clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s) just under the access lid.

20.4 BMP F130: Detention Vaults

20.4.1 Description

- *Detention vaults* are box-shaped underground storage facilities typically constructed with reinforced concrete. A standard detention vault detail is shown in Figure 4 - 54: Typical Detention Vault. Control structure details are shown in A500: Control Structures.

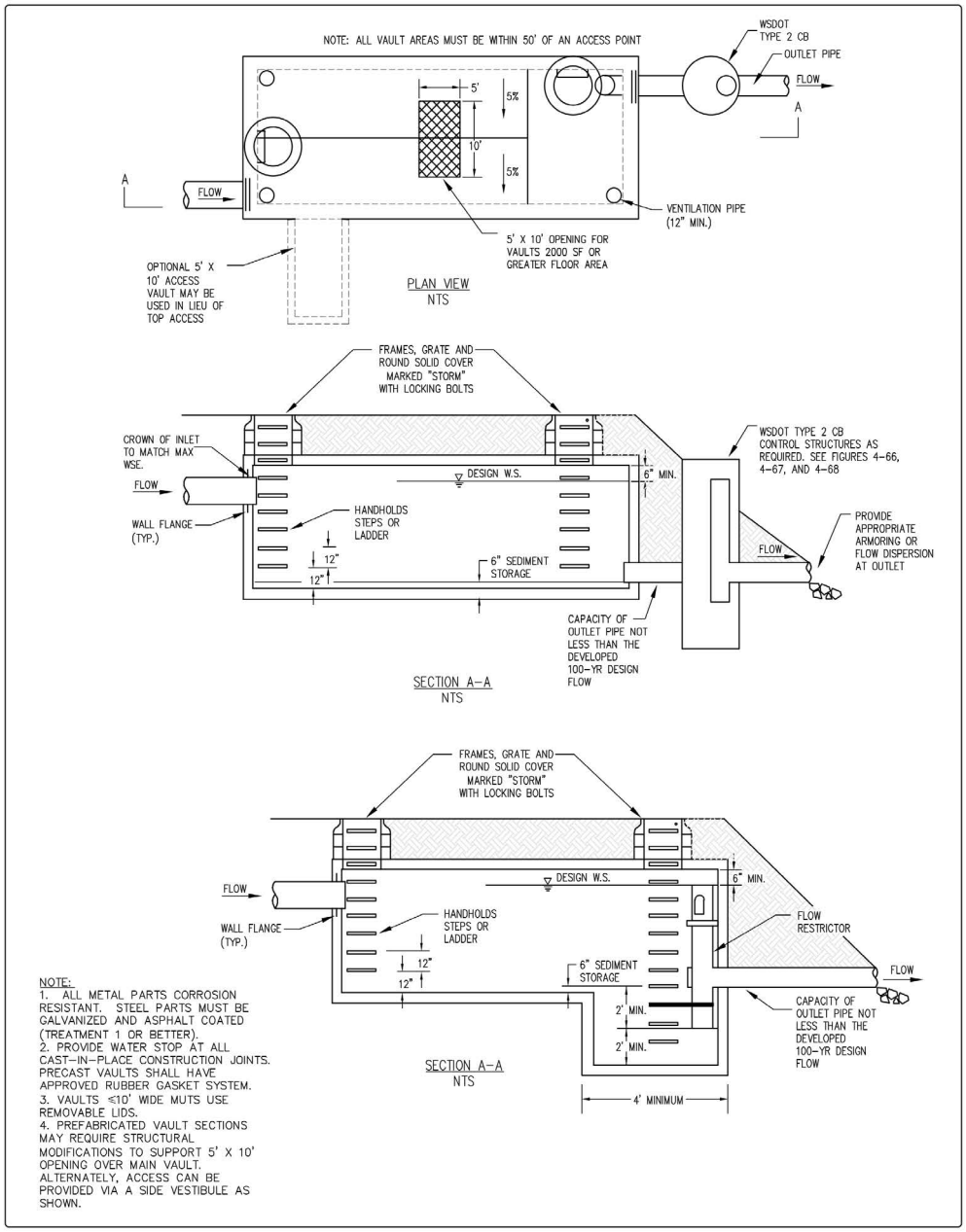


Figure 4 - 54: Typical Detention Vault

20.4.2 Design Criteria

20.4.2.1 General

Comply with Design Criteria for All Detention Facilities in addition to the design criteria below.

- Detention vaults shall be designed as flow-through systems with bottoms level (longitudinally) or sloped toward the inlet to facilitate sediment removal. Distance between the inlet and outlet should be maximized (as feasible).
- The detention vault bottom shall slope at least 5 percent from each side towards the center, forming a broad “v” to facilitate sediment removal. More than one “v” may be used to minimize vault depth. The vault bottom may be flat with 0.5 – 1 foot of sediment storage if removable panels are provided over the entire vault. It is recommended that the removable panels be at grade, have stainless steel lifting eyes, and weigh no more than 5 tons per panel.
- The invert elevation of the outlet shall be elevated above the bottom of the vault to provide an average 6 inches of sediment storage over the entire bottom. This sediment storage area is modeled by setting the bottom orifice 0.5 feet (or whatever sediment storage is chosen) above the bottom of the detention pondThe outlet shall also be elevated a minimum of 2 feet above the orifice to retain oil within the vault.
- Details of outflow control structures are given in A500: Control Structures.

20.4.2.2 Materials

Minimum 3,000 psi structural reinforced concrete may be used for detention vaults. Provide all construction joints with water stops.

20.4.2.3 Structural Stability

- All vaults must meet structural requirements for overburden support and H20 traffic loading. Vaults located under roadways must meet City of Tacoma live load requirements.
- Design cast in place wall sections as retaining walls.
- Structural design for cast in place vaults must be stamped by a Washington State Licensed Professional Engineer.
- Place vaults on stable, well consolidated native material with suitable bedding. Do not place vaults in fill slopes, unless analyzed by a Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist for stability.

20.4.2.4 Access

- Access must be provided over the inlet pipe and outlet structure.
- Access openings shall be positioned a maximum of 50 feet from any location within the vault. Additional access points may be needed on large vaults.
- An access opening shall be provided directly above the lowest point of each “v” in the vault floor.
- An access opening shall be provided directly above each connection to the vault.
- For vaults with greater than 1,250 square feet of floor area, a 5’ x 10’ removable panel shall be provided over the inlet pipe (instead of a standard frame, grate and solid cover). Alternatively, a separate access vault may be provided, as shown in Figure 4 - 54: Typical Detention Vault.

- For vaults under roadways, the removable panel must be located outside the travel lanes. Alternatively, multiple standard locking manhole covers may be provided.
- Ladders and hand-holds shall be provided at all access openings, and as needed to meet OSHA confined space requirements.
- All access openings, except those covered by removable panels, may have round, solid locking lids, or 3-foot square, locking diamond plate covers.
- Vaults with widths 10 feet or less must have removable lids.
- The maximum depth from finished grade to the vault invert shall be 20 feet.
- Internal structural walls of large vaults shall be provided with openings sufficient for maintenance access between cells. The openings should be sized and situated to allow access to the maintenance “v” in the vault floor.
- A minimum of two access openings shall be provided into each cell.
- The minimum internal height shall be 7 feet from the highest point of the vault floor (not sump), and the minimum width shall be 4 feet. However, concrete vaults may be a minimum 3 feet in height and width if used as a tank with access manholes at each end, and if the width is no larger than the height. Also the minimum internal height requirement may not be needed for any areas covered by removable panels.
- Vaults must comply with the OSHA confined space requirements, which include clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.
- Ventilation pipes (minimum 12-inch diameter or equivalent) shall be provided in all four corners of vaults to allow for artificial ventilation prior to entry of maintenance personnel into the vault. Alternatively, removable panels over the entire vault, or manhole access at 12-foot spacing, may be provided.

20.5 BMP F140: Parking Lots for Additional Detention

Private parking lots may be used to provide additional detention volume for runoff events greater than the 2-year runoff event provided all of the following are met:

- The depth of water detained does not exceed 0.5 feet (6 inches) at any location in the parking lot for runoff events up to and including the 100-year event.
- The gradient of the parking lot area subject to ponding is 1 percent or greater.
- The emergency overflow path is identified and noted on the engineering plan. The overflow must not create a significant adverse impact to downhill properties or the downstream stormwater system.
- Fire lanes be used for emergency equipment are free of ponding water for all runoff events up to and including the 100-year event.
- A downstream stormwater treatment BMP that provides oil control is provided.
- A signed letter from the property owner is provided stating they understand that the Parking Lot is being proposed for detention and a covenant and easement agreement is signed and recorded and includes the parking lot as part of the detention facility.
- Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

20.6 BMP F150: Roofs for Detention

Detention ponding on roofs of structures may be used to meet flow control requirements provided all of the following are met:

- The roof support structure is analyzed by a Washington State Licensed Professional Engineer to address the weight of ponded water and meets the requirements of the applicable building code.
- The roof area subject to ponding is sufficiently waterproofed to achieve a minimum service life of 30 years.
- The minimum pitch of the roof area subject to ponding is 1/4-inch per foot.
- An overflow system is included in the design to safely convey the 100-year peak flow from the roof.
- A mechanism is included in the design to allow the ponding area to be drained for maintenance purposes, or in the event the restrictor device is plugged.
- A signed letter from the property owner is provided stating they understand that the roof is being proposed for detention and a covenant and easement agreement is signed and recorded and includes the roof as part of the detention facility.
- Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

Chapter 21 BMP Components

21.1 A100: Liners

21.1.1 Purpose

Liners are intended to reduce the likelihood that pollutants in stormwater will reach groundwater. Where necessary, a liner is incorporated into the base of the treatment facility as the facility is constructed. In addition to groundwater protection considerations, some facility types require permanent water for proper functioning. An example is the first cell of a wetpond.

21.1.2 Design Criteria for All Liner Types

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

- Check each BMP to determine if a liner is required or recommended and if there are specific liner requirements for a given BMP.
- Table 4 - 37: Lining Types Recommend for Stormwater Treatment Facilities shows recommendations for the type of liner generally best suited for use with various stormwater treatment facilities.
- Liners shall be evenly placed over the bottom and/or sides of the treatment area of the facility as indicated in Table 4 - 37: Lining Types Recommend for Stormwater Treatment Facilities. Areas above the treatment volume that are required to pass flows greater than the water quality design flowrate (or volume) need not be lined. However, the lining must be extended to the top of the interior side slope and anchored if it cannot be permanently secured by other means.
- For low permeability liners, the following criteria apply:
    - Where the seasonal high groundwater elevation is likely to contact a low permeability liner, liner buoyancy evaluation and recommendation for use and possible anchoring by a Washington State Licensed Professional Engineer is required.
    - Where grass must be planted over a low permeability liner per the facility design, a minimum of 6 inches of good topsoil or compost-amended native soil (2 inches compost tilled into 6 inches of native till soil) must be placed over the liner in the area to be planted. Twelve inches of cover is preferred. Compost shall comply with A900: Compost.
- If a treatment liner will be below the seasonal high water level, the pollutant removal performance of the liner must be evaluated by a geotechnical or groundwater specialist and found to be as protective as if the liner were above the level of the groundwater.

Table 4 - 37: Lining Types Recommended for Stormwater Treatment Facilities

WQ Facility	Area to be Lined	Type of Liner Recommended
BMP T610: Presettling Basin	Bottom and sides	Low permeability liner or Treatment liner (If the basin will intercept the seasonal high groundwater table, a treatment liner is recommended.)
BMP T1110: Wetponds - Basic and Large	First cell: bottom and sides to WQ design water surface	Low permeability liner or Treatment liner (If the wet pond will intercept the seasonal high groundwater table, a treatment liner is recommended.)
	Second cell: bottom and sides to WQ design water surface	Treatment liner
BMP T1140: Combined Detention and Wetpool Facilities	First cell: bottom and sides to WQ design water surface	Low permeability liner or treatment liner (If the facility will intercept the seasonal high groundwater table a treatment liner is recommended.)
	Second cell: bottom and sides to WQ design water surface	Treatment liner
BMP T1130: Stormwater Treatment Wetlands	Bottom and sides, both cells	Low permeability liner (If the facility will intercept the seasonal high groundwater table, a treatment liner is recommended.)
BMP T808: Basic Sand Filter and BMP T809: Large Sand Filter	Basin sides only	Treatment liner
BMP T810: Sand Filter Vault	Not applicable	No liner needed
BMP T820: Linear Sand Filter	Not applicable if in vault Bottom and sides of presettling cell if not in vault	No liner needed Low permeability or treatment liner

21.1.3 Design Criteria for Low Permeability Liner Options

This section presents the design criteria for each of the following four low permeability liner options: earthen geomembrane liners, and concrete liners.

21.1.3.1 Earthen Liners

- Soils used for earthen liners should be free from foreign material such as paper, brush, trees, and large rocks.
- All soil liners constructed of compacted material should be at least 24 inches thick, compacted in lifts no greater than 6 inches thick, and compacted to 95 percent of maximum density as determined by the Standard Proctor Density test (WSDOT test method No. 606).

- For in-situ clay soils meeting the soils liner criteria above, a minimum of 6 inches below planned grade should be excavated and re-compacted to assure a uniformly compacted finished surface.
- Soil liners should meet the following particle size gradation and Atterberg limits:
  - Thirty percent or more passing a number 200 mesh sieve.
  - A liquid limit of 30 percent or greater.
  - A plasticity index of 15 or greater.
  - A permeability less than or equal to 1 X 10^{-7} cm/sec.
- Soil embankment walls should have a top width of at least five feet.
- The interior and exterior slopes of soil embankment walls should be no steeper than one foot vertical to three feet horizontal.
- All soil embankment walls should have a vegetative cover or other stabilizing material to prevent erosion.
- All piping penetrating the embankments should have erosion stops and water seals.

21.1.3.2 Geomembrane Liners

- Geomembrane liners shall have a minimum thickness of 30 mils. A thickness of 40 mils shall be used in areas of maintenance access or where heavy machinery must be operated over the membrane.
- Geomembranes shall be bedded according to the manufacturer's recommendations.
- Liners shall be installed so that they can be covered with 12 inches of top dressing forming the bottom and sides of the stormwater treatment facility, except for linear sand filters. Top dressing shall consist of 6 inches of crushed rock covered with 6 inches of native soil. The rock layer is to mark the location of the liner for future maintenance operations. As an alternative to crushed rock, 12 inches of native soil may be used if orange plastic “safety fencing” or another highly-visible, continuous marker is embedded 6 inches above the membrane.
- If possible, liners should be of a contrasting color so that maintenance workers are aware of any areas where a liner may have become exposed when maintaining the facility.
- Geomembrane liners shall not be used on slopes steeper than 5H:1V to prevent the top dressing material from slipping. Textured liners may be used on slopes up to 3H:1V upon recommendation by a Washington State Licensed Professional Engineer that the top dressing will be stable for all site conditions, including maintenance.

21.1.3.3 Concrete Liners

- Portland cement liners are allowed irrespective of facility size, and shotcrete may be used on slopes. However, specifications must be developed by a Washington State Licensed Professional Engineer who certifies the liner against cracking or losing water retention ability under expected conditions of operation, including facility maintenance operations. Weight of maintenance equipment can be up to 80,000 pounds when fully loaded.
- Asphalt concrete may not be used for liners due to its permeability to many organic pollutants.
- If grass is to be grown over a concrete liner, slopes must be no steeper than 5H:1V to prevent the top dressing material from slipping.

21.1.4 Treatment Liners

The following criteria apply for treatment liners:

- Depth of liner shall be 2 feet.
- Organic content shall be a minimum of 1%. Organic content shall be measured on a dry weight basis using ASTM D2974.
- Cation exchange capacity shall be a minimum of 5 millequivalents/100 grams. Cation exchange shall be tested using EPA lab method 9081.
- The treatment liner shall have an infiltration of 2.4 inches per hour or less.
- If native soils are proposed to be used for the treatment liner, one sample per 1,000 square feet of facility area shall be tested. Each sample shall be a composite of subsamples taken throughout the depth of the soil log for the proposed treatment layer. Testing shall be performed by a professional Washington State Licensed Professional Engineer or Washington State Licensed Professional Geologist.
- Certification by a soils testing laboratory that imported soil meets the organic content and CEC criteria is required.

21.2 A200: Flow Splitters

21.2.1 Purpose

Flow splitters are typically manholes or vaults with internal baffles, riser structures, or pipes designed to split off a portion of the main stormwater flow within the pipe. Flow splitters can be used in a variety of ways including:

- Placing stormwater treatment facilities in an offline configuration so that only the water quality design flowrate reaches the facility.
- Flow control purposes
- Bypassing flows around a facility
- Ensuring wetland hydrology is met,

The design of the flow splitter is dependent on the purpose of splitting the flows.

21.2.2 General Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

- A flow splitter must be designed to deliver flowrates as necessary for the purpose of the flow splitter installation.
    - For stormwater facilities configured offline:
        - The flow splitter shall be designed to deliver the water quality design flowrate to the stormwater facility.
        - For baffle type flow splitting, the top of the weir shall be located at the water surface for the water quality design flowrate.
        - The maximum head must be minimized for flow in excess of the water quality design flowrate. At the 100-year water surface, the flowrate to the stormwater treatment facility cannot increase by more than 10%.
- A backwater analysis of the existing or proposed conveyance system may be required by the City of Tacoma.
- Design flow splitters per Figure 4 - 55: Flow Splitter - Baffle Type and Figure 4 - 56: Flow Splitter - Riser Tee Type or provide an equivalent design.
    - Only baffle wall type flow splitters may be used for oil treatment BMPs.
    - As an alternative to using a solid top plate in Figure 4 - 56: Flow Splitter - Riser Tee Type, a full tee section may be used with the top of the tee at the 100-year water surface. This alternative would route emergency overflows (if the overflow pipe were plugged) through the WQ facility rather than back up from the manhole.
    - Special applications, such as roads, may require the use of a modified flow splitter. The baffle wall may be fitted with a notch and adjustable weir plate to proportion runoff volumes other than high flows.

- For ponding facilities, backwater effects must be considered in the design of the flow splitter.
- Backwater effects from any downstream stormwater facility, and natural or artificial empoundment or any other feature that may cause backwater conditions shall be considered in design of the flow splitting structures.
- Ladder or step and handhold access must be provided. If the weir wall is higher than 36 inches, two ladders, one to either side of the wall, must be used.
- See A500: Control Structures for orifice and weir design equations.
- City of Tacoma owned flow splitters shall have concentric cones when feasible. Access shall be provided to the entire flow splitter for maintenance.

21.2.3 Materials

- The splitter baffle may be installed in a Type 2 manhole or vault.
- The baffle wall must be made of reinforced concrete or another suitable material resistant to corrosion, and have a minimum 4-inch thickness. The minimum clearance between the top of the baffle wall and the bottom of the manhole cover must be 4 feet; otherwise, dual access points shall be provided.

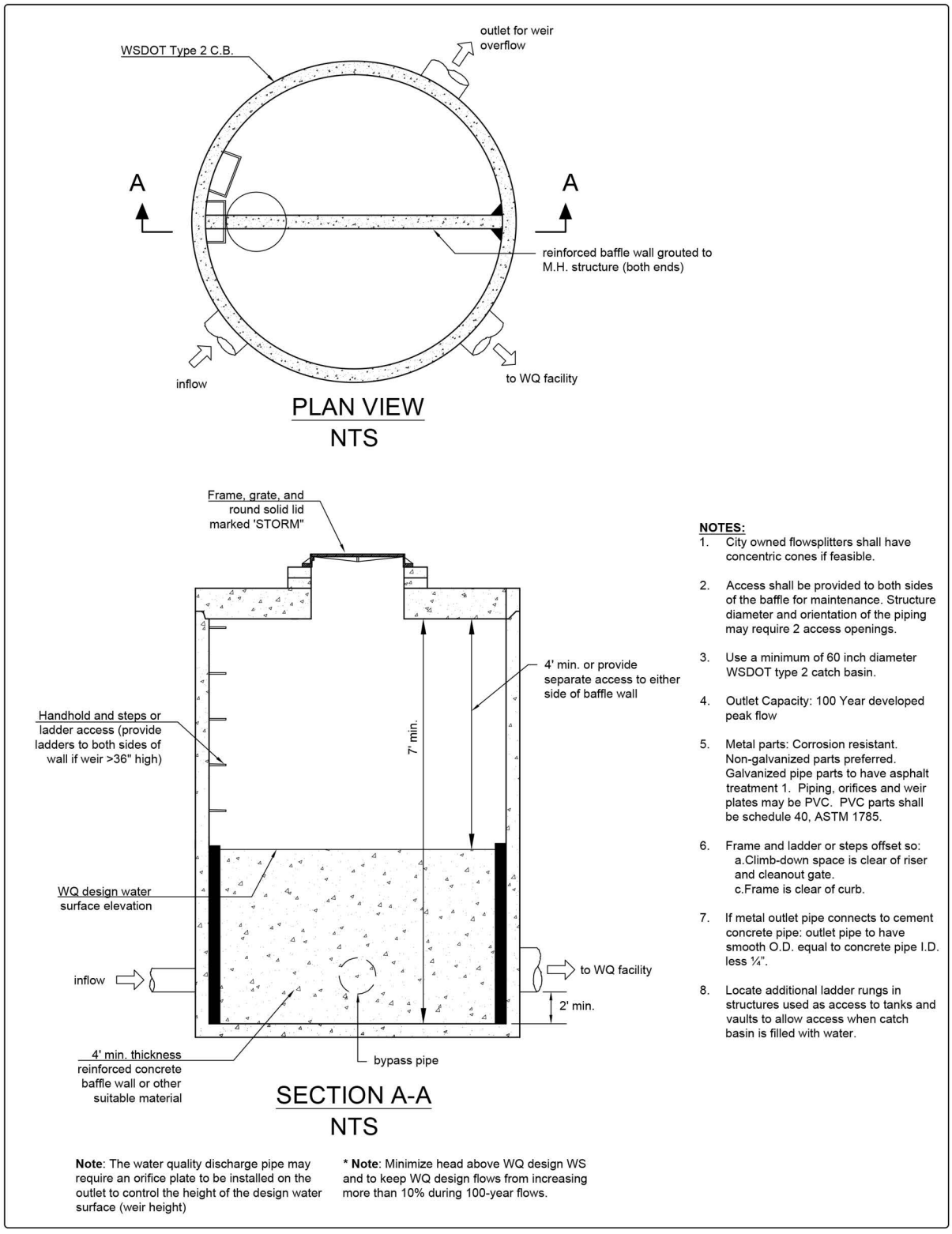
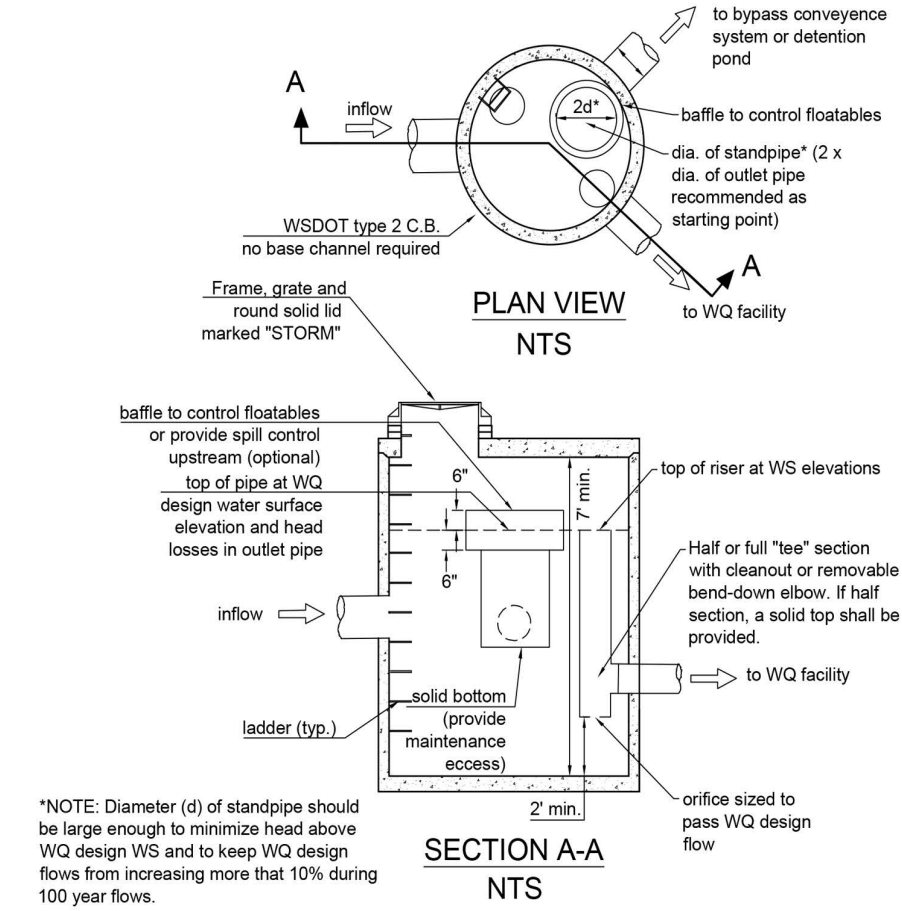


Figure 4 - 55: Flow Splitter - Baffle Type



1. City owned flow splitter shall concentric cones if feasible.
2. Use a minimum of 60 inch diameter WSDOT type 2 catch basin.
3. Outlet Capacity: 100 Year developed peak flow
4. Riser structure shall be installed so that it can be removed and replaced from within the catch basin. Provide removable water tight coupling or gasketed pipe for PVC.
5. Metal parts: Corrosion resistant. Non-galvanized parts preferred. Galvanized pipe parts to have asphalt treatment 1. Riser structure piping orifices and weir plates may be PVC. PVC parts shall be schedule 40, ASTM 1785.
6. Frame and ladder or steps offset so:
   a. Cleanout gate is visible from top.
   b. Climb-down space is clear of riser and cleanout gate.
   c. Frame is clear of curb.
7. If metal outlet pipe connects to cement concrete pipe: outlet pipe to have smooth O.D. equal to concrete pipe I.D. less ¼".
8. Provide at least one 3" X 0.090 gage support bracket anchored to concrete wall. (one per maximum 3'-0" vertical spacing).
9. Locate elbow restrictor(s) as necessary to provide minimum clearance as shown.
10. Locate additional ladder rungs in structures used as access to tanks and vaults to allow access when catch basin is filled with water.

Figure 4 - 56: Flow Splitter - Riser Tee Type

21.3 A300: Flow Spreading Devices

Flow spreaders function to uniformly spread flows There are five flow spreader options presented in this section:

- Option A – Anchored plate (Figure 4 - 57)
- Option B – Concrete sump box (Figure 4 - 58)
- Option C – Notched curb spreader (Figure 4 - 59)
- Option D – Through-curb ports (Figure 4 - 60)
- Option E – Interrupted curb

Options A through C can be used for spreading flows that are concentrated. Any one of these options can be used when spreading is required by the facility design criteria. Options A through C can also be used for unconcentrated flows, and in some cases must be used, such as to correct for moderate grade changes along a vegetated filter strip (BMP T1040).

Options D and E are only for flows that are already unconcentrated (such as entering a Vegetated Filter Strip (BMP T1040) or a continuous inflow biofiltration swale (BMP T1030). Other flow spreader options may be allowed by the City of Tacoma provided a basis for design is included.

21.3.1 General Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

- Where flow enters the flow spreader through a pipe, it is recommended that the pipe be submerged to the extent practical to dissipate as much energy as possible.
- Flow spreaders are difficult to maintain in a way that allows for continual evenly distributed flow. Flow spreaders should not be used on slopes greater than 5% or areas easily accessible to the public.
- For higher inflows (greater than 5 cfs for the 100-yr storm), a Type 1 catch basin shall be positioned in the spreader and the inflow pipe shall enter the catch basin with flows exiting through the top grate. The top of the grate shall be lower than the level spreader plate, or if a notched spreader is used, lower than the bottom of the v-notches.

Option A -- Anchored Plate

- An anchored plate flow spreader must be preceded by a sump having a minimum depth of 8 inches and minimum width of 24 inches. If not otherwise stabilized, the sump area must be lined to reduce erosion and to provide energy dissipation.
- The top surface of the flow spreader plate must be level, projecting a minimum of 2 inches above the ground surface of the stormwater treatment facility, or V-notched with notches 6 to 10 inches on center and 1 to 6 inches deep (use shallower notches with closer spacing). Alternative designs may also be used if approved by the City of Tacoma. A basis for design must be included for any alternative designs.
- A flow spreader plate must extend horizontally beyond the bottom width of the facility to prevent water from eroding the side slope. The horizontal extent shall be such that the

bank is protected for all flows up to the 100-year flow or the maximum flow that will enter the stormwater treatment facility.

- Flow spreader plates must be securely fixed in place.
- Flow spreader plates may be made of either wood, metal, fiberglass reinforced plastic, or other durable material. If wood, pressure treated 4 by 10-inch lumber or landscape timbers are acceptable.
- Anchor posts must be 4-inch square concrete, tubular stainless steel, or other material resistant to decay.

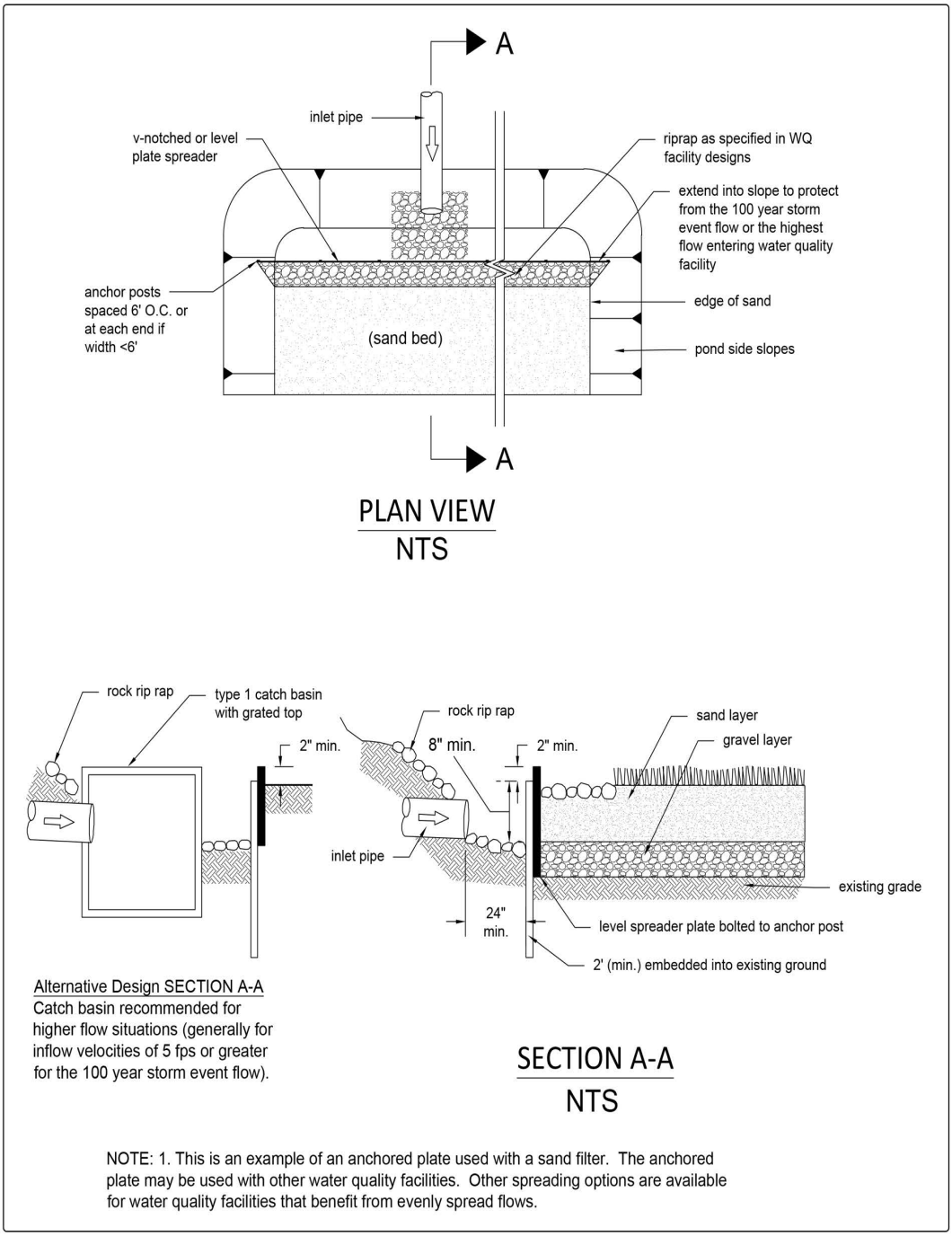


Figure 4 - 57: Flow Spreader Option A – Anchored Plate

Option B -- Concrete Sump Box

- The wall of the downstream side of a rectangular concrete sump box must extend a minimum of 2 inches above the flow spreading area. This serves as a weir to spread the flows uniformly across the area.
- The downstream wall of a sump box must have “wing walls” at both ends. Side walls and returns must be slightly higher than the weir so that erosion of the side slope is minimized.
- Concrete for a sump box can be either cast-in-place or precast, but the bottom of the sump must be reinforced with wire mesh for cast-in-place sumps.
- Sump boxes must be placed over bases that consist of 4 inches of crushed rock, 5/8-inch minus to help assure the sump remains level.

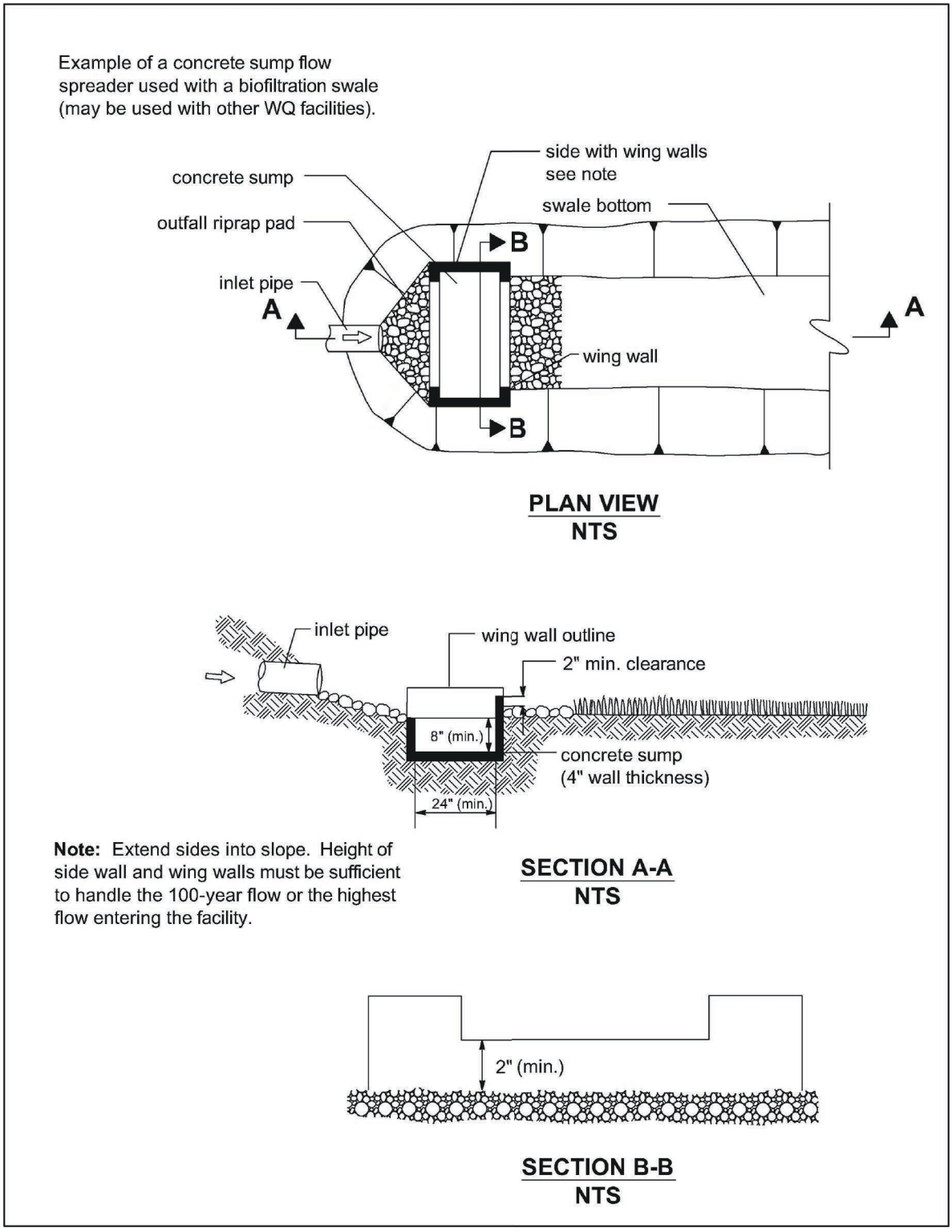


Figure 4 - 58: Flow Spreader Option B – Concrete Sump Box

Option C -- Notched Curb Spreader

Notched curb spreader sections must be made of extruded concrete laid side-by-side and level. Typically five “teeth” per four-foot section provide good spacing. The space between adjacent “teeth” forms a v-notch.

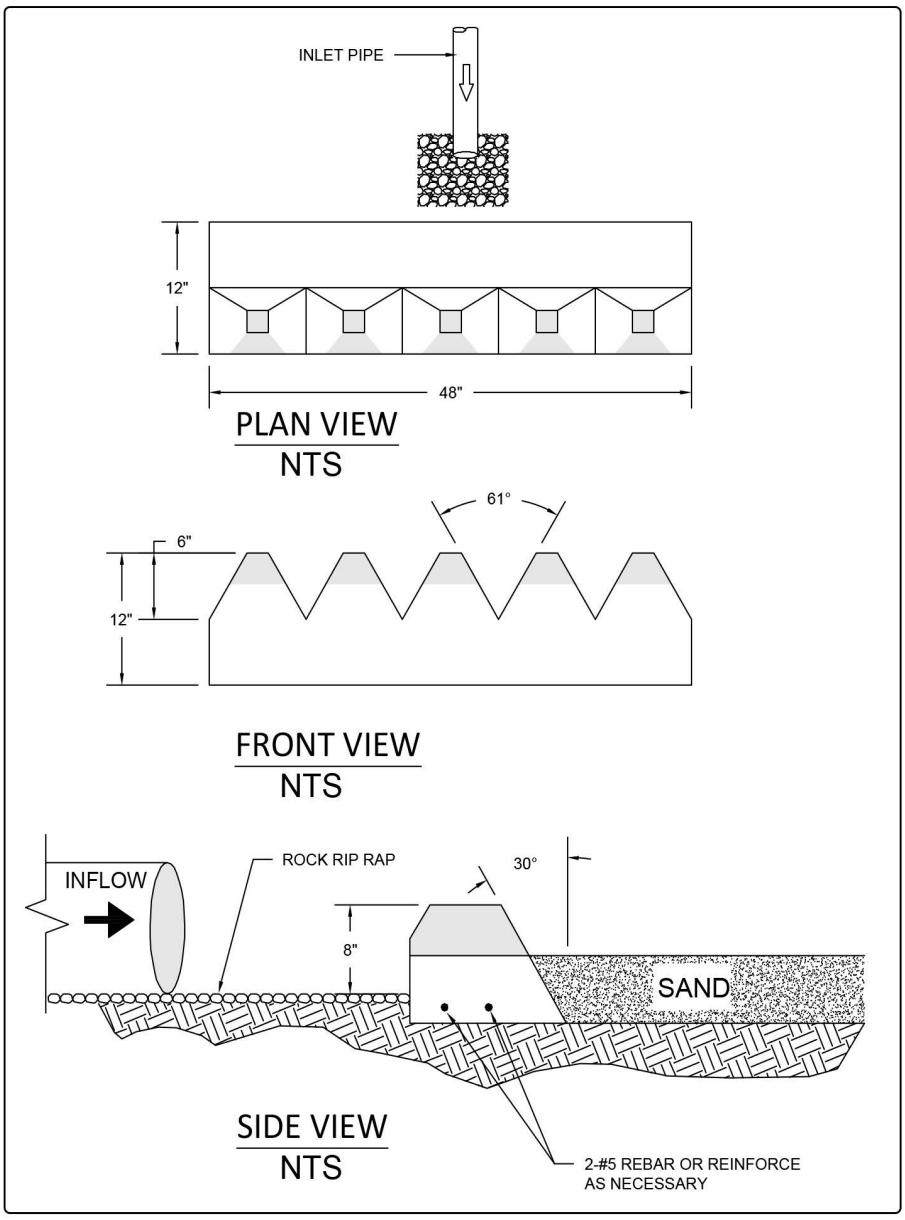


Figure 4 - 59: Flow Spreader Option C – Notched Curb Spreader

Option D -- Through-Curb Ports

Unconcentrated flows from paved areas can use curb ports or interrupted curbs (Option E). Curb ports use fabricated openings that allow concrete curbing to be poured or extruded while still providing an opening through the curb to admit water to the stormwater treatment facility.

Openings in the curb must be at regular intervals but at least every 6 feet (minimum). The width of each curb port opening must be a minimum of 11 inches. Approximately 15 percent or more of the curb section length shall be in open ports, and no port shall discharge more than about 10 percent of the flow.

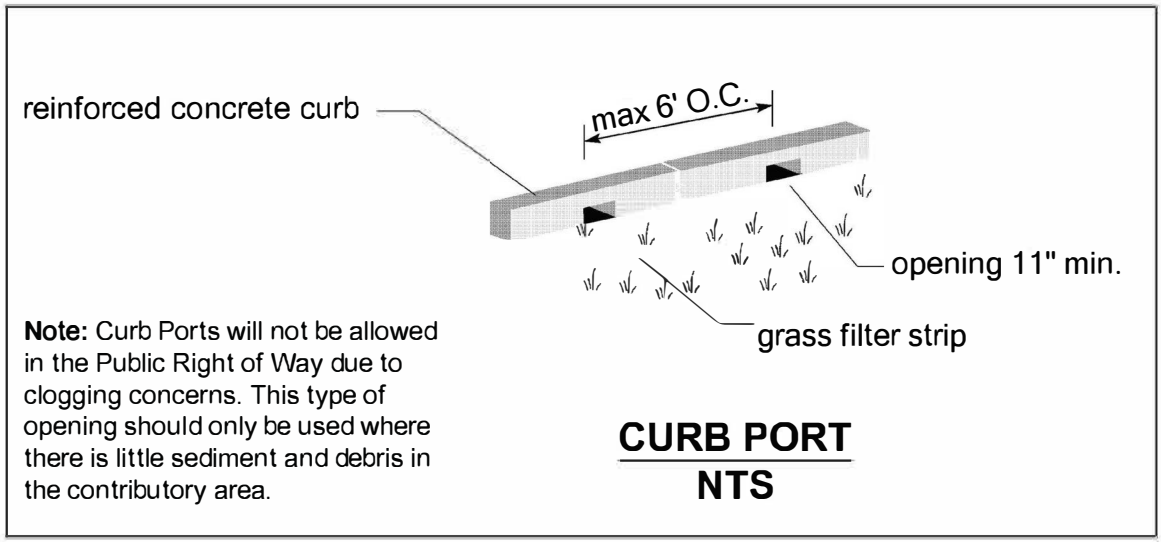


Figure 4 - 60: Flow Spreader Option D – Through-Curb Ports

Option E -- Interrupted Curb

Interrupted curbs are sections of curb placed to have gaps spaced at regular intervals along the total width (or length, depending on facility) of the area where flows are spread. At a minimum, gaps must be every 6 feet to allow distribution of flows into the treatment facility before they become too concentrated. The opening must be a minimum of 11 inches. As a general rule, no opening shall discharge more than 10 percent of the overall flow entering the facility. See City of Tacoma Standard Details GSI-09.

21.4 A400: End of Pipe Discharge Protection

This section presents the methods, criteria and details for analysis and design of end of conveyance system discharge locations. Properly designed discharge locations are critical to reducing the chance of adverse impacts as the result of concentrated discharges from pipe systems and culverts, both onsite and downstream. End of pipe discharge protection includes piping, rock splash pads, flow dispersal trenches, gabion or other energy dissipaters.

21.4.1 End of Pipe Discharge Protection Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

All end of pipe discharge locations must be provided with an appropriate outlet / energy dissipation structure such as a dispersal trench, gabion outfall, or rock splash pad (see Figure 4 - 61: Pipe/Culvert Outfall Discharge Protection) as specified below and in Table 4 - 38: Rock Protection at Outfalls.

No erosion or flooding of downstream properties shall result from discharge from a conveyance system.

Table 4 - 38: Rock Protection at and Discharge Locations

Discharge Velocity at Design Flow in Feet per Second (fps)[3]	Required Protection (Minimum Dimensions)				
	Type	Thickness	Width	Length	Height
0 – 5	Rock lining[1]	1 foot	Diameter + 6 feet	8 feet *or* 4 x diameter, whichever is greater	Crown + 1 foot
>5 - 10	Riprap[2]	2 feet	Diameter + 6 feet *or* 3 x diameter, whichever is greater	12 feet *or* 4 x diameter, whichever is greater	Crown + 1 foot
>10 - 20	Gabion outfall	As required	As required	As required	Crown + 1 foot
>20	Engineered energy dissipater				

NOTES:
[1] **Rock lining** shall be quarry spalls with gradation as follows:
- Passing 8-inch square sieve: 100%
- Passing 3-inch square sieve: 40 to 60% maximum
- Passing 3/4-inch square sieve: 0 to 10% maximum

[2] **Riprap** shall be reasonably well graded with gradation as follows. Riprap sizing is based on outlet channel side slopes of approximately 3:1.:
- Maximum stone size: 24 inches (nominal diameter)
- Median stone size: 16 inches
- Minimum stone size: 4 inches

[3] Assume pipe is 90% full.

21.4.1.1 Energy Dissipation

- State, federal and local permits are required for work near or within receiving waters. See https://www.oria.wa.gov/site/alias__oria/permitting_our_permitting_services/347/our_permitting_services.aspx for information about potential State and Federal Permits that may be required. See tacomapermits.org for information on the types of City of Tacoma permits that may need to be obtained when installing an outfall system.
- Outfall structures should be located where they minimize impacts to fish, shellfish, and their habitat.
- Energy dissipaters shall be located above the Ordinary High Water Mark on fish bearing streams. Outfalls not intended for fish passage shall have an invert elevation a minimum of 1' above the Ordinary High Water Mark.
- Bank stabilization, bioengineering, and habitat features may be required for disturbed areas.
- For marine outfalls:

- Rock splash pads and gabion structures are not recommended due to corrosion and destruction of the structure, particularly in high energy environments.
- Diffuser Tee structures, such as shown in Figure 4 - 65: Diffuser Tee, are not recommended in or above the intertidal zone though they may be acceptable in low bank or rock shoreline locations.
- Piped conveyance systems trenched to extreme low water or dissipation above the high water line are preferred.
- Outfalls and other discharge locations below extreme low water may still need an energy dissipation device to prevent erosion in the immediate vicinity of the discharge.
- Stormwater outfalls submerged in a marine environment are subject to plugging due to biological growth and shifting debris and sediment. Regular maintenance is needed to ensure outfall can function as designed.

- Gabion outfall and engineered energy dissipater shall be designed by a Washington State Licensed Professional Engineer. The basis for design and accompanying calculations shall be include in the signed and stamped Stormwater Site Plan Report.
  - Gabion outfalls are required when the design velocity is greater than 10 ft/s.
    - The gabion outfall detail shown in Figure 4 - 64: Gabion Outfall Detail is for illustrative purposes only. A site specific detail is needed for all gabion outfalls.
    - The in-stream sample gabion mattress may not be acceptable within the ordinary high water mark of fish-bearing waters or where gabions will be subject to abrasion from upstream channel sediments. A four-sided basion basket located outside the ordinary high water mark should be considered for these applications.
  - Engineered energy dissipaters, such as stilling basins, drop pools, hydraulic jump basins, baffled aprons, and bucket aprons area required when the design velocity is greater than 20 ft/s.
- The flow dispersion trenches shown in Figure 4 - 62: Flow Dispersal Trench and Figure 4 - 63: Alternative Flow Dispersal Trench, shall only be used when both criteria are met:
  - An end of pipe discharge is necessary to disperse concentrated flows across uplands where no conveyance system exists and the natural (existing) discharge is unconcentrated; and
  - The 100-year peak discharge rate is less than or equal to 0.5 cfs.
- Alternative end of pipe protection may be used provided the design is based on sound hydraulic principles and ease of construction and maintenance. A Washington State Licensed Professional Engineer shall design the alternative measure. The basis for design and accompanying calculations shall be include in the signed and stamped Stormwater Site Plan Report.
- Piped conveyance systems (tightline systems) shall:
  - Be designed by a Washington State Licensed Professional Engineer.
  - Use the appropriate pipe type and fittings for the situation.
  - Consider the need for thermal expansion and contraction.

  - Be buried to a depth sufficient to avoid exposure of the pipe during storm events and changes in beach elevation. If non-native material is used to bed the pipe, the material must be covered with at least 3 feet of native bed or equivalent.
  - Consider the need for pipe anchoring based on pipe material and location characteristics. See Volume 5 for additional information.

- Mechanisms that reduce velocity prior to discharge from conveyance systems are encouraged. Some of these are drop manholes and rapid expansion into pipes of much larger size. Other discharge end features may be used to dissipate the discharge energy. An example of an end feature is the use of a Diffuser Tee with holes in the front half, as shown in Figure 4 - 65: Diffuser Tee.

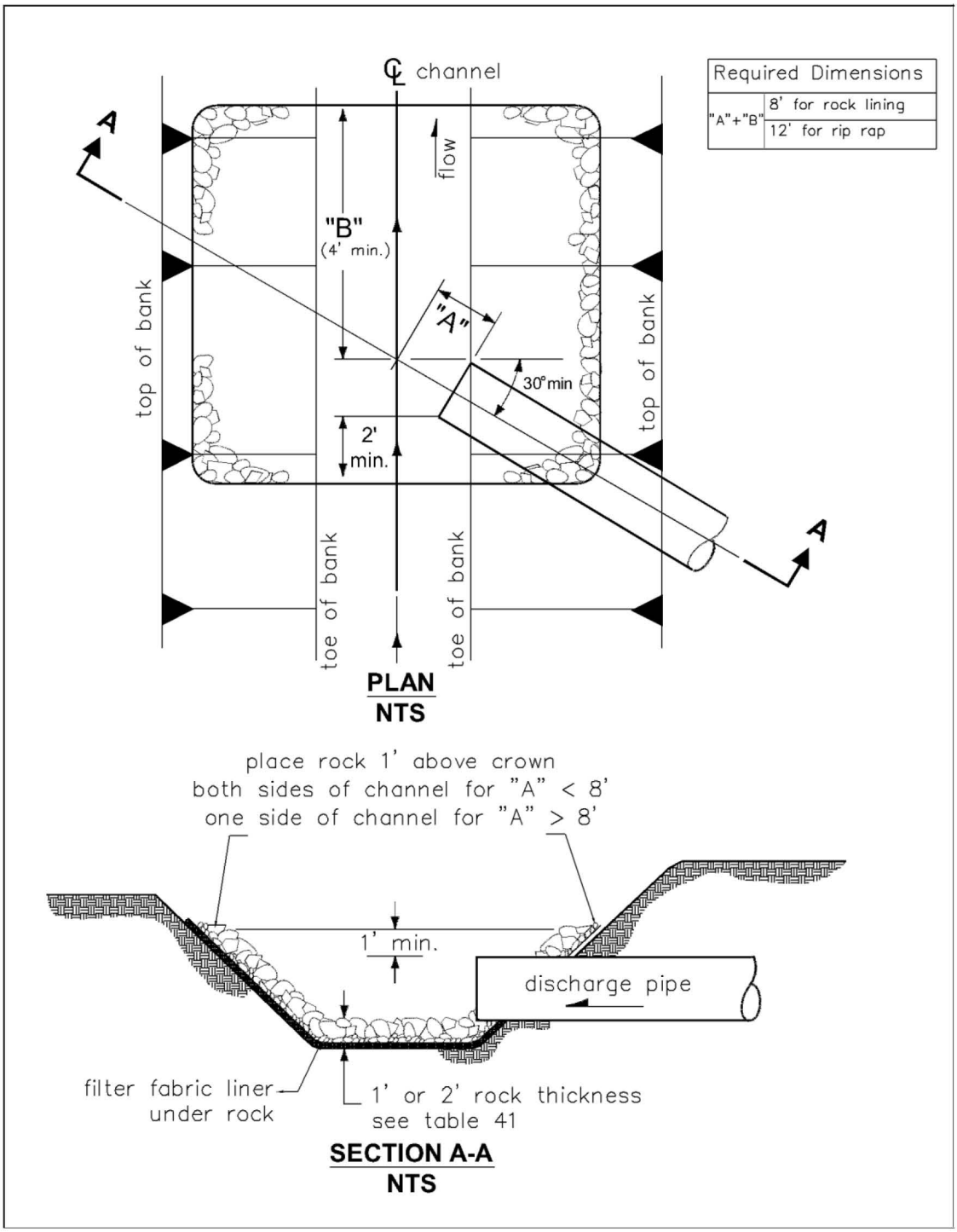


Figure 4 - 61: Pipe/Culvert Outfall Discharge Protection

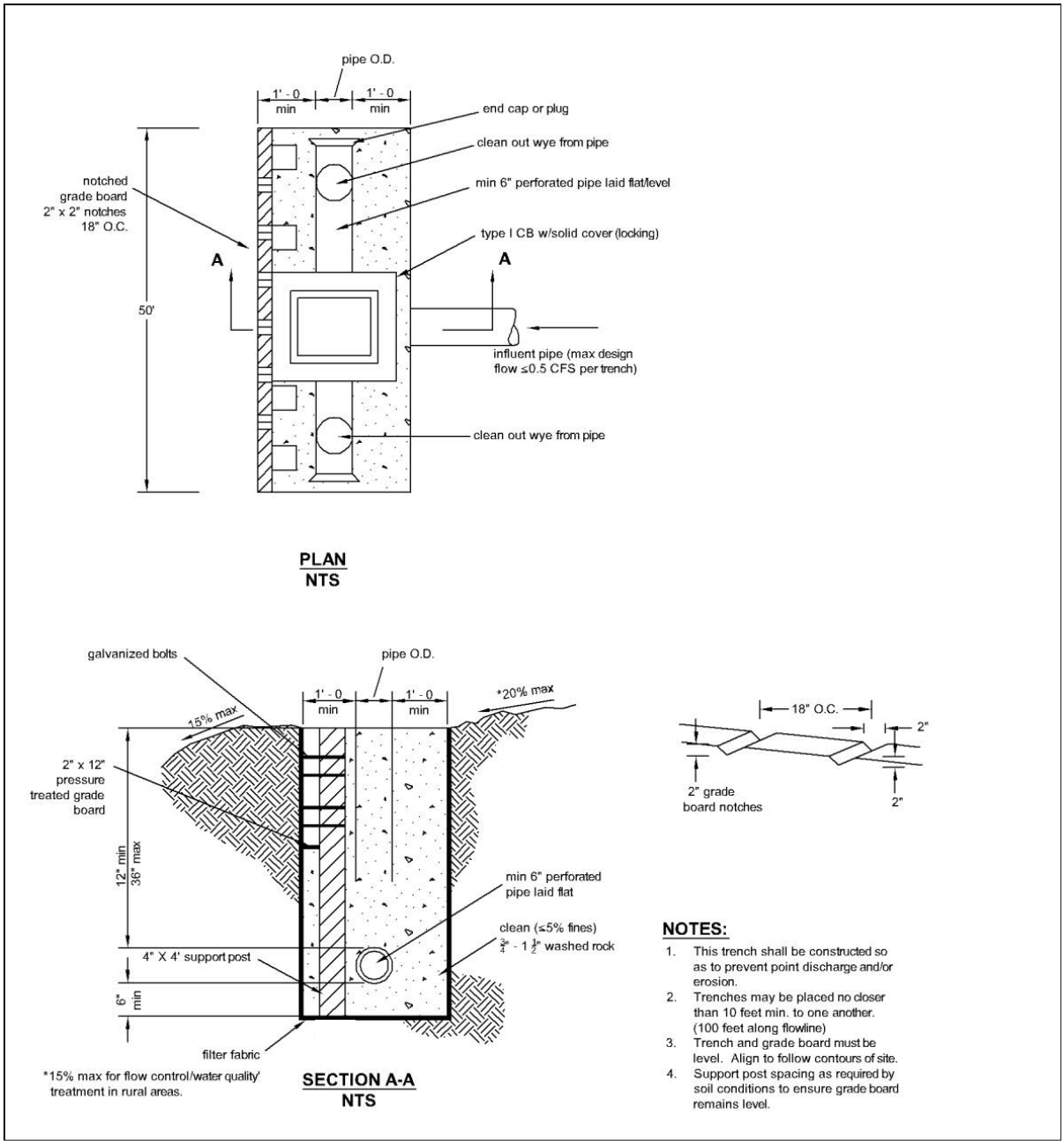


Figure 4 - 62: Flow Dispersal Trench

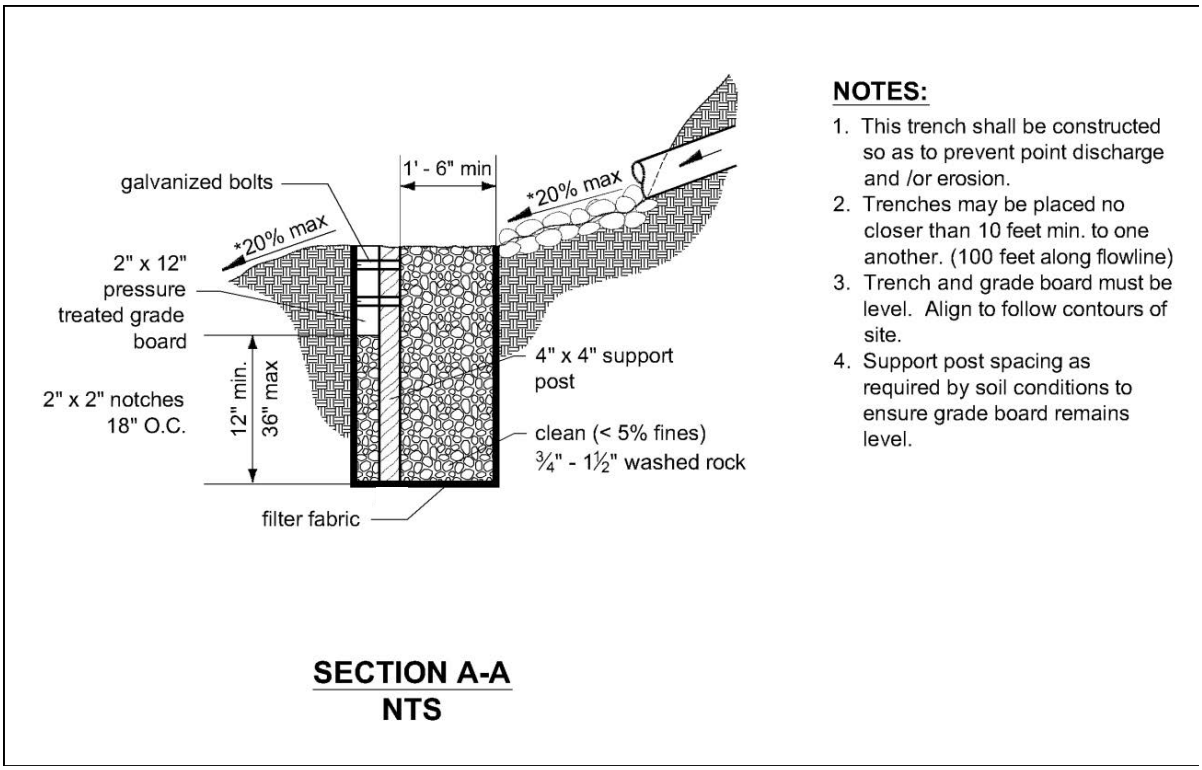


Figure 4 - 63: Alternative Flow Dispersal Trench

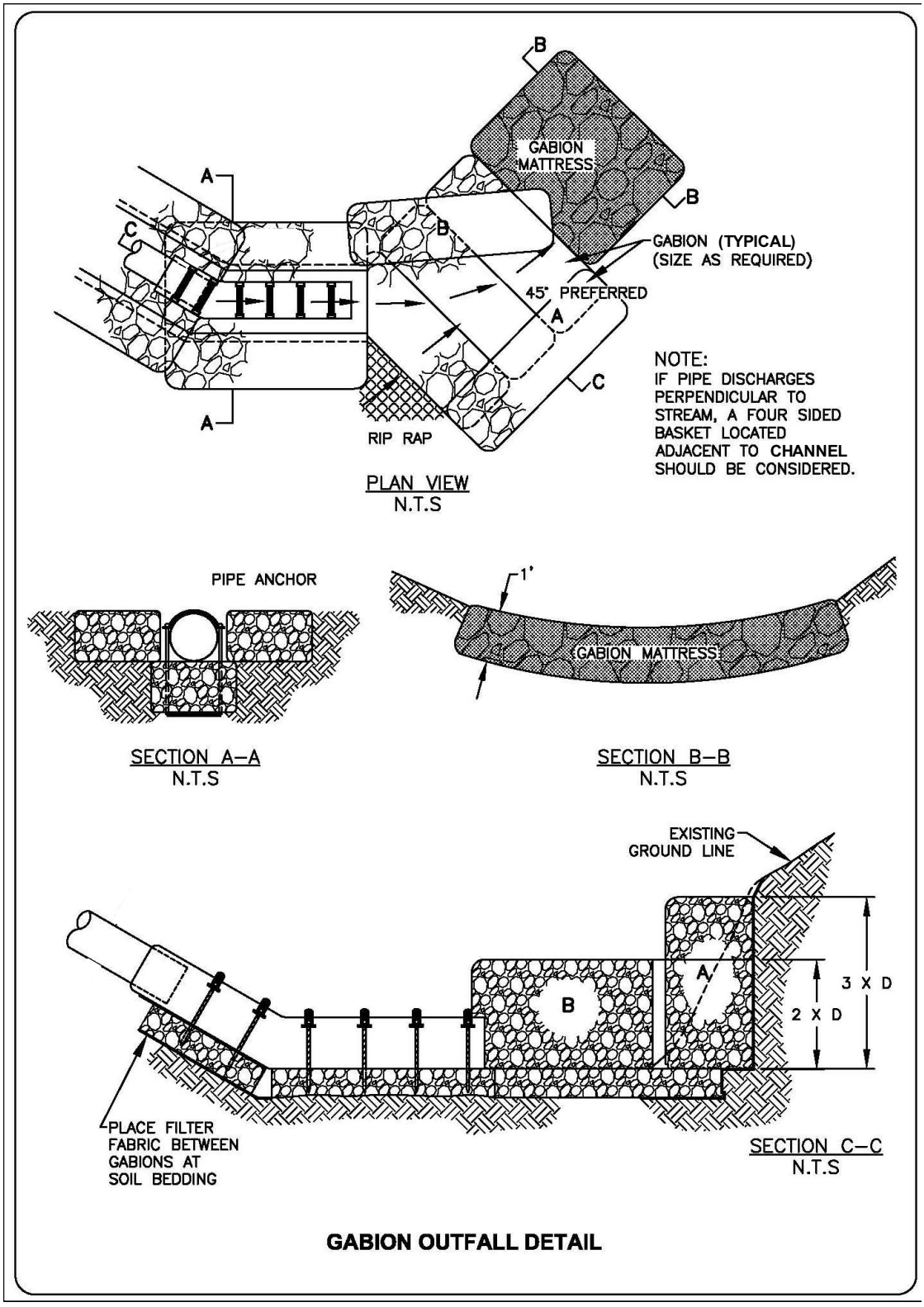


Figure 4 - 64: Gabion Outfall Detail

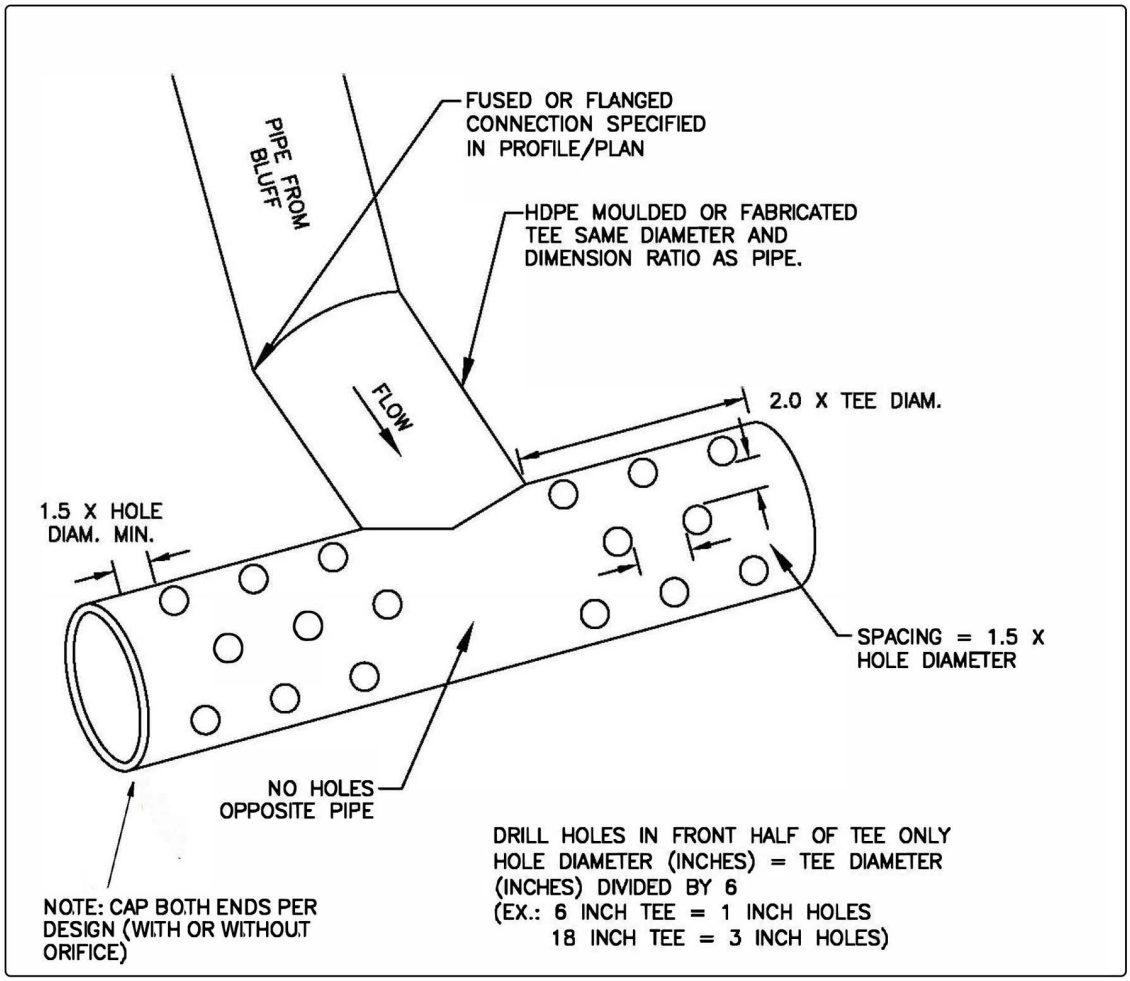


Figure 4 - 65: Diffuser Tee

21.5 A500: Control Structures

21.5.1 Description

Control structures are catch basins or manholes with a restrictor device for controlling outflow from a facility to meet the desired performance.

The restrictor device usually consists of two or more orifices and/or a weir section sized to meet performance requirements. Standard control structure details are shown in Figure 4 - 66 through Figure 4 -73.

21.5.2 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

21.5.2.1 Multiple Orifice Restrictor

In most cases, control structures need only two orifices: one at the bottom and one near the top of the riser, although additional orifices may best utilize detention storage volume. Several orifices may be located at the same elevation if necessary to meet performance requirements.

- Minimum orifice diameter is 0.5 inches. In some instances, a 0.5-inch bottom orifice will be too large to meet target release rates, even with minimal head. In these cases, do not reduce the live storage depth to less than 3 feet in an attempt to meet the performance standards. Under such circumstances, flow-throttling devices may be a feasible option. These devices will throttle flows while maintaining a plug-resistant opening.
- Orifices may be constructed on a tee section as shown in Figure 4 - 66: Flow Restrictor (TEE) or on a baffle as shown in Figure 4 - 67: Flow Restrictor (Baffle).
- In some cases, performance requirements may require the top orifice/elbow to be located too high on the riser to be physically constructed (e.g. a 13-inch diameter orifice positioned 0.5 feet from the top of the riser). In these cases, a notch weir in the riser pipe may be used to meet performance requirements (see Figure 4 - 68: Flow Resctrictor (Weir)).
- Backwater effects from water surface elevations in the conveyance system shall be evaluated. High tailwater elevations may affect performance of the restrictor system and reduce live storage volumes. Backwater effects shall also be analyzed for areas that are influenced by tides.
- Backwater effects from any downstream stormwater facility, and natural or artificial empoundment or any other feature that may cause backwater conditions shall be considered in design of the control structures.

21.5.2.2 Riser and Weir Restrictor

- Properly designed weirs may be used as flow restrictors (see Figure 4 - 69 and Figure 4 - 71 through Figure 4 - 73). However, they must be designed to provide for primary overflow of the developed 100-year peak flow discharging to the detention facility.
- The combined orifice and riser (or weir) overflow may be used to meet performance requirements. However, the design must still provide for primary overflow of the developed peak volumetric flowrate calculated using a 10-minute timestep from a Type

1A, 100-year, 24-hour frequency storm using a single event model or 100-year return period flowrate, indicated by an Ecology-approved continuous simulation model, using a 15-minute timestep, assuming all orifices are plugged. Figure 4 - 73 Riser Inflow Curves can be used to calculate the head in feet above a riser of given diameter and flow.

21.5.2.3 Access

- An access road to the control structure is needed for inspection and maintenance, and must be designed and constructed as specified in A3000: Access Ramps and Roads.
- Manhole and catch basin lids for control structures must be locking, and rim elevations must match proposed finish grade.
- Manholes and catch basins must meet the OSHA confined space requirements, which include clearly marking entrances to confined space areas.

21.5.2.4 Materials

Acceptable materials for stormwater facilities include thermoplastics, iron, steel, aluminum, and concrete. Steel and iron shall be aluminum coated (aluminized Type 2). Zinc coated (galvanized) materials are prohibited. Painted metal parts shall not be used because of poor longevity.

21.5.3 Methods of Analysis

This section presents the methods and equations for design of control structure restrictor devices. Included are details for the design of orifices, rectangular sharp-crested weirs, v-notch weirs, sutro weirs, and overflow risers.

21.5.3.1 Orifices

Flow-through orifice plates in the standard tee section or turn-down elbow may be approximated by the general equation:

$$Q = CA\sqrt{2gh}$$

Where:

Q = flow (cfs)
C = coefficient of discharge (0.62 for plate orifice)
A = area of orifice (ft^2)
h = hydraulic head (ft)
g = gravity (32.2 ft/sec^2)

Figure 4 - 69: Simple Orifice illustrates this simplified application of the orifice equation.

The diameter of the orifice is calculated from the flow. The orifice equation is often useful when expressed as the orifice diameter in inches:

$$d = \sqrt{\frac{36.88Q}{\sqrt{h}}}$$

Where:

d = orifice diameter (inches)
Q = flow (cfs)
h = hydraulic head (ft)

21.5.3.2 Rectangular Sharp-Crested Weir

The rectangular sharp-crested weir design shown in Figure 4 - 70: Rectangular, Sharp-Crested Weir may be analyzed using standard weir equations for the fully contracted condition. The Francis Formula is shown below and requires use of Imperial units.

$$Q = C(L - 0.2h)h^{\frac{3}{2}}$$

Where:

Q = flow (cfs)
C = 3.27 + 0.40 h/P (ft)
h = head as shown in Figure 4 - 70: Rectangular, Sharp-Crested Weir

P = height above the pipe invert (ft) as shown in Figure 4-70: Rectangular, Sharp-Crested Weir
L = length (ft) of the portion of the riser circumference as necessary not to exceed 50 percent of the circumference
D = inside riser diameter (ft)

Note: This equation accounts for side contractions by subtracting 0.1h from L for each side of the notch weir.

21.5.3.3 V-Notch Sharp-Crested Weir

V-notch weirs as shown in Figure 4 - 71: V-Notch, Sharp-Crested Weir may be analyzed using standard equations for the fully contracted condition.

21.5.3.4 Proportional or Sutro Weir

Sutro weirs are designed so that the discharge is proportional to the total head. This design may be useful in some cases to meet performance requirements.

The sutro weir consists of a rectangular section joined to a curved portion that provides proportionality for all heads above the line A-B (see Figure 4 - 72: Suto Weir). The weir may be symmetrical or non-symmetrical.

For this type of weir, the curved portion is defined by the following equation (calculated in radians):

$$\frac{x}{b} = 1 - \frac{2}{\pi}\mathrm{Tan}^{-1}\sqrt{\frac{Z}{a}}$$

Where:

a, b, x and Z are as shown in Figure 4 - 72: Suto Weir.

The head-discharge relationship is:

$$Q = (C_d)(b)(\sqrt{2ga})\left(h_1 - \frac{a}{3}\right)$$

Where:

Q = flow (cfs)
g = gravity

Values of *Cd* for both symmetrical and non-symmetrical sutro weirs are summarized in Table 4 - 39: Values of Cd for Sutro Weirs; h_1 is shown in Figure 4 - 72: Sutro Weir.

When b > 1.50 or a > 0.30, use Cd=0.6.

21.5.3.5 Riser Overflow

The nomograph in Figure 4 - 73: Riser Inflow Curves can be used to determine the head (in feet) above a riser of given diameter and for a given flow (usually the 100-year peak flow for developed conditions).

Q_{100} is either the peak 10-minute flow computed from the 100-year, 24-hour storm and a Type 1A distribution, or the 100-year return period flowrate as estimated by an Ecology approved continuous simulation model assuming 15-minute timesteps.

Table 4 - 39: Values of C_d for Sutro Weirs

C_d Values, Symmetrical					
a (ft)	**b (ft)**				
	0.50	**0.75**	**1.0**	**1.25**	**1.50**
0.02	0.608	0.613	0.617	0.6185	0.619
0.05	0.606	0.611	0.615	0.617	0.6175
0.10	0.603	0.608	0.612	0.6135	0.614
0.15	0.601	0.6055	0.610	0.6115	0.612
0.20	0.599	0.604	0.608	0.6095	0.610
0.25	0.598	0.6025	0.6065	0.608	0.6085
0.30	0.597	0.602	0.606	0.6075	0.608
C_d Values, Non-Symmetrical					
a (ft)	**b (ft)**				
	0.50	**0.75**	**1.0**	**1.25**	**1.50**
0.02	0.614	0.619	0.623	0.6245	0.625
0.05	0.612	0.617	0.621	0.623	0.6235

Table 4 - 39: Values of C_d for Sutro Weirs

C_d Values, Symmetrical					
0.10	0.609	0.614	0.618	0.6195	0.620
0.15	0.607	0.6115	0.616	0.6175	0.618
0.20	0.605	0.610	0.614	0.6155	0.616
0.25	0.604	0.6085	0.6125	0.614	0.6145
0.30	0.603	0.608	0.612	0.6135	0.614

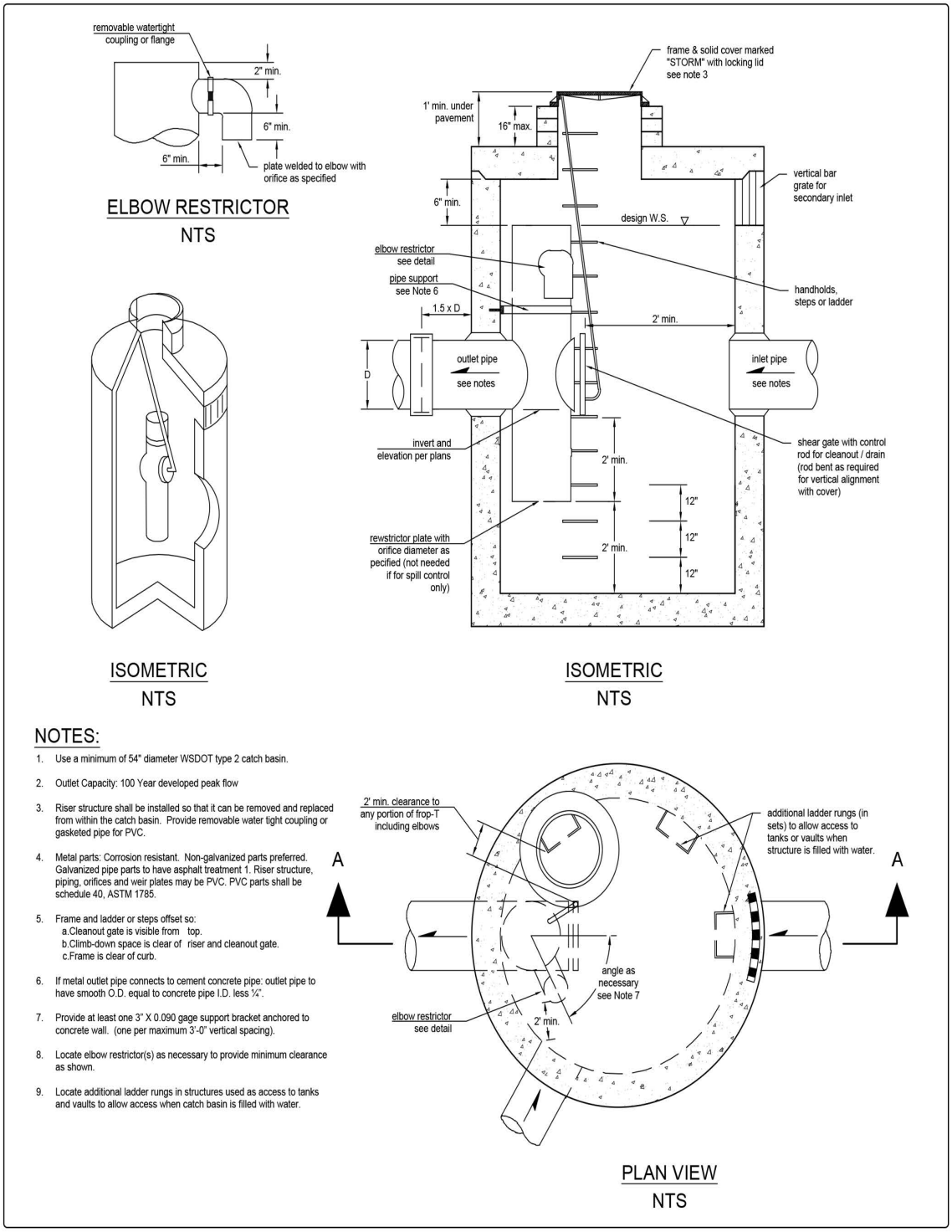


Figure 4 - 66: Flow Restrictor (TEE)

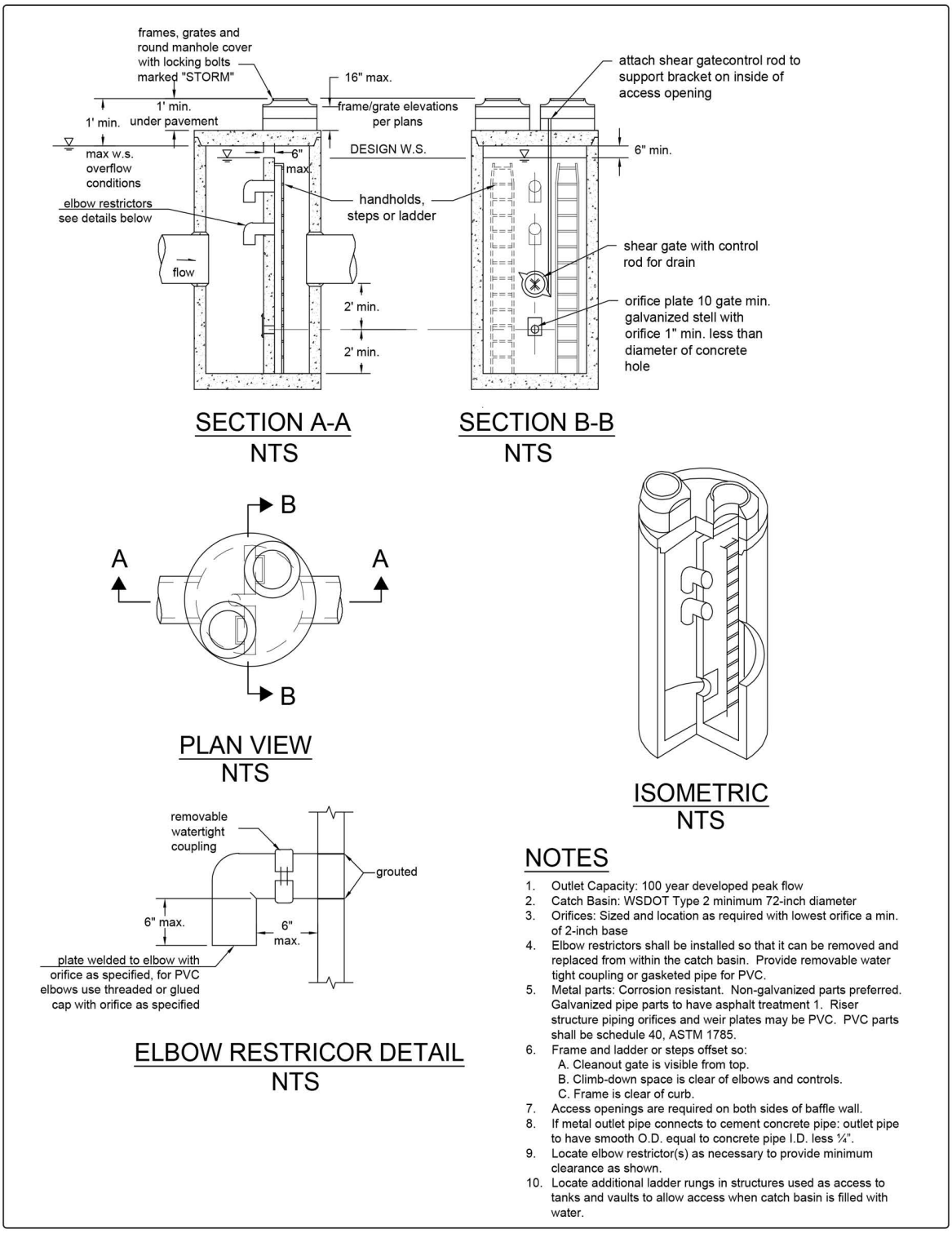


Figure 4 - 67: Flow Restrictor (Baffle)

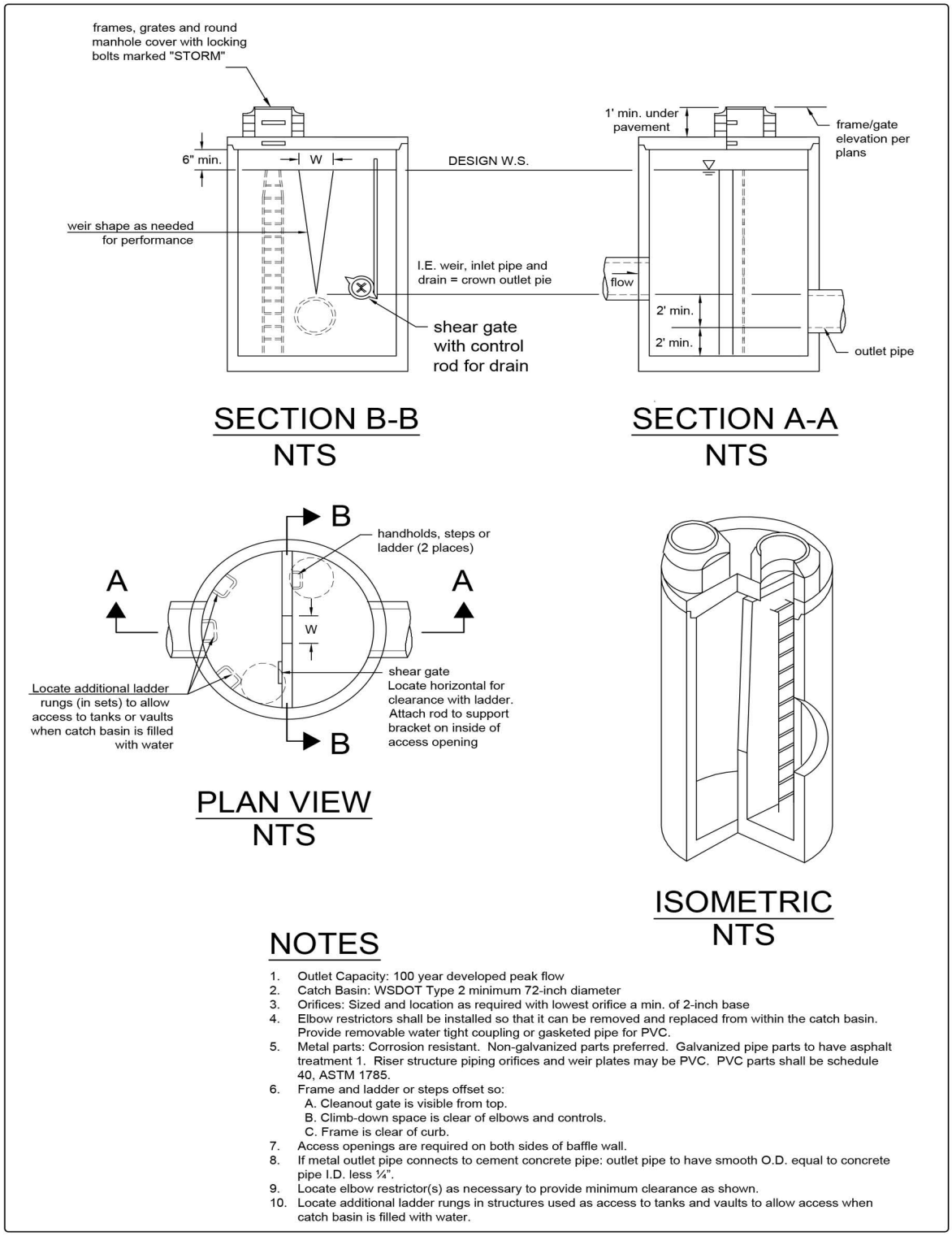


Figure 4 - 68: Flow Restrictor (Weir)

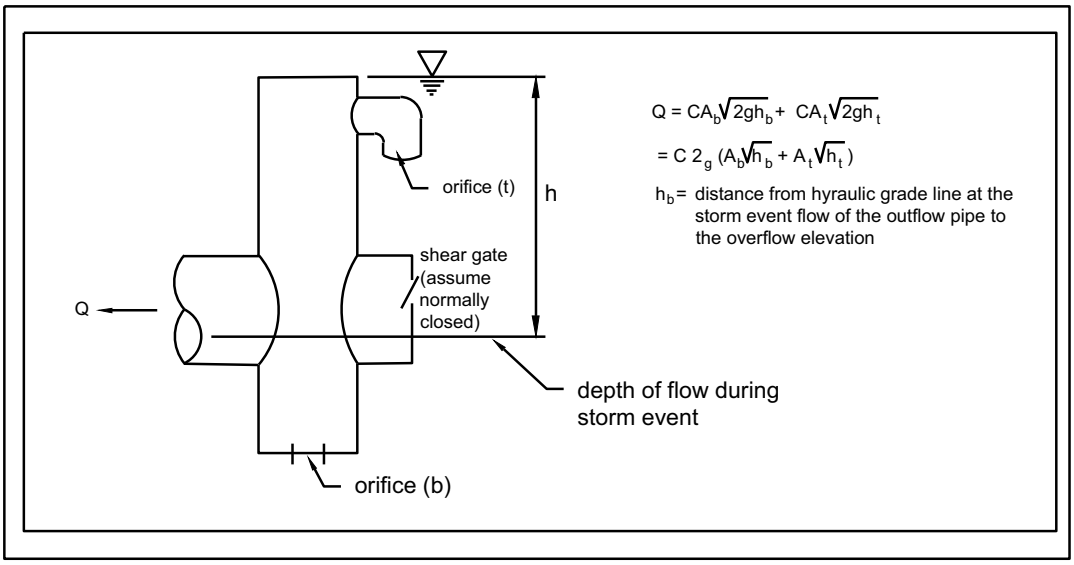


Figure 4 - 69: Simple Orifice

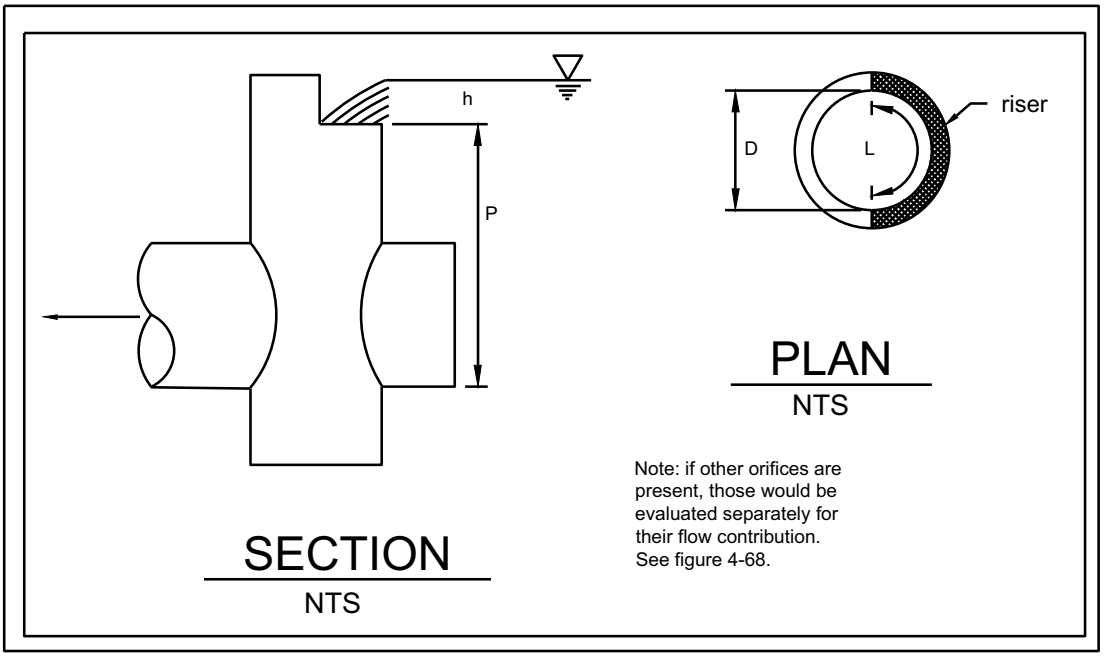


Figure 4 - 70: Rectangular, Sharp-Crested Weir

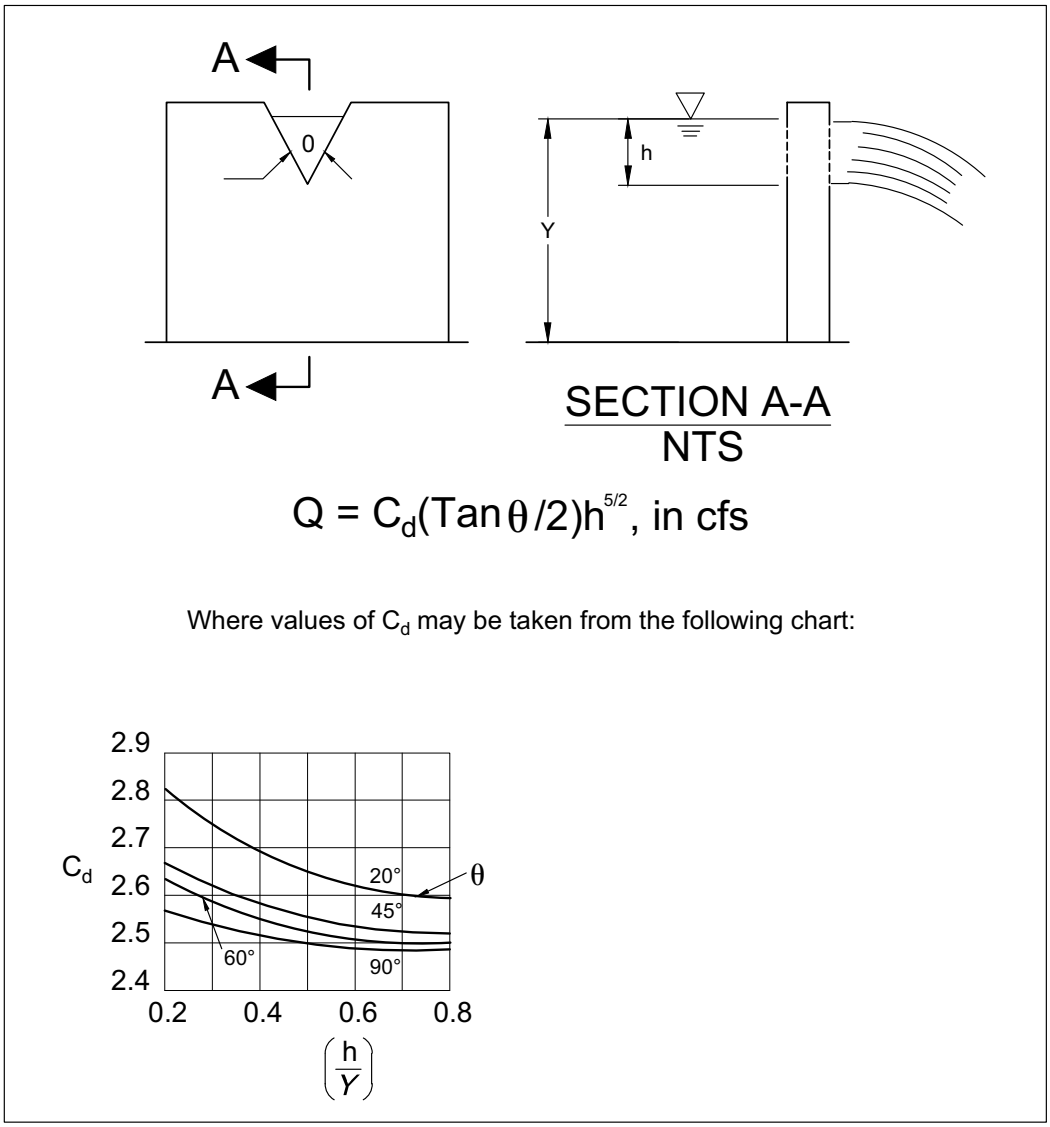


Figure 4 - 71: V-Notch, Sharp-Crested Weir

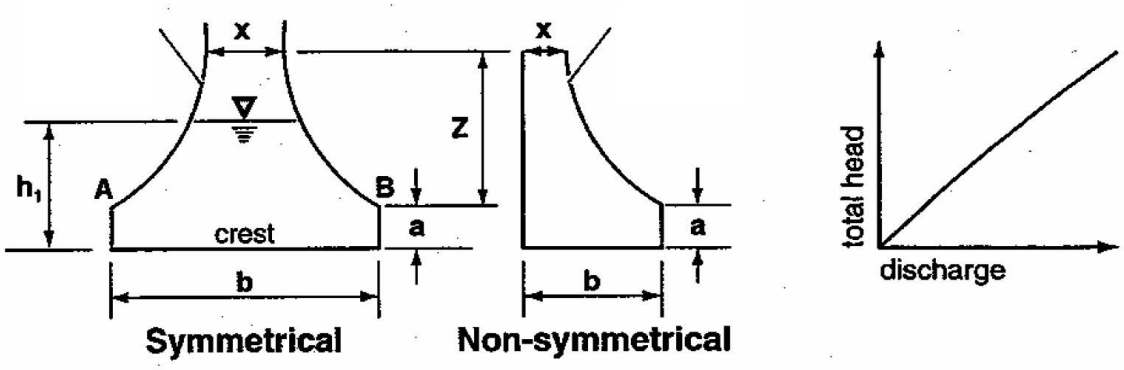


Figure 4 - 72: Sutro Weir

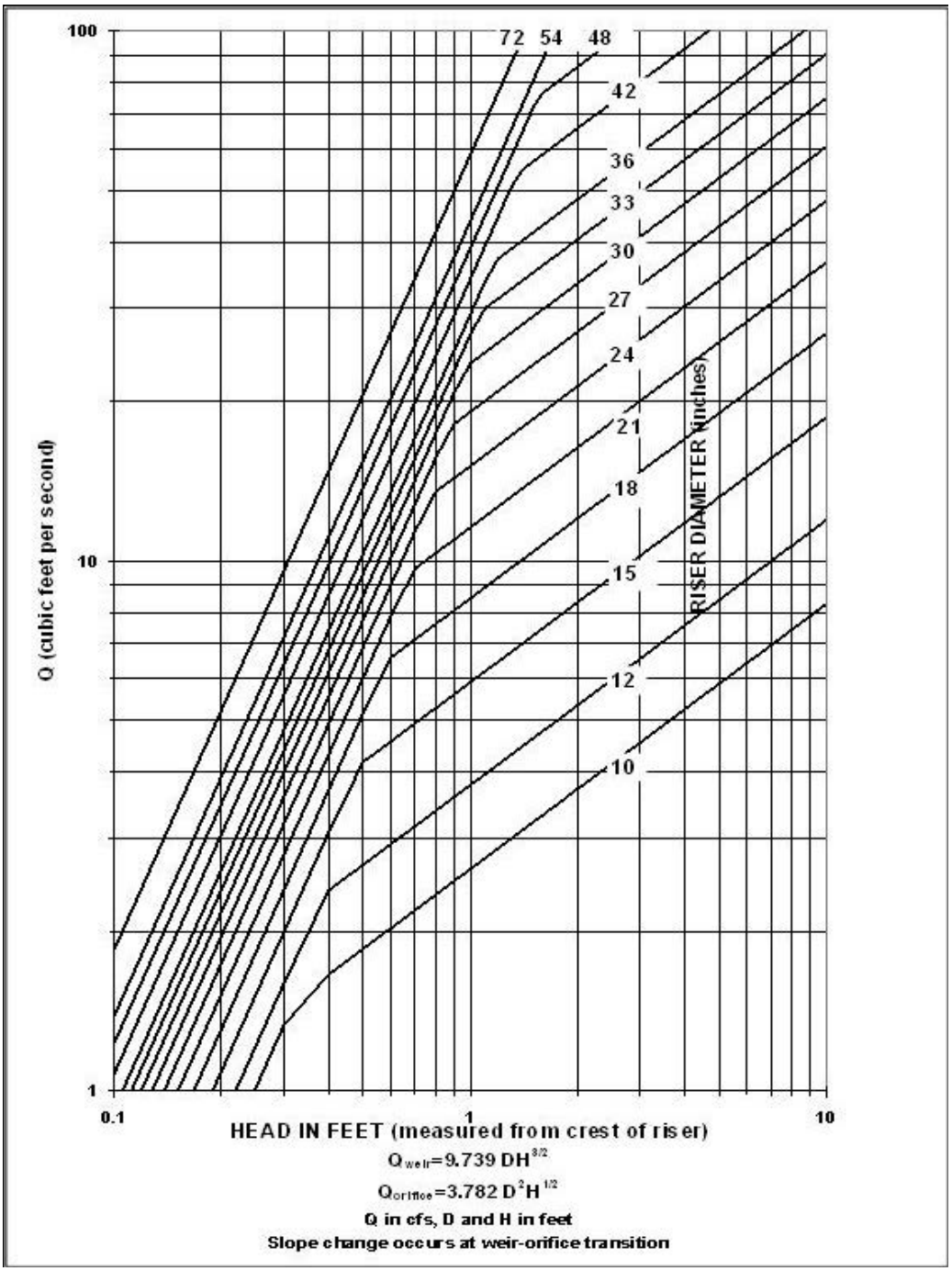


Figure 4 - 73: Riser Inflow Curves

21.6 A600: Emergency Overflow Spillway

21.6.1 Description

Emergency overflow spillways control the location of stormwater facility overtopping and direct overflow to the downstream conveyance system or other acceptable location.

21.6.2 Design Criteria

Comply with all criteria and standards in Modeling Your Best Management Practices, Design Criteria for All Stormwater Treatment and Flow Control BMPs, Constructing Your Best Management Practices and Accessing and Maintaining Your Best Management Practices as applicable to the project in addition to criteria within each BMP. Where criteria or standards conflict, utilize the criteria and standards contained within the specific BMP.

- Armor the emergency overflow spillway with riprap per A400: End of Pipe Discharge Protection. Armor the full width, beginning at a point midway across the berm embankment and extending downstream to where emergency overflows reenter the conveyance system.
- Design the overflow spillway as a broad crested weir designed to pass the 100-year storm event for the developed condition and to allow a minimum of 1 foot of freeboard above the maximum design storm water surface level. A sizing spreadsheet is available at tacoma.gov/stormwatermanual, this spreadsheet uses the equation below.

$$Q_{100} = C2g^{\frac{1}{2}}\left[\frac{2}{3}LH^{\frac{3}{2}} + \frac{8}{15}(\tan\theta)H^{\frac{5}{2}}\right]$$

Where:

Q_{100} = peak flow for the 100-year runoff event (ft^3/s)

Q_{100} is calculated by either:

An Ecology approved continuous simulation model, assuming a 15-minute timestep, to obtain the 100-year return period flowrate.

A single event model to obtain the peak volumetric flowrate from the 100-year, 24-hour storm event, assuming a Type 1A distribution using the SCS (TR-20) method. The 100-year, 24-hour storm event in the City of Tacoma is 4.1".

C = discharge coefficient = 0.6

g = gravity = 32.2 ft/s^2

L - length of weir (ft)

H - height of water over weir (ft)

θ - angle of side slopes

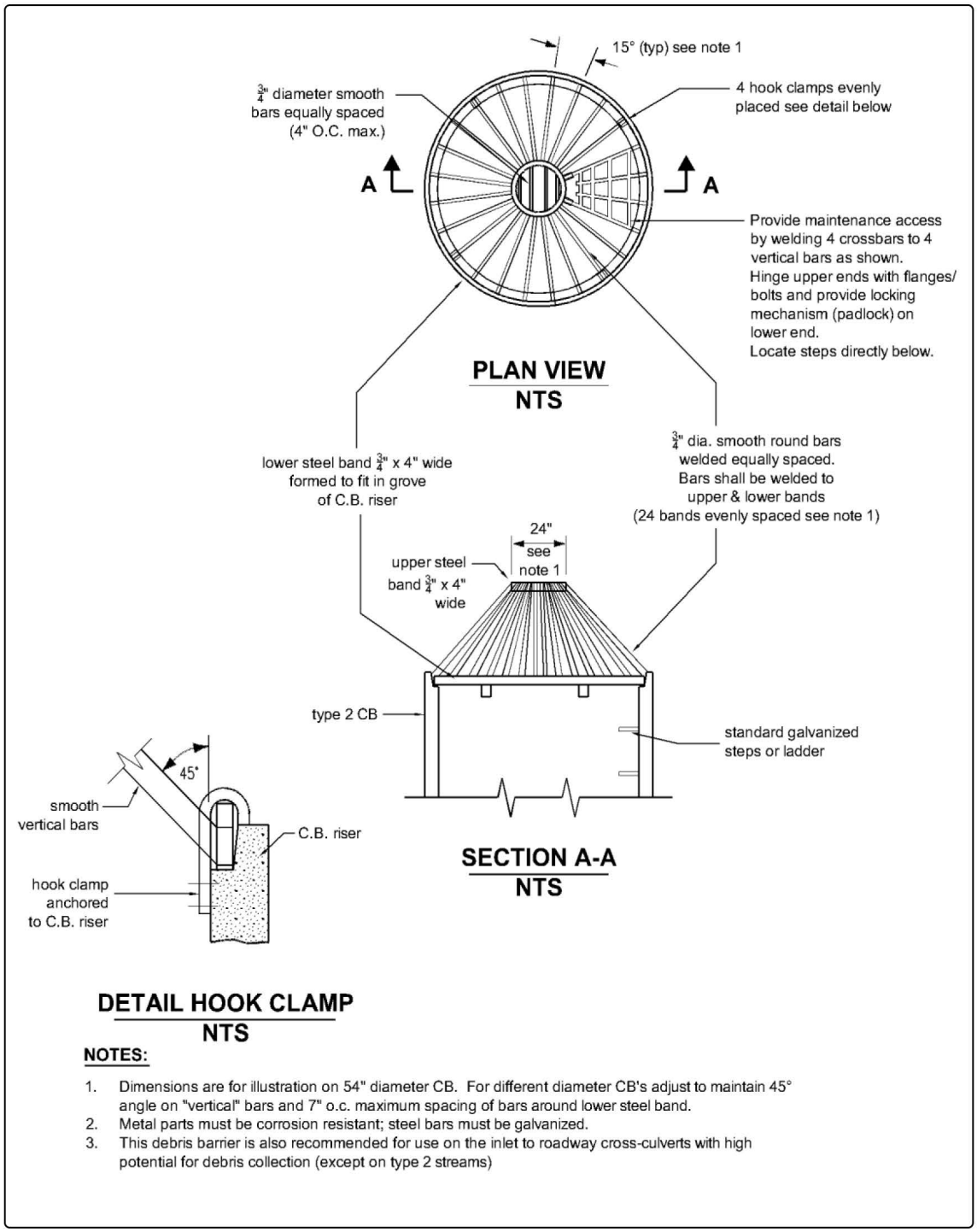
Assuming C is 0.6 and Tan θ = 3

$$Q_{100} = 3.21\left[LH^{\frac{3}{2}} + 2.4H^{\frac{5}{2}}\right]$$

To find L, the equation is rearranged to use Q100 and trial versions of H set at 0.2 feet minimum.

$$L = \left[\frac{Q_{100}}{3.21H^{\frac{3}{2}}}\right] - 2.4H$$

- The minimum width shall be 6 feet.
- Facilities regulated as dams must size the emergency overflow spillway per the Washington State Dam Safety Requirements available at http://www.ecology.wa.gov/Water-Shorelines/Water-supply/Dams
- Where an emergency overflow spillway would discharge to slopes steeper than 15%, an emergency overflow structure may be more appropriate. For facilities with berms less than 2 feet in height and located at grades less than 5%, the emergency overflow may be provided by an emergency overflow structure. Figure 4 - 74: Overflow Structure provides an example of an emergency overflow structure.
  - The emergency overflow structure must be sized to pass the 100-year developed peak volumetric flowrate calculated using a 10-minute timestep from a Type 1A, 100-year, 24-hour frequency storm using a single event model (SCS - TR20) or the 100-year return period flowrate as estimated using an Ecology-approved continuous simulation model, assuming a 15-minute timestep with a minimum 6" of freeboard.



NOTES:

1. Dimensions are for illustration on 54" diameter CB. For different diameter CB's adjust to maintain 45° angle on "vertical" bars and 7" o.c. maximum spacing of bars around lower steel band.
2. Metal parts must be corrosion resistant; steel bars must be galvanized.
3. This debris barrier is also recommended for use on the inlet to roadway cross-culverts with high potential for debris collection (except on type 2 streams)

Figure 4 - 74: Overflow Structure

21.7 A700: Fencing

Fences shall be constructed as appropriate for the given project and property. Consideration shall be given for the use of the property and must take into account any federal, state, or local requirements.

Fences shall be built at the emergency overflow water surface elevation or higher.

It is recommended that fences be 6 feet in height for ponds or 4 feet if the depth of the pond from bottom elevation to emergency overflow water surface elevation is 5 feet or less.

Access to the facility shall be a consideration. Fencing must include swinging gates large enough for truck access when necessary. Pedestrian access gates shall be a minimum of 4 feet in width.

See https://www.tacomapermits.org/tip-sheet-index/fences for additional information about fence construction and permitting.

21.8 A800: Signage

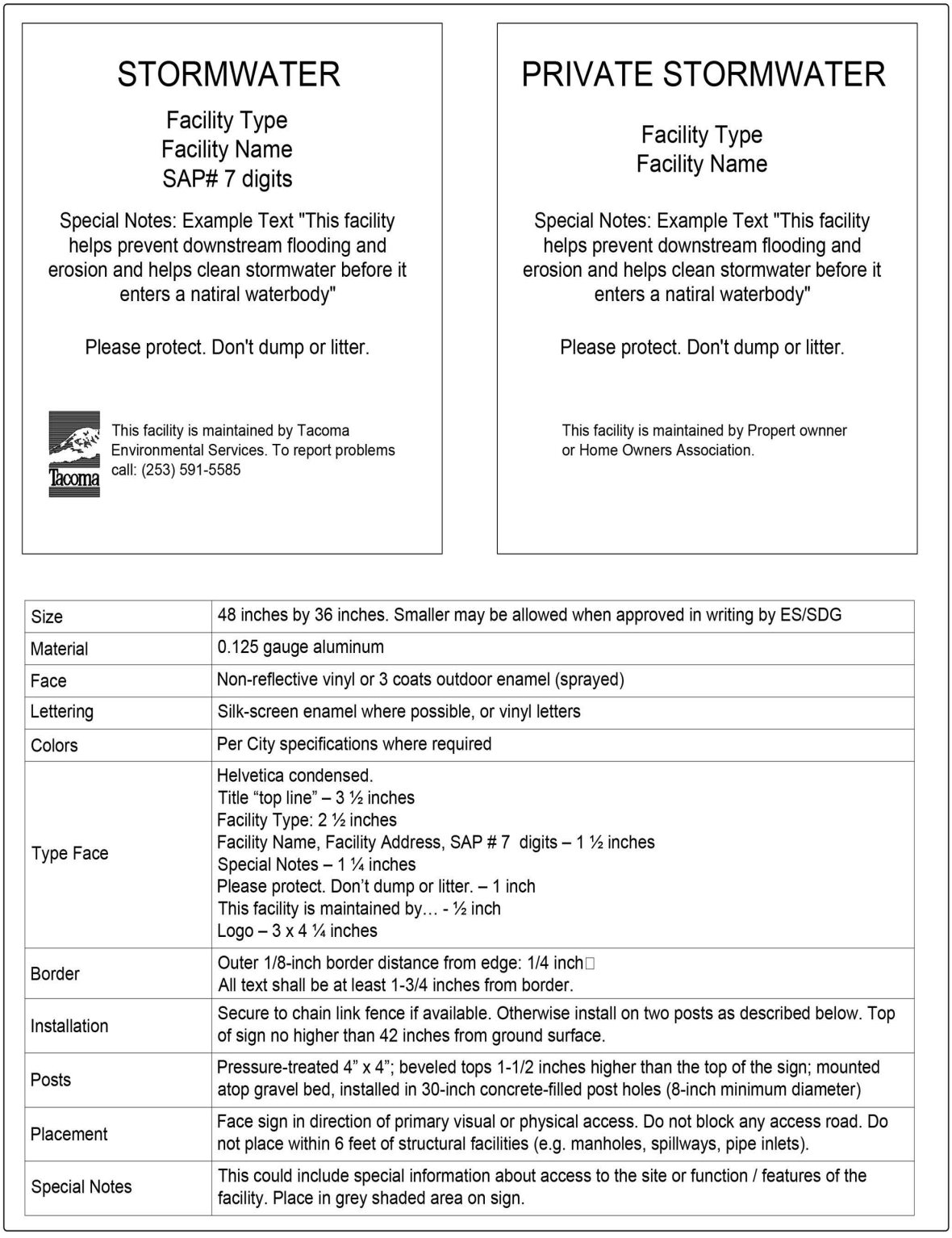
Stormwater facility signs shall provide a brief description of the stormwater facility and provide contact information for facility maintenance needs.

Place sign for maximum visibility. Consideration shall be given for the use of the property when determining appropriate materials and location for signage.

The City of Tacoma has a template that can be used for both public and provide stormwater facilities - tacoma.gov/stormwatermanual. Public stormwater facility signs shall utilize the template.

See https://www.tacomapermits.org/tip-sheet-index/sign-permits for additional permitting information about signs. Signs associated with stormwater facilities should generally be exempt from any permit requirements.

Figure 4 - 75: Stormwater Facility Sign example below provides an example of a sign.



Size	48 inches by 36 inches. Smaller may be allowed when approved in writing by ES/SDG
Material	0.125 gauge aluminum
Face	Non-reflective vinyl or 3 coats outdoor enamel (sprayed)
Lettering	Silk-screen enamel where possible, or vinyl letters
Colors	Per City specifications where required
Type Face	Helvetica condensed. Title “top line” – 3 ½ inches Facility Type: 2 ½ inches Facility Name, Facility Address, SAP # 7 digits – 1 ½ inches Special Notes – 1 ¼ inches Please protect. Don’t dump or litter. – 1 inch This facility is maintained by… - ½ inch Logo – 3 x 4 ¼ inches
Border	Outer 1/8-inch border distance from edge: 1/4 inch All text shall be at least 1-3/4 inches from border.
Installation	Secure to chain link fence if available. Otherwise install on two posts as described below. Top of sign no higher than 42 inches from ground surface.
Posts	Pressure-treated 4” x 4”; beveled tops 1-1/2 inches higher than the top of the sign; mounted atop gravel bed, installed in 30-inch concrete-filled post holes (8-inch minimum diameter)
Placement	Face sign in direction of primary visual or physical access. Do not block any access road. Do not place within 6 feet of structural facilities (e.g. manholes, spillways, pipe inlets).
Special Notes	This could include special information about access to the site or function / features of the facility. Place in grey shaded area on sign.

Figure 4 - 75: Stormwater Facility Sign

21.9 A900: Compost

21.9.1 Description

This section provides the compost specifications specific to BMPs throughout the SWMM and is arranged in a table format for ease of use. Refer to the specific BMP for all other design and material specifications.

Table 4 - 40: Compost Specifications

BMP C120: Temporary and Permanent Seeding

Compost shall:

- Meet the definition for "composted material" per WAC 173-350-100 and comply with standards in WAC 173-350-220, except the feedstock may contain biosolids or manure feedstocks.
- Have no visible water or dust during handling.
- Have soil organic matter content of 40% to 65%.
- Have a carbon to nitrogen ratio below 25:1. Carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.

  City of Tacoma TAGRO Potting Soil Mix may be used as an alternative to the compost component.

BMP C121: Mulching

Compost shall:

- Meet the definition for "composted material" per WAC 173-350-100 and comply with standards in WAC 173-350-220, except the feedstock may contain biosolids or manure feedstocks.
- Be coarse compost meeting the following size gradations (by dry weight) when tested in accordance with the U.S. Composting Council "Test Methods for the Examination of Compost and Composting" (TMECC) Test Method 02.02-B.

Sieve Size	Minimum Percent Passing
3"	100
1"	90
3/4"	70
¼"	40

- Have no visible water or dust during handling
- Have soil organic matter content of 40% to 65%.
- Have a carbon to nitrogen ratio below 25:1. Carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.

Table 4 - 40: Compost Specifications

BMP C124: Sodding

Compost shall:

- Meet the definition for "composted material" per WAC 173-350-100 and comply with standards in WAC 173-350-220, except the feedstock may contain biosolids or manure feedstocks.
- Have no visible water or dust during handling.
- Have soil organic matter content of 40% to 65%.
- Have a carbon to nitrogen ratio below 25:1. Carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.

  City of Tacoma TAGRO Potting Soil Mix may be used as an alternative to the compost component.

BMP C125: Compost

Compost shall:

- Meet the definition for "composted material" per WAC 173-350-100 and comply with standards in WAC 173-350-220, except the feedstock may contain biosolids or manure feedstocks.
- Be coarse compost meeting the following size gradations (by dry weight) when tested in accordance with the U.S. Composting Council "Test Methods for the Examination of Compost and Composting" (TMECC) Test Method 02.02-B.

Sieve Size	Minimum Percent Passing
3"	100
1"	90
3/4"	70
¼"	40

- Have no visible water or dust during handling.
- Have soil organic matter content of 40% to 65%.
- Have a carbon to nitrogen ratio below 25:1. Carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.

  City of Tacoma TAGRO Potting Soil Mix may be used as an alternative to the compost component.

BMP C126: Topsoiling

Compost shall:

- Meet the definition for "composted material" per WAC 173-350-100 and comply with standards in WAC 173-350-220, except the feedstock may contain biosolids or manure feedstocks.
- Have no visible water or dust during handling.
- Have soil organic matter content of 40% to 65%.
- Have a carbon to nitrogen ratio below 25:1. Carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.

  City of Tacoma TAGRO Potting Soil Mix may be used as an alternative to the compost component.

Table 4 - 40: Compost Specifications

BMP C231: Brush Barrier

Compost shall:

- Meet the definition for “composted material” per WAC 173-350-100 and comply with standards in WAC 173-350-220, except the feedstock may contain biosolids or manure feedstocks.
- Be coarse compost meeting the following size gradations (by dry weight) when tested in accordance with the U.S. Composting Council “Test Methods for the Examination of Compost and Composting” (TMECC) Test Method 02.02-B.

Sieve Size	Minimum Percent Passing
3”	100
1”	90
3/4”	70
¼”	40

- Have no visible water or dust during handling.
- Have soil organic matter content of 40% to 65%.
- Have a carbon to nitrogen ratio below 25:1. Carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.

  City of Tacoma TAGRO Potting Soil Mix may be used as an alternative to the compost component.

BMP C235: Wattles

Compost shall:

- Meet the definition for “composted material” per WAC 173-350-100 and comply with standards in WAC 173-350-220, except the feedstock may contain biosolids or manure feedstocks.
- Be coarse compost meeting the following size gradations (by dry weight) when tested in accordance with the U.S. Composting Council “Test Methods for the Examination of Compost and Composting” (TMECC) Test Method 02.02-B

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Sieve Size	Minimum Percent Passing
3”	100
1”	90
3/4”	70
¼”	40

- Have no visible water or dust during handling.
- Have soil organic matter content of 40% to 65%.
- Have a carbon to nitrogen ratio below 25:1. Carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region

  City of Tacoma TAGRO Potting Soil Mix may be used as an alternative to the compost component.

Table 4 - 40: Compost Specifications

BMP L613: Post-Construction Soil Quality and Depth

Compost used to meet the organic content requirements shall meet the following standards:

- Meet the definition of “composted material” in WAC 173-350-100 and complies with testing parameters and other standards in WAC 173-350-220.
- Produced at a permitted composting facility. Permitted compost facilities in Washington are included on a list available at: https://ecology.wa.gov/Waste-Toxics/Reducing-recycling-waste/Organic-materials/Managing-organics-compost
- The compost product must originate from a feedstock that contains a minimum of 65% by volume recycled plant waste comprised of “yard debris,” “crop residues,” and “bulking agents”. A maximum of 35% by volume of "post-consumer food waste" may be substituted for recycled plant waste. Compost may have up to 35% biosolids or manure. Terms are defined in WAC 173-350-100.
- Stable (low oxygen use and CO2 generation) and mature (capable of supporting plant growth) by tests shown below. This is critical to plant success in a bioretention soil mix. Moisture content range: no visible free water or dust produced when handling the material.
- Tested in accordance with U.S. Composting Council “Test Method for the Examination of Compost and Composting” (TMECC), as established in the Composting Council’s “Seal of Testing Assurance” (STA) program. Most Washington compost facilities now use these tests.
- Be fine compost meeting the following size gradation (by dry weight) when tested in accordance with TMECC test method 02.02-B, “Sample Sieving for Aggregate Size Classification.”

Sieve Size	Minimum Percent Passing
2”	100
1”	99
⅝”	90
¼”	75

- pH between 6.0 and 8.5 (TMECC 04.11-A).
- “Physical contaminants” (as defined in WAC 173-350-100) content less than 1% by weight (TMECC 03.08-A) total, not to exceed 0.25 percent film plastic by dry weight.
- Minimum organic matter content of 40% and maximum organic matter content of 65% (TMECC 05.07-A “Loss on Ignition”)
- Soluble salt content less than 4.0 dS/m (mmhos/cm) (TMECC 04.10-A “Electrical Conductivity, 1.5 Slurry Method, Mass Basis”)
- Maturity indicators from a cucumber bioassay (TMEC 05.05-A “Seedling Emergence and Relative Growth”) must be greater than 80% for both emergence and vigor
- Stability of 7 mg CO2-C/g OM/day or below (TMECC 05.08-B “Carbon Dioxide Evolution Rate”)
- Carbon to nitrogen ratio (TMECC 05.02A “Carbon to Nitrogen Ratio” which uses 04.01 “Organic Carbon” and 04.02D “Total Nitrogen by Oxidation”) of less than 25:1. The C:N ratio may be up to 35:1 for planting composed entirely of Puget Sound Lowland native species.

Table 4 - 40: Compost Specifications

BMP L601: Rain Gardens (as a component of rain garden oil mix)

Compost shall:

- Meet the definition of “composted material” in WAC 173-350-100 and complies with testing parameters and other standards in WAC 173-350-220.
- Be Fine Compost meeting the following size gradation (by dry weight) when tested in accordance with TMECC test method 02.02-B, “Sample Sieving for Aggregate Size Classification.”

Sieve Size	Minimum Percent Passing
2”	100
1”	99
5/8”	90
¼”	75

- Compost shall not include biosolids or manure.

Table 4 - 40: Compost Specifications

BMP L630: Bioretention (compost used as a component of bioretention soil mix)

Compost:

- Meets the definition of “composted material” in WAC 173-350-100 and complies with testing parameters and other standards in WAC 173-350-220.
- Produced at a permitted composting facility. Permitted compost facilities in Washington are included on a list available at: https://ecology.wa.gov/Waste-Toxics/Reducing-recycling-waste/Organic-materials/Managing-organics-compost
- The compost product must originate from a feedstock that contains a minimum of 65% by volume recycled plant waste comprised of “yard debris,” “crop residues,” and “bulking agents”. A maximum of 35% by volume of "post-consumer food waste" may be substituted for recycled plant waste. Biosolids and/or manure are not allowed. Terms are defined in WAC 173-350-100.
- Stable (low oxygen use and CO2 generation) and mature (capable of supporting plant growth) by tests shown below. This is critical to plant success in a bioretention soil mix.
- Moisture content range: no visible free water or dust produced when handling the material.
- Tested in accordance with U.S. Composting Council “Test Method for the Examination of Compost and Composting” (TMECC), as established in the Composting Council’s “Seal of Testing Assurance” (STA) program. Most Washington compost facilities now use these tests.
- Be fine compost meeting the following size gradation (by dry weight) when tested in accordance with TMECC test method 02.02-B, “Sample Sieving for Aggregate Size Classification.”.

Sieve Size	Minimum Percent Passing
2”	100
1”	99
5/8”	90
¼”	75

- pH between 6.0 and 8.5 (TMECC 04.11-A).
- “Physical contaminants” (as defined in WAC 173-350-100) content less than 1% by weight (TMECC 03.08-A) total, not to exceed 0.25 percent film plastic by dry weight.
- Minimum organic matter content of 40% (TMECC 05.07-A “Loss on Ignition”)
- Soluable salt content less than 4.0 dS/m (mmhos/cm) (TMECC 04.10-A “Electrical Conductivity, 1.5 Slurry Method, Mass Basis”)
- Maturity indicators from a cucumber bioassay (TMEC 05.05-A “Seedling Emergence and Relative Growth”) must be greater than 80% for both emergence and vigor
- Stability of 7 mg CO2-C/g OM/day or below (TMECC 05.08-B “Carbon Dioxide Evolution Rate”)
- Carbon to nitrogen ratio (TMECC 05.02A “Carbon to Nitrogen Ratio” which uses 04.01 “Organic Carbon” and 04.02D “Total Nitrogen by Oxidation”) of less than 25:1. The C:N ratio may be up to 35:1 for planting composed entirely of Puget Sound Lowland native species and up to 40:1 for coarse compost to be used as a surface mulch (not in a soil mix).

Table 4 - 40: Compost Specifications

BMP L630: Bioretention (compost used as mulch layer)
Compost used as the mulch layer in the bioretention facility shall conform to WSDOT Standard Specification 9-14.5(8) - Compost using the medium compost gradation.
BMP T1110: Wetponds - Basic and Large
Compost shall: • Meet the definition for “composted material” per WAC 173-350-100 and comply with standards in WAC 173-350-220, except the feedstock may contain biosolids or manure feedstocks. • Have no visible water or dust during handling. • Have soil organic matter content of 40% to 65%. • Have a carbon to nitrogen ratio below 25:1. Carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.
BMP F110: Detention Ponds
Compost shall: • Meet the definition for “composted material” per WAC 173-350-100 and comply with standards in WAC 173-350-220, except the feedstock may contain biosolids or manure feedstocks. • Have no visible water or dust during handling. • Have soil organic matter content of 40% to 65%. • Have a carbon to nitrogen ratio below 25:1. Carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.
A100: Liners
Compost shall: • Meet the definition for “composted material” per WAC 173-350-100 and comply with standards in WAC 173-350-220, except the feedstock may contain biosolids or manure feedstocks. • Have no visible water or dust during handling. • Have soil organic matter content of 40% to 65%. • Have a carbon to nitrogen ratio below 25:1. Carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.

Table 4 - 40: Compost Specifications

BMP T1010: Basic Biofiltration Swale
Compost shall: • Meet the definition for “composted material” per WAC 173-350-100 and comply with standards in WAC 173-350-220. • Have no visible water or dust during handling. • Have soil organic matter content of 40% to 65%. • Have a carbon to nitrogen ratio below 25:1. Carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.

Table 4 - 40: Compost Specifications

BMP T1050: Compost-Amended Vegetated Filter Strip (CAVFS)

Compost shall meet the specifications below:

- Meets the definition of “composted material” in WAC 173-350-100 and complies with testing parameters and other standards in WAC 173-350-220.
- Be produced at a permitted composting facility. Permitted compost facilities in Washington are included on a list available at https://ecology.wa.gov/Waste-Toxics/Reducing-recycling-waste/Organic-materials/Managing-organics-compost.
- The compost product must originate from a feedstock that contains a minimum of 65% by volume recycled plant waste comprised of “yard debris,” “crop residues,” and “bulking agents”. A maximum of 35% by volume of "post-consumer food waste" may be substituted for recycled plant waste. Biosolids and/or manure are not allowed. Terms are defined in WAC 173-350-100.
- Stable (low oxygen use and CO2 generation) and mature (capable of supporting plant growth) by tests shown below. This is critical to plant success.
- Moisture content range: no visible free water or dust produced when handling the material.
- Tested in accordance with U.S. Composting Council “Test Method for the Examination of Compost and Composting” (TMECC), as established in the Composting Council’s “Seal of Testing Assurance” (STA) program. Most Washington compost facilities now use these tests.
- Be fine compost meeting the following size gradation (by dry weight) when tested in accordance with TMECC test method 02.02-B, “Sample Sieving for Aggregate Size Classification.”

Sieve Size	Minimum Percent Passing
2”	100
1”	99
5/8”	90
¼”	75

- pH between 6.0 and 8.5 (TMECC 04.11-A).
- “Physical contaminants” (as defined in WAC 173-350-100) content less than 1% by weight (TMECC 03.08-A) total, not to exceed 0.25 percent film plastic by dry weight.
- Minimum organic matter content of 40% (TMECC 05.07-A “Loss on Ignition”)
- Soluble salt content less than 4.0 dS/m (mmhos/cm) (TMECC 04.10-A “Electrical Conductivity, 1.5 Slurry Method, Mass Basis”)
- Maturity indicators from a cucumber bioassay (TMEC 05.05-A “Seedling Emergence and Relative Growth”) must be greater than 80% for both emergence and vigor
- Stability of 7 mg CO2-C/g OM/day or below (TMECC 05.08-B “Carbon Dioxide Evolution Rate”)
- Carbon to nitrogen ratio (TMECC 05.02A “Carbon to Nitrogen Ratio” which uses 04.01 “Organic Carbon” and 04.02D “Total Nitrogen by Oxidation”) of less than 25:1. The C:N ratio may be up to 35:1 for planting composed entirely of Puget Sound Lowland native species. Lowland native species and up to 40:1 for coarse compost to be used as a surface mulch (not in a soil mix).

Table 4 - 40: Compost Specifications

Mulch in Stormwater Treatment BMPs (General)
Compost shall: • Meet the definition for “composted material” per WAC 173-350-100 and comply with standards in WAC 173-350-220. • Have no visible water or dust during handling.

21.10 A1000: Vegetation

21.10.1 Introduction

The chapter shows plant and seed mixes appropriate for a given situations. Consideration shall be given for visibility, amount of sunlight, irrigation, aesthetics, ease of maintenance, and slope when considering which plant/seed mixes are appropriate for a project.

21.10.2 General Maintenance Notes

- Irrigate plants for 2-3 years during the establishment period.
- Emphasize evergreen vegetation to limit debris accumulating in stormwater facilities.
- Cut back dead plant material in late fall.
- Prune to improve visibility as necessary.
- Do not plant trees where they will impact underground infrastructure or liners.

21.10.3 Seed Mixes

Tables 4-43 through 4-49 provide various recommended seed mixes.

Table 4 - 41: Seed Mix Reference shows which seed mixes are appropriate for various BMPs.

Table 4 -41: Seed Mix Reference Table

BMP	Appropriate Seed Mix Reference
BMP C120: Temporary and Permanent Seeding	Table 4 - 42: Standard Temporary Erosion Control Seed Mix Table 4 - 43: Native Temporary Erosion Control Seed Mix Table 4 - 44: Landscaping Seed Mix Table 4 - 45: Low Growing Turf Seed Mix Table 4 - 46: Native Meadow Seed Mix
BMP T1010: Basic Biofiltration Swale	Table 4 - 47: Native Basic Biofiltration Swale Seed Mix
BMP T1020: Wet Biofiltration Swale	Table 4 - 48: Native Wet Biofiltration Swale Mix
BMP T1030: Continuous Inflow Biofiltration Swale	Table 4 - 48: Native Wet Biofiltration Swale Mix

Table 4 - 42: Standard Temporary Erosion Control Seed Mix

Scientific Name	Common Name	Percent by Weight
Grasses		
Festuca rubra var. commutata	Chewings fescue	40
Lolium perenne	perennial rye	40
Agrostis capillaris	colonial bentgrass	10
Trifolium repens	white Dutch clover	10

Table 4 - 43: Native Temporary Erosion Control Seed Mix

Scientific Name	Common Name	Percent by Weight
Grasses		
Bromus carinatus	California brome	25
Deschampsia caespitosa	tufted hairgrass	15
Festuca rubra rubra	native red fescue	20
Hordeum brachyantherum	meadow barley	40

Table 4 - 44: Landscaping Seed Mix

Scientific Name	Common Name	Percent by Weight
Grasses		
Lolium perenne	perennial rye	70
Festuca rubra var. commutata	Chewings fescue	30

Table 4 - 45: Low Growing Turf Seed Mix

Scientific Name	Common Name	Percent by Weight
Grasses		
Festuca arundinaceae	dwarf tall fescue	45
Lolium perenne var. barclay	dwarf perennial rye	30
Festuca rubra	red fescue	20
Agrostis capillaris	colonial bentgrass	5

Table 4 - 46: Native Meadow Seed Mix

Scientific Name	Common Name	Percent by Weight
Grasses		
Bromus carinatus	California brome	30
Deschampsia caespitosa	tufted hairgrass	10
Elymus glaucus	blue wildrye	10
Festuca roemerii	Roemer's fescue	20
Perennials		
Achillea millefolium	yarrow	5
Eriophyllum lanatum	Oregon sunshine	5
Eschscholzia californica	California poppy	3
Lupinus bicolor	bicolor lupine	6
Solidago canadensis	Canada goldenrod	3
Annuals		
Clarkia amoena	farewell to spring	5
Gilia capitata	globe gilia	3

Table 4 - 47: Native Basic Biofiltration Swale Seed Mix

Scientific Name	Common Name	Percent by Weight
Grasses		
Beckmannia syzigachne	American slough grass	5
Danthonia californica	California oat grass	5
Deschampsia caespitosa	tufted hairgrass	15
Elymus glaucus	blue wildrye	30
Glyceria occidentalis	western mannagrass	15
Hordeum brachyantherum	meadow barley	30

Table 4 - 48: Native Wet Biofiltration Swale Mix

Scientific Name	Common Name	Percent by Weight
Grasses, Sedges, Rushes		
Beckmannia syzigachne	American slough grass	10
Carex obnupta	slough sedge	40
Carex stipata	beaked sedge	5
Eleocharis palustris	common spikerush	5
Glyceria occidentalis	western mannagrass	20
Juncus patens	spreading rush	15
Scirpus microcarpus	small-fruited bullrush	5

21.10.4 Stormwater Facility Plants

Tables 4-49 through 4-52 provide plants appropriate for stormwater facilities. Pick plants that appropriate for the individual project site.

- Table 4 - 50: General Stormwater Facility List: provides a list of recommended plants that are appropriate where there are no visibility concerns and where it is likely that plants will be regulary watered and maintained (where staff/residents work or reside).
- Table 4 - 51: High-Visibility and Low-Maintenance Stormwater Facility Plant List provides a list of recommended plants that are appropriate where visibility is a concern (such as facilities in the right-of-way).
- Table 4 - 52: Saturated Stormwater Facility List provides a list of recommended plants that are appropriate where plants will be inundated with stormwater on a regular basis.

Applicants are also encouraged to utilize the Low Impact Development Technical: Guidance for Puget Sound available at: https://www.psp.wa.gov/downloads/LID/20121221_LIDmanual_FINAL_secure.pdf and the Rain Garden Handbook for Western Washington available at https://fortress.wa.gov/ecy/publications/publications/1310027.pdf as additional references.

Table 4 - 49: Plant List BMP Reference Tableshows which plants are appropriate for various BMPs.

Table 4 - 49: Plant List BMP Reference Table

BMP	Appropriate Plant List Reference
BMP L601: Rain Gardens	Table 4 - 50: General Stormwater Facility List Table 4 - 51: High-Visibility and Low-Maintenance Stormwater Facility Plant List Table 4 - 52: Saturated Stormwater Facility List
BMP L630: Bioretention	Table 4 - 50: General Stormwater Facility List Table 4 - 51: High-Visibility and Low-Maintenance Stormwater Facility Plant List Table 4 - 52: Saturated Stormwater Facility List
BMP T1110: Wetponds - Basic and Large	Table 4 - 52: Saturated Stormwater Facility List
BMP T1130: Stormwater Treatment Wetlands	Table 4 - 50: General Stormwater Facility List Table 4 - 52: Saturated Stormwater Facility List
BMP T1140a: Combined Detention and Wetponds	Table 4 - 50: General Stormwater Facility List Table 4 - 52: Saturated Stormwater Facility List
BMP T1140c: Combined Detention and Stormwater Treatment Wetland	Table 4 - 50: General Stormwater Facility List Table 4 - 52: Saturated Stormwater Facility List

Table 4 - 50: General Stormwater Facility List

Scientific Name	Common Name	Zone			Exposure			Evergreen PNW Native		Mature Height	O.C. Spacing	Notes
		1	2	3	shade	p/s	sun					
Trees												
Acer circinatum	vine maple			X	●	◗		N	Y	20’-25’	15’	multi stemmed tree, attractive fall foliage
Arbutus unedo 'compacta'	dwarf strawberry tree			X		◗	O	Y	N	6’-8’	10’	bright red-orange berries, adds winter interest
Frangula purshiana	cascara		X	X		◗	O	N	Y	15’-20’	15’	high wildlife value
Parrotia persica	Persian ironwood			X		◗	O	N	N	25’-30’	15’	multi-stemmed tree, attractive fall foliage
Xanthocyparis nootkatensis	weeping Alaska yellow cear			X		◗	O	Y	N	20’-30’	15’	slender evergreen adds winter interest
Shrubs												
Cornus stolonifera 'kelseyii'	Kelsey redstem dogwood	X	X	X		◗	O	N	Y	2’-3’	3’	red stems add winter interest
Gaultheria shallon	salal		X	X		◗	O	Y	Y	2’-3’	3’	blue-purple berries, spreads well in shade
Lavandula angustifolia	English lavendar			X		◗	O	Y	N	2’-3’	3’	high pollinator value, aromatic
Mahonia aquifolium	tall Oregon-grape		X	X		◗	O	Y	Y	5’-7’	3’	durable, high wildlife value

Table 4 - 50: General Stormwater Facility List

Scientific Name	Common Name	Zone			Exposure			Evergreen PNW Native		Mature Height	O.C. Spacing	Notes
		1	2	3	shade	p/s	sun					
Mahonia nervosa	low Oregon-grape		X	X	●	◗		Y	Y	1’-2’	2’	high wildlife value, performs well in shade
Mahonia repens	creeping Oregon-grape		X	X		◗	O	Y	Y	1’-2’	2’	high wildlife value, drought tolerant
Morella californica	Pacific wax myrtle	X	X	X		◗	O	Y	Y	10’-20’	10’	needs room to grow, prunes well
Physocarpus capitatus	Pacific ninebark	X	X	X		◗	O	N	Y	8’-10’	6’	may require pruning, exfoliating bark
Ribes sanguineum	red-flowering currant		X	X		◗	O	N	Y	6’-8’	3’	high wildlife value, pink-red spring flowers attract hummingbirds
Symphoricar-pos albus	snowberry		X	X	●	◗	O	N	Y	3’-5’	3’	white berries add winter interest
Spiraea japonica	Japanese meadow-sweet	X	X	X		◗	O	N	N	3’-4’	3’	pink flowers, compact varieties
Vaccinium ovatutm	evergreen huckleberry		X	X	●	◗	O	Y	Y	5’-8’	3’	high wildlife value, edible fruits, slow-growing
Grasses, Sedges, and Rushes												
Carex obnupta	slough sedge	X	X		●	◗	O	Y	Y	2’-5’	2’	spreads well in moist to wet areas, pollution tolerant

Table 4 - 50: General Stormwater Facility List

Scientific Name	Common Name	Zone			Exposure			Evergreen PNW Native		Mature Height	O.C. Spacing	Notes
		1	2	3	shade	p/s	sun					
Carex stipata	beaked sedge	X	X			◗	O	N	Y	2'-3'	3'	high wildlife value
Carex testacea	orange New Zealand sedge	X	X	X		◗	O	N	N	1'-2'	2'	orange-bronze color adds year round interest
Deschampsia caespitosa	tufted hairgrass	X	X	X		◗	O	N	Y	2'-3'	3'	clump-forming cool season grass
Juncus effusus	soft rush	X	X			◗	O	Y	Y	1'-4'	3'	spreads aggressively in moist areas
Juncus ensifolius	dagger-leaf rush	X	X				O	Y	Y	<1'	1'	flattened stems, high wildlife value
Juncus patens	spreading rush	X	X			◗	O	Y	Y	1'-2'	2'	blue-green foliage, spreads well in moist areas
Juncus tenuis	path rush	X	X			◗	O	Y	Y	1'-2'	2'	bright green foliage
Ground Covers, Perennials, and Ferns												
Achillea millefolium	yarrow			X	●	◗	O	N	Y	1'-3'	3'	high pollinator value, aromatic foliage
Aquilegia formosa	columbine			X		◗	O	N	Y	1'-2'	2'	cut back at end of season
Arctostaphy-los uva-ursi	kinnikinnick		X	X			O	Y	Y	<1'	2'	low-growing evergreen, white-pink flowers

Table 4 - 50: General Stormwater Facility List

Scientific Name	Common Name	Zone			Exposure			Evergreen PNW Native		Mature Height	O.C. Spacing	Notes
		1	2	3	shade	p/s	sun					
Camus quamash	camas		X	X		◗	O	N	Y	<1’	1’	blue flowers add spring interest, dies back after flowering
Ceanothus gloriosus	Pt. Reyes Ceanothus		X	X			O	Y	Y	<1’	3’	high pollinator value
Echinacea purpurea	purple coneflower		X	X		◗	O	N	N	2’-3’	2’	high pollinator value, cut back at end of season
Fragaria chiloensis	coast strawberry		X	X		◗	O	Y	Y	<1’	1’	glossy leaves, spreads quickly by runners
Heuchera spp.	coral bells		X	X	●	◗		N	N	<1’	1’	many varieties with colorful foliage, trim dead leaves and flowers
Iris douglasiana	Douglas iris	X	X	X		◗	O	N	Y	1’-2’	2’	cut back at end of season
Polystichum munitum	sword fern		X	X	●	◗		Y	Y	2’-3’	2’	large evergreen fronds add winter interest and structure
Rudbeckia fulgida	black-eyed susan		X	X		◗	O	N	N	1’-2’	2’	yellow flowers throughout sumer, cut back at end of season

Table 4 - 50: General Stormwater Facility List

Scientific Name	Common Name	Zone			Exposure			Evergreen PNW Native		Mature Height	O.C. Spacing	Notes
		1	2	3	shade	p/s	sun					
Sedum 'autumn joy'	Autumn joy stonecrop			X			O	N	N	1’-2’	2’	pink flowers add fall interest, cut back at end of season
Sedum reflexum	reflexed stonecrop			X			O	Y	Y	<1’	1’	low-growing, spreads well in dry areas and between rocks
Solidago canadensis	Canada goldenrod		X	X		◗	O	N	Y	2’-3’	2’	yellow flowers add late summer interest, high pollinator value
Solidago canadensis	Douglas aster		X	X		◗	O	N	Y	2’-3’	2’	high pollinator value, cut back at end of season
Tolmeia menziesii	youth-on-age		X	X	●	◗		N	Y	<1’	1’	spreads well in moist areas, trim dead leaves and flowers

Table 4 - 51: High-Visibility and Low-Maintenance Stormwater Facility Plant List

Scientific Name	Common Name	Zone			Exposure			Evergreen PNW Native		Mature Height	O.C. Spacing	Notes
		1	2	3	shade	p/s	sun					
Shrubs												
Cornus sericea 'kelseyii'	Kelsey redstem dogwood	X	X	X		◗	O	N	Y	2'-3'	3'	compact form, red stems add winter interest
Gaultheria shallon	salal		X	X	●	◗		Y	Y	2'-3'	3'	blue-purple berries, spreads well in shade
Mahonia nervosa	low Oregon grape		X	X	●	◗		Y	Y	1'-2'	2'	high wildlife value, performs well in shade
Mahonia repens	creeping Oregon grape		X	X		◗	O	Y	Y	1'-2'	2'	high wildlife value, drought tolerant
Symphoricar-pos albus	snowberry		X	X	●	◗	O	N	Y	3'-5'	3'	white berries add winter interest
Grasses, Sedges, and Rushes												
Carex obnupta	slough sedge	X	X		●	◗	O	Y	Y	2'-4'	3'	spreads well in moist to wet areas, pollution tolerant
Juncus effusus	soft rush	X	X			◗	O	Y	Y	1'-4'	3'	spreads aggressively in moist areas
Juncus ensifolius	dagger-leaf rush	X	X			◗	O	Y	Y	<1'	1'	flattened stems, high wildlife value
Juncus patens	spreading rush	X	X			◗	O	Y	Y	1'-2'	3'	blue-green foliage, spreads well in moist areas

Table 4 - 51: High-Visibility and Low-Maintenance Stormwater Facility Plant List

Scientific Name	Common Name	Zone			Exposure			Evergreen PNW Native		Mature Height	O.C. Spacing	Notes
		1	2	3	shade	p/s	sun					
Ground Covers, Perennials, and Ferns												
Arctostaphy-los uva-ursi	kinnikinnick		X	X			O	Y	Y	<1’	2’	low-growing evergreen, white-pink flowers
Ceanothus gloriosus	Pt. Reyes Ceanothus		X	X		◗	O	Y	Y	<1’	3’	blue flowers add spring interest, dies back after flowering
Fragaria chiloensis	coast strawberry		X	X		◗	O	Y	Y	<1’	1’	glossy leaves, spreads quickly by runners
Polystichum munitum	sword fern		X	X	●	◗		Y	Y	2’-3’	2’	large evergreen fronds add winter interest and structure
Sedum reflexum	reflexed stonecrop			X			O	Y	Y	<1’	1’	low-growing, spreads well in dry areas and between rocks

Table 4 - 52: Saturated Stormwater Facility List

Scientific Name	Common Name	Zone			Exposure			Evergreen PNW Native		Mature Height	O.C. Spacing	Notes
		1	2	3	shade	p/s	sun					
Grasses, Sedges, and Rushes												
Carex obnupta	slough sedge	saturated			●	◗	O	Y	Y	2’-5’	2’	spreads well in moist to wet areas, pollution tolerant
Carex stipata	beaked sedge	saturated				◗	O	N	Y	2’-3’	3’	high wildlife value
Eleocharis palustris	creeping spikerush	saturated					O	N	Y	1-3’	2’	forms small clumps
Schoenoplectus acutus	hardstem bulrush	saturated					O	N	Y	3’-6’	2’	spreads well in wet areas
Scirpus microcarpus	panicled bulrush	saturated					O	Y	Y	2’-3’	1’	persistent spiky flowers, spreads well in moist to wet areas
Shrubs												
Cornus stolonifera	redosier dogwood	saturated				◗	O	N	Y	7’-9’	6’	native form, spreads aggressively in moist to wet areas
Spiraea douglasii	Douglas spiraea	saturated				◗	O	N	Y	4’-7’	5’	spreads aggressively in moist to wet areas, pink flowers

21.11 A2000: Geotextile Specifications

Table 4 - 53: Geotextile Properties for Underground Drainage

Geotextile Property Requirements[1]			
Low Survivability			Moderate Survivability
Geotextile Property	**Test Method**	**Woven/Nonwoven**	**Woven/Nonwoven**
Grab Tensile Strength, min. in machine and x-machine direction	ASTM D4632	180 lbs/115 lbs min.	250 lbs/160 lbs min.
Grab Failure Strain, in machine and x-machine direction	ASTM D4632	<50%/>50%	<50%/>50%
Seam Breaking Strength (if seams are present)	ASTM D4632 and ASTM D4884 (adapted for grab test)	160 lbs/100 lbs min.	220 lbs/140 lbs min.
Puncture Resistance	ASTM D6241	370 lbs/220 lbs min.	495 lbs/310 lbs min.
Tear Strength, min. in machine and x-machine direction	ASTM D4533	67 lbs/40 lbs min.	80 lbs/50 lbs min.
Ultraviolet (UV) Radiation stability	ASTM D4355	50% strength retained min., after 500 hrs. in a xenon arc device	50% strength retained min., after 500 hrs. in a xenon arc device
NOTES: (1) All geotextile properties are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in the table).			

Table 4 - 54: Geotextile for Underground Drainage Filtration Properties (Same as WSDOT Standard Specification 9-33.2(1) - Table 1)

Geotextile Property Requirements[1]				
Geotextile Property	**Test Method**	**Class A**	**Class B**	**Class C**
AOS[2]	ASTM D4751	#40 sieve max	#60 sieve max	#80 sieve max
Water Permittivity	ASTM D4491	.5 sec -1 min.	.4 sec -1 min.	.3 sec -1 min.
NOTES: (1) All geotextile properties are minimum average roll values (i.e. the test result for any sampled roll in a lot shall meet or exceed the values shown in the table). (2) Apparent Opening Size (measure of diameter of the pores in the geotextile).				

Table 4 - 55: Geotextile Strength Properties for Impermeable Liner Protection (Same as WSDOT Standard Specification 9-33.2(1) - Table 2.)

Geotextile Property	Test Method	Geotextile Property Requirements[(1)]
Grab Tensile Strength, min. in machine and x-machine direction	ASTM D4632	250 lbs min.
Grab Failure Strain, in machine and x-machine direction	ASTM D4632	>50%
Seam Breaking Strength (if seams are present)	ASTM D4632 and ASTM D4884 (adapted for grab test)	220 lbs min.
Puncture Resistance	ASTM D4833	125 lbs min.
Tear Strength, min. in machine and x-machine direction	ASTM D4533	90 lbs min.
Ultraviolet (UV) Radiation	ASTM D4355	50% strength stability retained min., after 500 hrs. in a xenon arc device

NOTES:
[(1)] All geotextile properties are minimum average roll values (i.e., the test resut for any sampled roll in a lot shall meet or exteed the values shown in the table).

21.12 A3000: Access Ramps and Roads

21.12.1 Access Roads

Access roads shall:

- Be a maximum 15% grade.
- Have a minimum 40 foot outside turning radius.
- Be a minimum of 15 feet wide on curves and a minimum of 12 feet wide on straight sections.
- Provide a paved apron where the access road connects to paved roads.
- Be constructed with permeable pavement, gravel, modular grid pavement, asphalt, or concrete.
- The drivable surface should have a 20-year design life to carry the load of a 24-ton truck; assume three trips per year. Provide a basis for surfacing design.
- Be limited by a double posted gate or bollards to discourage vehicular use.
- A truck turnaround may be necessary.

21.12.2 Access Ramps

Access ramps shall:

- Be sufficient to provide sediment removal with a trackhoe and truck.
- Extend as far into the facility as necessary to allow for maintenance.
- Be a maximum of 15% slope.
- Be constructed with permeable pavement, gravel, modular grid pavement, asphalt, or concrete.
- The driveable surface should have a 20-year design life to carry the load of a 24-ton truck; assume three trips per year. Provide a basis for surfacing design.
- Be limited by a double posted gate or bollards to discourage vehicular use

Appendix A Determining the Design Infiltration Rate

A.1 Design Infiltration Rate Steps

For BMPs that are designed to infiltrate, facility size is based upon the design infiltration rate. In order to determine the design infiltration rate, first determine the measured (initial) saturated hydraulic conductivity (K_{sat}) of the soil. Once the measured saturated hydraulic conductivity is measured, calculation of the design infiltration rate is required.

Methods for determining the initial and design rates are provided below.

A.2 Determining the Measured Infiltration Rate

Use one of the following three methods to determine the measured infiltration rate. The method used is dependent upon the BMP proposed. Review the design criteria for the BMP proposed to determine which method to use. The value obtained from either the Large Scale Pilot Infiltration Test, Small Scale Pilot Infiltration Test, or Soil Grain Size Analysis is then used to calculate the Design Infiltration Rate (Section A.3).

A.2.1 Large Scale Pilot Infiltration Test (PIT)

Large-scale in-situ infiltration measurements, using the Pilot Infiltration Test (PIT) described below is the preferred method for estimating the measured infiltration rate (Ksat - measured) of the soil profile beneath the proposed infiltration facility. While we note that infiltration rate is not the same as saturated hydraulic conductivity, for the purpose of this guidance, they are synonymous.The PIT reduces some of the scale errors associated with relatively small-scale double ring infiltrometer or “stove-pipe” infiltration tests. It is not a standard test but rather a practical field procedure recommended by Ecology’s Technical Advisory Committee.

A.2.1.1 Infiltration Test Method and Requirements

Conduct testing between December 1 and April 1.

The horizontal and vertical locations of the test pit shall be surveyed by a Washington State Licensed Land Surveyor with location clearly shown in the Soils Report.

Steps:

1. Excavate the test pit to the estimated bottom surface elevation of the proposed infiltration facility where the infiltration facility meets the native soil. If the native soil has to meet subgrade compaction requirements (such as needed for BMP L633: Permeable Pavements), compact the native soil prior to testing. Lay back the slopes sufficiently to avoid caving and erosion during the test. Alternatively, consider shoring the sides of the test pit.
2. The horizontal surface area of the bottom of the test pit should be approximately 100 square feet. Accurately document the size and geometry of the test pit.
3. Install a vertical measuring rod (minimum 5-ft. long) marked in half-inch increments in the center of the pit bottom.
4. Use a rigid 6-inch diameter pipe with a splash plate on the bottom to convey water to the pit and reduce side-wall erosion or excessive disturbance of the pond bottom. Excessive erosion and bottom disturbance will result in clogging of the infiltration receptor and yield lower than actual infiltration rates.

5. Add water to the pit at a rate that will maintain a water level between 6 and 12 inches above the bottom of the pit. A rotameter can be used to measure the flowrate into the pit

   Note: The depth should not exceed the proposed maximum depth of water expected in the completed facility. For infiltration facilities serving large contributing areas, designs with multiple feet of standing water can have infiltration tests with greater than 1 foot of standing water.

6. Every 15-30 min, record the cumulative volume and instantaneous flowrate in gallons per minute necessary to maintain the water level at the same point on the measuring rod.
7. Keep adding water to the pit until one hour after the flow rate into the pit has stabilized (constant flowrate; a goal of 5% variation or less variation in the total flow) while maintaining the same pond water level. The total of the pre-soak time plus one hour after the flowrate has stabilized should be no less than 6 hours.
8. After the flowrate has stabilized for at least one hour, turn off the water and record the rate of infiltration (the drop rate of the standing water) in inches per hour from the measuring rod data, until the pit is empty. Consider running this falling head phase of the test several times to estimate the dependency of infiltration rate with head.
9. At the conclusion of testing, over-excavate the pit to see if the test water is mounded on shallow restrictive layers or if it has continued to flow deep into the subsurface. The depth of over-excavation varies depending on soil type and depth to hydraulic restricting layer, and is determined by the design engineer or certified soils professional. Mounding is an indication that a mounding analysis is necessary.

A.2.1.2 Data Analysis

1. Calculate and record the saturated hydraulic conductivity rate in inches per hour in 30 minutes or one-hour increments until one hour after the flow has stabilized.
2. Use statistical/trend analysis to obtain the hourly flowrate when the flow stabilizes. This would be the lowest hourly flowrate.

A.2.2 Small Scale Pilot Infiltration Test (PIT)

A.2.2.1 Infiltration Test

- Use the same procedure as used for the Large Scale Pilot Infiltration Test with the following changes:
  - The side slopes must be laid back sufficiently to avoid caving and erosion during the test. However, the side slopes for the depth of ponding (6" - 12") during the test should be vertical.
  - The horizontal surface area of the bottom of the test pit should be 12 to 32 square feet. It may be circular or rectangular, but accurately document the size and geometry of the test pit.
  - The rigid pipe with splash plate may be a 3 inch diameter pipe for pits on the smaller end of the recommended surface area, and a 4 inch pipe for pits on the larger end of the recommended surface area.

- Pre-soak period: Add water to the pit so that there is standing water for at least 6 hours. Maintain the pre-soak water level at least 12 inches above the bottom of the pit. If standing water cannot be measured after 30 minutes and while maintaining a flowrate greater than or equal to 50 gallons per minute, the presoak period can be terminated early.
- At the end of the pre-soak period, add water to the pit at a rate that will maintain a 6-12 inch water level above the bottom of the pit over a full hour. The depth should not exceed the proposed maximum depth of water expected in the completed facility.
- Every 15 minutes, record the cumulative volume and instantaneous flowrate in gallons per minute necessary to maintain the water level at the same point (between 6 inches and 1 foot) on the measuring rod. The specific depth should be the same as the maximum designed ponding depth (usually 6 – 12 inches).
- After one hour, turn off the water and record the rate of infiltration (the drop rate of the standing water) in inches per hour from the measuring rod data, until the pit is empty.
- A self-logging pressure sensor may also be used to determine water depth and drain-down.
- At the conclusion of testing, over-excavate the pit to see if the test water is mounded on shallow restrictive layers or if it has continued to flow deep into the subsurface. The depth of excavation varies depending on soil type and depth to hydraulic restricting layer, and is determined by the design engineer or certified soils professional. The soils professional should judge whether a mounding analysis is necessary.

A.2.2.2 Data Analysis

1. Calculate and record the saturated hydraulic conductivity rate in inches per hour in 30 minute or one-hour increments until one hour after the flow has stabilized.
2. Use statistical/trend analysis to obtain the hourly flowrate when the flow stabilizes. This would be the lowest hourly flowrate.

A.2.3 Soil Grain Size Analysis Method

A.2.3.1 Calculation Method

- Conduct an adequate number of grain size analyses to characterize each defined layer below the top of the final subgrade of the infiltration Best Management Practice (BMP). See Appendix B for depth and number of borings required for each BMP.
- Estimate the saturated hydraulic conductivity (K_{sat}) of each applicable soil layer using the equation(s) below (Massmann, 2008):

  Equation: Saturated Hydraulic Conductivity (Soil Grain Size Analysis Method)

$$log_{10}(K_{sat}) = -1.57 + 1.90 * d_{10} + 0.015 * d_{60} - 0.013 * d_{90} - 2.08 * f_{fines}$$

  where:

  K_{sat} = saturated hydraulic conductivity (centimeters per second [cm/sec])
  d_{10} = grain size for which 10% of the sample is finer (millimeters [mm])
  d_{60} = grain size for which 60% of the sample is finer (mm)

d_{90} = grain size for which 90% of the sample is finer (mm)
f_{fines} = fraction of the soil (by weight) that passes a No. 200 sieve

If the estimate using *Equation: Saturated Hydraulic Conductivity (Soil Grain Size Analysis Method)* is greater than 0.01 cm/sec, recalculate K_{sat} using *Equation: Saturated Hydraulic Conductivity for Coarse-Grained Soils (Soil Grain Size Analysis Method)* and use the greater of the two values:

Equation: Saturated Hydraulic Conductivity for Coarse-Grained Soils (Soil Grain Size Analysis Method)

$$log_{10}(K_{sat}) = -1.32 + 1.225 * d_{10} - 0.376 * f_{fines}$$

where:

K_{sat} = saturated hydraulic conductivity (cm/sec)
d_{10} = grain size for which 10% of the sample is finer (mm)
f_{fines} = fraction of the soil (by weight) that passes a No. 200 sieve

If the estimate using *Equation: Saturated Hydraulic Conductivity (Soil Grain Size Analysis Method)* is less than 0.01 cm/s, recalculate K_{sat} using *Equation: Saturated Hydraulic Conductivity for Fine-Grained Soils (Soil Grain Size Analysis Method):*

Equation: Saturated Hydraulic Conductivity for Fine-Grained Soils (Soil Grain Size Analysis Method)

$$log_{10}(K_{sat}) = -2.89 + 7.57 * d_{10} - 0.527 * d_{60} + 0.030 * d_{90} + 0.142 * f_{fines}$$

where:

K_{sat} = saturated hydraulic conductivity (cm/sec)
d_{10} = grain size for which 10% of the sample is finer (mm)
d_{60} = grain size for which 60% of the sample is finer (mm)
d_{90} = grain size for which 90% of the sample is finer (mm)
f_{fines} = fraction of the soil (by weight) that passes a No. 200 sieve

A.2.3.2 Soil Grain Size Analysis: Data Analysis

- If the licensed professional conducting the investigation determines that deeper layers will influence the rate of infiltration for the infiltration BMP area, soil layers at greater depths should be considered when assessing the site's initial K_{sat}.
- Machinery or material stockpiles and associated compaction should not be allowed in infiltration areas. *Equation: Saturated Hydraulic Conductivity (Soil Grain Size Analysis Method)* through *Equation: Saturated Hydraulic Conductivity for Fine-Grained Soils (Soil Grain Size Analysis Method)* assume minimal compaction consistent with the use of tracked (e.g. low to moderate ground pressure) excavation equipment. If the soil layer being characterized has been exposed to heavy compaction, the hydraulic conductivity for the layer could be approximately an order of magnitude less than what would be estimated based on grain size characteristics alone (Pitt et al., 1995), (Massmann, 2008).

In such cases, compaction effects should be taken into account when estimating hydraulic conductivity unless mitigated as determined by a licensed professional. (Methods for correcting K_{sat} for compaction effects are provided by (Massmann, 2008) and (WSDOT, 2017b)

- Use the layer with the lowest saturated hydraulic conductivity to determine the measured hydraulic conductivity.
- If greater certainty is desired, the in-situ saturated hydraulic conductivity of a specific layer can be obtained through the use of a pilot infiltration test (PIT), as described above.

A.3 Calculating the Design Infiltration Rate

Using the initial Ksat determined by one of the methods in A.2 - Determining the Measured Saturated Conductivity, calculate the design infiltration rate using the Simplified Method or Detailed Method described below.

A.3.1 Simplified Method

The simplified approach will generally produce more conservative values for design infiltration rates.

This method can be used for infiltration facilities with contributing areas less than 1 acre. Facilities with larger contribution areas shall use the Detailed Approach.

The Simplified Method adjusts the measured K_{sat} value using correction factors.

Correction factors account for site variability, number of tests conducted, uncertainty of test method, and potential for long-term clogging.

Table 4 - 56: Measured Hydraulic Saturated Conductivity Rate Reduction Factors provides a range of correction factors. The professional completing the soils report should specify factors based on site characteristics and best professional judgment.

Table 4 - 56: Measured Hydraulic Saturated Conductivity Rate Reduction Factors

Site Analysis Issue or Method	Partial Correction Factor
Site Variability and Number of Locations Tested	CF_v = 0.33 to 1.0
Test Method - Large Scale PIT	CF_t = 0.75
Test Method - Small Scale PIT	CF_t = 0.50
Test Method - Grain Size Method a. Percent Passing the U.S. No 200 Sieve is > 10 b. Percent Passing the U.S. No 200 Sieve is <10 but >5 c. Percent Passing the U.S. No 200 Sieve is < 5	a. CF_t = 0.40 b. CF_t = 0.50 c. CF_t = 0.75
Siltation and Biofouling	CF_m = 0.9 CF_m = 1.0 (may be used for bioretention and permeable pavement only)
Quality of Pavement Aggregate Base Material	CF_b = 0.9 to 1.0 (for permeable pavement) CF_b = 1.0 for all BMPs other than permeable pavement

Total Correction Factor, $CF_T = CF_v \times CF_t \times CF_m \times CFb$

$$k_{\text{Design Infiltration Rate}} = k_{\text{sat measured}} \times CF_T$$

The design infiltration rate is calculated by multiplying the initial K_{sat} by the total correction factor.

A.3.1.1 Site variability and number of locations tested (CF_v)

The number of locations tested must be capable of producing a picture of the subsurface conditions that fully represents the conditions throughout the facility site. The partial correction factor used for this issue depends on the level of uncertainty that adverse subsurface conditions may occur. If the range of uncertainty is low - for example, conditions are known to be uniform through previous exploration and site geological factors - one pilot infiltration test (or grain size analysis location) may be adequate to justify a partial correction factor at the high end of the range.

If the level of uncertainty is high, a partial correction factor near the low end of the range may be appropriate. This might be the case where the site conditions are highly variable due to conditions such as a deposit of ancient landslide debris, or buried stream channels. In these cases, even with many explorations and several pilot infiltration tests (or several grain size test locations), the level of uncertainty may still be high.

A partial correction factor near the low end of the range could be assigned where conditions have a more typical variability, but few explorations and only one pilot infiltration test (or one grain size analysis location) is conducted. That is, the number of explorations and tests conducted do not match the degree of site variability anticipated.

A.3.1.2 Uncertainty of Test Method (CF_t)

This correction factor accounts for uncertainties in the testing methods. These values are intended to represent the difference in each test's ability to estimate the actual saturated hydraulic conductivity. The assumption is the larger the scale of the test, the more reliable the result.

A.3.1.3 Siltation and Biofouling (CF_m)

Even with a presettling basin or a basic treatment facility for pretreatment, the soil's initial infiltration rate will gradually decline as more and more stormwater, with some amount of suspended material, passes through the soil profile. The maintenance schedule calls for removing sediment when the facility is infiltrating at only 90% of its design capacity. Therefore, a correction factor, CF_m, of 0.9 is called for.

The correction factor for bioretention is set at 1.0 because correction factors are already applied to the bioretention soil mix to account of siltation. The correction factor for permeable pavement is set at 1.0 because the wearing layer provides protection from sedimentation.

A.3.1.4 Quality of Pavement Aggregate Base Material (CF_b)

This correction factor is used for permeable pavement only. All other infiltration BMPs may use 1.0 as the CF_b correction factor when calculating the design infiltration rate of the native soils.

For permeable pavement, 1 may be used for CF_b if a Washington State Licensed Professional Engineer determines that the aggregate base is clean washed material with less than 1% fines passing the No. 200 sieve. If more than 1% fines pass the No. 200 sieve, use 0.9.

A.3.2 Detailed Method

This detailed approach was obtained from (Massman, 2003).

Using the detailed approach, estimate the design (long-term) infiltration rate as follows:

1. Use any of the three options above, or other method approved by the local jurisdiction (as appropriate for the site) to estimate the initial K_{sat}.
2. Calculate the steady state hydraulic gradient(i) as follows:

$$\text{gradient} = i \approx \frac{D_{wt} + D_{pond}}{138.62(K^{0.1})} CF_{size}$$

Where:

D_{wt} is the depth from the base of the infiltration facility to the water table in feet,

K is the initial saturated hydraulic conductivity in feet/day,

D_{pond} is one quarter of the maximum depth of water in the facility in feet (see Massmann et. al., 2003, for development of this equation), and

CF_{size} is the correction for the pond size. The correction factor was developed for ponds with bottom areas between 0.6 and 6 acres in size. For small ponds (ponds with area

equal to 2/3 acre), the correction factor is equal to 1.0. For large ponds (ponds with area equal to 6 acres), the correction factor is 0.2.

$$CF_{size} = 0.73(A_{pond})^{-0.76}$$

Where:

A_{pond} is the area of pond bottom in acres.

This equation generally will result in a calculated steady state hydraulic gradient of less than 1.0 for moderate to shallow groundwater depths (or to a low permeability layer) below the BMP, and conservatively accounts for the development of a groundwater mound. A more detailed groundwater mounding analysis using a program such a MODFLOW will usually result in a gradient that is equal to or greater than the gradient calculated using the equation above.

If the calculated steady state hydraulic is greater than 1.0, the water table is considered to be deep, and a maximum gradient of 1.0 must be used. Typically, a depth to groundwater of 100 feet or more is required to obtain a gradient of 1.0 or more using this equation.

Since the gradient is a function of depth of water in the BMP, the gradient will vary as the pond fills during the season. The gradient could be calculated as part of the stage discharge calculation used in continuous runoff modeling software. As of the date of this update, no Ecology approved continuous runoff models have that capability. However, updates to those models may incorporate the capability. Until that time, calculate the steady-state hydraulic gradient using the equation above assuming a ponded depth of ¼ of the maximum ponded depth - as measured from the pond floor to the overflow.

3. Determine the pond aspect ratio adjustment factor as follows:

$$CF_{aspect} = 0.02A_r + 0.98$$

Where:

A_r is the aspect ratio for the pond (length/width of the bottom area).

In no case shall CF_{aspect} be greater than 1.4.

4. Determine C_{FT} as described in The Simplified Approach to Calculating the Design Infiltration Rate of the Native Soils.
5. The design infiltration rate is calculated by multiplying the initial K_{sat} (this is the value determined in A.2) by the steady state hydraulic gradient, the aspect ratio adjustment factor, and the total correction factor:

$$Design\ Infiltration\ Rate = K_{sat} * i * CF_{aspect} * CF_T$$

Appendix B Soil Reports

B.1 Introduction

Historical soils reports typically cannot be used as the sole means for stormwater design or determining if a BMP is feasible. It may be possible to utilize historical soils reports to supplement new soils investigations. A Washington State Licensed Professional Engineer, Washington State Licensed Professional Geologist, a Certified Professional Soil Scientist (CPSS) certified by the Soil Science Society of America, Washington State Licensed On-Site Wastewater Treatment System Designers, or other suitable trained persons working under the professional shall note the applicability of using the historical soils reports for the current project including noting where the historical reports do not meet the Soils Report requirements of this Appendix and what affect that might have on the outcome.

B.1.1 Soils Report Requirements for BMP L602: Downspout Full Infiltration

A soils report is required to design downspout full infiltration facilities. A soils report is also required if citing that downspout full infiltration is not feasible due to subsurface characteristics.

The soils report shall be based on site specific subsurface explorations.

The soils report shall be prepared by a Washington State Licensed Professional Engineer, Washington State Licensed Professional Geologist, a Certified Professional Soils Scientist (CPSS) certified by the Soil Science Society of America, Washington State Licensed On-Site Wastewater Treatment System Designers, or other suitable trained persons working under the professional.

The soils report shall be based on site specific explorations and:

1. Classify the underlying soils of the project site. Identify the NRCS series of the soil and the USDA textural class. The USDA textural class is needed to size the facility.
    - Use soil borings or soil test pits to classify the soils. Published USDA/ NRCS soil surveys may supplement soils reports but cannot be used as the sole means to classify soils.
        - Soil surveys are available here: https://websoilsurvey.nrcs.usda.gov/app/HomePage.htm
    - Prepare detailed logs for each boring or test pit and a map showing the location of the boring or test pit. Borings or test pits shall be taken at the location of the proposed downspout full infiltration system. Soils logs must include:
        - The depth of boring or pit.
            - The boring or pit must be at least 4 feet deep (from proposed grade) and at least one foot below expected bottom elevation of the infiltration facility.
        - Soil description
        - Depth to water (if present)
2. Identify the hydraulic restriction layer (groundwater, low permeability layer, bedrock, etc.).
    - Perform explorations or other analyses that may be performed to identify the groundwater layer) during the wet season (December 1 - April 1).
    - The hydraulic restriction layer may be identified by:
        - Depth to water
        - Soil evidence of groundwater such as mottling
        - Reliable site historical data

B.1.2 Soils Report Requirements for BMP L601: Rain Gardens

A soils report is required to design a rain garden. A soils report is also required if citing that a rain garden is not feasible due to subsurface characteristics.

The soils report shall be based on site specific subsurface explorations.

The soils report shall be prepared by a Washington State Licensed Professional Engineer, Washington State Licensed Professional Geologist, a Certified Professional Soils Scientist (CPSS) certified by the Soil Science Society of America, Washington State Licensed On-Site Wastewater Treatment System Designers, or other suitable trained persons working under the professional.

The soils report shall be based on site specific explorations and:

1. Classify the underlying soils of the site.
    - Use soil borings or soil test pits to classify the soils. Published USDA/ NRCS soil surveys may supplement soils reports but cannot be used as the sole means to classify soils.
        - Soil surveys are available here: https://websoilsurvey.nrcs.usda.gov/app/HomePage.htm.
    - Prepare detailed logs for each boring or test pit and a map showing the location of the boring or test pit. Borings or test pits shall be taken at the location of the proposed rain garden. Soils logs must include:
        - The depth of boring or pit.
            - The boring or pit must be at least 4 feet deep (from proposed grade) and at least one foot below expected bottom elevation of the rain garden.
        - Soil description
        - Depth to water (if present)
2. Identify the hydraulic restriction layer (groundwater, low permeability layer, bedrock, etc.).
    - Perform explorations or other analyses that may be performed to identify the groundwater layer during the wet season (December 1 - April 1).
    - The hydraulic restriction layer may be identified by:
        - Depth to water
        - Soil evidence of groundwater such as mottling
        - Reliable site historical data
3. Identify the measured infiltration rate. Use either of the following methods to determine the measured infiltration rate. It is not necessary to identify the measured infiltration rate for determining infeasibility if other subsurface characteristics such as high groundwater preclude the use of a rain garden.
    - Small Scale Pilot Infiltration Test (PIT) per Volume 4 - Appendix A - Determining the Design Infiltration Rate.

- Soil Grain Size Analysis per Volume 4 - Appendix A -Determining the Design Infiltration Rate.
  - This method is only allowed if subsurface is underlain with soils not consolidated by glacial advance.
  - The rate determined can be based on one test pit or boring.

B.1.3 Soils Report Requirements for BMP L630: Bioretention

A soils report is required to design a bioretention facility that will infilitrate. A soils report is also required if citing that a bioretention facility is not feasible due to subsurface characteristics.

The soils report shall be based on site specific subsurface explorations.

The soils report shall be prepared by a Washington State Licensed Professional Engineer, Washington State Licensed Professional Geologist, a Certified Professional Soils Scientist (CPSS) certified by the Soil Science Society of America, or other suitable trained persons working under the professional.

As each site is ultimately unique, if items/methods/etc. below are not relevant to a project or different items/methods/etc. are more appropriate a detailed description of why they are not relevant or why a different standard is more appropriate based upon the site must be provided in the soils report. Note, the City will generally not allow different methods of determining the measured infiltration rate without an adjustment request.

The soils report shall be based on site specific explorations and:

1. Classify the underlying soils of the site.
    - Use soil borings or soil test pits to classify the soils. Published USDA/ NRCS soil surveys may supplement soils reports but cannot be used as the sole means to classify soils.
        - Soil surveys are available here: https://websoilsurvey.nrcs.usda.gov/app/HomePage.htm
    - One boring or test pit is required per every 15,000 square feet of infiltration area or every 200 linear feet of roadway with a minimum of three borings or test pits required
    - Prepare detailed logs for each boring or test pit and a map showing the location of the boring or test pit. Borings or test pits shall be taken at the location of the proposed bioretention facility. Soils logs must include:
        - The depth of boring or pit.
            - The depth must extend a minimum of 5 times the maximum design depth of ponded water below the base of the bioretention facility (but not less than 10 feet below the base of the bioretention facility).
                - If the final site grading is not known as the time of soil classification, it is recommended to increase the depth of the borings or pits to account for potential changes in site grade from the existing to proposed condition.
        - Soil description
        - Depth to water (if present)
        - Presence of stratification.
    - Assess soil stratigraphy for low permeability layers, highly permeable sand/gravel layers, depth to groundwater, and other soil structure variables necessary to assess subsurface flow patterns.

- Obtain soil samples for laboratory testing from each soil stratum within 3.0 times the maximum design water depth below the base of the bioretention (but not less than 3 feet below the base of the infiltration facility).
- Soil characteristics for each soil unit shall include:
  - Grain size distribution (ASTM D422 or AASHTO equivalent), if using the Grain Size Analysis Method for Determining Infiltration Rates
  - Texture Classification
    - Grain Size Classification
    - Percent Clay Content
    - Color/Mottling
- Variations and nature of stratification

2. Characterize the Infiltration Receptor (unsaturated and saturated soil receiving the stormwater). Characterization must be completed during the wet season (December 1 – April 1). Characterization must include:
   - Determination of:
     - Depth to hydraulic restriction layer (groundwater, low permeability layer, bedrock, etc.)
     - Seasonal variation of groundwater table based on well water levels and observed mottling.
     - Existing groundwater flow direction and gradient.
     - Lateral extent of infiltration receptor.
     - Horizontal hydraulic conductivity of the saturated zone to assess the aquifer's ability to laterally transport the infiltrated water.
     - Impact of the infiltration rate and volume at the BMP site on groundwater mounding, flow direction, and water table; and the discharge location or area of the infiltrating water. Conduct a groundwater mounding analysis at all sites where the depth to seasonal groundwater table or low permeability stratum is less than 15 feet from the estimated bottom elevation of the infiltration BMP, and the contributing basin to the infiltration BMP is more than one acre.
   - An estimate of the volumetric water holding capacity of the vadose zone. Conduct this analysis at a conservatively high infiltration rate based on vadose zone porosity and the volume of water to be infiltrated. This along with an analysis of groundwater movement can be used to determine if there are any volumetric limitations that would affect drawdown and determine if a groundwater mounding analysis is necessary.
   - As assessment of the ambient groundwater quality, if that is a concern.

   Groundwater monitoring wells will generally be necessary to obtain characterize the infiltration receptor.

   In general, a minimum of three wells per infiltration BMP, or three hydraulically connected surface or groundwater features, are needed to determine the direction of flow and

gradient. If in the assessment of the site professional, the surrounding site conditions indicate that gradient and flow direction are not critical (e.g., there is low risk of down-gradient impacts) one monitoring well may be sufficient. Alternative means of establishing the groundwater levels may also be considered. If the groundwater in the area is known to be greater than 50 feet below the proposed infiltration BMP, detailed investigation of the groundwater regime is not necessary.

Monitoring through at least one wet season is required, unless substantially equivalent site historical data regarding groundwater levels is available.

3. Determine the measured infiltration rate.
    - Identify the native soil infiltration rate using methods outlined in Volume 4 - Appendix A -Determining the Design Infiltration Rate. It is not necessary to identify the native soil infiltration rate for determining infeasibility if other subsurface characteristics such as high groundwater preclude the use of a bioretention facility.
    - Small bioretention facilities that receive stormwater from less than 10,000 square feet can use one of the following to determine the native soil infiltration rate:
        - Large Scale Pilot Infiltration Test (PIT) per Volume 4 - Appendix A - Determining the Design Infiltration Rate.
        - Small Scale Pilot Infiltration Test (PIT) per Volume 4 - Appendix A - Determining the Design Infiltration Rate.
        - Soil Grain Size Analysis per Volume 4 - Appendix A -Determining the Design Infiltration Rate.
            - This method is only allowed if subsurface is underlain with soils not consolidated by glacial advance.
            - The rate determined can be based on one test pit or boring.
    - Large bioretention facilities that receive stormwater from 10,000 square feet or more can use one of the following to determine the native soil infiltration rate:
        - Large Scale Pilot Infiltration Test (PIT) per Volume 4 - Appendix A - Determining the Design Infiltration Rate.
        - Multiple Small Scale Pilot Infiltration Tests (PIT) per Volume 4 - Appendix A – Determining the Design Infiltration Rate.
            - Tests must occur at several locations approximately every 5,000 square feet.
        - Soil Grain Size Analysis per Volume 4 - Appendix A -Determining the Design Infiltration Rate.
            - This method is only allowed if subsurface is underlain with soils not consolidated by glacial advance.
            - The rate determined must be based on information obtained from more than one test pit or boring.

- Long, narrow bioretention facilities (such as those following the right of way) have the following options for determining the native soil infiltration rate:
  - Large Scale Pilot Infiltration Test (PIT) per Volume 4 - Appendix A - Determining the Design Infiltration Rate.
  - Small Scale Pilot Infiltration Test (PIT) per Volume 4 - Appendix A - Determining the Design Infiltration Rate.
    - One test pit per every 200 linear feet and within each length of road with significant differences in subsurface characteristics is required.
  - Soil Grain Size Analysis per Volume 4 - Appendix A -Determining the Design Infiltration Rate.
    - This method is only allowed if subsurface is underlain with soils not consolidated by glacial advance.
    - The rate determined shall be based on a boring or test pit taken every 200 feet and within each length of road with significant differences in subsurface characteristics.

4. Calculate the Design Infiltration Rate
   Use methods defined in Volume 4 - Appendix A. If the scope of work for the firm completing the soils report does not include calculating the Design Infiltration Rate, at a minimum the recommendation for correction factors based upon Site Variability and Number of Locations Tested (CFv), Test Method (CFt), and Siltation and Biofouling (CFm) must be provided.

B.1.4 Soils Report Requirements for BMP L604: Perforated Stub-Out Connections

A soils report is required if citing that perforated stub-outs are not feasible due to subsurface characteristics.

The soils report shall be based on site specific subsurface explorations.

The soils report shall be prepared by a Washington State Licensed Professional Engineer, Washington State Licensed Professional Geologist, a Certified Professional Soils Scientist (CPSS) certified by the Soil Science Society of America, Washington State Licensed On-Site Wastewater Treatment System Designers, or other suitable trained persons working under the professional.

The soils report shall be based on site specific explorations and:

1. Classify the underlying soils of the site. Classification is not needed if it is determined that there is a hydraulic restriction layer that deems a perforated stubout infeasible.
   - Use soil borings or soil test pits to classify the soils. Published USDA/ NRCS soil surveys may supplement soils reports but cannot be used as the sole means to classify soils.
     - Soil surveys are available here: https://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

- Prepare detailed logs for each boring or test pit and a map showing the location of the boring or test pit. Borings or test pits shall be taken at the location of the proposed downspout full infiltration system. Soils logs must include:
  - The depth of boring or pit.
    - The boring or pit must be at least 4 feet deep (from proposed grade) and at least one foot below expected bottom elevation of the infiltration facility.
  - Soil description
  - Depth to water (if present)

2. Identify the hydraulic restriction layer (groundwater, low permeability layer, bedrock, etc.).
   - Perform explorations or other analyses that may be performed to identify the groundwater layer during the wet season (December 1 - April 1).
   - The hydraulic restriction layer may be identified by:
     - Depth to water
     - Soil evidence of groundwater such as mottling
     - Reliable site historical date

B.1.5 Soils Report Requirements for BMP L633: Permeable Pavements

A soils report is required to design a permeable pavement. A soils report is also required if citing that permeable pavement is not feasible due to subsurface characteristics.

The soils report shall be based on site specific subsurface explorations.

The soils report shall be prepared by a Washington State Licensed Professional Engineer, Washington State Licensed Professional Geologist, a Certified Professional Soils Scientist (CPSS) certified by the Soil Science Society of America, or other suitable trained persons working under the professional.

As each site is ultimately unique, if items/methods/etc. below are not relevant to a project or different items/methods/etc. are more appropriate a detailed description of why they are not relevant or why a different standard is more appropriate based upon the site must be provided in the soils report. Note, the City will generally not allow different methods of determining the measured infiltration rate without an adjustment request.

The soils report shall be based on site specific explorations and:

1. Classify the underlying soils of the site.
   - Use soil borings or soil test pits to classify the soils. Published USDA/ NRCS soil surveys may supplement soils reports but cannot be used as the sole means to classify soils.
     - Soil surveys are available here: https://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

- One boring or test pit is required per every 15,000 square feet of infiltration area or every 200 linear feet of roadway with a minimum of three borings or test pits required.
- Prepare detailed logs for each boring or test pit and a map showing the location of the boring or test pit. Borings or test pits shall be taken at the location of the proposed bioretention facility. Soils logs must include:
    - The depth of boring or pit.
        - The depth must extend a minumum of 5 times the maximum design depth of ponded water below the base of the permeable pavement (but not less than 10 feet below the base of the permeable pavement).
            - If the final site grading is not known as the time of soil classification, it is recommended to increase the depth of the borings or pits to account for potential changes in site grade from the existing to proposed condition.
    - Soil description
    - Depth to water (if present)
    - Presence of stratification.

- Assess soil stratigraphy for low permeability layers, highly permeable sand/gravel layers, depth to groundwater, and other soil structure variables necessary to assess subsurface flow patterns.
    - Obtain soil samples for laboratory testing from each soil stratum within 3.0 times the maximum design water depth below the base of the permeable pavement (but not less than 3 feet below the base of the infiltration facility).
    - Soil characteristics for each soil unit shall include:
        - Grain size distribution (ASTM D422 or AASHTO equivalent), if using the Grain Size Analysis Method for Determining Infiltration Rates
        - Texture Classification
            - Grain Size Classification
            - Percent Clay Content
            - Color/Mottling
        - Cation exchange capacity (needed to determine if the native soils can provide treatment)
        - Percent organic content (needed to determine if the native soils can provide treatment)
        - Variations and nature of stratification

2. Characterize the Infiltration Receptor (unsaturated and saturated soil receiving the stormwater). Characterization must be completed during the wet season (December 1 – April 1). Characterization must include:
    - Determination of:

- Depth to hydraulic restriction layer (groundwater, low permeability layer, bedrock, etc.)
- Seasonal variation of groundwater table based on well water levels and observed mottling.
- Existing groundwater flow direction and gradient.
- Lateral extent of infiltration receptor.
- Horizontal hydraulic conductivity of the saturated zone to assess the aquifer's ability to laterally transport the infiltrated water.
- Impact of the infiltration rate and volume at the BMP site on groundwater mounding, flow direction, and water table; and the discharge location or area of the infiltrating water. Conduct a groundwater mounding analysis at all sites where the depth to seasonal groundwater table or low permeability stratum is less than 15 feet from the estimated bottom elevation of the infiltration BMP, and the contributing basin to the infiltration BMP is more than one acre.

- An estimate of the volumetric water holding capacity of the vadose zone. Conduct this analysis at a conservatively high infiltration rate based on vadose zone porosity and the volume of water to be infiltrated. This along with an analysis of groundwater movement can be used to determine if there are any volumetric limitations that would affect drawdown and determine if a groundwater mounding analysis is necessary.
- As assessment of the ambient groundwater quality, if that is a concern.

Groundwater monitoring wells will generally be necessary to obtain characterize the infiltration receptor.

In general, a minimum of three wells per infiltration BMP, or three hydraulically connected surface or groundwater features, are needed to determine the direction of flow and gradient. If in the assessment of the site professional, the surrounding site conditions indicate that gradient and flow direction are not critical (e.g., there is low risk of down-gradient impacts) one monitoring well may be sufficient. Alternative means of establishing the groundwater levels may also be considered. If the groundwater in the area is known to be greater than 50 feet below the proposed infiltration BMP, detailed investigation of the groundwater regime is not necessary.

Monitoring through at least one wet season is required, unless substantially equivalent site historical data regarding groundwater levels is available.

3. Determine the native soil infiltration rate.
   - Identify the native soil infiltration rate using methods outlined in Volume 4 - Appendix A - Determining the Design Infiltration Rate. It is not necessary to identify the native soil infiltration rate for determining infeasibility if other subsurface characteristics such as high groundwater preclude the use of permeable pavement. Use either of the following methods to determine the measured soil infiltration rate.
     - Large Scale Pilot Infiltration Test (PIT) per Volume 4 – Appendix A – Determining the Design Infiltration Rate

- Small Scale Pilot Infiltration Test (PIT) per Volume 4 - Appendix A - Determining the Design Infiltration Rate.
  - Use only when permeable pavements serve small drainage areas and/or are widely dispersed throughout the project site or the site has a high infiltration rate (greater than 4 inches/hour) and the soils characterization suggests uniform subsurface characteristics.
  - Perform test for every 5,000 ft^2 of permeable pavement and at least one per project site.
  - For residential developments, perform a test on every lot.
  - For linear projects or linear portions of a project, complete a test for every 200 feet of linear surface (roadway or sidewalk).
- Soil Grain Size Analysis per Volume 4 - Appendix A -Determining the Design Infiltration Rate.
  - This method is only allowed if subsurface is underlain with soils not consolidated by glacial advance.
  - For residential developments, a test pit or boring must be completed on each lot.
  - For linear projects or linear portions of a project the rate determined shall be based on a boring or test pit taken every 200 feet.

4. Calculate the Design Infiltration Rate
   Use methods defined in Volume 4 - Appendix A. If the scope of work for the firm completing the soils report does not include calculating the Design Infiltration Rate, at a minimum the recommendation for correction factors based upon Site Variability and Number of Locations Tested (CFv), Test Method (CFt), and Siltation and Biofouling (CFm) must be provided.

B.1.6 Soils Report Requirements for BMP 700: Infiltration - Basins, Trenches, Swales, and Drywells

A soils report is required to design infiltration facilities.

The soils report shall be based on site specific subsurface explorations.

The soils report shall be prepared by a Washington State Licensed Professional Engineer, Washington State Licensed Professional Geologist, a Certified Professional Soils Scientist (CPSS) certified by the Soil Science Society of America, or other suitable trained persons working under the professional.

As each site is ultimately unique, if items/methods/etc. below are not relevant to a project or different items/methods/etc. are more appropriate a detailed description of why they are not relevant or why a different standard is more appropriate based upon the site must be provided in the soils report. Note, the City will generally not allow different methods of determining the measured infiltration rate without an adjustment request.

The soils report shall be based on site specific explorations and:

1. Classify the underlying soils site:
    - Use soil borings or soil test pits to classify the soils. Published USDA/ NRCS soil surveys may supplement soils reports but cannot be used as the sole means to classify soils.
        - Soil surveys are available here: https://websoilsurvey.nrcs.usda.gov/app/HomePage.htm
    - One boring or test pit is required per every 15,000 square feet of infiltration area or every 200 linear feet of roadway with a minimum of three borings or test pits required.
    - Prepare detailed logs for each boring or test pit and a map showing the location of the boring or test pit. Borings or test pits shall be taken at the location of the proposed infiltration facility. Soils logs must include:
        - The depth of boring or pit.
            - The depth must extend a minimum of 5 times the maximum design depth of ponded water below the base of the infiltration facility (but not less than 10 feet below the base of the infiltration facility).
                - If the final site grading is not known as the time of soil classification, it is recommended to increase the depth of the borings or pits to account for potential changes in site grade from the existing to proposed condition.
        - Soil description
        - Depth to water (if present)
        - Presence of stratification.
    - Assess soil stratigraphy for low permeability layers, highly permeable sand/gravel layers, depth to groundwater, and other soil structure variables necessary to assess subsurface flow patterns.

- Obtain soil samples for laboratory testing from each soil stratum within 3.0 times the maximum design water depth below the base of the infiltration facility (but not less than 10 feet below the base of the infiltration facility).
- Soil characteristics for each soil unit shall include:
  - Grain size distribution (ASTM D422 or AASHTO equivalent), if using the Grain Size Analysis Method for Determining Infiltration Rates
  - Texture Classification
    - Grain Size Classification
    - Percent Clay Content
    - Color/Mottling
  - Cation exchange capacity (needed to determine if the native soils can provide treatment)
  - Percent organic content (needed to determine if the native soils can provide treatment)
  - Variations and nature of stratification

2. Characterize the Infiltration Receptor (unsaturated and saturated soil receiving the stormwater). Characterization must be completed during the wet season (December 1 – April 1). Characterization must include:
   - Determination of:
     - Depth to hydraulic restriction layer (groundwater, low permeability layer, bedrock, etc.)
     - Seasonal variation of groundwater table based on well water levels and observed mottling.
     - Existing groundwater flow direction and gradient.
     - Lateral extent of infiltration receptor.
     - Horizontal hydraulic conductivity of the saturated zone to assess the aquifer's ability to laterally transport the infiltrated water.
     - Impact of the infiltration rate and volume at the BMP site on groundwater mounding, flow direction, and water table; and the discharge location or area of the infiltrating water. Conduct a groundwater mounding analysis at all sites where the depth to seasonal groundwater table or low permeability stratum is less than 15 feet from the estimated bottom elevation of the infiltration BMP, and the contributing basin to the infiltration BMP is more than one acre.
   - An estimate of the volumetric water holding capacity of the vadose zone. Conduct this analysis at a conservatively high infiltration rate based on vadose zone porosity and the volume of water to be infiltrated. This along with an analysis of groundwater movement can be used to determine if there are any volumetric limitations that would affect drawdown and determine if a groundwater mounding analysis is necessary.
   - As assessment of the ambient groundwater quality, if that is a concern.

   Groundwater monitoring wells will generally be necessary to obtain characterize the infiltration receptor.

In general, a minimum of three wells per infiltration BMP, or three hydraulically connected surface or groundwater features, are needed to determine the direction of flow and gradient. If in the assessment of the site professional, the surrounding site conditions indicate that gradient and flow direction are not critical (e.g., there is low risk of down-gradient impacts) one monitoring well may be sufficient. Alternative means of establishing the groundwater levels may also be considered. If the groundwater in the area is known to be greater than 50 feet below the proposed infiltration BMP, detailed investigation of the groundwater regime is not necessary.

Monitoring through at least one wet season is required, unless substantially equivalent site historical data regarding groundwater levels is available.

3. Determine the native soil infiltration rate.
   - Identify the native soil infiltration rate using methods outlined in Volume 4 - Appendix A -Determining the Design Infiltration Rate. It is not necessary to identify the native soil infiltration rate for determining infeasibility if other subsurface characteristics such as high groundwater preclude the use of the infiltration facility. Use either of the following methods to determine the measured soil infiltration rate.
     - Large Scale Pilot Infiltration Test (PIT) per Volume 4 – Appendix A – Determining the Design Infiltration Rate
     - Small Scale Pilot Infiltration Test (PIT) per Volume 4 - Appendix A - Determining the Design Infiltration Rate
       - Can only be used where the drainage area to the infiltration facility is less than 1 acre.
     - Soil Grain Size Analysis per Volume 4 - Appendix A -Determining the Design Infiltration Rate.
       - This method is only allowed if subsurface is underlain with soils not consolidated by glacial advance.
4. Calculate the Design Infiltration Rate
   Use methods defined in Volume 4 - Appendix A. If the scope of work for the firm completing the soils report does not include calculating the Design Infiltration Rate, at a minimum the recommendation for correction factors based upon Site Variability and Number of Locations Tested (CFv), Test Method (CFt), and Siltation and Biofouling (CFm) must be provided.

B.1.7 Soils Report Requirements for BMP T1050: Compost-Amended Vegetated Filter Strip (CAVFS)

A soils report is required to design infiltration facilities.

The soils report shall be based on site specific subsurface explorations.

The soils report shall be prepared by a Washington State Licensed Professional Engineer, Washington State Licensed Professional Geologist, a Certified Professional Soils Scientist (CPSS) certified by the Soil Science Society of America, or other suitable trained persons working under the professional.

As each site is ultimately unique, if items/methods/etc. below are not relevant to a project or different items/methods/etc. are more appropriate a detailed description of why they are not relevant or why a different standard is more appropriate based upon the site must be provided in the soils report. Note, the City will generally not allow different methods of determining the measured infiltration rate without an adjustment request.

The soils report shall be based on site specific explorations and:

1. Classify the underlying soils of the site.
    - Use soil borings or soil test pits to classify the soils. Published USDA/ NRCS soil surveys may supplement soils reports but cannot be used as the sole means to classify soils.
        - Soil surveys are available here: https://websoilsurvey.nrcs.usda.gov/app/HomePage.htm
    - One boring or test pit is required per every 15,000 square feet of infiltration area or every 200 linear feet of roadway with a minimum of three borings or test pits required.
    - Prepare detailed logs for each boring or test pit and a map showing the location of the boring or test pit. Borings or test pits shall be taken at the location of the proposed infiltration facility. Soils logs must include:
        - The depth of boring or pit.
            - The depth must extend a minimum of 5 times the maximum design depth of ponded water below the base of the infiltration facility (but not less than 10 feet below the base of the infiltration facility).
                - If the final site grading is not known as the time of soil classification, it is recommended to increase the depth of the borings or pits to account for potential changes in site grade from the existing to proposed condition.
        - Soil description
        - Depth to water (if present)
        - Presence of stratification.
    - Assess soil stratigraphy for low permeability layers, highly permeable sand/gravel layers, depth to groundwater, and other soil structure variables necessary to assess subsurface flow patterns.
        - Obtain soil samples for laboratory testing from each soil stratum within 3.0 times the maximum design water depth below the base of the infiltration facility (but not less than 10 feet below the base of the infiltration facility).
        - Soil characteristics for each soil unit shall include:
            - Grain size distribution (ASTM D422 or AASHTO equivalent), if using the Grain Size Analysis Method for Determining Infiltration Rates
            - Texture Classification
                - Grain Size Classification
                - Percent Clay Content

- Color/Mottling
- Cation exchange capacity (needed to determine if the native soils can provide treatment)
- Percent organic content (needed to determine if the native soils can provide treatment)
- Variations and nature of stratification

2. Characterize the Infiltration Receptor (unsaturated and saturated soil receiving the stormwater). Characterization must be completed during the wet season (December 1 – April 1). Characterization must include:
   - Determination of:
     - Depth to hydraulic restriction layer (groundwater, low permeability layer, bedrock, etc.)
     - Seasonal variation of groundwater table based on well water levels and observed mottling.
     - Existing groundwater flow direction and gradient.
     - Lateral extent of infiltration receptor.
     - Horizontal hydraulic conductivity of the saturated zone to assess the aquifer's ability to laterally transport the infiltrated water.
     - Impact of the infiltration rate and volume at the BMP site on groundwater mounding, flow direction, and water table; and the discharge location or area of the infiltrating water. Conduct a groundwater mounding analysis at all sites where the depth to seasonal groundwater table or low permeability stratum is less than 15 feet from the estimated bottom elevation of the infiltration BMP, and the contributing basin to the infiltration BMP is more than one acre.
   - An estimate of the volumetric water holding capacity of the vadose zone. Conduct this analysis at a conservatively high infiltration rate based on vadose zone porosity and the volume of water to be infiltrated. This along with an analysis of groundwater movement can be used to determine if there are any volumetric limitations that would affect drawdown and determine if a groundwater mounding analysis is necessary.
   - As assessment of the ambient groundwater quality, if that is a concern.

   Groundwater monitoring wells will generally be necessary to obtain characterize the infiltration receptor.

   In general, a minimum of three wells per infiltration BMP, or three hydraulically connected surface or groundwater features, are needed to determine the direction of flow and gradient. If in the assessment of the site professional, the surrounding site conditions indicate that gradient and flow direction are not critical (e.g., there is low risk of down-gradient impacts) one monitoring well may be sufficient. Alternative means of establishing the groundwater levels may also be considered. If the groundwater in the area is known to be greater than 50 feet below the proposed infiltration BMP, detailed investigation of the groundwater regime is not necessary.

Monitoring through at least one wet season is required, unless substantially equivalent site historical data regarding groundwater levels is available.

3. Determine the native soil infiltration rate.
   - Identify the native soil infiltration rate using methods outlined in Volume 4 - Appendix A -Determining the Design Infiltration Rate. It is not necessary to identify the native soil infiltration rate for determining infeasibility if other subsurface characteristics such as high groundwater preclude the use of the infiltration facility. Use either of the following methods to determine the measured soil infiltration rate.
     - Large Scale Pilot Infiltration Test (PIT) per Volume 4 – Appendix A – Determining the Design Infiltration Rate.
     - Small Scale Pilot Infiltration Test (PIT) per Volume 4 - Appendix A - Determining the Design Infiltration Rate.
       - Can only be used where the drainage area to the infiltration facility is less than 1 acre.
     - Soil Grain Size Analysis per Volume 4 - Appendix A -Determining the Design Infiltration Rate.
       - This method is only allowed if subsurface is underlain with soils not consolidated by glacial advance.
4. Calculate the Design Infiltration Rate
   Use methods defined in Volume 4 - Appendix A. If the scope of work for the firm completing the soils report does not include calculating the Design Infiltration Rate, at a minimum the recommendation for correction factors based upon Site Variability and Number of Locations Tested (CFv), Test Method (CFt), and Siltation and Biofouling (CFm) must be provided.

Appendix C Operation and Maintenance

The following pages contain maintenance standards for typical stormwater facilities that may be required for stormwater mitigation. The maintenance standards should be included in the project Operations and Maintenance Manual. If the proposed stormwater system contains facilities or components that are not contained within this Volume, the applicant is responsible for developing additional maintenance standards for the proposed facility or component. If there are components listed on the maintenance standard that are not applicable to the proposed design, those components shall be removed. The operation and maintenance standards shall accurately reflect the proposed design. The Maintenance Standard includes recommended timeframes for inspection. Maintenance frequency is site specific depending on factors such as use of the site and traffic volumes. Maintenance frequencies shall be based upon inspections. It is recommended to conduct monthly inspections during the first few years after installation to develop maintenance frequencies. At a minimum, inspections of all components of the stormwater system shall occur yearly.

The facility-specific maintenance standards contained in this section are intended to be conditions for determining if maintenance actions are required as identified through inspection. They are not intended to be measures of the facility's required condition at all times between inspections. In other words, exceeding these conditions at any time between inspections and/or maintenance does not automatically constitute a violation of these standards. However, based upon inspection observations, the inspection and maintenance schedules shall be adjusted to minimize the length of time that a facility is in a condition that requires a maintenance action.

Note: Maintenance checklist #32 - General Maintenance Concerns for Stormwater Facilities contains maintenance concerns that may be applicable to any stormwater facility. This checklist must be included in all Operation and Maintenance manuals as applicable.

Appendix C Contents

#1 - Maintenance Standard for Detention Ponds
#2 - Maintenance Standard for Infiltration Ponds
#3 - Maintenance Standard for Infiltration Trenches
#4 - Maintenance Standard for Ballasted Sidewalks
#5 - Maintenance Standard for Infiltration Swales
#6 - Maitenance Standards for Drywells
#7 - Maintenance Standard for Closed Detention Systems (Tanks/Vaults)
#8 - Maintenance Standard for Control Structure/Flow Restrictor
#9 - Maintenance Standard for Catch Basins/Manhole
#10 - Maintenance Standard for Debris Barriers (e.g., Trash Racks)
#11 - Maintenance Standard for Energy Dissipaters
#12 - Maintenance Standard for Typical Biofiltration Swales
#13 - Maintenance Standard for Wet Biofiltration Swales
#14 - Maintenance Standard for Filter Strips
#15 - Maintenance Standard for Wet Ponds
#16 - Maintenance Standard for Treatment Wetlands
#17 - Maintenance Standard for Wetvaults
#18 - Maintenance Standard for Sand Filters (above ground/open)
#19 - Maintenance Standard for Sand Filters (below ground/enclosed)
#20 - Maintenance Standard for Baffle Oil/Water Separators - American Petroleum Institute (API) Type
#21 - Maintenance Standard for Coalescing Plate Oil/Water Separators
#22 - Maintenance Standard for Fencing/Shrubbery Screen/Other Landscaping
#23 - Maintenance Standard for Gates
#24 - Maintenance Standard for Grounds (Landscaping)
#25 - Maintenance Standard for Bioretention Facilities
#26 - Maintenance Standard for Rain Gardens
#27 - Maintenance Standard for Cisterns
#28 - Maintenance Standard for Compost Amended Soil
#29 - Maintenance Standard for Vegetated Roofs
#30 - Maintenance Standard for Pervious Pavement
#31 - Emerging Technologies
#32 - General Maintenance Concerns for Stormwater Facilities
#33 - Maintenance Standard for Trees
#34 - Maintenance Standard for Downspout Infiltration Trench or Drywell
#35 - Maintenance Standard for Downspout Dispersion
#36 - Maintenance Standard for Media Filter Drains

#1 - Maintenance Standard for Detention Ponds

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Trash and Debris	Any trash and debris which exceeds 1 cubic feet per 1,000 square feet. In general, there should be no visual evidence of dumping. If less than threshold, all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site.
Annually (preferably Sept.)	General	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 (Apply requirements of adopted integrated pest management policies for the use of herbicides.)	No danger of poisonous vegetation where maintenance personnel or the public might normally be. Complete eradication of noxious weeds may not be possible. Compliance with state or local eradication policies required. (Coordinate with the Pierce County Noxious Weed Control Board.)
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants.	No contaminants or pollutants present. Review https:// ecology.wa.gov/spills-cleanup for other reporting requirements.
Monthly from Oct. – Apr.	General	Rodent Holes	If the facility is constructed with a dam or berm, look for rodent holes or any evidence of water piping through the dam or berm.	Rodents removed and dam or berm repaired. (Coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)
Monthly from Oct. – Apr.	General	Beaver Dams	Beaver dam results in an adverse change in the functioning of the facility.	Facility is returned to design function. (Contact WDFW Region 6 to identify the appropriate Nuisance Wildlife Control Operator)

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site in compliance with adopted integrated pest management policies.
Annually (preferably Sept.)	General	Tree Growth and Dense Vegetation	Tree growth and dense vegetation which impedes inspection, maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements).	Trees and vegetation that do not hinder inspection or maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses.
Annually (preferably Sept.)	General	Hazard Trees	If dead, diseased, or dying trees are identified (Use a certified Arborist to determine health of tree or removal requirements).	Remove hazard trees
Monthly from Oct. – Apr.	Side Slopes of Pond	Erosion	Erosion 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.	Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Side Slopes of Pond	Erosion	Any erosion observed over 2” deep on a compacted berm embankment.	If erosion is occurring on compacted berms a Washington State Licensed Professional Engineer should be consulted to resolve source of erosion.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr.	Storage Area	Sediment	Accumulated sediment that exceeds 10 percent of the design pond depth unless otherwise specified or affects inletting or outletting condition of the facility. Consider providing a fixed vertical sediment depth marker to measure sediment deposition over time.	Sediment cleaned out to design pond shape and depth; pond reseeded if necessary to control erosion. (If sediment contamination is a potential problem, sediment should be tested regularly to determine leaching potential prior to disposal.)
Monthly from Oct. – Apr.	Storage Area	Liner (If Applicable)	Liner is visible and has more than three 1/4 inch holes in it.	Liner repaired or replaced. Liner is fully covered.
Annually (preferably Sept.)	Pond Berms (Dikes)	Settlement	Any part of berm which has settled 4 inches lower than the design elevation. 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. A Washington State Licensed Professional Engineer should be consulted to determine the source of the settlement.	Dike is restored to the design elevation.
Annually (preferably Sept.)	Pond Berms Over 4 ft in height (Dikes)	Tree Growth	Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A Washington State Licensed Professional Engineer should be consulted for proper berm/spillway restoration.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	Pond Berms (Dikes)	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Washington State Licensed Professional Engineer be called in to inspect and evaluate condition and recommend repair.)	Piping eliminated. Erosion potential eliminated.
Annually (preferably Sept.)	Emergency Overflow/ Spillway	Tree Growth	Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A Washington State Licensed Professional Engineer should be consulted for proper berm/spillway restoration.
Annually (preferably Sept.)	Emergency Overflow/ Spillway	Rock Missing	Only one layer of rock exists above native soil in area 5 square feet or larger, or any exposure of native soil at the top of outflow path of spillway. (Riprap on inside slopes need not be replaced.)	Rocks and pad depth are restored to design standards.
Annually (preferably Sept.)	Emergency Overflow/ Spillway	Erosion	Erosion 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 over 2“deep.	Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. If erosion is occurring on compacted berms a Washington State Licensed Professional Engineer should be consulted to resolve source of erosion.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#2 - Maintenance Standard for Infiltration Ponds

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1" in 24 hours)	General	Trash and Debris	Any trash and debris which exceeds 1 cubic feet per 1,000 square feet. In general, there should be no visual evidence of dumping. If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site.
Annually (preferably Sept.)	General	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. (Apply requirements of adopted integrated pest management policies for the use of herbicides.)	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with the Pierce County Noxious Weed Control Board) Complete eradication of noxious weeds may not be possible. Compliance with state or local eradication policies required.
Monthly from Oct. – Apr. and after any major storm event (1" in 24 hours)	General	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants.	No contaminants or pollutants present. Review https://ecology.wa.gov/spills-cleanup for other reporting requirements.
Monthly from Oct. – Apr.	General	Rodent Holes	If the facility is constructed with a dam or berm, look for rodent holes or any evidence of water piping through the dam or berm.	Rodents removed and dam or berm repaired. (Coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)
Monthly from Oct. – Apr.	General	Beaver Dams	Beaver dam results in an adverse change in the functioning of the facility.	Facility is returned to design function. (Contact WDFW to identify the appropriate Nuisance Wildlife Control Operator)

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.
Monthly from Oct. – Apr.	Storage Area	Water Not Infiltrating	Water ponding in infiltration pond after rainfall ceases and appropriate time allowed for infiltration (24 hours or design infiltration time). (A percolation test pit or test of facility indicates facility is only working at 90 percent of its designed capabilities. If 2 inches or more sediment is present, remove).	Sediment is removed and/or facility is cleaned so that infiltration system works according to design.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Rock Filters	Sediment and Debris	By visual inspection, little or no water flows through filter during heavy rain storms.	Gravel in rock filter is replaced.
Monthly from Oct. – Apr.	Ponds	Vegetation	Exceeds 18 inches.	Mow or remove vegetation as necessary. Remove all clippings.
Monthly from Oct. – Apr.	Ponds	Vegetation	Bare spots.	Revegetate and stabilize immediately. Do not apply fertilizers.
Monthly from Oct. – Apr.	Side Slopes of Pond	Erosion	Erosion 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.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	Pond Berms (Dikes)	Settlements	Any part of berm which has settled 4 inches lower than the design elevation. If settlement is apparent, measure berm to determine amount of settlement. Settling can be an indication of more severe problems with the berm or piping. A Washington State Licensed Professional Engineer should be consulted to determine the source of the settlement.	Dike is built back to the design elevation.
Annually (preferably Sept.)	Pond Berms (Dikes)	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Washington State Licensed Professional Engineer be called in to inspect and evaluate condition and recommend repair.)	Piping eliminated. Erosion potential eliminated.
Annually (preferably Sept.)	General	Hazard Trees	If dead, diseased, or dying trees are identified (Use a certified Arborist to determine health of tree or removal requirements)	Remove hazard trees
Annually (preferably Sept.)	General	Tree Growth and Dense Vegetation	Tree growth and dense vegetation which impedes inspection, maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements).	Trees and vegetation that do not hinder inspection or maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	Pond Berms (Dikes)	Tree Growth	Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A Washington State Licensed Professional Engineer should be consulted for proper berm/spillway restoration.
Annually (preferably Sept.)	Emergency Overflow/ Spillway	Tree Growth	Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A Washington State Licensed Professional Engineershould be consulted for proper berm/spillway restoration.
Annually (preferably Sept.)	Emergency Overflow/ Spillway	Rock Missing	Only one layer of rock exists above native soil in area 5 square feet or larger, or any exposure of native soil at the top of out flowpath of spillway. (Riprap on inside slopes need not be replaced.)	Rocks and pad depth are restored to design standards.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	Emergency Overflow/ Spillway	Erosion	Erosion 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.	Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. If erosion is occurring on compacted berms a Washington State Licensed Professional Engineer should be consulted to resolve source of erosion.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#3 - Maintenance Standard for Infiltration Trenches

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1" in 24 hours)	General	Trash and Debris	Trash and debris in presettling basin, sump, or observation well/port.	Trash and debris cleared from site.
Annually (preferably Sept.)	General	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. (Apply requirements of adopted integrated pest management policies for the use of herbicides.)	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with the Pierce County Noxious Weed Control Board) Complete eradication of noxious weeds may not be possible. Compliance with state or local eradication policies required.
Monthly from Oct. – Apr. and after any major storm event (1" in 24 hours)	General	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants	No contaminants or pollutants present. Review https://ecology.wa.gov/spills-cleanup for other reporting requirements.
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.
Monthly from Oct. – Apr.	General	Water Not Infiltrating	Water ponding on surface or visible in observation well 24 hours after storm event.	Sediment is removed and/or facility is cleaned so that infiltration system works according to design. Remove any sediment from surface inlet if applicable.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.) and after any major storm event (1" in 24 hours)	Trenches	Observation Well (Use surface of trench if well is not present)	Water ponds at surface during storm events. Water visible in observation well 48 hours after storm event.	Remove and Replace rock layer and geomembrane or clean rock and geomembrane. Check underdrain pipe for sediment accumulation and remove sediment.
Annually (preferably Sept.)	General	Tree Growth and Dense Vegetation	Tree growth and dense vegetation which impedes inspection, maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements).	Trees and vegetation that do not hinder inspection or maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses.
Annually (preferably Sept.)	Emergency Overflow/ Spillway	Erosion	Erosion 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.	Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. If erosion is occurring on compacted berms a Washington State Licensed Professional Engineer should be consulted to resolve source of erosion.
Monthly from Oct. – Apr.	Presettling Sump	Facility or sump filled with sediment and/or debris	6 inches or designed sediment trap depth of sediment.	Sediment is removed.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#4 - Maintenance Standard for Ballasted Sidewalks

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Biannually (Fall and Spring)	Trench Surface	Water Not Reaching Facility	Accumulated Trash, debris, or sediment on surface that impedes sheet flow into facility.	Remove/dispose in accordance with local solid waste requirements.
Annually and After Major Storm Events	Trench Surface	Excessive Sedimentation	Run-on from adjacent areas deposits soil, mulch or sediment on trench surface.	Clean deposited soil or other materials. Check if surface elevation of adjacent planted areas is too high or slopes toward pavement and can be regraded. Mulch and/or plant exposed soils.
Biannually (Fall and Spring)	Trench Surface/ Surrounding Soils	Ponding or Soggy Areas	Inspect to see if water is ponding at surface during storm events.	Remove and replace clogged ballast.
Annually	Sidewalk Pavement	Ponding or Erosion of Adjacent Surfaces	Uneven surfaces or potholes that prohibit sheet flow into trench entrance.	Remove and replace sidewalk panel and possible regrade or replace permeable ballast.

#5 - Maintenance Standard for Infiltration Swales

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after major storm events (1” in 24 hours)	General	Sediment Accumulation on Grass or Rock Layer	Sediment Depth Exceeds 2 inches.	Remove sediment deposits. Ensure swale maintains design slope.
Monthly from Oct. – Apr. and after major storm events (1” in 24 hours)	General	Water Not Infiltrating	Water ponding on surface or visible 48 hours after storm event.	Sediment is removed and/or facility is cleaned so that infiltration system works according to design. Remove any sediment from surface inlet if applicable.
Monthly from Oct. – Apr. and after major storm events (1” in 24 hours)	General	Poor Vegetation Cover	When vegetation is sparse or bare or erode patches occur in more than 10 percent of the swale bottom.	Determine why grass growth is poor and correct that condition. Re-plant with plugs of grass from the upper slope: plant in the swale bottom at 8-inch intervals or re-seed into loosened, fertile soil.
Monthly from Oct. – Apr. and after major storm events (1” in 24 hours)	General	Poor Rock Cover	When vegetation is sparse or bare or eroded patches occur in more than 10 percent of the swale bottom.	Replace missing rocks
Monthly from Oct. – Apr. and after major storm events (1” in 24 hours)	General	Inlet/Outlet	Inlet/Outlet areas clogged with sediment/ debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area.
Monthly from Oct. – Apr. and after major storm events (1” in 24 hours)	General	Trash and Debris Accumulation	Trash and debris accumulated in the swale.	Remove leaves, litter, and oily materials, and re-seed or resod,and regrade, as needed. Clean curb cuts and level spreaders as needed.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after major storm events (1” in 24 hours)	General	Erosion/ Scouring	Eroded or scoured swale bottom due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. If bare areas are large, generally greater than 12 inches wide, the swale shoule be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident, or take plugs of grass from the upper slope and plant in the swale bottom at 8-inch intervals.
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

Maintenance Standard #6 – Maintenance Standard for Drywells

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after major storm events (1” in 24 hours)	General	Trash and Debris	Trash or debris that inhibits flow into the facility. Clean all sediment before depth reaches the lowest row of slots providing outflow from drywell.	Ensure metal grate and drywell are free of debris and obstructions. Remove debris from top of and around the drywell and grate and from inside barrel.
Monthly from Oct. – Apr. and after major storm events (1” in 24 hours)	General	Water Not Infiltrating	Water ponding on surface or visible 24 hours after storm event.	Check for signs of illicit discharge. If illicit discharges are suspected, remove and replace sod, topsoil, and drain rock. Sediment is removed and/or facility is cleaned so that infiltration system works according to design. Remove any sediment from surface inlet if applicable.
Annually (preferably Sept.)	Drywell	Metal Grate	Metal grate should sit flush on the top ring.	Any separation of greater than or equal to 0.75 inches must be adjusted and repaired. Replace or repair drywell if settling is greater than 2 inches or if standing water fails to drain.
Annually (preferably Sept.)	Drywell Rings	Adjustment Rings	Cracks in adjustment rings.	The maximum width of crack shall be: Top Ring of Drywell: 0.25 Inches Drywell Barrel: 0.5” and Longer Than 3 Feet. Drywell Floor: 0.5” and Longer Than 1 Foot

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after major storm events (1” in 24 hours)	General	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants	No contaminants or pollutants present. (Coordinate removal/ cleanup with Environmental Services at 253.502.2222 and/or DOE Spill Response 800.424.8802.)
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management poli-cies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#7 - Maintenance Standard for Closed Detention Systems (Tanks/Vaults)

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Storage Area	Plugged Air Vents	One-half of the cross-section of a vent is blocked at any point or the vent is damaged.	Vents open and functioning.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Storage Area	Debris and Sediment	Accumulated sediment depth exceeds 10 percent of the diameter of the storage area for one-half length of storage vault or any point depth exceeds 15 percent of diameter. (Example: 72-inch storage tank would require cleaning when sediment reaches depth of 7 inches for more than one-half length of tank.)	All sediment and debris removed from storage area.
Annually (preferably Sept.)	Storage Area	Joints Between Tank/Pipe Section	Any openings or voids allowing material to be transported into facility. (Will require engineering analysis to determine structural stability.)	All joints between tank/ pipe sections are sealed.
Annually (preferably Sept.)	Storage Area	Tank/Pipe Bent Out of Shape	Any part of tank/pipe is bent out of shape more than 10 percent of its design shape. (Will require engineering analysis to determine structural stability.)	Tank/pipe repaired or replaced to design.
Annually (preferably Sept.)	Storage Area	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than one-half inch and any evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determines that the vault is not structurally sound.	Vault replaced or repaired to design specifications and is structurally sound.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	Storage Area	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than one-half inch at the joint of any inlet/outlet pipe or any evidence of soil particles entering the vault through the walls.	No cracks more than one-fourth inch wide at the joint of the inlet/ outlet pipe.
Annually (preferably Sept.)	Manhole	Cover Not in Place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole cover is in place.
Annually (preferably Sept.)	Manhole	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than one-half inch of thread (may not apply to self-locking lids).	Mechanism opens with proper tools.
Annually (preferably Sept.)	Manhole	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. Intent is to keep cover from sealing off access to maintenance.	Cover can be removed and reinstalled by one maintenance person.
Annually (preferably Sept.)	Manhole	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, misalignment, not securely attached to structure wall, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Tanks and vaults are a confined space. Visual inspections should be performed aboveground. If entry is required it should be performed by qualified personnel.

Comments:

#8 - Maintenance Standard for Control Structure/Flow Restrictor

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Trash and Debris (Includes Sediment)	Material exceeds 25 percent of sump depth or 1 foot below orifice plate.	Control structure orifice is not blocked. All trash and debris removed.
Annually (preferably Sept.)	General	Structural Damage	Structure is not securely attached to manhole wall.	Structure securely attached to wall and outlet pipe.
Annually (preferably Sept.)	General	Structural Damage	Structure is not in upright position (allow up to 10 percent from plumb).	Structure in correct position.
Annually (preferably Sept.)	General	Structural Damage	Connections to outlet pipe are not watertight and show signs of rust.	Connections to outlet pipe are watertight; structure repaired or replaced and works as designed.
Annually (preferably Sept.)	General	Structural Damage	Any holes–other than designed holes–in the structure.	Structure has no holes other than designed holes.
Annually (preferably Sept.)	Cleanout Gate	Damaged or Missing	Cleanout gate is not watertight or is missing.	Gate is watertight and works as designed.
Annually (preferably Sept.)	Cleanout Gate	Damaged or Missing	Gate cannot be moved up and down by one maintenance person.	Gate moves up and down easily and is watertight.
Annually (preferably Sept.)	Cleanout Gate	Damaged or Missing	Chain/rod leading to gate is missing or damaged.	Chain is in place and works as designed.
Annually (preferably Sept.)	Cleanout Gate	Damaged or Missing	Gate is rusted over 50 percent of its surface area.	Gate is repaired or replaced to meet design standards.
Annually (preferably Sept.)	Orifice Plate	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.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Orifice Plate	Obstructions	Any trash, debris, sediment, or vegetation blocking the plate.	Plate is free of all obstructions and works as designed.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Overflow Pipe	Obstructions	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Pipe is free of all obstructions and works as designed.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	Manhole	Cover Not in Place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole is closed.
Annually (preferably Sept.)	Manhole	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than one-half inch of thread (may not apply to self-locking lids).	Mechanism opens with proper tools.
Annually (preferably Sept.)	Manhole	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. Intent is to keep cover from sealing off access to maintenance.	Cover can be removed and reinstalled by one maintenance person.
Annually (preferably Sept.)	Manhole	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, misalignment, not securely attached to structure wall, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Control structures are usually considered a confined space. Visual inspections should be performed aboveground. If entry is required it should be performed by qualified personnel.

Comments:

#9 - Maintenance Standard for Catch Basins/Manholes

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	General	“Dump no pollutants” Stencil or stamp not visible	Stencil or stamp should be visible and easily read	Warning signs (e.g., ”Dump No Waste-Drains to Stream") shall be painted or embossed on or adjacent to all storm drain inlets.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Trash and Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inlet capacity of the basin by more than 10 percent.	No trash or debris located immediately in front of catch basin or on grate opening.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Trash and Debris	Trash or debris (in the basin) that exceeds 60 percent of the sump depth 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 6 inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the catch basin.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Trash and Debris	Trash or debris in any inlet or outlet pipe blocking more than one-third of its height.	Inlet and outlet pipes free of trash or debris.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Trash and Debris	Dead animals or vegetation that could generate odors and cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Sediment	Sediment (in the basin) that exceeds 60 percent of the sump depth 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 6 inches clearance from the sediment surface to the invert of the lowest pipe.	No sediment in the catch basin.
Annually (preferably Sept.)	General	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than one-fourth inch (intent is to make sure no material is running into basin).	Top slab is free of holes and cracks.
Annually (preferably Sept.)	General	Structure Damage to Frame and/or Top Slab	Frame not sitting flush on top slab, i.e., separation of more than three-fourth inch of the frame from the top slab. Frame not securely attached.	Frame is sitting flush on the riser rings or top slab and firmly attached.
Annually (preferably Sept.)	General	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.
Annually (preferably Sept.)	General	Fractures or Cracks in Basin Walls/ Bottom	Grout fillet has separated or cracked wider than one-half-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 regrouted and secure at basin wall.
Annually (preferably Sept.)	General	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Vegetation	Vegetation growing across and blocking more than 10 percent of the basin opening.	No vegetation blocking opening to basin.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1" in 24 hours)	General	Vegetation	Vegetation growing in inlet/outlet pipe joints that is more than 6 inches tall and less than 6 inches apart.	No vegetation or root growth present.
Monthly from Oct. – Apr. and after any major storm event (1" in 24 hours)	General	Contamination and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants.	No contaminants or pollutants present. Review https://ecology.wa.gov/spills-cleanup for other reporting requirements.
Annually (preferably Sept.)	Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place.	Catch basin cover is in place.
Annually (preferably Sept.)	Catch Basin Cover	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than one-half-inch of thread.	Mechanism opens with proper tools.
Annually (preferably Sept.)	Catch Basin Cover	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
Annually (preferably Sept.)	Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Annually (preferably Sept.)	Grates	Grate opening Unsafe	Grate with opening wider than seven-eighths of an inch.	Grate opening meets design standards.
Monthly from Oct. – Apr. and after any major storm event (1" in 24 hours)	Grates	Trash and Debris	Trash and debris that is blocking more than 20 percent of grate surface inletting capacity.	Grate free of trash and debris.
Annually (preferably Sept.)	Grates	Damaged or Missing.	Grate missing or broken member(s) of the grate.	Grate is in place, meets design standards, and is installed and aligned with flowpath.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#10 - Maintenance Standard for Debris Barriers (e.g., Trash Racks)

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Trash and Debris	Trash or debris that is plugging more than 20 percent of the openings in the barrier.	Barrier cleared to design flow capacity.
Annually (preferably Sept.)	General	Damaged/ Missing Bars.	Bars are bent out of shape more than 3 inches.	Bars in place with no bends more than three-fourth inch.
Annually (preferably Sept.)	General	Damaged/ Missing Bars.	Bars are missing or entire barrier missing.	Bars in place according to design.
Annually (preferably Sept.)	General	Damaged/ Missing Bars.	Bars are loose and rust is causing 50 percent deterioration to any part of barrier.	Barrier replaced or repaired to design standards.
Annually (preferably Sept.)	General	Inlet/Outlet Pipe	Debris barrier missing or not attached to pipe.	Barrier firmly attached to pipe.
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#11 - Maintenance Standard for Energy Dissipaters

Recommended Inspection Frequency	Stormwater System Feature	Problem	Conditions When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Rock Pad	Erosion	Soil erosion in or adjacent to rock pad.	Rock pad replaced to design standards.
Monthly from Oct. - Apr. and after any major storm event (1" in 24 hours)	Rock Pad	Missing or Moved Rock	Only one layer of rock exists above soil in area 5 square feet or larger, or any soil exposure.	Rock pad replaced to design standards.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Dispersion Trench	Pipe Plugged with Sediment	Accumulated sediment that exceeds 20 percent of the design depth.	Pipe cleaned/flushed so that it matches design.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Dispersion Trench	Not Discharging Water Properly	Visual evidence of water discharging at concentrated points along trench (normal condition is a “sheet flow” of water along trench). Intent is to prevent erosion damage.	Trench redesigned or rebuilt to standards.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Dispersion Trench	Perforations Plugged	Over 1/2 of perforations in pipe are plugged with debris and sediment.	Perforated pipe cleaned or replaced.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Dispersion Trench	Water Flows Out Top of ”Distributor” Catch Basin.	Maintenance person observes or receives credible report of water flowing out during any storm less than the design storm or the trench is causing or appears likely to cause damage.	Facility rebuilt or redesigned to standards.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Dispersion Trench	Receiving Area Over-Saturated	Water in receiving area is causing or has potential to cause landslide problems.	No danger of landslides.
Spring and Summer	Flowpath	No or minimal vegetation	Vegetation removed or dead. Vegetation replaced by hard surface.	Design vegetated flowpath is restored.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Conditions When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Manhole/ Chamber	Worn or Damaged Post, Baffles, Side of Chamber	Structure dissipating flow deteriorates to one-half of original size or any concentrated worn spot exceeding 1 square foot which would make structure unsound	Structure replaced to design standards.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Manhole/ Chamber	Trash and Debris	Trash or debris (in the basin) that exceeds 60 percent of the sump depth 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 6 inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the catch basin.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Manhole/ Chamber	Trash and Debris	Trash or debris in any inlet or outlet pipe blocking more than one-third of its height.	Inlet and outlet pipes free of trash or debris.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Manhole/ Chamber	Trash and Debris	Dead animals, trash or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals, trash or vegetation present within the catch basin.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Manhole/ Chamber	Sediment	Sediment (in the basin) that exceeds 60 percent of the sump depth 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 6 inches clearance from the sediment surface to the invert of the lowest pipe.	No sediment in the catch basin.
Annually (preferably Sept.)	Manhole/ Chamber	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than one-fourth inch (intent is to make sure no material is running into basin).	Top slab is free of holes and cracks.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Conditions When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	Manhole/ Chamber	Structure Damage to Frame and/or Top Slab	Frame not sitting flush on top slab, i.e., separation of more than three-fourth inch of the frame from the top slab. Frame not securely attached.	Frame is sitting flush on the riser rings or top slab and firmly attached.
Annually (preferably Sept.)	Manhole/ Chamber	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.
Annually (preferably Sept.)	Manhole/ Chamber	Fractures or Cracks in Basin Walls/ Bottom	Grout fillet has separated or cracked wider than one-half-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 regrouted and secure at basin wall.
Annually (preferably Sept.)	Manhole/ Chamber	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
Monthly from Oct. – Apr. and after any major storm event (1" in 24 hours)	Manhole/ Chamber	Contamination and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants.	No contaminants or pollutants present. Review https://ecology.wa.gov/spills-cleanup for other reporting requirements.
Annually (preferably Sept.)	Catch Basin/ Manhole Cover	Cover Not in Place	Cover is missing or only partially in place.	Any open catch basin/ manhole requires maintenance. Catch basin cover is closed.
Annually (preferably Sept.)	Catch Basin/ Manhole Cover	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than one-half-inch of thread.	Mechanism opens with proper tools.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Conditions When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	Catch Basin/ Manhole Cover	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#12 - Maintenance Standard for Typical Biofiltration Swales

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits on grass treatment area of the bioswale. When finished, swale should be level from side to side and drain freely toward outlet. There should be no areas of standing water once inflow has ceased.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Standing Water	Water stands in the swale between storms and does not drain freely.	Any of the following may apply: remove sediment or trash blockages, improve grade from head to foot of swale, remove clogged check dams, add underdrains or convert to a wet biofiltration swale. Consult the design engineer if underdrains are proposed to be removed or conversion is proposed.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire swale width.	Level the spreader and clean so that flows are spread evenly over entire swale width.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Constant Baseflow	When small quantities of water continually flow through the swale, even when it has been dry for weeks, and an eroded, muddy channel has formed in the swale bottom.	Add a low-flow pea-gravel drain the length of the swale or by-pass the baseflow around the swale.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Poor Vegetation Coverage	When grass is sparse or bare or eroded patches occur in more than 10 percent of the swale bottom.	Determine why grass growth is poor and correct that condition. Re-plant with plugs of grass from the upper slope: plant in the swale bottom at 8-inch intervals or re-seed into loosened, fertile soil.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Vegetation	When the grass becomes excessively tall (greater than 10 inches); when nuisance weeds and other vegetation start to take over.	Mow vegetation or remove nuisance vegetation so that flow is not impeded. Grass should be mowed to a height of 3 to 8 inches, but not below design flow level. Remove grass clippings.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Excessive Shading	Grass growth is poor because sunlight does not reach swale.	If possible, trim back over-hanging limbs and remove brushy vegetation on adjacent slopes.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Inlet/Outlet/ Underdrain	Inlet/outlet areas clogged with sediment and/or debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area. If underdrain, avoid vehicular traffic on swale bottom.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Trash and Debris Accumulation	Trash and debris accumulated in the bioswale.	Remove leaves, litter, and oily materials, and re-seed or resod, and regrade, as needed. Clean curb cuts and level spreaders as needed.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Erosion/ Scouring	Eroded or scoured swale bottom due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. If bare areas are large, generally greater than 12 inches wide, the swale should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident, or take plugs of grass from the upper slope and plant in the swale bottom at 8-inch intervals.
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#13 - Maintenance Standard for Wet Biofiltration Swales

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Sediment Accumulation	Sediment depth exceeds 2 inches in 10 percent of the swale treatment area.	Remove sediment deposits in treatment area.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Water Depth	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.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	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 offsite. Dig out roots as necessary. Note: Normally wetland vegetation does not need to be harvested unless die-back is causing oxygen depletion in downstream waters. Fall harvesting of Juncus species is not recommended.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Inlet/Outlet	Inlet/outlet area clogged with sediment and/or debris.	Remove clogging or blockage in the inlet and outlet areas.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Trash and Debris Accumulation	Any trash and debris which exceeds 1 cubic feet per 1,000 square feet. In general, there should be no visual evidence of dumping. If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Remove trash and debris from wet swale.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Erosion/ Scouring	Swale has eroded or scoured due to flow channelization, or higher flows.	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 drier areas, or as recommended by a wetland specialist.
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#14 - Maintenance Standard for Filter Strips

Recommended Inspection Frequency	Stormwater System Feature	Problem	Conditions When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits, re-level so slope is even and flows pass evenly through strip.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Vegetation	When the grass becomes excessively tall (greater than 10 inches); when nuisance weeds and other vegetation start to take over.	Mow grass, control nuisance vegetation, such that flow not impeded. Grass should be mowed to a height between 3-4 inches.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Trash and Debris Accumulation	Trash and debris accumulated on the filter strip.	Remove trash and Debris from filter.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Erosion/ Scouring	Eroded or scoured areas due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the filter strip should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire filter width.	Level the spreader and clean so that flows are spread evenly over entire filter width

Recommended Inspection Frequency	Stormwater System Feature	Problem	Conditions When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#15 - Maintenance Standard for Wet Ponds

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Water level	First cell is empty, doesn't hold water.	Line the first cell to maintain at least 4 feet of water. Although the second cell may drain, the first cell must remain full to control turbulence of the incoming flow and reduce sediment resuspension.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)		Trash and Debris	Accumulation that exceeds 1 cubic foot per 1000 square feet of pond area.	Trash and debris removed from pond
Biannually (Spring & Fall)	General	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 in State and Local Regulations. (Apply requirements of adopted integrated vegetation management (IVM) policies for the use of herbicides.)	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with the Pierce County Noxious Weed Control Board). Complete eradication of noxious weeds may not be possible, however compliance with state or local eradication policies are required.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)		Inlet/Outlet Pipe	Inlet and/or outlet pipe clogged with sediment and/or debris material	No clogging or blockage in the inlet and outlet piping.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)		Sediment Accumulation in Pond Bottom	Sediment accumulations in pond bottom that exceeds the depth of sediment zone plus 6 inches, usually in the first cell. Consider providing a fixed vertical sediment depth marker to measure sediment deposition over time.	Sediment removed from pond bottom.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly		Vegetation	Vegetation is overgrown or sparse.	Trim vegetation as necessary to keep pond free of leaves and maintain aesthetic appearance. Revegetate bare sloped areas. Regrade before revegetation as needed.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)		Oil Sheen on Water	Prevalent and visible oil sheen.	Oil removed from water using oil-absorbent pads or vactor truck. Source of oil located and corrected. If chronic low levels of oil persist, plant wetland plants such as Juncus effusus (soft rush) which can uptake small concentrations of oil.
Annually (preferably Sept.)		Erosion	Erosion of the pond’s side slopes and/or scouring of the pond bottom that exceeds 6 inches, or where continued erosion is prevalent.	Slopes stabilized using proper erosion control measures and repair methods.
Annually (preferably Sept.)		Settlement of Pond Dike/ Berm	Any part of these components that has settled 4 inches or lower than the design elevation, or inspector determines dike/berm is unsound.	Dike/berm is repaired to specifications
Annually (preferably Sept.)		Internal Berm	Berm dividing cells should be level.	Berm surface is leveled so that water flows evenly over entire length of berm.
Annually (preferably Sept.)		Overflow Spillway	Rock is missing and soil is exposed at top of spillway or outside slope.	Rocks replaced to specifications.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.
Monthly from Oct. – Apr.	General	Rodent Holes	If the facility is constructed with a dam or berm, look for rodent holes or any evidence of water piping through the dam or berm.	Rodents removed and dam or berm repaired. (Coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)
Monthly from Oct. – Apr.	General	Beaver Dams	Beaver dam results in an adverse change in the functioning of the facility.	Facility is returned to design function. (Contact WDFW Region 6 to identify the appropriate Nuisance Wildlife Control Operator)
Annually (preferably Sept.)	General	Tree Growth and Dense Vegetation	Tree growth and dense vegetation which impedes inspection, maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements).	Trees and vegetation that do not hinder inspection or maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses.
Annually (preferably Sept.)	General	Hazard Trees	If dead, diseased, or dying trees are identified (Use a certified Arborist to determine health of tree or removal requirements).	Remove hazard trees
Monthly from Oct. – Apr.	Storage Area	Liner (If Applicable)	Liner is visible and has more than three 1/4 inch holes in it.	Liner repaired or replaced. Liner is fully covered.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#16 - Maintenance Standard for Treatment Wetlands

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Biannually (Spring & Fall)	General	Trash and Debris	Any trash and debris accumulations which exceed 1 cubic feet per 1,000 square feet. In general, there should be no visual evidence of dumping. If there is less than the threshold, remove all trash and debris as part of the next scheduled maintenance.	Trash and debris cleared from site.
Biannually (Spring & Fall)	General	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 in State and Local Regulations. (Apply requirements of adopted integrated vegetation management (IVM) policies for the use of herbicides.)	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with the Pierce County Noxious Weed Control Board). Complete eradication of noxious weeds may not be possible, however compliance with state or local eradication policies are required.
Biannually (Spring & Fall)	General	Oil Sheen on Water	Prevalent and visible oil sheen.	Oil removed from water using oil-absorbent pads or vactor truck. Source of oil located and corrected. If chronic low levels of oil persist, plant emergent wetland plants such as Juncus effusus (soft rush) which can assist filtering small concentrations of oil.
Biannually (Spring & Fall) and after any major storm event (1” in 24 hours)	General	Inlet/Outlet Pipe	Inlet/Outlet pipe clogged with sediment and/or debris material or damaged.	No clogging or blockage in the inlet and outlet piping.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Biannually (Spring & Fall)	General	Rodent Holes	If the facility is constructed with a dam or berm, look for rodent holes or any evidence of water piping through the dam or berm.	Rodents removed and dam or berm repaired. (Coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)
Biannually (Spring & Fall)	General	Beaver Dams	Beaver dam results in an adverse change in the functioning of the facility.	Facility is returned to design function. Contact WDFW to identify the appropriate Nuisance Wildlife Control Operator.
Biannually (Spring & Fall)	General	Tree Growth and Hazard Trees	Tree growth that impedes maintenance access.	Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses.
Biannually (Spring & Fall)	General	Tree Growth and Hazard Trees	If dead, diseased, or dying trees are identified, use a Certified Arborist to determine the health of tree and whether removal is required.	Remove hazard trees.
Biannually (Spring & Fall)	General	Liner	Liner is visible and has more than three one-fourth inch holes in it.	Liner is repaired or replaced. Liner is fully covered.
Biannually (Spring & Fall)	Forebay	Sediment Accumulation	Sediment accumulation in forebay exceeds the design depth of the sediment zone plus 6 inches. Consider providing a fixed vertical sediment depth marker to measure sediment deposition over time.	Accumulated sediment is removed from forebay bottom to the design depth of the sediment zone.
Biannually (Spring & Fall)	Side Slopes of Wetland	Erosion	Erosion 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) such as rock reinforcement, planting of grass, or additional compaction.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Biannually (Spring & Fall) and after any major storm event (1” in 24 hours)	Side Slopes of Wetland	Erosion	Any erosion observed on a compacted berm embankment over 2” deep.	If erosion is occurring on compacted berms a Washington State Licensed Professional Engineer should be consulted to resolve source of erosion.
Biannually (Spring & Fall)	Wetland Cell	Wetland Vegetation	20 percent or more of the constructed wetland area has dead or dying vegetation, as measured by stem counts relative to the design plant coverage.	Dead or dying vegetation is replaced by like species, unless recommended otherwise by the Wetlands Consultant and approved by the City. (Watering, physical support, mulching, and weed removal may be required on a regular basis especially during the first 3 years.)
Biannually (Spring & Fall)	Wetland Cell	Wetland Vegetation	Percent vegetated cover of constructed wetland bottom area, excluding exotic and invasive species, is less than 50 percent after 2 years.	Remove exotic/ invasive species, additional plantings may be required.
Biannually (Spring & Fall)	Wetland Cell	Wetland Vegetation	Decaying vegetation produces foul odors.	Decaying vegetation is removed, preferably in late summer.
Once in mid summer (July or August)	Wetland Cell	Wetland Vegetation	Wetland vegetation is blocking flowpaths causing flow back-up and flooding.	Areas of blocking vegetation are cut back sufficient to allow design flows and prevent flooding.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	Wetland Cell	Wetland Vegetation	Water quality monitoring indicates that wetland vegetation is contributing phosphorus and metals to downstream waters rather than sequestering them. Environmental Services will determine when water quality monitoring is required.	To maximize removal of wetland pollutants, vegetation must be periodically harvested, particularly with respect to phosphorus and metals removal. Harvesting should occur by mid-summer before plants begin to transfer phosphorus from the aboveground foliage to subsurface roots, or begin to lose metals that desorb during plant die off. Every 3 to 5 years the entire plant mass including roots should be harvested because the below ground biomass constitutes a significant reservoir (as much as half) of the nutrients and metals that are removed from stormwater by plants.
Biannually (Spring & Fall)	Wetland Cell	Sediment Accumulation	Sediment accumulation inhibits growth of wetland plants or reduces wetland volume (greater than 1 foot of sediment accumulation).	Dredge to design depth.
Annually (preferably Sept.)	Wetland Berms (Dikes)	Settlements	Any part of berm which has settled 4 inches lower than the design elevation. 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. A Washington State Licensed Professional Engineer should be consulted to determine the source of the settlement.	Dike restored to the design elevation.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	Wetland Berms (Dikes)	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Washington State Licensed Professional Engineer be called in to inspect and evaluate condition and recommend repairs.	Piping eliminated. Erosion potential eliminated.
Annually (preferably Sept.)	Wetland Berms over 4 ft in height (Dikes)	Tree Growth	Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A Washington State Licensed Professional Engineer should be consulted for proper berm/spillway restoration.
Annually (preferably Sept.)	Emergency Overflow/ Spillway	Obstruction	Tree growth or other blockage on emergency spillways may cause failure of the berm due to uncontrolled overtopping.	Obstruction should be removed. A Washington State Licensed Professional Engineer should be consulted for proper berm/spillway restoration.
Annually (preferably Sept.)	Emergency Overflow/ Spillway	Rock Missing	Only one layer of rock exists above native soil in an area 5 square feet or larger, or any exposure of native soil at the top of outflow path of spillway. (Riprap on inside slopes need not be replaced.)	Rocks and pad depth are restored to design standards.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	Emergency Overflow/ Spillway	Erosion	Erosion 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.	Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. If erosion is occurring on compacted berms a Washington State Licensed Professional Engineer should be consulted to resolve source of erosion.
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#17 - Maintenance Standard for Wetvaults

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Trash/Debris Accumulation	Trash and debris accumulated in vault, pipe or inlet/outlet (includes floatables and non-floatables).	Remove trash and debris from vault.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Sediment Accumulation in Vault	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6 inches.	Remove sediment from vault. (If sediment contamination is a potential problem, sediment should be tested regularly to determine leaching potential prior to disposal.)
Annually (preferably Sept.)	General	Damaged Pipes	Inlet/outlet piping damaged or broken and in need of repair.	Pipe repaired and/or replaced.
Annually (preferably Sept.)	General	Access Cover Damaged/Not Working	Cover cannot be opened or removed, especially by one person.	Pipe repaired or replaced to proper working specifications.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Ventilation	Ventilation area blocked or plugged.	Blocking material removed or cleared from ventilation area. A specified percentage of the vault surface area must provide ventilation to the vault interior (see design specifications).
Annually (preferably Sept.)	Vault Structure	Damage - Includes Cracks in Walls/Bottom, Damage to Frame and/or Top Slab	Maintenance/inspection personnel determine that the vault is not structurally sound	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
Annually (preferably Sept.)	Vault Structure	Damage - Includes Cracks in Walls/Bottom, Damage to Frame and/or Top Slab	Cracks wider than one-half-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than one-fourth inch at the joint of the inlet/ outlet pipe.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	Vault Structure	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection staff.	Baffles repaired or replaced to specifications.
Annually (preferably Sept.)	Access Ladder	Damage	Ladder is corroded or deteriorated, not functioning properly, not attached to structure wall, missing rungs, has cracks and/or misaligned. Confined space warning sign missing.	Ladder replaced or repaired to specifications, and is safe to use as determined by inspection personnel. Replace sign warning of confined space entry requirements.
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

A vault is a confined space. Visual inspections should be performed aboveground. If entry is required it should be performed by qualified personnel.

Comments:

#18 - Maintenance Standard for Sand Filters (above ground/open)

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Above ground (open sand filter)	Sediment Accumulation on top layer	Sediment depth exceeds one-half inch.	No sediment deposit on grass layer of sand filter that would impede permeability of the filter section.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Above ground (open sand filter)	Trash and Debris Accumulations	Trash and debris accumulated on sand filter bed.	Trash and debris removed from sand filter bed.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Above ground (open sand filter)	Sediment/ Debris in Clean-Outs	When the clean-outs become full or partially plugged with sediment and/or debris.	Sediment removed from clean-outs.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Above ground (open sand filter)	Sand Filter Media	Drawdown of water through the sand filter media takes longer than 24-hours, and/or flow through the overflow pipes occurs frequently.	Top several inches of sand are scraped. May require replacement of entire sand filter depth depending on extent of plugging (a sieve analysis is helpful to determine if the lower sand has too high a proportion of fine material).
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Above ground (open sand filter)	Prolonged Flows	Sand is saturated for prolonged periods of time (several weeks) and does not dry out between storms due to continuous base flow or prolonged flows from detention facilities. (Consider 4-8 hour drawdown tests)	Low, continuous flows are limited to a small portion of the facility by using a low wooden divider or slightly depressed sand surface.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Above ground (open sand filter)	Short Circuiting	Drawdown greater than 12 inches per hour. When flows become concentrated over one section of the sand filter rather than dispersed. (Consider 4-8 hour drawdown tests)	Flow and percolation of water through sand filter is uniform and dispersed across the entire filter area. Inspect periphery and cleanouts for leakage.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Above ground (open sand filter)	Erosion Damage to Slopes	Erosion over 2 inches deep where cause of damage is prevalent or potential for continued erosion is evident.	Slopes stabilized using proper erosion control measures.
Annually (preferably Sept.)	Above ground (open sand filter)	Rock Pad Missing or Out of Place	Soil beneath the rock is visible.	Rock pad replaced or rebuilt to design specifications.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Above ground (open sand filter)	Flow Spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed across sand filter. Rills and gullies on the surface of the filter can indicate improper function of the inlet flow spreader.	Spreader leveled and cleaned so that flows are spread evenly over sand filter. Refill rills and gullies with sand.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Above ground (open sand filter)	Damaged Pipes	Any part of the piping that is crushed or deformed more than 20 percent or any other failure to the piping.	Pipe repaired or replaced.
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.
Every other year	General	Drawdown		Every two years conduct a drawdown test by filling the filter with water and measuring the decline in water level over a 4 - 8 hour period.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.
Comments:

#19 - Maintenance Standard for Sand Filters (below ground/enclosed)

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Below Ground Vault	Sediment Accumulation on Sand Media Section	Sediment depth exceeds one-half inch.	No sediment deposits on sand filter section that would impede permeability of the filter section.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Below Ground Vault	Sediment Accumulation in Presettling Portion of Vault	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6 inches.	No sediment deposits in first chamber of vault.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Below Ground Vault	Trash/Debris Accumulation	Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault and inlet/outlet piping.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Below Ground Vault	Sediment in Drain Pipes/ Cleanouts	When drain pipes, cleanouts become full with sediment and/or debris.	Sediment and debris removed.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Below Ground Vault	Clogged Sand Filter Media	Drawdown of water through the sand filter media takes longer than 24-hours, and/or flow through the overflow pipes occurs frequently. (Consider 4-8 hour drawdown tests.)	Top several inches of sand are scraped. May require replacement of entire sand filter depth depending on extent of plugging (a sieve analysis is helpful to determine if the lower sand has too high a proportion of fine material).
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Below Ground Vault	Short Circuiting	Drawdown greater than 12 inches per hour. When seepage/flow occurs along the vault walls and corners. Sand eroding near inflow area. (Consider 4-8 hour drawdown tests.)	Sand filter media section re-laid and compacted along perimeter of vault to form a semi-seal. Erosion protection added to dissipate force of incoming flow and curtail erosion.
Annually (preferably Sept.)	Below Ground Vault	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and/or replaced.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Below Ground Vault	Flow Spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed across sand filter.	Spreader leveled and cleaned so that flows are spread evenly over sand filter.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Below Ground Vault	Ventilation	Ventilation area blocked or plugged	Blocking material removed or cleared from ventilation area. A specified percentage of the vault surface area must provide ventilation to the vault interior (see design specifications).
Annually (preferably Sept.)	Below Ground Vault	Access Cover Damaged/Not Working	Cover cannot be opened, corrosion/ deformation of cover. Maintenance person cannot remove cover using normal lifting pressure.	Cover repaired to proper working specifications or replaced.
Annually (preferably Sept.)	Below Ground Vault	Vault Structure Damaged; Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab.	Cracks wider than one-half inch or evidence of soil particles entering the structure through the cracks, or maintenance/ inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
Annually (preferably Sept.)	Below Ground Vault	Vault Structure Damaged; Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab.	Cracks wider than one-half inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than one-fourth inch at the joint of the inlet/ outlet pipe.
Annually (preferably Sept.)	Below Ground Vault	Baffles/ Internal walls	Baffles or walls corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	Below Ground Vault	Access Ladder	Damaged ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired to specifications, and is safe to use as determined by inspection personnel.
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

A below ground enclosed sand filter is a confined space. Visual inspections should be performed aboveground. If entry is required it should be performed by qualified personnel.

Comments:

#20 - Maintenance Standard for Baffle Oil/Water Separators - American Petroleum Institute (API) Type

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Monitoring	Inspection of discharge water for obvious signs of poor water quality.	Sheen, obvious oil present in discharge.	Effluent discharge from vault should be clear without visible sheen.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Monitoring	Sediment Accumulation	Sediment depth in bottom of vault exceeds 6 inches in depth.	No sediment deposits on vault bottom that would impede flow through the vault and reduce separation efficiency.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Monitoring	Trash and Debris Accumulation	Trash and debris accumulation in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault, and inlet/outlet piping.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	Monitoring	Oil Accumulation	Oil accumulations that exceed 1 inch, at the surface of the water or 6 inches of sludge in the sump.	Extract oil/sludge from vault by vactoring. Dispose of in accordance with state and local rules and regulations. Clean separators after spills. Replace wash water with clean water before returning to service.
Annually (preferably Sept.)	Structure	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired or replaced.
Annually (preferably Sept.)	Structure	Access Cover Damaged/Not Working	Cover cannot be opened, corrosion/ deformation of cover.	Cover repaired to proper working specifications or replaced.
Annually (preferably Sept.)	Structure	Vault Structure Damage Includes Cracks in Walls/Bottom, Damage to Frame and/or Top Slab	Maintenance person judges that structure is unsound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	Structure	Vault Structure Damage Includes Cracks in Walls/Bottom, Damage to Frame and/or Top Slab	Cracks wider than one-half inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than one-fourth inch at the joint of the inlet/ outlet pipe.
Annually (preferably Sept.)	Structure	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
Annually (preferably Sept.)	Structure	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

An oil/water separator vault is a confined space. Visual inspections should be performed aboveground. If entry is required it should be performed by qualified personnel.

Comments:

#21 - Maintenance Standard for Coalescing Plate Oil/Water Separators

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Inspection of discharge water for obvious signs of poor water quality.	Sheen, obvious oil present in discharge.	Effluent discharge from vault should be clear with no visible sheen.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Sediment Accumulation	Sediment depth in bottom of vault exceeds 6 inches in depth and/or visible signs of sediment on plates.	No sediment deposits on vault bottom and plate media, which would impede flow through the vault and reduce separation efficiency.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Trash and Debris Accumulation	Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault, and inlet/outlet piping.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Oil Accumulation	Oil accumulation that exceeds 1 inch at the water surface.	Oil is extracted from vault using vactoring methods. Dispose of in accordance with state and local rules and regulations. Coalescing plates are cleaned by thoroughly rinsing and flushing. Direct wash-down effluent to the sanitary sewer system where permitted. Should be no visible oil depth on water. Clean separators by October 15 to remove material accumulated during the dry season. Clean separators after spills. Replace wash water with clean water before returning to service.
Annually (preferably Sept.)	Structure	Damaged Coalescing Plates	Plate media broken, deformed, cracked and/ or showing signs of failure.	A portion of the media pack or the entire plate pack is replaced depending on severity of failure.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	Structure	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and or replaced.
Annually (preferably Sept.)	Structure	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced per specifications.
Annually (preferably Sept.)	Structure	Vault Structure Damage - Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab	Cracks wider than one-half inch or evidence of soil particles entering the structure through the cracks, or maintenance/ inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
Annually (preferably Sept.)	Structure	Vault Structure Damage - Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab	Cracks wider than one-half inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than one-fourth inch at the joint of the inlet/ outlet pipe.
Annually (preferably Sept.)	Structure	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

An oil/water separator vault is a confined space. Visual inspections should be performed aboveground. If entry is required it should be performed by qualified personnel.

Comments:

#22 - Maintenance Standard for Fencing/Shrubbery Screen/Other Landscaping

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr.	General	Missing or broken parts/ dead shrubbery	Any defect in the fence or screen that permits easy entry to a facility.	Fence is mended or shrubs replaced to form a solid barrier to entry.
Monthly from Oct. – Apr. and after any major storm event (1" in 24 hours)	General	Erosion	Erosion has resulted in an opening under a fence that allows entry by people or pets.	Replace soil under fence so that no opening exceeds 4 inches in height.
Monthly from Oct. – Apr.	General	Unruly Vegetation	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.
Annually (preferably Sept.)	Fences	Damaged Parts	Posts out of plumb more than 6 inches.	Posts are within 1.5 inches of plumb.
Annually (preferably Sept.)	Fences	Damaged Parts	Top rails bent more than 6 inches.	Top rail free of bends greater than 1 inch.
Annually (preferably Sept.)	Fences	Damaged Parts	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.
Annually (preferably Sept.)	Fences	Damaged Parts	Missing or loose tension wire.	Tension wire in place and holding fabric.
Annually (preferably Sept.)	Fences	Damaged Parts	Missing or loose barbed wire that is sagging more than 2.5 inches between posts.	Barbed wire in place with less than three-fourth inch sag between posts.
Annually (preferably Sept.)	Fences	Damaged Parts	Extension arm missing, broken, or bent out of shape more than 1.5 inches.	Extension arm in place with no bends larger than three-fourth inch.
Annually (preferably Sept.)	Fences	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.
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#23 - Maintenance Standard for Gates

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr.	General	Damaged or Missing Components	Gate is broken, jammed, or missing.	Pond has a functioning gate to allow entry of people and maintenance equipment such as mowers and backhoe. If a lock is used, make sure the City field staff have a key.
Monthly from Oct. – Apr.	General	Damaged or Missing Components	Broken or missing hinges such that gate cannot be easily opened and closed by one maintenance person.	Hinges intact and lubed. Gate is working freely.
Annually (preferably Sept.)	General	Damaged or Missing Components	Gate is out of plumb more than 6 inches and more than 1 foot out of design alignment.	Gate is aligned and vertical.
Annually (preferably Sept.)	General	Damaged or Missing Components	Missing stretcher bands, and ties.	Stretcher bar, bands, and ties in place.
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#24 - Maintenance Standard for Grounds (Landscaping)

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr.	General	Weeds (non-poisonous)	Weeds growing in more than 20 percent of the landscaped area (trees and shrubs only).	Weeds present in less than 5 percent of the landscaped area.
Biannually (Spring & Fall)	General	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 in State and Local Regulations. (Apply requirements of adopted integrated vegetation management (IVM) policies for the use of herbicides.)	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with the Pierce County Noxious Weed Control Board). Complete eradication of noxious weeds may not be possible, however compliance with state or local eradication policies are required.
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Trash and Debris	Any trash and debris which exceeds 1 cubic feet per 1,000 square feet. In general, there should be no visual evidence of dumping.	Trash and debris cleared from site.
Monthly from Oct. – Apr. and after any major storm event (1” in 24 hours)	General	Erosion of Ground Surface	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.
Annually (preferably Sept.)	Trees and shrubs	Damage	Limbs or parts of trees or shrubs that are split or broken which affect more than 25 percent of the total foliage of the tree or shrub.	Trim trees/shrubs to restore shape. Replace severely damaged trees/shrubs.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly from Oct. – Apr.	Trees and shrubs	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.
Annually (preferably Sept.)	Trees and shrubs	Damage	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.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#25 - Maintenance Standard for Bioretention Facilities

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Biannually and After Major Storm Events	Earthen side slopes and berms	Failure in earthen reservoir	Erosion (gullies/rills) greater than 2 inches deep around inlets, outlet and alongside slopes.	Eliminate cause of erosion and stabilize damaged area (regrade, rock, vegetation, erosion control matting). For deep channels or cuts (over 3 inches in ponding depth), temporary erosion control measures should be put in place until permanent repairs can be made. Properly designed, constructed and established facilities with appropriate flow velocities should not have erosion problems except perhaps in extreme events. If erosion problems persist, the following should be reassessed: (1) flow volumes from contributing areas and bioretention facility sizing; (2) flow velocities and gradients within the facility; and (3) flow dissipation and erosion protection strategies at the facility inlet.
Annually	Earthen side slopes and berms	Failure in earthen reservoir	Erosion of sides causes slope to become a hazard.	Take actions to eliminate the hazard and stabilize slopes.
Annually and After Major Storm Events	Earthen side slopes and berms	Failure in earthen reservoir	Settlement greater than 3 inches (relative to undisturbed sections of the berm).	Restore to design height.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually and After Major Storm Events	Earthen side slopes and berms	Failure in earthen reservoir	Downstream face of berm wet, seeps or leaks evident.	Plug any holes and compact berm (may require consultation with a Washington State Licensed Professional Engineer, particularly for larger berms).
Annually	Earthen side slopes and berms	Failure in earthen reservoir	Any evidence of rodent holes or water piping in berm.	Eradicate rodents (see “Pest control”). Fill holes and compact (may require consultation with a Washington State Licensed Professional Engineer, particularly for larger berms).
Annually	Concrete sidewalls	Failure in sidewalls	Cracks or failure of concrete sidewalls.	Repair/seal cracks. Replace if repair is insufficient.
Annually	Rockery sidewalls	Failure in sidewalls	Rockery side walls are insecure.	Stabilize rockery sidewalls (may require consultation with a Washington State Licensed Professional Engineer particularly for walls 4 feet or greater in height).
As Needed	Facility area	Accumulation of sediment or debris	Trash and debris present.	Clean out trash and debris.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually and After Major Storm Events	Facility bottom area	Accumulation of sediment or debris	Accumulated sediment to the extent that infiltration rate is reduced (See “Ponded water”) or surface storage capacity significantly impacted.	Remove excess sediment. Replace any vegetation damaged or destroyed by sediment accumulation and removal. Mulch newly planted vegetation. Identify and control the sediment source (if feasible). If accumulated sediment is recurrent, consider adding presettlement or installing berms to create a forebay at the inlet.
As Needed During and After Fall Leaf Drop	Facility bottom area	Accumulation of sediment or debris	Accumulated leaves in facility.	Remove leaves if there is a risk to clogging outlet structure or water flow is impeded.
Annually and After Major Storm Events	Low permeability check dams and weirs	Accumulation of sediment or debris	Sediment, vegetation, or debris accumulated at or blocking (or having the potential to block) check dam, flow control weir or orifice.	Clear the blockage.
Annually and After Major Storm Events	Low permeability check dams and weirs	Failure of check dams and weirs	Erosion and/or undercutting present.	Repair and take preventative measures to prevent future erosion and/or undercutting.
Annually	Low permeability check dams and weirs	Failure of check dams and weirs	Grade board or top of weir damaged and not level.	Restore to level position.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Biannually and After Major Storm Events	Ponded water	Water remains in bioretention facility after storm event	Excessive ponding water: Water overflows during storms smaller than the design event or ponded water remains in the basin 48 hours or longer after the end of a storm.	Determine cause and resolve in the following order: 1) Confirm leaf or debris buildup in the bottom of the facility is not impeding infiltration. If necessary, remove leaf litter/debris. 2) Ensure that underdrain (if present) is not clogged. If necessary, clear underdrain. 3) Check for other water inputs (e.g., groundwater, illicit connections). 4) Verify that the facility is sized appropriately for the contributing area. Confirm that the contributing area has not increased. If steps #1-4 do not solve the problem, the bioretention soil is likely clogged by sediment accumulation at the surface or has become overly compacted. Dig a small hole to observe soil profile and identify compaction depth or clogging front to help determine the soil depth to be removed or otherwise rehabilitated (e.g., tilled). Consultation with a Washington State Licensed Professional Engineer is recommended.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
As needed	Bioretention soil media		Bioretention soil media protection is needed when performing maintenance requiring entrance into the facility footprint.	Minimize all loading in the facility footprint (foot traffic and other loads) to the degree feasible in order to prevent compaction of bioretention soils. Never drive equipment or apply heavy loads in facility footprint. Because the risk of compaction is higher during saturated soil conditions, any type of loading in the cell (including foot traffic) should be minimized during wet conditions. Consider measures to distribute loading if heavy foot traffic is required or equipment must be placed in facility. As an example, boards may be placed across soil to distribute loads and minimize compaction. If compaction occurs, soil must be loosened or otherwise rehabilitated to original design state.
Annually	Splash block inlet	Inlet Failure	Water is not being directed properly to the facility and away from the inlet structure.	Reconfigure/repair blocks to direct water to facility and away from structure.
Monthly during the wet season and before severe storm is forecasted	Curb cut inlet/ outlet	Inlet Clogged	Accumulated leaves at curb cuts.	Clear leaves (particularly important for key inlet and low points along long, linear facilities).
Annually	Pipe inlet/outlet	Inlet Pipe Structure Failure	Pipe is damaged.	Repair/replace.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually During the Wet Season	Pipe inlet/outlet	Inlet Pipe Clogged	Pipe is clogged.	Remove roots or debris.
Annually and After Major Storm Events	Pipe inlet/outlet	Inlet Pipe Clogged	Sediment, debris, trash or mulch reducing capacity of inlet/outlet.	Clear the blockage. Identify the source of the blockage and take actions to prevent future blockages.
Weekly During Fall Leaf Drop	Pipe inlet/outlet	Inlet Clogged	Accumulated leaves at the inlets/outlets.	Clear leaves (particularly important for key inlets and low points along long, linear facilities).
Annually	Pipe inlet/outlet	Inlet Blocked	Maintain access for inspections.	Clear vegetation (transplant vegetation when possible) within 1 foot of inlets and outlets, maintain access pathways. Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants.
After Major Storm Events	Trash rack	Trash Rack clogged	Trash or other debris present on trash rack.	Remove/dispose.
Annually	Trash rack	Trash Rack Damaged	Bar screen damaged or missing.	Repair/replace.
Annually and After Major Storm Events	Overflow	Overflow clogged	Capacity reduced by sediment or debris.	Remove sediment or debris/dispose.
As Needed Clean Orifice as Needed, At Least Biannually	Underdrain pipe	Prolonged surface ponding (see “Ponded water”)	Plant roots, sediment or debris reducing capacity of underdrain.	Jet clean or rotary cut debris/roots from underdrain(s). If underdrains are equipped with a flow restrictor (e.g., orifice) to attenuate flows, the orifice must be cleaned regularly.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Biannually (Fall and Spring)	Facility bottom area and upland slope vegetation	Dead vegetation	Vegetation survival rate falls below 75% within first two years of establishment (unless project O&M manual or record drawing stipulates more or less than 75% survival rate).	Determine cause of poor vegetation growth and correct condition. Replant as necessary to obtain 75% survival rate or greater. Refer to original planting plan, or approved jurisdictional species list for appropriate plant replacements (See Appendix 3 - Bioretention Plant List, in the LID Technical Guidance Manual for Puget Sound). Confirm that plant selection is appropriate for site growing conditions. Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
As needed	Vegetation (general)	Diseased Vegetation	Presence of diseased plants and plant material.	Remove any diseased plants or plant parts and dispose of in an approved location (e.g., commercial landfill) to avoid risk of spreading the disease to other plants. Disinfect gardening tools after pruning to prevent the spread of disease. See Pacific Northwest Plant Disease Management Handbook for information on disease recognition and for additional resources. Replant as necessary according to recommendations provided for “facility bottom area and upland slope vegetation”.
All Pruning Seasons	Trees and shrubs	Oversized trees and shrubs	Pruning as needed.	Prune trees and shrubs in a manner appropriate for each species. Pruning should be performed by landscape professionals familiar with proper pruning techniques. All pruning of mature trees should be performed by or under the direct guidance of an ISA Certified Arborist.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually	Trees and Shrubs	Oversized trees and shrubs	Large trees and shrubs interfere with operation of the facility or access for maintenance.	Prune trees and shrubs using most current ANSI A300 standards and ISA BMPs. Remove trees and shrubs, if necessary.
Biannually (Fall and Spring)	Trees and shrubs	Dead trees or shrubs	Standing dead vegetation is present.	Remove standing dead vegetation. Replace dead vegetation within 30 days of reported dead and dying plants (as practical depending on weather/planting season). If vegetation replacement is not feasible within 30 days, and absence of vegetation may result in erosion problems, temporary erosion control measures should be put in place immediately. Determine cause of dead vegetation and address issue, if possible. If specific plants have a high mortality rate, assess the cause and replace with appropriate species. Consultation with a landscape architect is recommended.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Biannually (Fall and Spring)	Trees and shrubs		Planting beneath mature trees.	When working around and below mature trees, follow the most current ANSI A300 standards and ISA BMPs to the extent practicable (e.g., take care to minimize any damage to tree roots and avoid compaction of soil). Planting of small shrubs or groundcovers beneath mature trees may be desirable in some cases; such plantings should use mainly plants that come as bulbs, bare root or in 4-inch pots; plants should be in no larger than 1-gallon containers.
Biannually (Fall and Spring)	Trees and shrubs	Tree support	Presence of or need for stakes and guys (tree growth, maturation, and support needs).	Verify location of facility liners and underdrain (if any) prior to stake installation in order to prevent liner puncture or pipe damage. Monitor tree support systems: Repair and adjust as needed to provide support and prevent damage to tree. Remove tree supports (stakes, guys, etc.) after one growing season or maximum of 1 year. Backfill stake holes after removal.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually	Trees and shrubs adjacent to vehicle travel areas (or areas where visibility needs to be maintained)	Line of sight	Vegetation causes some visibility (line of sight) or driver safety issues.	Maintain appropriate height for sight clearance. Regular pruning (more than one time/ growing season) is required to maintain visual sight lines for safety or clearance along a walk or drive, consider relocating the plant to a more appropriate location. Remove or transplant if continual safety hazard. Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants.
Annually	Flower plants	Dead flowers	Dead or spent flowers present.	Remove spent flowers (deadhead).
Annually (Fall)	Perennials	Dead plants	Spent plants.	Cut back dying or dead and fallen foliage and stems.
Annually (Spring)	Emergent vegetation	Slow moving or ponded water	Vegetation compromises conveyance.	Hand rake sedges and rushes with a small rake or fingers to remove dead foliage before new growth emerges in spring or earlier only if the foliage is blocking water flow (sedges and rushes do not respond well to pruning).

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Biannually (Winter and Spring	Ornamental grasses (perennial)	Dead plant material	Dead material from previous year's growing cycle or dead collapsed foliage.	Leave dry foliage for winter interest. Hand rake with a small rake or fingers to remove dead foliage back to within several inches from the soil before new growth emerges in spring or earlier if the foliage collapses and is blocking water flow.
Biannually (Winter and Spring	Ornamental grasses (evergreen)	Dead plant material	Dead growth present in spring.	Hand rake with a small rake or fingers to remove dead growth before new growth emerges in spring. Clean, rake, and comb grasses when they become too tall. Cut back to ground or thin every 2-3 years as needed.
Monthly (March - October, preceding seed dispersal)	Vegetation	Noxious weeds	Listed noxious vegetation is present (refer to current Pierce County Noxious Weed Control Board noxious weed list).	By law, class A & B noxious weeds must be removed, bagged and disposed as garbage immediately. Reasonable attempts must be made to remove and dispose of class C noxious weeds. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality; use of herbicides and pesticides may be prohibited in some jurisdictions. Apply mulch after weed removal (see "Mulch").

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly (March - October, preceding seed dispersal)	Vegetation	Weeds	Weeds are present.	Remove weeds with their roots manually with pincer-type weeding tools, flame weeders, or hot water weeders as appropriate. Follow IPM protocols for weed management.
Once in early to mid-May and once in early to mid-September	Vegetation	Excessive vegetation	Low-lying vegetation growing beyond facility edge onto sidewalks, paths, or street edge poses pedestrian safety hazard or may clog adjacent permeable pavement surfaces due to associated leaf litter, mulch, and soil.	Edge or trim groundcovers and shrubs at facility edge. Avoid mechanical blade-type edger and do not use edger or trimmer within 2 feet of tree trunks. While some clippings can be left in the facility to replenish organic material in the soil, excessive leaf litter can cause surface soil clogging.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
As needed	Vegetation	Excessive vegetation	Excessive vegetation density inhibits stormwater flow beyond design ponding or becomes a hazard for pedestrian and vehicular circulation and safety.	Determine whether pruning or other routine maintenance is adequate to maintain proper plant density and aesthetics. Determine if plant type should be replaced to avoid ongoing maintenance issues (an aggressive grower under perfect growing conditions should be transplanted to a location where it will not impact flow) . Remove plants that are weak, broken or not true to form; replace in-kind. Thin grass or plants impacting facility function without leaving visual holes or bare soil areas. Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants.
As needed	Vegetation	Excessive Vegetation	Vegetation blocking curb cuts, causing excessive sediment buildup and flow bypass.	Remove vegetation and sediment buildup.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Following weeding	Vegetation	Mulch	Bare spots (without mulch cover) are present or mulch depth less than 2 inches.	Supplement mulch with hand tools to a depth of 2 to 3 inches. Replenish mulch per O&M manual. Often coarse compost is used in the bottom of the facility and arborist wood chips are used on side slopes and rim (above typical water levels). Keep all mulch away from woody stems.
Based on manufacturer instructions	Irrigation system (if any)	Plant Watering	Irrigation system present.	Follow manufacturer's instructions for O&M.
Annually	Irrigation system (if any)	Plant Watering	Sprinklers or drip irrigation not directed/ located to properly water plants.	Redirect sprinklers or move drip irrigration to desired areas.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Once every 1-2 weeks or as needed during prolonged dry periods	summer watering (first year)	Plant Watering	Trees, shrubs and ground cover in the first year of establishment period.	10 to 15 gallons per tree. 3 to 5 gallons per shrub. 2 gallons water per square foot for groundcover areas. Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist. Use soaker hoses or spot water with a shower type wand when irrigation system is not present. • Pulse water to enhance soil absorption, when feasible. • Pre-moisten soil to break surface tension of dry or hydrophobic soils/ mulch, followed by several more passes. With this method , each pass increases soil absorption and allows more water to infiltrate prior to runoff. Add a tree bag or slow-release watering device (e.g., bucket with a perforated bottom) for watering newly installed trees when irrigation system is not present.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Once every 2 -4 weeks or as needed during prolonged dry periods	Summer watering (second and third years)	Plant Watering	Trees, shrubs and groundcovers in the second or third year of establishment period.	10 to 15 gallons per tree. 3 to 5 gallons per shrub. 2 gallons water per square foot for groundcover areas. Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist. Use soaker hoses or spot water with a shower type wand when irrigation system is not present. • Pulse water to enhance soil absorption, when feasible. • Pre-moisten soil to break surface tension of dry or hydrophobic soils/ mulch, followed by several more passes. With this method , each pass increases soil absorption and allows more water to infiltrate prior to runoff.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
As needed	Summer watering (after establishment)	Plant Watering	Established vegetation (after 3 years).	Plants are typically selected to be drought tolerant and not require regular watering after establishment; however, trees may take up to 5 years of watering to become fully established. Identify trigger mechanisms for drought-stress (e.g., leaf wilt, leaf senescence, etc.) of different species and water immediately after initial signs of stress appear. Water during drought conditions or more often if necessary to maintain plant cover.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Biannually and After Major Storm Events	Pest Control	Mosquitoes	Standing water remains for more than 3 days after the end of a storm.	Identify the cause of the standing water and take appropriate actions to address the problem (see “Ponded water”). To facilitate maintenance, manually remove standing water and direct to the stormwater system (if runoff is from non pollution-generating surfaces) or wastewater (if runoff is from pollution-generating surfaces) after getting approval from The City of Tacoma. Use of pesticides or *Bacillus thuringiensis israelensis* (Bti) may be considered as a temporary measure only. Obtain Aquatic Mosquito Control NPDES General Permit as necessary.
As needed	Pest Control	Nuisance animals	Nuisance animals causing erosion, damaging plants, or depositing large volumes of feces.	Reduce site conditions that attract nuisance species where possible (e.g., plant shrubs and tall grasses to reduce open areas for geese, etc.). Place predator decoys. Follow IPM protocols for specific nuisance animal issues . Remove pet waste regularly. For public and right-of-way sites consider adding garbage cans with dog bags for picking up pet waste.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Every site visited associated with vegetation management	Pest Control	Insect pests	Signs of pests, such as wilting leaves, chewed leaves, and bark spotting or other indicators.	Reduce hiding places for pests by removing diseased and dead plants. For infestations, follow IPM protocols.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#26 - Maintenance Standard for Rain Gardens

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Biannually (During Wet Season)	Earthen side slopes and berms	Failure in earthen reservoir	Persistent soil erosion on slopes.	If erosion persists, water may be flowing into the garden too rapidly. In this case, the slope of the pipe or swale directing water to the garden, or the amount of water may need to be reduced (see "Erosion control at inlet").
Annually	Rockery sidewalls	Failure in sidewalls	Rockery sidewalls are insecure.	Stabilize rockery sidewalls (may require consultation with a Washington State Licensed Professional Engineer particularly for walls 4 feet or greater in height.
Biannually	Rain Garden Footprint	Accumulation of sediment or debris	Trash and debris present.	Clean out trash and debris.
Annually	Facility bottom area	Accumulation of sediment or debris	Visible sediment deposition in the rain garden that reduces drawdown time of water in the rain garden.	Remove sediment accumulation. If sediment is deposited from water entering the rain garden, determine the source and stabilize the area or provide pretreatment.
As Needed, During and After Fall Leaf Drop	Facility Bottom Area	Accumulation of leaves	Accumulated leaves in rain garden may reduce infiltration capacity of rain garden or clog overflow.	Remove Leaves.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Biannually and After Major Storm Events	Ponded Water	Water remains in bioretention facility 3 days after storm event	Excessive ponding water. Ponded water remains in the basin more than 3 days after the end of a storm.	Confirm leaf, debris or sediment buildup in the bottom of the rain garden is not impeding infiltration. If necessary, remove leaf litter/debris/ sediment. If this does not solve the problem, consultation with a professional with rain garden expertise is recommended to evaluate the following: • Check for other water inputs (e.g., groundwater, illicit connections). • Verify that the facility is sized appropriately for the contributing area. Confirm that the contributing area has not increased. • Determine if the soil is clogged by sediment accumulation at the surface or if the soil has become overly compacted.
Annually	Splash Block Inlet	Inlet Failure	Water is not being directed properly to the rain garden and away from the building.	Reconfigure/repair splash blocks to direct water to the rain garden and away from the building.
Annually	Pipe inlet/outlet	Inlet Pipe Structure Failure	Damaged/cracked pipes.	Repair/seal cracks. Replace when repair is insufficient.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually	Pipe inlet/outlet	Inlet Pipe Clogged	Pipe capacity is reduced by sediment or debris (can cause backups and flooding).	Clear pipes of sediment and debris.
Annually	Erosion control at inlet	Excessive Sedimentation	Rock or cobble is removed or missing and concentrated flows are contacting soil.	Maintain a cover of rock or cobbles to protect the ground where concentrated water flows into the rain garden from a pipe or swale.
As needed	Vegetation	Diseased Vegetation	Dying, dead, or unhealthy plants.	Maintain a healthy cover of plants. Remove any diseased plants or plant parts and dispose of in commercial landfill to avoid risk of spreading the disease to other plants. Disinfect gardening tools after pruning to prevent the spread of disease. Re-stake trees if they need more support, but plan to remove stakes and ties after the first year. Cars can damage roots – protect root areas of trees and plants from vehicle traffic.
As needed	Vegetation	Line of Sight	Vegetation inhibits sight distances and sidewalks.	Keep sidewalks and sight distances on roadways clear.
As needed	Vegetation	Dead Vegetation	Broken, dead, or sucker vegetation is present.	Remove broken or dead branches and suckers.
As needed	Vegetation	Localized Ponding or Obstruction of flow	Vegetation is crowding inlets and outlets.	Keep water inlets and outlines in the rain garden clear or vegetation.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
One time March through June	Vegetation	Dead/ diseased plants	Yellowing: possible Nitrogen (N) deficiency. Poor growth: possible Phosphorous (P) deficiency. Poor flowering, spotting or curled leaves, or weak roots or stems: possible Potassium (K) deficiency.	Test soil to identify specific nutrient deficiencies. Consult with a professional knowledgeable in the area of natural amendments or refer to Natural Lawn and Garden Care resources and avoid synthetic fertilizers. Consider selecting different plants for soil conditions.
As needed, Preceding seed dispersal	Vegetation	Weeds Present	Problem weeds are present.	Remove weeds by hand, especially in spring when the soil is moist and the weeds are small. Dig or pull weeds out by the roots before they go to seed. Apply mulch after weeding (see “Mulch”).
Monthly March - October, preceding seed dispersal	Vegetation	Noxious Weeds	Listed noxious vegetation is present (refer to current Pierce County Noxious Weed Control Board noxious weed list).	By law, class A & B noxious weeds must be removed, bagged and disposed as garbage immediately. Reasonable attempts must be made to remove and dispose of class C noxious weeds. It is strongly encouraged that herbicides not be used in order to protect water quality; use of herbicides may be prohibited in some jurisdictions. Apply mulch after weed removal (see “Mulch”).

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Following weeding	Vegetation	Mulch	Bare spots (without mulch cover) are present or mulch depth less than 2 inches.	Supplement mulch, using hand tools, to a depth of 2 to 3 inches. Use coarse compost in the bottom of the rain garden and arborist wood chips on side slopes and rim (above typical water levels). Keep all mulch from being in contact with woody stems.
Once every 1-2 weeks or as needed during prolong dry periods	Summer watering (first year)	Plant Watering	Tree, shrubs and groundcovers in first year of establishment.	10 to 15 gallons per tree. 3 to 5 gallons per shrub. 2 gallons water per square foot for groundcover areas. Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist. Use soaker hoses or spot water with a shower type wand when irrigation system is not present. Add a tree bag or slow-release watering device (e.g., bucket with a perforated bottom) for watering newly installed trees when irrigation system is not present.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Once every 2-4 weeks or as needed during prolonged dry periods	Summer watering (second and third years)	Plant Watering	Tree shrubs and groundcovers in the second or third year of establishment.	10 to 15 gallons per tree. 3 to 5 gallons per shrub. 2 gallons water per square foot for groundcover areas. Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist. Use soaker hoses or spot water with a shower type wand when irrigation system is not present.
As needed	Summer watering (after establishment)	Plant Watering	Established vegetation (after 3 years).	Water during drought conditions or more often if necessary to maintain plant cover. Identify trigger mechanisms for drought-stress (e.g., leaf wilt, leaf senescence, etc.) of different rain garden species and water immediately after initial signs of stress appear.
Biannually and After Major Storm Events	Pest Control	Mosquitoes	Standing water remains for more than 3 days after the end of a storm.	Identify the cause of the standing water and take appropriate actions to address the problem (see “Ponded water”). Use of pesticides or *Bacillus thuringiensis israelensis* (Bti) may be considered as a temporary measure only. Obtain Aquatic Mosquito Control General Permit as necessary.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#27 - Maintenance Standard for Cisterns

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Biannually (Spring & Fall)	Roof	Low flow into cistern or excessive overflow	Debris has accumulated.	Remove debris.
Biannually (Spring & Fall)	Gutter	Low flow into cistern or excessive overflow	Debris has accumulated.	Clean gutters (the most critical cleaning is in mid- to late-spring to flush the pollen deposits from surrounding trees).
Annually (preferably Sept.)	Screens	Excessive sediment accumulation in cistern	Screen has deteriorated.	Replace.
Monthly from Oct. – Apr.	Screens	Low flow into cistern or excessive overflow	Accumulation of material on screen.	Clear screen of any accumulated debris.
Monthly from Oct. – Apr.	Low Flow Orifice	Low or no flow out of cistern.	Material clogging orifice.	Clean low flow orifice.
Biannually (Spring & Fall)	Overflow pipe	Low or no flow out of cistern.	Pipe is damaged.	Repair/replace.
Biannually (Spring & Fall)	Overflow pipe	Low or no flow out of cistern.	Pipe is clogged.	Remove debris.
Annually (preferably Sept.)	Cistern	Excess overflow	Debris has accumulated at bottom of tank.	Remove debris.
At startup	Training and Documentation	Training / written guidance	Training / written guidance is required for proper O&M.	Provide property owners and tenants with proper training and a copy of the O&M manual.
Ongoing	Safety	Access and Safety	Access to cistern required for maintenance or cleaning.	Any cistern detention system opening that could allow the entry of people must be marked: “DANGER—CONFINED SPACE".
Ongoing	Cistern	Leaking Cistern	Excess water around cistern. Damage to cistern.	Disconnect inlets. Contact design engineer.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted integrated pest management policies.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#28 - Maintenance Standard for Compost Amended Soil

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually	Soil Media (maintain high organic soil content)	Potential Erosion	Vegetation not fully covering ground surface or vegetation health is poor.	Maintain 2 to 3 inches of mulch over bare areas in landscape beds. Add plants if sufficient space. Re-seed bare turf areas until the vegetation fully covers ground surface.
Ongoing	Soil media (maintain high organic soil content)	Routine Maintenance	None. (routine maintenance)	Return leaf fall and shredded woody materials from the landscape to the site when possible in order to replenish soil nutrients and structure.
Ongoing	Soil media (maintain high organic soil content)	Routine Maintenance	None. (routine maintenance)	On turf areas, “grasscycle” (mulch-mow or leave the clippings) to improve turf health.
Ongoing	Soil media (maintain high organic soil content)	Routine Maintenance	None. (routine maintenance)	Avoid use of pesticides (bug and weed killers) and herbicides, like “weed & feed”, which damage the soil.
Annually	Soil media (maintain high organic soil content)	Routine Maintenance	None. (routine maintenance)	Where fertilization is needed (mainly turf and annual flower beds), a moderate fertilization program should be used which relies on compost, natural fertilizers or slow-release synthetic balanced fertilizers. Follow IPM protocols for fertilization procedures.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (inspect during storm event)	Soil media (maintain infiltration)	Wet Soils Ponding	Soils become waterlogged, do not appear to be infiltrating.	To remediate compaction, aerate soil, till to at least 8-inch depth, or further amend soil with compost and re-till. If areas are turf, aerate compacted areas and topdress them with 1/4 to 1/2 inch of compost to renovate them. If drainage is still slow, consider investigating alternative causes (e.g., high wet season groundwater levels, low permeability soils). Also consider site use and protection from compacting activities.
Annually (at least once during the wet season) and after major storm events)	Erosion/ Scouring	Visible Erosion	Areas of potential erosion are visible.	Identify and address cause of erosion (e.g., concentrated flow entering area, channelization of runoff) and stabilize damaged area (regrade, rock, vegetation, erosion control matting). For deep channels or cuts (over 3 inches in ponding depth), temporary erosion control measures should be put in place until permanent repairs can be made.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually	Grass/ vegetation	Unhealthy Vegetation	Less than 75% of planted vegetation is healthy with a generally good appearance.	Take appropriate maintenance actions (e.g., remove/replace plants). If problem persists, evaluate if vegetation is appropriate for the location (e.g., exposure, soil, soil moisture).
Monthly (March - October, preceding seed dispersal)	Vegetation	Noxious weeds	Listed noxious vegetation is present (refer to current Pierce County Noxious Weed Control Board noxious weed list).	By law, class A & B noxious weeds must be removed, bagged and disposed as garbage immediately. Reasonable attempts must be made to remove and dispose of class C noxious weeds. Watch for and respond to new occurrences of especially aggressive weeds such as Himalayan blackberry, Japanese knotweed, morning glory, English ivy, and reed canary grass to avoid invasions. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality; use of herbicides and pesticides may be prohibited in some jurisdictions.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly (March - October, preceding seed dispersal)	Vegetation	Weeds	Weeds are present.	Remove weeds with their roots manually with pincer-type weeding tools, flame weeders, or hot water weeders as appropriate. Follow IPM protocols for weed management.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#29 - Maintenance Standard for Vegetated Roofs

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (Inspect During Rain Event)	Growth Medium	Ponding or slow infiltration	Water does not permeate growth media (runs off soil surface) or crusting is observed.	Aerate (e.g., rake) or replace medium taking care not to damage the waterproof membrane.
Annually	Growth Medium	Thin growth medium	Growth medium thickness is less than design thickness (due to erosion and plant uptake).	Supplement growth medium to design thickness.
Biannually (at least once during wet season)	Growth Medium	Leaf/Debris Buildup	Fallen leaves or debris are present.	Remove/dispose of debris and fallen leaves.
Annually (at least once during the wet season and after major storm events	Growth Medium	Erosion and sedimentation	Growth media erosion/ scour is visible (e.g., gullies).	Take steps to repair or prevent erosion. Fill, hand tamp, or lightly compact, and stabilize with additional soil substrate/growth medium (similar in nature to the original material) and additional plants.
Biannually (inspect during plant establishment)	Erosion Control Measures	Erosion	Mat or other erosion control is damaged or depleted during plant establishment period.	Repair/replace erosion control measures until 90% vegetation coverage attained. Avoid application of mulch on extensive vegetated roofs.
Biannually and after major storm events	Roof Drain	Water Flow Issues	Sediment, vegetation, or debris reducing capacity of inlet structure.	Clear blockage. Identify and correct any problems that led to blockage.
Annually	Roof Drain	Water Flow Issues	Pipe is clogged.	Remove roots or debris.
Annually	Roof Drain	Damaged roof drain	Inlet pipe is in poor condition.	Repair/replace.
Annually	Border Zone	Aesthetics	Vegetation is encroaching into border zone aggregate.	Remove and dispose of weeds and transplant desirable vegetation to growth medium area.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually	Flashing, gravel, stops, utilities, or other structures on roof	Deteriorating roof components	Flashing, utilities or other structures on roof are deteriorating (can serve as source of metal pollution in vegetated roof runoff).	Repair (e.g., recoat) or replace to eliminate potential pollutant source. Note that any work done around flashings and drains should be done with care to protect the waterproof membrane.
Biannually	Access and Safety	Access Concerns	Insufficient egress/ ingress routes and fall protection.	Maintain egress and ingress routes to design standards and fire codes. Ensure appropriate fall protection.
Biannually	Vegetation	Plant Coverage	Vegetative coverage falls below 90% (unless design specifications stipulate less than 90% coverage).	Plant bare areas with vegetation. If necessary, install erosion control measures until percent coverage goal is attained.
Annually (first 2 years in spring, as needed thereafter)	Vegetation	Sedum Coverage	Extensive roof with low density sedum population.	Mulch mow sedums-creating cuttings from existing plants to encourage colonization.
Biannually (Fall and Spring)	Dead Plants	Dead Vegetation	Dead vegetation is present.	Normally dead plant material can be recycled on the roof; however, specific plants or aesthetic considerations may warrant removing and replacing dead material (see manufacturer's recommendations).
All pruning seasons (timing varies by species)	Trees and shrubs - intensive vegetated roof	Plants Overgrown	Pruning as needed.	All pruning of mature trees should be performed by or under the direct guidance of an ISA Certified Arborist.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually	Vegetation - extensive vegetated roof	Fertilization	Poor plant establishment and possible nutrient deficiency in growth medium.	Allow organic debris to replenish and maintain long-term nutrient balance and growth medium structure. Conduct annual soil test 2-3 weeks prior to the spring growth flush to assess need for fertilizer. Utilize test results to adjust fertilizer type and quantity appropriately. Apply minimum amount slow-release fertilizer necessary to achieve successful plant establishment. Apply fertilizer only after acquiring required approval from facility owner and operator. Note that extensive vegetated roofs are designed to require zero to minimal fertilization after establishment (excess fertilization can contribute to nutrient export).

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually	Vegetation	Fertilization - intensive vegetated roof	Fertilization may be necessary during establishment period or for plant health and survivability after establishment.	Conduct annual soil test 2-3 weeks prior to the spring growth flush to assess need for fertilizer. Utilize test results to adjust fertilizer type and quantity appropriately. Apply minimum amount slow-release fertilizer necessary to achieve successful plant establishment. Apply fertilizer only after acquiring required approval from facility owner and operator. Intensive vegetated roofs may require more fertilization than extensive vegetated roofs.
Monthly (March-October) Preceding Seed Dispersal	Vegetation	Weeds	Weeds are present.	Remove weeds with their roots manually with pincer-type weeding tools or hot water weeders as appropriate. Follow IPM protocols for weed management.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Monthly (March-October Preceding Seed Dispersal)	Vegetation - intensive vegetated roof	Noxious Weeds	Listed Noxious vegetation is present (refer to the Pierce County Noxious Control Board noxious weed list).	By law, class A & B noxious weeds must be removed, bagged and disposed as garbage immediately. Reasonable attempts must be made to remove and dispose of class C noxious weeds. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality; use of herbicides and pesticides may be prohibited in some jurisdictions.
Based on manufacturer's Instructions	Irrigation System (if any)	Irrigation	Irrigation system present and functioning.	Follow manufacturer's instructions for operation and maintenance.
Once every 1-2 weeks as needed during prolonged dry periods	Summer watering - extensive vegetated roof	Watering	Vegetation in establishment period (1-2 years).	Water weekly during periods of no rain to ensure establishment (30 to 50 gallons per 100 square feet).
Once every 1-2 weeks as needed during prolonged dry periods	Summer watering - intensive vegetated roof	Watering	Vegetation in establishment period (1-2 years).	Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist. Use soaker hoses or spot water with a shower type wand when irrigation system not present.
As needed	Summer watering - intensive vegetated roof	Watering	Established vegetation (after 2 years).	Water during drought conditions or more often if necessary to maintain plant cover.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Biannually and After Major Storm Events	Pests	Mosquito	Standing water remains for more than 3 days after the end of a storm.	Identify the cause of the standing water and take appropriate actions to address the problem (e.g., aerate or replace medium, unplug drainage). Manually remove standing water and direct to stormwater system. Use of pesticides or Bacillus thuringiensis israelensis (Bti) may be considered as a temporary measure only. Obtain Aquatic Mosquito Control General Permit as necessary..
As Needed	Pests	Nuisance Animals	Nuisance animals causing erosion, damaging plants, or depositing large volumes of feces.	Reduce site conditions that attract nuisance species. Place predator decoys. Follow IPM protocols for specific nuisance animal issues.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#30 - Maintenance Standard for Pervious Pavement

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually and After Major Storm Events	Permeable Pavements, All	Excessive Sedimentation	Run-on from adjacent areas deposits soil, mulch or sediment on paving.	Clean deposited soil or other materials. Check if surface elevation of adjacent planted area is too high, or slopes towards pavement, and can be regraded (prior to regrading, protect permeable pavement by covering with temporary plastic and secure covering in place). Mulch and/or plant all exposed soils that may erode to pavement surface.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually or Biannually	Porous asphalt or pervious concrete	Routine Maintenance	None (routine maintenance)	Clean surface debris from pavement surface using one or a combination of the following methods: Remove sediment, debris, trash, vegetation, and other debris deposited onto pavement (rakes and leaf blowers can be used for removing leaves). Vacuum/sweep permeable paving installation using: • Walk-behind vacuum (sidewalks) • High efficiency regenerative air or vacuum sweeper (roadways, parking lots) • ShopVac or brush brooms (small areas) • Hand held pressure washer or power washer with rotating brushes Follow equipment manufacturer guidelines for determining when equipment is most effective for cleaning permeable pavement. Dry weather is more effective for some equipment.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (inspect during rain event	Porous asphalt or pervious concrete	Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)	Surface is clogged.	Review the overall performance of the facility (note that small clogged areas may not reduce overall performance of facility). Test the surface infiltration rate using ASTM C1701 as a corrective maintenance indicator. Perform one test per installation, up to 2,500 square feet. Perform an additional test for each additional 2,500 square feet up to 15,000 square feet total. Above 15,000 square feet, add one test for every 10,000 square feet. If the results indicate an infiltration rate of 10 inches per hour or less, then perform corrective maintenance to restore permeability. To clean clogged pavement surfaces, use one or combination of the following methods: • Combined pressure wash and vacuum system calibrated to not dislodge wearing course aggregate. Hand held pressure washer or power washer with rotating brushes. • Pure vacuum sweepers.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually	Porous asphalt or pervious concrete	Sedimentation	Sediment present at the surface of the pavement.	Assess the overall performance of the pavement system during a rain event. If water runs off the pavement and/or there is ponding then see above. Determine source of sediment loading and evaluate whether or not the source can be reduced/eliminated. If the source cannot be addressed, consider increasing frequency of routine cleaning (e.g., twice per year instead of once per year).
Annually (Summer)	Porous Asphalt or pervious concrete	Moss Growth	Moss growth inhibits infiltration or poses slip/ safety hazard.	Sidewalks: Use a stiff broom to remove moss in the summer when it is dry. Parking lots and roadways: Pressure wash, vacuum sweep, or use a combination of the two for cleaning moss from pavement surface. May require stiff broom or power brush in areas of heavy moss.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually	Porous Asphalt or pervious concrete	Damaged Pavement	Major cracks or trip hazards and concrete spalling and raveling.	Fill potholes or small cracks with patching mixes. Large cracks and settlement may require cutting and replacing the pavement section. Replace in-kind where feasible. Replacing porous asphalt with conventional asphalt is acceptable if it is a small percentage of the total facility area and does not impact the overall facility function. Take appropriate precautions during pavement repair and replacement efforts to prevent clogging of adjacent porous materials.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually or Biannually	Interlocking concrete paver blocks and aggregate pavers	Routine Maintenance	None (routine maintenance)	Clean pavement surface using one or a combination of the following methods: Remove sediment, debris, trash, vegetation, and other debris deposited onto pavement (rakes and leaf blowers can be used for removing leaves). Vacuum/sweep permeable paving installation using: • Walk-behind vacuum (sidewalks) • High efficiency regenerative air or vacuum sweeper (roadways, parking lots) • ShopVac or brush brooms (small areas) Note: Vacuum settings may have to be adjusted to prevent excess uptake of aggregate from paver openings or joints. Vacuum surface openings in dry weather to remove dry, encrusted sediment.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (inspect during rain event)	Interlocking concrete paver blocks and aggregate pavers	Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate).	Surface is clogged.	Review the overall performance of the facility (note that small clogged areas may not reduce overall performance of facility). Test the surface infiltration rate using ASTM C1701 as a corrective maintenance indicator. Perform one test per installation, up to 2,500 square feet. Perform an additional test for each additional 2,500 square feet up to 15,000 square feet total. Above 15,000 square feet, add one test for every 10,000 square feet. If the results indicate an infiltration rate of 10 inches per hour or less, then perform corrective maintenance to restore permeability. Clogging is usually an issue in the upper 2 to 3 centimeters of aggregate. Remove the upper layer of encrusted sediment, and fines, and/or vegetation from openings and joints between the pavers by mechanical means and/or suction equipment (e.g., pure vacuum sweeper). Replace aggregate in paver cells, joints, or openings per manufacturer's recommendations.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually	Interlocking concrete paver blocks and aggregate pavers	Sedimentation	Sediment present at the surface of the pavement.	Assess the overall performance of the pavement system during a rain event. If water runs off the pavement and/or there is ponding, then see above. Determine source of sediment loading and evaluate whether or not the source can be reduced/eliminated. If the source cannot be addressed, consider increasing frequency of routine cleaning (e.g., twice per year instead of once per year).
Annually	Interlocking concrete paver blocks and aggregate pavers	Moss Growth	Moss growth inhibits infiltration or poses slip/ safety hazard.	Sidewalks: Use a stiff broom to remove moss in the summer when it is dry. Parking lots and roadways: Vacuum sweep or stiff broom/ power brush for cleaning moss from pavement surface.
Annually	Interlocking concrete paver blocks and aggregate pavers	Damaged Surface	Paver block missing or damaged.	Remove individual damaged paver blocks by hand and replace or repair per manufacturer's recommendations.
Annually	Interlocking Concrete paver blocks and aggregate pavers	Damaged Surface	Loss of aggregate material between paver blocks.	Refill per manufacturer's recommendations for interlocking paver sections.
Annually	Interlocking concrete paver blocks and aggregate pavers	Damaged Surface	Settlement of surface.	May require resetting.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually or Biannually	Open-celled paving grid with gravel	Routine Maintenance	None (routine maintenance).	Remove sediment, debris, trash, vegetation, and other debris deposited onto pavement (rakes and leaf blowers can be used for removing leaves). Follow equipment manufacturer guidelines for cleaning surface.
Annually (inspect during rain event)	Open-celled paving grid with gravel	Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)	Aggregate is clogged.	Use vacuum truck to remove and replace top course aggregate. Replace aggregate in paving grid per manufacturer's recommendations.
Annually	Open-celled paving grid with gravel	Damaged Surface	Paving grid missing or damaged.	Remove pins, pry up grid segments, and replace gravel. Replace grid segments where three or more adjacent rings are broken or damaged. Follow manufacturer guidelines for repairing surface.
Annually	Open-celled paving grid with gravel	Damaged Surface	Settlement of surface.	May require resetting.
Annually	Open-celled paving grid with gravel	Damaged Surface	Loss of aggregate material in paving grid.	Replenish aggregate material by spreading gravel with a rake (gravel level should be maintained at the same level as the plastic rings or no more than 1/4 inch above the top of rings). See manufacturer's recommendations.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually	Open-celled paving grid with gravel	Weeds	Weeds present.	Manually remove weeds. Presence of weeds may indicate that too many fines are present (refer to Actions Needed under "Aggregate is clogged" to address this issue).
Annually or Biannually	Open-celled paving grid with grass	Routine Maintenance	None (routine maintenance).	Remove sediment, debris, trash, vegetation, and other debris deposited onto pavement (rakes and leaf blowers can be used for removing leaves). Follow equipment manufacturer guidelines for cleaning surface.
Annually (inspect during rain event)	Open-celled paving grid with grass	Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)	Aggregate is clogged.	Rehabilitate per manufacturer's recommendations.
Annually	Open-celled paving grid with grass	Damaged Surface	Paving grid missing or damaged.	Remove pins, pry up grid segments, and replace grass. Replace grid segments where three or more adjacent rings are broken or damaged. Follow manufacturer guidelines for repairing surface.
Annually	Open-celled paving grid with grass	Damaged Surface	Settlement of surface.	May require resetting.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually	Open-celled paving grid with grass	Aesthetics, erosion potential	Poor grass coverage in paving grid.	Restore growing medium, reseed or plant, aerate, and/or amend vegetated area as needed. Traffic loading may be inhibiting grass growth; reconsider traffic loading if feasible.
As Needed	Open-celled paving grid with grass	Routine Maintenance	None (routine maintenance).	Use a mulch mower to mow grass.
Annually	Open-celled paving grid with grass	Routine Maintenance	None (routine maintenance).	Sprinkle a thin layer of compost on top of grass surface (1/2” top dressing) and sweep it in. Do not use fertilizer.
Annually	Open-celled paving grid with grass	Weeds	Weeds present.	Manually remove weeds. Mow, torch, or inoculate and replace with preferred vegetation.
Annually	Inlet/outlet pipe	Water Flow	Pipe is damaged.	Repair/replace.
Annually	Inlet/outlet pipe	Water Flow	Pipe is clogged.	Remove roots or debris.
As needed, clean orifice at least biannually	Underdrain pipe	Water Flow	Plant roots, sediment, or debris is reducing capacity of underdrain (may cause prolonged drawdown period).	Jet clean or rotary cut debris/roots from underdrain(s). If underdrains are equipped with a flow restrictor (e.g., orifice) to attenuate flows, the orifice must be cleaned regularly.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
As needed, clean orifice at least biannually	Raised subsurface overflow pipe	Water Flow	Plant roots, sediment, or debris is reducing capacity of underdrain.	Jet clean or rotary cut debris/roots from under-drain(s). If underdrains are equipped with a flow restrictor (e.g., orifice) to attenuate flows, the orifice must be cleaned regularly.
Annually and After Major Storm Events	Outlet structure	Water Flow	Sediment vegetation, or debris reducing capacity of outlet structure.	Clear the blockage. Identify the source of the blockage and take actions to prevent future blockages.
Biannually	Overflow	Erosion Potential	Native soil is exposed or other signs of erosion damage are present at discharge location.	Repair erosion and stabilize surface.
Annually and After Major Storm Events	Observation port	Water ponding or infiltrating slowly	Water remains in the storage aggregate longer than anticipated by design after the end of the storm.	If immediate cause of extended ponding is not identified, schedule investigation of subsurface materials or other potential causes of system failure.
As needed	Adjacent large shrubs or trees	Water ponding or infiltrating slowly	Vegetation related fallout clogs or will potentially clog voids.	Sweep leaf litter and sediment to prevent surface clogging and ponding. Prevent large root systems from damaging subsurface structural components.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Once in May and Once in September	Adjacent large shrubs or trees	Aesthetics	Vegetation growing beyond facility edge onto sidewalks, paths and street edge.	Edging and trimming of planted areas to control groundcovers and shrubs from overreaching the sidewalks, paths and street edge improves appearance and reduces clogging of permeable pavements by leaf litter, mulch and soil.
In fall (October to December) after leaf drop (1-3 times, depending on canopy cover)	Leaves, needles, and organic debris	Clog Potential	Accumulation of organic debris and leaf litter.	Use leaf blower or vacuum to blow or remove leaves, evergreen needles, and debris (i.e., flowers, blossoms) off of and away from permeable pavement.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#31 - Emerging Technologies

At a minimum all stormwater devices must be inspected every six months and after every major storm event. Use the manufacturer's recommendations as tailored to the use of the site and as outlined in the Operation and Maintenance Manual. Operations and Maintenance shall conform to any Ecology issued use level designation as applicable.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#32 - General Maintenance Concerns for Stormwater Facilities

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Based on manufacturers instructions	Irrigation	Irrigation system (if any)	Irrigation system present.	Follow manufacturer's instructions for O&M.
Weekly (May – September)	Irrigation	Plant watering	Plant establishment period (1-3 years).	Water weekly during periods of no rain to ensure plant establishment.
As Needed	Irrigation	Plant watering	Longer term period (3+ years).	Water during drought conditions or more often if necessary to maintain plant cover.
Ongoing	Spill Prevention and Response	Spill prevention	Storage or use of potential contaminants in the vicinity of facility.	Exercise spill prevention measures whenever handling or storing potential contaminants.
As needed	Spill Prevention and Response	Spill response	Release of pollutants. Call to report any spill to City of Tacoma Source Control 253.502.2222. Review https://ecology.wa.gov/spills-cleanup for other reporting requirements.	Cleanup spills as soon as possible to prevent contamination of stormwater.
At startup	Training and Documentation	Training / written guidance	Training / written guidance is required for proper O&M.	Provide property owners and tenants with proper training and a copy of the O&M manual.
Annually (preferably Sept.)	Safety	Safety (slopes)	Erosion of sides causes slope to exceed 1:4 or otherwise becomes a hazard.	Restore to design slope.
Annually (preferably Sept.)	Safety	Safety (hydraulic structures)	Hydraulic structures (pipes, culverts, vaults, etc.) become a hazard to children playing in and around the facility.	Take actions to eliminate the hazard (such as covering and securing any openings).
Annually (preferably Sept.)	Safety	Line of sight	Vegetation causes some visibility (line of sight) or driver safety issues.	Prune or replace plants as necessary.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (preferably Sept.)	Aesthetics	Aesthetics	Damage/vandalism/ debris accumulation.	Clean, repair, and restore facility to original aesthetic conditions.
Annually (preferably Sept.)	Aesthetics	Grass/ vegetation	Less than 75% of planted vegetation is healthy with a generally good appearance.	Take appropriate maintenance actions. (e.g., remove/replace plants, amend soil, etc.).
Annually (preferably Sept.)	Aesthetics	Edging	Grass is starting to encroach on facility.	Repair edging. Remove encroaching grass. Install additional measures to prevent encroachment.
Annually (preferably Sept.)	General	Poisonous Vegetation and noxious weeds	Any poisonous or nuisance vegetation may constitute a hazard to maintenance personnel or to the public. Any evidence of noxious weeds as defined by the State or local regulations. The Washington State Noxious Weed Control Board has a list of common noxious weeds at www.nwcb.wa.gov.	No danger of poisonous vegetation. Compliance with state or local eradication policies is required. Apply requirements of adopted integrated pest management plan as necessary.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#33 - Maintenance Standard for Trees

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Once a year for the first three years	Trees	Future failure	Weak branch attachments; co-dominant stems.	Structural Pruning[a].
As needed	Trees	Threat to public safety	Low branches that may cause safety concerns if they remain.	Crown Raising[a].
As neeed, for safety	Trees	Threat to public safety	Dead, diseased and/or broken branches.	Pruning to remove dead, diseased and/or broken branches.
As needed	Trees	Threat to public safety	Dead, severely damaged or declining.	Replace per planting plan or acceptable substitute.

a. Trees shall be pruned according to industry standards, ANSI A300 Part 1 and the International Society of Arboriculture's Best Management Practices - Tree Pruning.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

Comments:

#34 - Maintenance Standard for Downspout Infiltration Trench or Drywell

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Biannually (Fall and Spring)	Surface of trench/well (i.e., water enters through exposed aggregate)	Water not reaching facility	Accumulated trash, debris, or sediment on drain rock surface impedes sheet flow into facility.	Remove/dispose in accordance with local solid waste requirements.
Annually (At least one visit during the wet season)	Surface of trench/well (i.e., water enters through exposed aggregate)	Water not reaching facility	Vegetation/moss present on drain rock surface impedes sheet flow into facility.	Maintain open, freely draining drain rock surface.
Biannually (Fall and Spring)	Drain Rock	Ponding	If water enters the facility from the surface, inspect to see if water is ponding at the surface during storm events. If buried drain rock, observe drawdown through observation port or cleanout.	Clear piping through facility when ponding occurs. Replace rock/sand reservoirs as necessary. Tilling of subgrade below reservoir may be necessary (for trenches) prior to backfill.
Annually (at least once during the wet season)	Pipe(s)	Water flow issues	Accumulation of trash, debris, or sediment in roof drains, gutters, driveway drains, area drains, etc.	Remove/ dispose.
Annually (at least once during the wet season)	Pipe(s)	Sedimentation	Pipe from sump to trench or drywell has accumulated sediment or is plugged.	Clear sediment from inlet/outlet pipe screen and inlet/outlet pipe. Cleaning operation should not move sediment into rock layer. Remove and dispose of sediment.
Annually (at least once during the wet season)	Pipe(s)	Damaged piping, water flow impeded	Cracked, collapsed, broken, or misaligned drain pipes.	Repair/seal cracks. Replace when repair is insufficient.
Biannually (at least once during the wet season)	Roof Downspout	Erosion Potential	Splash pad missing or damaged.	Repair/ replace.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (at least once during the wet season)	Roof Downspout	Water flow impeded	Leaves or other debris plugging downspout.	Remove/ dispose.
Annually	Sump	Water flow impeded	Sediment in the sump.	Remove/ dispose in accordance with local solid waste requirements.
Annually	Access Lid	Damaged Lid	Cannot be easily opened.	Repair/ replace.
Annually	Access Lid	No lid	Buried.	Refer to record drawings for design intent. If the access lid was designed to be exposed, expose and restore to surface grade.
Annually	Access Lid	Missing lid	Lid not present.	Replace.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588.

#35 - Maintenance Standard for Downspout Dispersion

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Splashblocks				
Biannually	Splash Block	Water flow incorrect	Water is being directed towards building structure.	Reconfigure/ repair splash blocks to direct water away from building structure.
Biannually	Splash Block	Erosion Potential	Water disrupts soil media.	Reconfigure/ repair blocks, repair eroded soil, replant as necessary.
Sheet Flow Dispersion				
Annually	Transition Zone	Erosion Potential	Adjacent soil erosion; uneven surface creating concentrated flow discharge; or less than 2 feet of width.	Repair/replace transition zone to meet design criteria and eliminate concentrated flows.
Downspout Dispersion – Dispersion Trench				
Annually	Dispersion trench	Water flow issues	Visual evidence of water discharging at concentrated points along trench (normal condition is a “sheet flow” from edge of trench; intent is to prevent erosion damage).	Remove debris from trench surface, if necessary. Realign notched grade board or other distributor type, if possible. Rebuild trench to standards, if necessary.
Biannually (Fall and Spring)	Surface of Dispersion Trench	Flow impeded	Accumulated trash, debris, or sediment on drain rock surface impedes sheet flow from facility.	Remove/dispose in accordance with local solid waste requirements.
Annually (at least once during the wet season)	Surface of Dispersion Trench	Sheet flow impeded	Vegetation/moss present on drain rock surface impedes sheet flow from facility.	Maintain open, freely draining drain rock surface.
Annually (at least once during the wet season)	Pipe to dispersion trench	Flow impeded	Accumulation of trash, debris, or sediment in roof drains, gutters, driveway drains, area drains, etc.	Remove/ dispose.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually (at least once during the wet season)	Pipe to dispersion trench	Flow Impeded	Pipe from sump to trench or drywell has accumulated sediment or is plugged.	Clear sediment from inlet/outlet pipe screen and inlet/outlet pipe.
Annually (at least once during the wet season)	Pipe to dispersion trench	Flow Impeded	Cracked, collapsed, broken, or misaligned drain pipes.	Repair/seal cracks. Replace when repair is insufficient.
Annually	Sump	Sediment Buildup	Sediment in the sump.	Remove/ dispose in accordance with local solid waste requirements. Clear sediment from inlet/outlet pipe screen and/or inlet/outlet pipe. Do not flush sediment downstream.
Annually	Access Lid	Damaged Cover	Cannot be easily opened.	Repair/replace.
Annually	Access Lid	No Cover	Buried.	Refer to record drawings for design intent. If the access lid was designed to be exposed, expose and restore to surface grade.
Annually	Access Lid	Missing Cover	Cover missing.	Replace.
Rock Pad (Concentrated Flow Dispersion)				
Annually	Rock pad	Erosion Potential	Only one layer of rock exists above native soil in area 6 square feet or larger, or any exposure of native soil.	Replace/ repair rock pad to meet design standards. Enlarge pad size or add additional courses of rock, if necessary.
Annually	Rock pad	Erosion	Soil erosion in or adjacent to rock pad.	Repair/replace rock pad to meet design standards.
Dispersal Area				
Biannually and After Major Storm Events	Dispersal area (general)	Erosion	Erosion (gullies/ rills) greater than 2 inches deep in dispersal area.	Eliminate cause of erosion and stabilize damaged area (regrade, rock, revegetate).

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Biannually and After Major Storm Events	Dispersal area (general)	Flow impeded	Accumulated sediment or debris to extent that blocks or channelizes flowpath.	Remove excess sediment or debris. Identify and control the sediment source (if feasible).
Biannually and After Major Storm Events	Ponded water	Standing water	Standing surface water in dispersion area remains for more than 3 days after the end of a storm event.	Identify the cause of the standing water (e.g., grade depressions, compacted soil) and take appropriate actions to address the problem (e.g., regrade to eliminate depressions or aerate/ amend soils).
Biannually	Plant establishment		Dispersal area vegetation in establishment period (1-2 years, or additional 3rd year during extreme dry weather).	Water weekly during periods of no rain to ensure plant establishment.
As Needed	Vegetation	Vegetation cover inadequate	Poor vegetation cover such that erosion is occurring.	Ensure proper care (e.g., watering). Assess for nutrient deficiencies. Replant as needed with appropriate plant species for the soil and moisture conditions. Consider amending soils to promote plant health.
Biannually and After Major Storm Events	Vegetation	Flow impeded.	Vegetation inhibits dispersed flow along flowpath.	Trim, weed or replant to restore dispersed flowpath.
Storage Sump				
Annually	Sump	Sediment	Accumulated sediment in the sump.	Remove/ dispose in accordance with local solid waste requirements. Clear sediment from inlet/outlet pipe screen and/or inlet/outlet pipe.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
Annually	Access Lid	Lid Broken	Cannot be easily opened.	Repair/replace.
Annually	Access Lid	Cannot find lid.	Buried.	Expose and restore to surface grade.
Annually	Access Lid	Lid Missing	Lid missing.	Replace.
Pest Control				
As Needed	Pest Control	General Pests	Signs of pest infestations (IPM protocol threshold(s) are exceeded).	Follow IPM protocols for weed and pest management.
Biannually and After Major Storm Events	Pest Control	Mosquitoes	Standing surface water in dispersion area remains for more than 3 days after the end of a storm.	Identify the cause of the standing water and take appropriate actions to address the problem. Use of pesticides or *Bacillus thuringiensis israelensis* (Bti) may be considered as a temporary measure only. Obtain Aquatic Mosquito Control General Permit as necessary.
As Needed	Pest Control	Rodents	Rodent holes or mounds disturb dispersion flowpaths.	Fill and compact soil around the holes and vegetate to restore flowpath.

If you are unsure whether a problem exists, please contact Environmental Services at 253.591.5588

#36 - Maintenance Standard for Media Filter Drains

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
	General	Sediment accumulation on grass filter strip	Sediment depth exceeds 2 inches or creates uneven grading that interferes with sheet flow.	Remove sediment deposits on grass treatment area of the embankment. When finished, embankment should be level from side to side and drain freely toward the toe of the embankment slope. There should be no areas of standing water once inflow has ceased.
	General	No-vegetation zone/flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed over entire embankment width.	Level the spreader and clean to spread flows evenly over entire embankment width.
	General	Poor vegetation coverage	Grass is sparse or bare, or eroded patches are observed in more than 10% of the grass strip surface area.	Determine why grass growth is poor and correct the offending condition. Reseed into loosened, fertile soil or compost; or, replant with plugs of grass from the upper slope.
	General	Vegetation	Grass becomes excessively tall (greater than 10 inches); nuisance weeds and other vegetation start to take over.	Mow vegetation or remove nuisance vegetation to not impede flow. Mow grass to a height of 6 inches.
	General	Media filter drain mix replacement	Water is seen on the surface of the media filter drain mix long after the storms have ceased. Typically, the 6-month, 24-hour precipitation event should drain within 48 hours. More common storms should drain within 24 hours. Maintenance also needed on a 10-year cycle and during a preservation project.	Excavate and replace all of the media filter drain mix contained within the media filter drain.

Recommended Inspection Frequency	Stormwater System Feature	Problem	Condition When Maintenance is Required	Maintenance Activities and Conditions that Should Exist
	General	Excessive shading	Grass growth is poor because sunlight does not reach embankment.	If possible, trim back overhanging limbs and remove brushy vegetation on adjacent slopes.
	General	Trash and debris	Trash and debris have accumulated on embankment.	Remove trash and debris from embankment.
	General	Flooding of Media filter drain	When media filter drain is inundated by flood water	Evaluate media filter drain material for acceptable infiltration rate and replace if media filter drain does not meet long-term infiltration rate standards.

VOLUME

5

Stormwater Conveyance Design and Protection

How to Use this Volume

Use the information in this volume to Analyze Existing Private and Public Stormwater Conveyance Systems to ensure compliance with Additional Protective Measure - Infrastructure Protection and to Design New Conveyance System. This volume shall be used for analyzing and designing stormwater conveyance systems. Stormwater conveyance systems include pipes, culverts, open channels, and pumps. Information on system discharge locations can be found in A400: End of Pipe Discharge Protection. Conveyance systems shall be accessible for inspection and maintenance purposes which may require obtaining easements. See Volume 4 - Chapter 5 Accessing and Maintaining Your Best Management Practices.

Chapter 1 Additional Protective Measure - Infrastructure Protection

1.1 Quantitative Analysis

Additional Protective Measure - Infrastructure Protection applies to any project that increases the amount of stormwater to the downstream stormwater conveyance system.

Certain projects shall complete a Quantitative Analysis of the existing downstream system before additional stormwater can be added to that system. The type of analysis required is based upon the project impacts as described in Volume 1, Section 1-4: Additional Protective Measure - Infrastructure Protection.

Quantitative Analyses shall extend downstream for the entire flowpath from the site to the receiving waterbody or ¼ mile, whichever is less. The analysis may stop once a City identified trunk main is reached. Analyses may stop upstream of City-owned pump stations.

1.1.1 Quantitative Analysis for Discharges to the Cleveland Way Pump Station

The Cleveland Way Pump Station and portions of the conveyance system leading up to the Cleveland Way Pump Station act as a wet well from which stormwater is pumped. To account for the fact that the portions of the conveyance system upstream of the pump station act as a wet well, the quantitative downstream analysis shall be started at a location that more closely represents a non-pumped conveyance system.

The analysis shall start at the following manhole based upon project site discharge location. Working upstream from the manhole listed below, the tailwater elevation will be set at 90% full pipe elevation. Pipes downstream of the designated manhole shall be considered trunk mains and are not required to be included in the analysis. These manhole represent the next upstream manhole from the elevation of the first pump on.

Table 5 - 1: Cleveland Way Pump Station Trunk Main Manhole IDs

Manhole ID	Upstream Pipe Direction
6763458	Northwest
6763701	Northwest
6764221	Northwest
6776369	West
6764310	North
6764334	South
6764301	North & Northwest
6764275	North
6764256	West & South

1.1.2 Quantitative Analysis Mitigation

Projects that discharge stormwater directly or indirectly to any of the following may have to provide mitigation for Infrastructure Protection:

- To a conveyance system without capacity to convey the fully developed design event as determined through a full backwater quantitative analysis and/or Inlet and Gutter Capacity Analysis, or
- To a capacity problem downstream of the project as determined by the City of Tacoma, or
- To any other problem, such as downstream stabilization issues, as determined by the City of Tacoma.

The type of mitigation is dependent upon City of Tacoma review of the project impacts. Mitigation may include upsizing the existing stormwater conveyance system, installing additional catch basins, onsite stormwater detention or other mitigation measures as determined appropriate by the City of Tacoma.

Chapter 2 Collect and Convey - Connections to the City of Tacoma System

Onsite collection of stormwater and conveyance to the City of Tacoma stormwater system may be necessary if onsite stormwater management BMPs cannot fully infiltrate or disperse stormwater onsite. This may include conveyance to either the curb and gutter or wedge curb, if present, or a structure of the stormwater conveyance system. Connections directly to pipes (such as tee connections) are not allowed. Connections to the curb and gutter or asphalt wedge curb shall comply with City of Tacoma Standard Plans SU-29 and SU-29a available at tacoma.gov/government/departments/public-works/engineering/right-of-way-design-manual/.

Conveyance to the curb will only be allowed if:

- A catch basin or other inlet to the conveyance system is located within 350 feet downstream of the discharge location.
- Stormwater discharges from the site remains in the gutter line to the nearest stormwater system inlet. Existing or new curb shall be tall enough to ensure water remains in the gutter line.
- Stormwater discharges from the site enter a stormwater system inlet before the next downstream intersection.
- Stormwater discharges are not on the high side of full warp street section.

If the above conditions cannot be met, extension of the stormwater system shall be required. Based upon specific site conditions, the City of Tacoma may allow conveyance to the curb if all conditions cannot be met. Internal consultation with Asset Management and/or Traffic may be necessary.

Minimum pipe size for conveyance to the curb shall be 3 inches in diameter. Where capacity greater than a 3 inch diameter pipe is required, the City of Tacoma shall review the proposal and may require a storm main extension.

Note: The City of Tacoma will only approve those facilities that would require more than one through-curb discharge location on a case by case basis.

Stormwater may be allowed to be collected and conveyed to either the curb or directly connected to a structure - see Section 4.5 - System Connections. The runoff shall not be conveyed over driveways, sidewalks or other areas reserved for pedestrian traffic. A detail for the discharge shall be submitted to the City of Tacoma for review and approval.

An analysis of the downstream system may be required before the applicant can discharge stormwater to the City system. See Additional Protective Measure - Infrastructure Protection to determine if an analysis of the downstream system will be required.

No flow credits will be allowed for the collect and convey option.

Chapter 3 Conveyance System Analysis Methods

Single event modeling shall be used for designing conveyance systems and analyzing existing conveyance systems for capacity. Continuous simulation modeling is not accepted.

3.1 Computer Models for Conveyance Systems

All components of a conveyance system can be modeled using readily available computer models. There are several acceptable computer models available for these analyses. The design engineer is responsible for providing information describing how the model was used, assumptions the model makes and descriptions of all variables, columns, rows, summary tables, and graphs. The design engineer shall use the most current version of any model proposed within 1 year of the version's release. The City of Tacoma may determine that specific models are not acceptable for use in design. Please check with the City of Tacoma to confirm the applicability of a particular model prior to starting the analysis.

3.2 Basis of Design

Applicants may be required to submit a basis for pipe and culvert design which includes pipe type selection, suitability for depth of bury and loading, deflection calculations for above-ground pipes, anchoring, armoring, analysis for above ground pipes or outfalls, etc. The City of Tacoma reserves the right to make the final determination as to when the basis of design is required.

3.3 Single Segment Capacity Analysis

For projects required to complete the Single Segment Capacity Analysis per Additional Protective Measure - Infrastructure Protection, the following criteria applies:

The discharge rate from the increase in surface area or increase in surface area converted from pervious to impervious from a 25-year, 24-hour storm event shall be less than 5% of the discharge capacity in the most constrained pipe segment or channel of the existing downstream system within ¼ mile from the site's discharge location at 90% full. Note, the entire downstream ¼ mile must be analyzed to determine which segment is the most constrained. This analysis is not required for trunk mains.

The following design criteria shall be used in the analysis:

- The most constrained pipe segment or channel shall be considered the pipe or channel segment with the least capacity (typically the smallest diameter pipe segment or the pipe segment with the least slope) within ¼ mile from the site's discharge location.
    - The most constrained pipe or channel segment capacity shall be calculated assuming 90% full conditions.
    - Flowrates shall be calculated using the SCS (TR-20) Method.

If it is determined that the discharge rates from the increased impervious surfaces will be equal to or greater than 5% of the capacity of the most constrained downstream pipe or channel segment, a Full Backwater Analysis is required.

3.4 Full Backwater Analysis

The Full Backwater Analysis is used to compute a simple backwater profile (hydraulic grade line) for a proposed or existing conveyance system for the purposes of verifying capacity.

The Full Backwater Analysis begins at the downstream end of the conveyance system, when the analysis reaches a trunk main, or at the last downstream manhole of a ¼ mile analysis and is computed back through each upstream pipe segment and structure.

3.4.1 Full Backwater Analysis Design Criteria

- Conveyance systems shall be modeled as if no onsite detention is provided upstream.
- Conveyance systems shall be analyzed for fully developed conditions. The fully developed conditions shall be derived from the following percentages of impervious area:
  - In commercial areas, the percent impervious shall be 85%.
  - In industrial areas, the percent impervious shall be 70%.
  - In residential areas, the percent impervious shall be 60%.

  The fully developed conditions shall apply to both the offsite and onsite basins.
- For discharges to tidally influenced areas, the tailwater elevation shall not be lower than 4.64 feet (which is a conservative estimate of the mean high tide) using current City of Tacoma datum.
- For discharge to stormwater facilities that may affect the upstream system due to discharge elevation (detention pond, infiltration facility, etc.), the tailwater elevation shall be set at the design surface elevation of that facility.
- For discharges to other features that may cause backwater conditions such as natural or artificial empoundments (ex. lakes), the tailwater condition will be site specific and require knowledge of the waterbody.

3.4.2 Pipe System Design Events

All new conveyance systems shall be designed using the Full Backwater Analysis. The design events for pipe systems are as follows.

- For privately maintained systems:
  - For the 10-year, 24-hour design storm, assuming a Type 1A rainfall distribution (3.0-inches) using a 10-minute timestep, there shall be a minimum of 0.5 feet of freeboard between the water surface and the top of any manhole or catch basin.
  - For the 100-year, 24-hour design storm, assuming a Type 1A rainfall distribution (4.1-inches) using a 10-minute timestep, overtopping of the pipe conveyance system may occur, however, the additional flow shall not extend beyond half the lane width of the outside lane of the traveled way and shall not exceed 4 inches in depth at its deepest point.
  - For the 100-year, 24-hour design storm assuming a Type 1A rainfall distribution (4.1-inches) using a 10-minute timestep, off-channel storage on private property is allowed with recording of the proper easements. When this occurs, the additional flow over the ground surface is analyzed using the methods for open channels described in Section 3.4.4 Open Channel Design Events. The City of Tacoma will evaluate and determine the acceptability of this type of localized flooding.
- For publicly maintained systems:

- For the 25-year, 24-hour design storm, assuming a Type 1A rainfall distribution (3.5-inches) using a 10-minute timestep, there shall be a minimum of 0.5 feet of freeboard between the water surface and the top of any manhole or catch basin.
- For the 100-year, 24-hour design storm, assuming a Type 1A rainfall distribution (4.1-inches) using a 10-minute timestep, overtopping of the pipe conveyance system may occur, however, the additional flow shall not extend beyond half the lane width of the outside lane of the traveled way and shall not exceed 4 inches in depth at its deepest point.

The starting tailwater elevation to be used in the backwater analysis for pipe systems is the water surface elevation of the next downstream pipe at an assumed depth of 90% full.

For discharges to tidally influenced areas, the tailwater elevation shall not be lower than 4.64 feet (which is a conservative estimate of the mean high tide) using current City of Tacoma datum.

For the 100-year, 24-hour design storm assuming a Type 1A rainfall distribution (4.1-inches), if overtopping of the system occurs, the applicant shall show the extent of the impacts on neighboring properties and the right-of-way. The full extent of flooding shall be shown. The applicant may be required to provide mitigation for localized flooding. The City of Tacoma reserves the right to make the determination of final mitigation requirements.

3.4.3 Culvert Design Events

All new conveyance systems shall be designed using the backwater analysis. The design events for culverts systems are as follows.

- Culverts shall convey the peak volumetric flowrate calculated using a 10-minute timestep from a Type 1A, 25-year, 24-hour frequency storm (3.5 inches) using a single event model, without submerging the culvert inlet.
- For culverts 18-inch diameter or less, the maximum allowable headwater elevation for the 100-year, 24-hour design storm, assuming a Type 1A rainfall distribution (4.1-inches) using a 10-minute timestep, (measured from the inlet invert) shall not exceed 2 times the pipe diameter or arch-culvert-rise.
- For culverts larger than 18-inch diameter, the maximum allowable headwater elevation for the 100-year, 24-hour design storm, assuming a Type 1A rainfall distribution (4.1-inches), (measured from the inlet invert) using a 10-minute timestep shall not exceed 1.5 times the pipe diameter or arch-culvert-rise.
- The maximum headwater elevation at the 100-year, 24-hour design flow, assuming a Type 1A rainfall distribution (4.1-inches) using a 10-minute timestep, shall be below any road or parking lot subgrade except as allowed per BMP F140: Parking Lots for Additional Detention.

The starting tailwater elevation to be used in the backwater analysis for culverts systems is the water surface elevation of the next downstream culvert at an assumed depth of 100% full.

For discharges to tidally influenced areas, the tailwater elevation shall not be lower than 4.64 feet (which is a conservative estimate of the mean high tide) using current City of Tacoma datum.

3.4.4 Open Channel Design Events

All new conveyance systems shall be designed using the backwater analysis. The design event for open channels is as follows:

- Constructed and natural channels shall contain the 100-year, 24-hour storm event, assuming a Type 1A rainfall distribution (4.1-inches) using a 10-minute timestep.
- A minimum of 6 inches of freeboard is required for all open channels.

The Direct Step Backwater Method can be used to compute backwater profiles on prismatic channel reaches (i.e. reaches having uniform cross section and slope) where a backwater condition or restriction to normal flow is known to exist. The method can be applied to a series of prismatic channel reaches in succession beginning at the downstream end of the channel and computing the profile upstream.

Calculating the coordinates of the water surface profile using this method is an iterative process achieved by choosing a range of flow depths, beginning at the downstream end, and proceeding incrementally up to the point of interest or to the point of normal flow depth. This is best accomplished by the use of a table or computer programs. Provide documentation of the equations and assumptions used in the analysis.

The Standard Step Backwater Method is a variation of the Direct Step Backwater Method and can be used to compute backwater profiles on both prismatic and non-prismatic channels. In this method, stations are established along the channel where cross section data is known or has been determined through field survey. The computation is carried out in steps from station to station rather than throughout a given channel reach as is done in the Direct Step method. As a result, the analysis involves significantly more trial-and-error calculation in order to determine the flow depth at each station.

3.5 Inlet Grate Capacity

This section has been divided into three areas: inlets on a continuous grade, side flow interception and sag analysis. Properties of typical grate are summarized in Table 5 - 2: Properties of Grate Inlets and further discussed below.

Additional information may also be found in WSDOT Hydraulics Manual.

Table 5 - 2: Properties of Grate Inlets

WSDOT Standard Plan	Description	Continuous Grade[a]		Sump Condition Perimeter Flows as Weir[b]	
		Grate Width	Grate Length	Width	Length
B-30.50[c]	Rectangular herringbone grate	1.67 ft (0.50 m)	2.0 ft (0.61 m)	0.69 ft (0.21 m)	0.78 ft (0.24 m)
B-30.30 or 30.40[d]	Vaned grate for catch basin and inlet	1.67 ft (0.50 m)	2.0 ft (0.61 m)	1.31. ft (0.40 m)	1.25 ft (0.38 m)
B-25.20[b]	Combination inlet	1.67 ft (0.50 m)	2.0 ft (0.61 m)	1.31. ft (0.40 m)	1.25 ft (0.38 m)
B-40.20	Grate Inlet Type 1 (Grate A or B[e])	2.01 ft (0.62 m) 3.89 ft[f] (1.20 m)	3.89 ft (0.62 m) 2.01 ft[f] (1.20 m)	1.67 ft (0.50 m) 3.52 ft (1.07 m)	3.52 ft (1.07 m) 1.67 ft (0.50 m)
B-30.80	Circular Grate[g]	1.52 ft (0.47 m)		2.55 ft[h] (0.79 m)	
B-40.40	Frame and Vaned Grates for Grate Inlet Type 2	1.75 ft[i] (0.52 m) 3.52 ft[j] (1.05 m)	3.52 ft[i] (1.05 m) 1.75 ft[j] (0.52 m)	1.29 ft (0.40 m) 2.58 ft[j] (0.80 m)	2.58 ft (0.50 m) 1.29 ft[j] (0.26 m)

a. Inlet widths on a continuous grade shown without reduction for bar area or for debris accumulation.
b. The perimeters and areas in this portion of the table have already been reduced for bar area. These values should be cut in half when used in a sag location, except for the Combination Inlet B-25-20.
c. Shown for information purposes only.
d. For sag conditions, combination inlets should use a Bi-Directional Vaned grate as shown in WSDOT Standard Plan B-30.40.
e. Type B grate shall not be used in areas of pedestrian or vehicular traffic.
f. Rotated installation. See WSDOT Standard Plans.
g. Circular grates are only allowed on private property and as otherwise approved by the City of Tacoma.
h. Only the perimeter value has been provided for use with weir equations.
i. Normal installation. See WSDOT Standard Plans.
j. Rotated installation. See WSDOT Standard Plans.

3.5.1 Inlet Types

The characteristics and allowed uses of the most commonly used inlets are summarized below. For inlet additional specifications including dimensions see the inlet specific WSDOT Standard Plan and Table 5 - 2: Properties of Grate Inlets.

3.5.1.1 Herringbone Pattern (WSDOT Standard Plan B-30.50)

Herringbone grates are not approved for installation within the City Right of Way. Herringbone pattern grate information is included for analyzing existing conditions and new construction on private property.

3.5.1.2 Vaned Grate (WSDOT Standard Plan B-30.30 or 30.40)

Catch basin grate installation within the City ROW shall use vaned type grates. The vaned grate is bicycle safe, and as described further in this section is hydraulically superior under most conditions. Installation of the vaned grate is critical as the grate is directional. If installed backwards the interception capacity is severely limited. At low velocities the vaned grate and herringbone grate are equally efficient. At higher velocities, greater than 5 ft/s (1.5 m/s), a portion of the flow tends to skip over the herringbone whereas the vaned grate will capture a greater portion of this flow. The vaned grate also has a higher capacity for passing debris and should be used for high debris areas. Where existing catch basins are modified, grates may be required to be replaced with vaned grates. The City of Tacoma reserves the right to make the final determination based on the condition of the existing grate.

3.5.1.3 Combination Inlets (WSDOT Standard Plan B-25.20)

The combination inlet is a vaned grate on a catch basin with a hooded curb cut area. Its vaned grate is very debris efficient, and if the grate does become clogged, the overflow goes into the hooded opening. These inlets are extremely useful for sag condition installations, although they can also be effective on continuous grades. The interception capacity of a combination inlet is only slightly greater than with a grate alone. Therefore the capacity is computed neglecting the curb opening and designers should follow the same analysis as for a vaned grate alone for typical design events. Combination inlets may be useful for providing additional inlet capacity during more intense peak events. See Section 3.5.4: Capacity of Inlets in Sag Locations for design guidance in a sag condition.

3.5.1.4 Grate Inlets Type 1 or 2 (WSDOT Standard Plans B-35.20, B-35.40, and B-40.20)

Both Type 1 or 2 grate inlets have large openings that can compensate for debris problems, however, there are limitations in their usage. A Type 1 grate inlet is a non-reinforced, cast-in-place concrete inlet, which cannot support traffic loads. Type 2 grate inlets are pre-cast and can withstand traffic loading. These inlets are installed with a Grate A or Grate B or a frame and vaned grate. Due to structural failure of both Grates A or B, neither of these grates can be installed in heavy traffic areas where wheel loads will pass directly over. Grate B has very large openings and is useful in ditches or non-paved median locations, in areas where there is no pedestrian or bicycle traffic. Grate A can be used anywhere Grate B is used as well as at the curb line of a wide interstate shoulder. Grate A may occasionally be hit by low-speed traffic or parked on but it cannot withstand repeated interstate loading or turning vehicles.

3.5.1.5 Frame and Vaned Grates (WSDOT Standard Plan B-40.40)

WSDOT Standard Plan B-40.40 has been tested in H-25 loading and was determined compatible with heavy traffic installations. This frame and double vaned grate should be installed in a Unit H on top of a grate inlet Type 2. The frame and vaned grates may be used in either new construction or retrofit situations. When used in areas of highway speeds, lock down grates should be specified.

3.5.1.6 Circular Grates

See WSDOT Standard Plans B-20.20 and WSDOT B-20.60 for details. Install with circular frames (rings) as detailed in WSDOT Standard Plan B-30.70. Circular grates are only allowed for use on private property and as approved by the City of Tacoma.

3.5.2 Capacity of Inlets on a Continuous Grade

The interception capacity of an inlet on a continuous grade depends on the amount of water flowing over the grate, the size and configuration of the grate, the velocity of the flow in the gutter, and the longitudinal slope of the roadway.

- For longitudinal slopes between 2 to 3 percent and for velocities in the range of 3 to 5 ft/s the interception capacity of an inlet is based mainly on frontal flow. Frontal flow is water that travels through the gutter and enters through the front side (width) of the inlet.
- For longitudinal slopes less than 2 percent and velocities less than 3 ft/s side flow interception shall also be considered as described in Section 3.5.3 Side Flow Interception. An inlet will intercept essentially all frontal flow passing over the width of the inlet as long as the velocity is less than 5 ft/s.
- When velocities exceed 5 ft/s water will "splash-over" the inlets reducing the portion of the flow that will be intercepted and increase the bypass flow. When this occurs, consult with the City of Tacoma to determine a design appropriate for the location. Additional guidance can be found in the FHWA HEC No. 22, Section 4-3 at: www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=22&id=47.

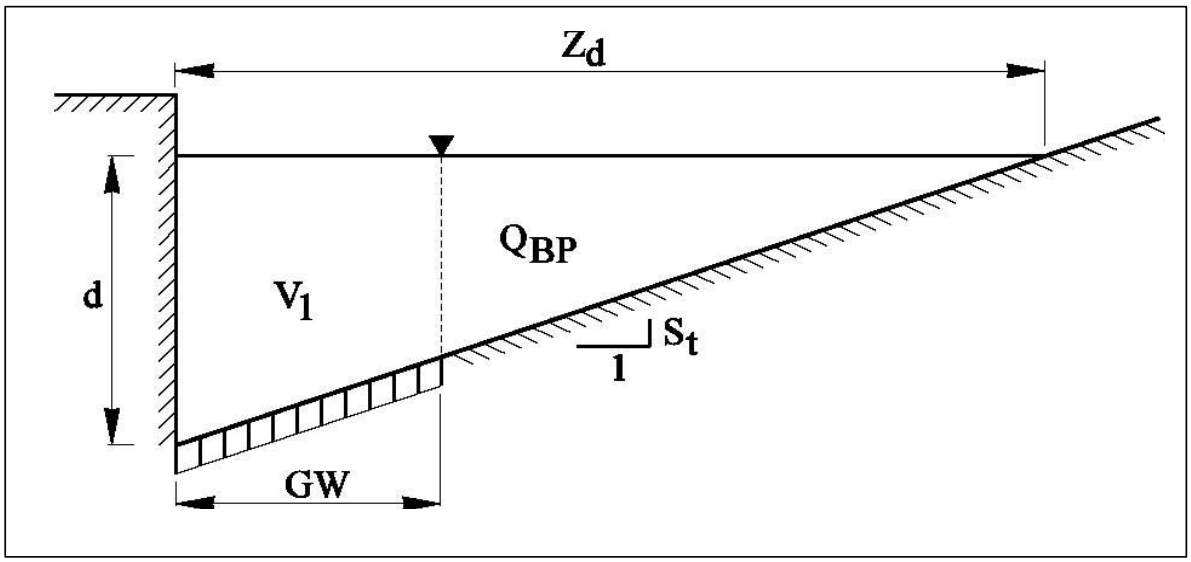

Figure 5 - 1: Section at Inlet

The flow that is not intercepted by the first grate inlet is considered bypass flow and should be added to the flow traveling toward the next grate located downstream. This carry-over process continues to the bottom of the grade or the end of the inlet system.

The last inlet on the system is allowed to bypass 0.28 cfs during the 25-year, 24-hour storm event as calculated using the SCS (TR-20) method of a single event model. If discharges exceed 0.28 cfs, additional catch basins or structures will be required to handle the flow.

The amount of flow bypassing the inlet on a continuous grade is computed as follows:

(Equation 5 - 1)

$$Q_{BP} = Q\left[\frac{(Z_d) - (GW)}{(Z_d)}\right]^{\frac{8}{3}}$$

Where:

Q_{BP} = portion of flow outside the width of the grate, cfs

Q = total flow of gutter approaching the inlet, cfs

Z_d = top width of the flow prism, feet

GW = width of the grate inlet perpendicular to the direction of flow in feet, assuming that grates areas are 80% free of debris and vaned grates are 95% free of debris.

The flow that is intercepted by the inlet is calculated as follows:

(Equation 5 - 2)

$$Q_i = \Delta Q - Q_{BP}$$

The velocity of flow directly over the inlet is calculated as follows:

(Equation 5 - 3)

$$V_{continuous} = \frac{Q - Q_{BP}}{(GW)[d - 0.5(GW)(S_t)]}$$

Where:

$V_{continuous}$ = velocity over the inlet in ft/s (m/s)

S_t = transverse slope or superelevation in ft/ft (m/m)

d = depth of flow at the face of the curb in ft (m)

3.5.3 Side Flow Interception

For longitudinal slopes less than 2 percent and when (Equation 5 - 3) yields velocities less than 3 ft/s, side flow interception begins to make an appreciable contribution to the inlet capacity analysis and should be considered.

The velocity of flow entering the side of an inlet is shown in (Equation 5 - 4).

(Equation 5 - 4)

$$V_{side} = \left(\frac{1.11}{n}\right)\left(S_L^{0.5} S_t^{0.67} Z_d^{0.67}\right)$$

Where:

V_{side} = velocity in triangular channel in ft/s

n = 0.015 (Manning's value for concrete pavement)

S_L = longitudinal slope in ft/ft

S_t = transverse slope or superelevation in ft/ft (m/m)

Z_d = top width of the flow prism, ft

The ratio of frontal flow to total gutter flow is shown in (Equation 5 - 5).

(Equation 5 - 5)

$$E_o = 1 - \left(1 - \frac{GW}{Z_d}\right)^{2.67}$$

Where:

GW = width of depressed grate in ft

Z_d = top width of the flow prism in ft

The ratio of side flow intercepted to total side flow is shown in (Equation 5 - 6).

(Equation 5 - 6)

$$R_S = \frac{1}{\left(1 + \frac{0.15V_{side}^{1.8}}{S_t GL^{2.3}}\right)}$$

Where:

GL = grate length

The efficiency of the grate is expressed in (Equation 5 - 7).

(Equation 5 - 7)

$$E = R_f E_o + R_s(1 - E_o)$$

Where:

R_f = Ratio of front flow intercepted to total frontal flow

The amount of flow intercepted by an inlet when side flow is considered is expressed in (Equation 5 - 8).

(Equation 5 - 8)

$$Q_i = Q(R_f E_o + R_s(1 - E_o))$$

3.5.4 Capacity of Inlets in Sag Locations

By definition, a sag is any portion of the roadway where the profile changes from a negative grade to a positive grade. Inlets at sag locations perform differently than inlets on a continuous grade and therefore require a different design criterion. Theoretically, inlets at sag locations may operate in one of two ways: (1) at low ponding depths, the inlet will operate as a weir; and (2) high ponding depths (5” depth above the grated inlet and 1.4 times the grate opening height for

combination inlets), the inlet will operate as an orifice. It is very rare that ponding on a roadway will become deep enough to force the inlet to operate as an orifice. As a result, this section will focus on inlets operating as a weir with flow spilling in from the three sides of the inlet that are exposed to the ponding.

Inlets at sag locations can easily become plugged with debris and therefore, it is good engineering practice to provide some type of relief. This relief can be accomplished by locating flanking inlets, on either side of the sag inlet, so they will operate before water exceeds the allowable spread into the travel lane at the sag. This manual recommends flanking inlets be located so the depth of water at the flanking inlet ponds to half the allowable depth at the sag (or $½d_B$). With that said, flanking inlets are only required when the sag is located in a depressed area and water has no outlet except through the system. However, if runoff is capable of overtopping the curb and flowing away from the roadway before exceeding the allowable limits noted in Table 5 - 3: Design Frequency and Spread, flanking inlets are not required. With this situation there is a low potential for danger to drivers if the inlets do not function as designed. Before flanking inlets are removed in this situation, designers should consider the potential damage of water going over the curb. Designers should use the guidelines provided in this section for locating flanking inlets. If a designer suspects flanking inlets are unnecessary, consult the City of Tacoma early in the design for approval.

Any section of roadway located in a sag should be designed according to the criteria described below. WSDOT created a spreadsheet to aid in the design. The City of Tacoma manipulated the spreadsheet to provide information specific to City of Tacoma requirements. The spreadsheet to provide information specific to City of Tacoma requirements. The spreadsheet shall be used and is available at tacoma.org/stormwatermanual. The 25-year, 24-hour storm event as predicted from a single event model shall be used in the analysis.

Once an inlet has been placed in a sag location, the total actual flow to the inlet can be determined as shown below. Q_{Total} must be less than $Q_{allowable}$ as described in (Equation 5 - 9).

(Equation 5 - 9)

$$Q_{Total} = Q_{BP1} + Q_{BP2} + \Delta Q_1 + \Delta Q_2$$

Where:

$Q_{BP1\&2}$ = bypass flow from the last inlet on either side of a continuous grade calculated using (Equation 5 - 1).

$\Delta Q_{1\&2}$ = runoff that is generated from the last inlet on either side of the continuous grades, see WSDOT Standard Plan B-25.20-00.

The effective perimeter of the flanking and sag inlets can be determined using the length and widths for various grates given in Table 5 - 2: Properties of Grate Inlets. This would be the sum of the three sides of the inlet where flow spills in and where ponding would occur. The grates shall be assumed to be 50 percent plugged, the vaned grates should be assumed to be 75% free, and the Combination Inlet B-25.20, which should be considered 100 percent free. This adjustment is in addition to reducing the perimeter to account for the obstruction caused by the bars in the grate. Table 5 - 2: Properties of Grate Inlets lists perimeters for various grates with reductions already made for bars.

(Equation 5 - 10)

$$P_n = 0.5[L + 2W]$$

Where:

P = effective perimeter of the flanking and sag inlet

L = length of the inlet from Table 5 - 2: Properties of Grate Inlets.

W = width of inlet from Table 5 - 2: Properties of Grate Inlets.

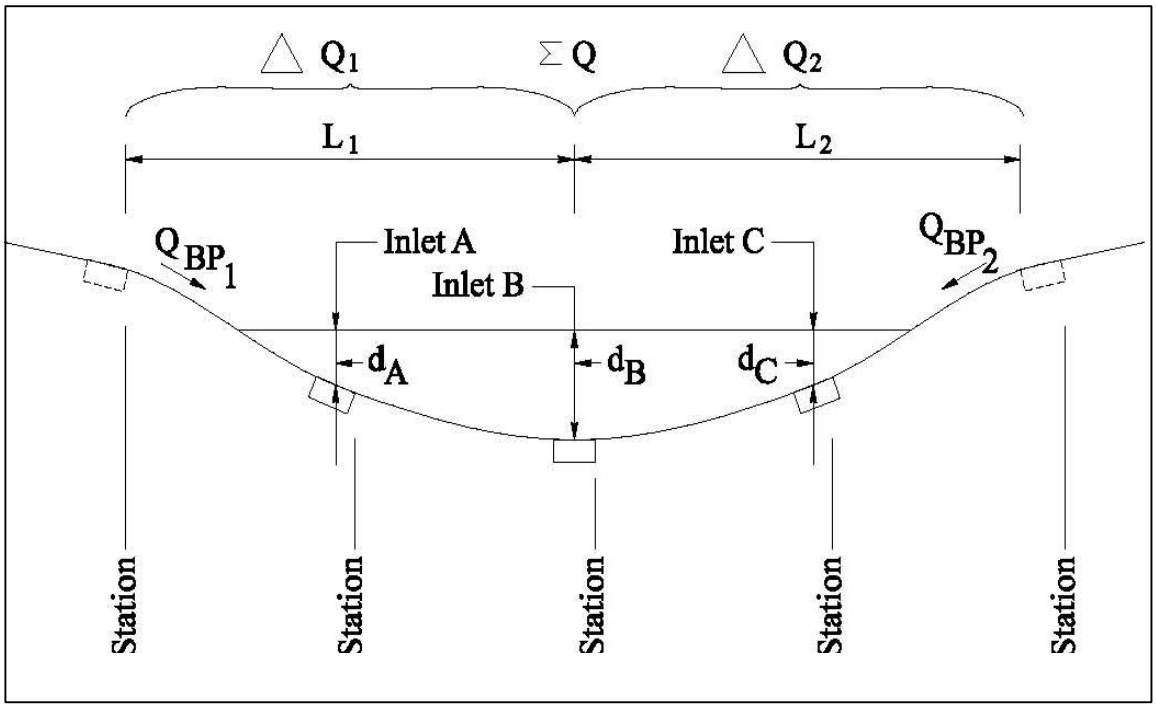

Figure 5 - 2: Sag Analysis

The allowable capacity of an inlet operating as a weir, that is the maximum $Q_{allowable}$, can be found depending on the inlet layout as described below:

When there is only a single inlet at the sag (no flanking inlets) the following equation should be used:

(Equation 5 - 11)

$$Q_{allowable} = C_w \times P \times d_{Ballowable}^{1.5}$$

Where:

C_W = weir coefficient; 3.0 for English Units, 1.66 for Metric Units

P = effective perimeter of the grate in feet

$d_{B\ allowable}$ = maximum depth of water at the sag inlet in feet

As noted previously it is recommended that flanking inlets be located laterally from the sag inlet at a distance equal to $0.5d_{B\ allowable}$. When this recommendation is followed, $Q_{allowable}$ can be simplified as shown below. If the inlets are not all the same size, the following equation will need to be modified to account for different perimeters:

(Equation 5 - 12)

$$\Sigma Q = C_w \times P \times \left[2(0.5d_B)^{1.5} + (d_B)^{1.5}\right]$$

Where:

d_B = depth of water at the sag inlet (ft)

In some applications, locating inlets so water ponds to $0.5d_{B\ allowable}$ is too far (generally in cases with long flat slopes). Designers should instead ensure that the spread of stormwater does not exceed those noted in Design Frequency and Spread and use (Equation 5 - 13).

(Equation 5 - 13)

$$Q_{allowable} = C_w P\left[d_A^{1.5} + d_B^{1.5} + d_C^{1.5}\right]$$

Where:

d_N = depth of water at the flanking inlets and the sag (ft)

The actual depth of water over the sag inlet can be found with (Equation 5 - 14) below and must be less than $d_{B\ allowable}$. If however, the inlets are or are not located at $0.5d_{B\ allowable}$, (Equation 5 - 13) will need to be modified to reflect this.

(Equation 5 - 14)

$$d_B = \left[\frac{Q_{total}}{(C_{WA}P_A 0.3536 + C_{WB}P_B + C_{WC}P_C 0.3536)}\right]$$

Where:

Q_{total} = actual flow into the inlet in cfs (cms)

C_W = weir coefficient, 3.0 (1.66 for metric)

P_N = effective grate perimeter, in feet (m), see Properties of Grate Inlets.

d_B = actual depth of ponded water at the inlet in feet (m)

Verify the allowable depth and flow have not been exceeded. That is verify $Q_{allowable} > Q_{Total}$ and $d_{B\ allowable} > d_B$. If the allowable flow and depth are greater than the actual, the maximum allowable spread will not be exceeded and the design is acceptable. If the actual depth or flow is greater than the allowable, then the runoff will spread beyond the maximum limits and the design is not acceptable. In this case, the designer should add flanking inlets or replace the three original inlets with inlets that have larger openings. If additional flanking inlets are used they should be placed close to the sag inlet to increase the flow interception and reduce the flow into the sag.

3.6 Gutter Capacity Analysis

When stormwater is collected and carried along the roadside in a gutter, the allowable top width of the flow prism (Zd) is dependent on the Road Classification as noted in Design Frequency and Spread.

Table 5 - 3: Design Frequency and Spread

Road Classification		Design Frequency[a]	Maximum Allowable Spread (Zd)
Arterial	< 45 mph (70 km/hr)	25-year	6.25 ft[b]
	≥ 45 mph (70 km/hr)	25-year	
	Sag Pt.	50-year	
Collector and Local Streets	< 45 mph (70 km/hr)	25-year	6.25 ft[c]
	≥ 45 mph (70 km/hr)	25-year	
	Sag Pt.	50-year	

a. The 24-hour storm event as calculated using the SCS (TR-20) method of a single event.
b. The travel way shall have at least 10 feet that is free of water.
c. In addition to the design spread requirement, the depth of flow shall not exceed 0.13 feet at the edge of the shoulder.

In addition to the requirements above, areas where a superelevation transition causes a crossover of gutter flow, the amount of flow calculated at the point of zero superelevation shall be limited to 0.28 cfs. The designer will find, by the time the roadway approaches the zero point, the Z_d will become very wide. The flow width criteria will be exceeded at the crossover point even when the flow is less than 0.28 cfs.

The equation for calculating the gutter flow capacity is a modified version of Manning's Equation. It is based on a roughness coefficient of 0.015, which assumes a rough, concrete or asphalt pavement gutter, (Equation 5 - 15) and (Equation 5 - 16) assume a uniform gutter section as shown in Typical Gutter Section. If the gutter section is different, designers should consult the *Hydraulic Engineering Circular No. 22*, Chapter 4, for further guidance found at: www.fhwa.dot.gov/bridge/hydpub.htm.

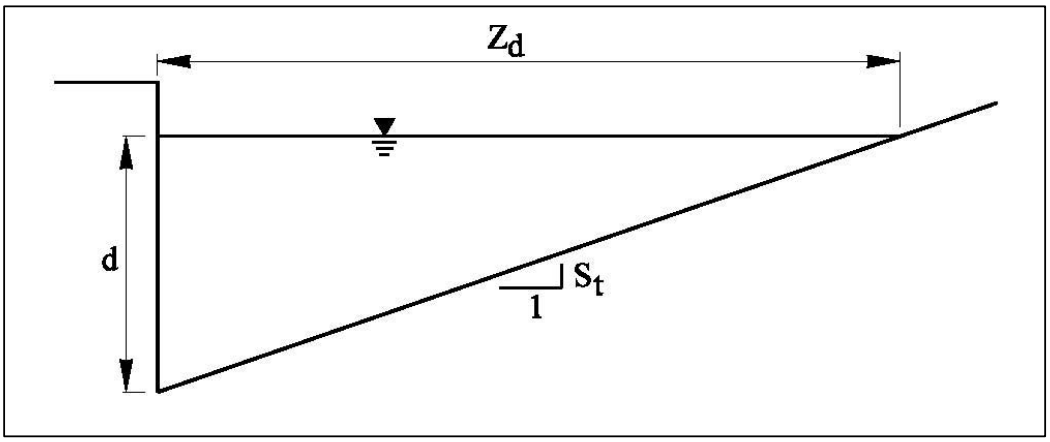

Figure 5 - 3: Typical Gutter Section

(Equation 5 - 15)

$$d = \left[\frac{\Delta O S_t}{37(S_L)^{0.5}}\right]^{\frac{3}{8}}$$

(Equation 5 - 16)

$$Z_d = \frac{d}{S_t}$$

Where:

d = depth of flow at the face of curb (ft)

ΔO = gutter discharge (cfs); this is the discharge based on the design event in Table 5 - 3: Design Frequency and Spread.

S_L = longitudinal slope of the gutter (ft/ft); assume minimum 0.4% for cement curb and gutter and 1% for asphalt unless survey of the gutter line is conducted.

S_t = transverse slope or superelevation (ft/ft); assume 2% unless survey of the slope is conducted

Z_d = top width of the flow prism (ft)

Chapter 4 Conveyance System Specifications

For specifications specific to pipes that will be maintained by the City of Tacoma, located in the City of Tacoma Right-of-Way, and/or that connect to the City of Tacoma system, see the City of Tacoma Design Manual (tacoma.gov/government/departments/public-works/engineering/right-of-way-design-manual) for design requirements and specifications.

When considering pipe and structure choice, it is required to consider the ease of maintenance, long-term maintenance, and life cycle costs. Pipe and structure materials and types chosen shall be upon good engineering practice and consider the end-user. Basis for design may be required by the City to justify the pipe and structure type.

When used in this manual, the term maintenance hole and manhole are interchangeable.

4.1 Pipe Specifications

This section deals specifically with pipes that are part of the conveyance system. See individual best management practices for specifications for specific stormwater facilities.

4.1.1 Pipe Materials

All pipe material, joints, and protective treatments shall be in accordance with the latest version of the WSDOT/APWA Standard Specifications and AASHTO and ASTM treatment standards as amended and as provided in the City of Tacoma Design Manual, this manual, or City of Tacoma Master Specifications as applicable.

4.1.1.1 Pipes Within the City Right-of-Way

Stormwater pipe to be installed in public right-of-way that will be publicly maintained, or privately owned but located within the right-of-way, and/or that connect to City of Tacoma maintained conveyance systems shall conform to the City of Tacoma Design Manual available at tacoma.gov/government/departments/public-works/engineering/right-of-way-design-manual.

4.1.1.2 Private Pipes Outside the City Right-of-Way

Below is a table that shows typical pipe types used for stormwater conveyance. Pipe material selection shall be based upon their proposed use of both the pipe and the overlying site use. The City may require a basis for design. Pipes to be installed in the public right-of-way that will be publicly maintained, privately owned but located within the right-of-way, and/or that connect to City maintained conveyance systems shall conform to pipe materials specified in the City of Tacoma Design Manual (tacoma.gov/government/departments/public-works/engineering/right-of-way-design-manual).

Table 5 - 4: Acceptable Pipe Material in the City Right-of Way

Pipe Material	Minimum SDR/ Class	Reference	Specification Reference	Applicability
Solid Wall PVC 15 inches in diameter or less	SDR 35	ASTM D 3034	WSDOT 9-05.12(1)	Standard use – Typical
Solid Wall PVC 18 inches in diameter or greater	115 psi SDR 26	ASTM F 679	WSDOT 9-05.12(1)	Standard use – Typical
Vitrified Clay	Extra Strength	ASTM C700	WSDOT 9-05.8	Standard use
Solid Wall PVC 12 inches in diameter or less	SDR 18	AWWA C900	WSDOT 9-30.1(5)A	Shallow or deep cover, non-standard separation from water main – Typical
Solid Wall PVC 12 inches in diameter or greater	SDR 18	AWWA C900 (AWWA combined C905 and C900 into one Standard)	WSDOT 9-30.1(5)A	Shallow or deep cover, non-standard separation from water main – Typical
Lined Ductile Iron	Special Thickness Class: 50 Minimum Pressure Class: 350 (If joined using bolted flanged joints – Special Thickness Class 53 required)	ANSI A21.51 or AWWA C151	WSDOT 9-015.13	Shallow or deep cover, non-standard separation from water main, above ground installation in vertical applications or steep slopes
Plain Concrete 12” diameter or less	Class 2	AASHTO M86	WSDOT 9-05.7(1)	Standard Use
Reinforced Concrete 12” diameter or greater	Per pipe Design	AASHTO M170	WSDOT 9-05.7(2)	Standard Use; Large Diameter

Pipe Material	Minimum SDR/ Class	Reference	Specification Reference	Applicability
Solid Wall High-Density Polyethylene (HPDE) Pipe, Heat Welded, Butt Fused	SDR 17	ASTM D 3350	City 9-05.23	Pipe Bursting; Steep Slope Installation; Above Ground Installation in vertical applications or steep slopes
Profile Wall HDPE, Integral Bell Joints (Spirolite or engineer approved equal)	Per pipe design, minimum class 100	ASTM F894 ASTM F477 ASTM D3350	Requires prior approval from Environmental Services. Additional design requirements may apply.	Large Diameter (typically 36” or larger)
Dual Wall Polypropylene Pipe (PP) 12 inches to 30 inches	Minimum Pipe Stiffness of 46pii in accordance with ASTM D2412	ASTM F2736 ASTM D3212 ASTM F477	WSDOT 9-05.24(2)	Standard Use
Triple Wall Polypropylene Pipe (PP) 30 inches to 60 inches	Minimum Pipe Stiffness of 46pii in accordance with ASTM D2412	ASTM F2764 ASTM D3212 ASTM F477	WSDOT 9-05.24(2) Requires prior approval from Environmental Services. Additional design requirements may apply.	Large Diameter (typically 36” or larger)
Single Wall Corrugated High Density Polyethylene Pipe (CPEP)		AASHTO M252		Downspout, Footing, Yard Drains
Single Wall Polypropylene Pipe (PP)		ASTM F2736		Slotted or Perforated Pipe
Corrugated High Intensity Polyethylene Pipe (CPEP) – 4-10” Diameter*		AASHTO M252, Type S		Standard Use

Pipe Material	Minimum SDR/ Class	Reference	Specification Reference	Applicability
Corrugated High Intensity Polyethylene Pipe (CPEP) – 12-60" Diameter*		AASHTO M294, Type S ASTM F2306	WSDOT 9-05.20	Standard Use

*Smooth interior CPEP shall have watertight joints meeting ASTM D3212 with gaskets meeting the requirements of ASTM F477. All CPEP fittings shall conform to AASHTO M252, AASHTO M294, or ASTM F2306.

4.1.2 Pipe Sizes

Pipes shall be sized to accommodate the amount of stormwater that is discharging to those pipes. Typically the minimum pipe size for roof drains is 3" and pipes used to convey other surfaces (ex. driveways, parking lots) is 6". Size of pipe shall consider the ability to maintain the system in addition to ensuring there is sufficient capacity. All new conveyance systems shall be designed per Volume 5, Chapter 3.

4.1.3 Changes in Pipe Sizes

To facility maintenance and help minimize issues associated with backwater conditions, the following are recommended:

- Pipe direction changes or size increases or decreases should be made at structures such as catch basins, manholes, and/or cleanouts.
- Pipes of different diameters should be aligned vertically in structures to match crowns to prevent backwater conditions in the smaller pipe.

4.1.4 Pipe Alignment and Depth

- Pipes must be laid true to line and grade with no curves, bends, or deflections (beyond manufacturer tolerance) in any direction.
- A break in grade or alignment or changes in pipe material should occur at structures to facilitate maintenance and help ensure a well functioning system.
- Pipe depths shall consider the intended site use and consider future use of the site (ex. will future extension be needed).
- Consideration shall be given when placing stormwater pipes where buoyancy is a concern such as areas with year-long high groundwater inundation. A Washington State Licensed Professional Engineer is required to design measures to mitigate buoyancy.

4.1.5 Pipe Slopes and Velocities

- A minimum slope for all pipes shall be 0.5%. Slopes less than 0.5% may be allowed on a case-by-case basis provided calculations are provided to demonstrate that a minimum velocity of 3 feet per second can be maintained at full flow.
- Where velocities exceed 15 feet per second energy dissipation may be necessary to protect structures. Pipe anchors and/or restrained joints may be required if velocities exceed 15 feet per second. Discharge locations shall be protected in accordance with

Volume 4 - Section 21.4 - End of Pipe Discharge Protection. A basis of design shall be required for pipes with velocities exceeding 15 feet per second.

4.1.6 Pipes on Steep Slopes

Pipe anchors may be required when placing pipes on steep slopes (15% or greater).

The following table shows criteria to be used in determining whether pipe anchoring is required and describes the maximum pipe slope allowed for various pipe types. The table does not fully encompass all scenarios where pipe anchors may be necessary - site specific conditions shall be reviewed to determine if pipe anchors are necessary. The table applies to pipes anchoring both above and below ground. Above ground installation shall address the thermal expansion/ contraction of the pipe material. An analysis shall be completed to demonstrate that the system will tolerate the thermal expansion of the pipe material. A basis for design shall be required for all instances where pipe anchors are required.

Table 5- 5: Maximum Pipe Slopes, Velocities and Anchor Requirements

Pipe Materials	Pipe Slope Requiring Pipe Anchors and Minimum Anchor Spacing	Max Slope Allowed	Max.Velocity Full Flow
Spiral Rib(1), PVC(1), CPEP-singlewall	20% (1 anchor per 100 L.F. of pipe)	30%(3)	30 fps
Concrete(1) or CPEP-smooth interior(1)	10% (1 anchor per 50 L.F. of pipe)	20%(3)	30 fps
Ductile Iron(4)(5)	40% (1 anchor per pipe section)	None	None
HDPE(2)(5)	50% (1 anchor per 100 L.F. of pipe – cross slope installations may be allowed with additional anchoring and analysis)	None	None
Concrete	10% 1 anchor per 50 L.F. of pipe	20%	30 fps

Notes:

(1) Not allowed in landslide hazard areas.

(2) Butt-fused pipe joints required. Above-ground installation is required on slopes greater than 40% to minimize disturbance to steep slopes.

(3) Maximum slope of 200% allowed for these pipe materials with no joints (one section) if structures are provided at each end and the pipes are property grouted or otherwise restrained to the structures.

(4) Restrained joints required on slopes greater than 20%. Above-ground installation is required on slopes greater than 40% to minimize disturbance to steep slopes.

(5) Anchoring shall be provided at upstream end per section 4.1.6 Pipes on Steep Slopes.

Key:

PVC = Polyvinyl chloride pipe
CPEP = Corrugated high density polyethylene pipe
HDPE = High density polyethylene pipe

4.1.7 Pipe Clearances

4.1.7.1 Horizontal Clearance

It is the applicant's responsibility to contact individual utilities to determine additional separation requirements. The most stringent separation requirement shall apply.

Pipes within the Right-of-Way

See the City of Tacoma Design Manual - tacoma.gov/government/departments/public-works/engineering/right-of-way-design-manual.

Pipes on Private Property

- Horizontal separation on private property shall comply with applicable building codes, plumbing codes, and Tacoma Water requirements.
- Horizontal separation from wastewater laterals shall comply with the City of Tacoma Side Sewer and Sanitary Sewer Availability Manual.
- Separation must be large enough to comply with proper bedding requirements.
- A minimum of 5 feet horizontal separation is recommended where feasible between the stormwater system and all other utilities.

4.1.7.2 Vertical Clearance

Pipes within the Right-of-Way

See the City of Tacoma Design Manual - tacoma.gov/government/departments/public-works/engineering/right-of-way-design-manual.

Pipes on Private Property

- Vertical separation on private property shall comply with applicable building codes, plumbing codes, and Tacoma Water requirements.
- Vertical separation from wastewater laterals shall comply with the City of Tacoma Side Sewer and Sanitary Sewer Availability Manual.
- Separation must be large enough to comply with proper bedding requirements.
- A minimum of 12" vertical separation is recommended where feasible between the stormwater system and all other utilities to ensure proper bedding and guarantee separation requirements of other utilities are met.
- A minimum of 2 feet vertical separation is recommended between any building tie-back, soil nails, anchors, etc. to ensure pipe integrity.

4.1.8 Pipe Cover

- Suitable pipe cover over storm pipes in areas subject to vehicle traffic shall be calculated for H-20 loading by the design engineer. Pipe manufacturer's recommendations are acceptable if verified by the design engineer.
- Minimum cover for all pipe types shall be three feet in areas subject to vehicular traffic. Pipe cover is measured from the finished grade down to the top outside diameter of the pipe. This pipe cover helps ensure the structural integrity of the pipe and ensure the pipe is located outside of the pavement section. When site conditions require pipe cover that is less than 3 feet, calculations shall be provided (calculations from the pipe manufacturer

can be provided) showing that the pipe type can handle the reduced pipe cover. Note, where the pavement section including crushed sufracing top course (CSTC) and crushed surfacing base course (CSBC) is 30" or greater, the minimum pipe cover shall be adjusted to ensure appropriate pipe bessing can be obtained. The CSCS should start above the pipe zone.

- Pipe cover in areas not subject to vehicular loads, such as landscape planters and yards, may be reduced to a 1-foot minimum.

4.2 Culvert Specifications

Culverts are relatively short segments of pipe of circular, elliptical, rectangular, or arch cross section and typically convey flow under road embankments or driveways. Culverts installed in stream and natural drainages shall meet the City's Critical Areas Preservation Ordinance and any fish passage requirements of the Washington State Department of Fish and Wildlife.

4.2.1 Inlets and Outlets

All inlets and outlets in or near roadway embankments must be flush with and conforming to the slope of the embankments.

- For culverts 18-inch diameter and larger, the embankment around the culvert inlet shall be protected from erosion by **rock lining or riprap** as specified in Table 5 - 6: Channel Protection, except the length shall extend at least 5 feet upstream of the culvert, and the height shall be at or above the design headwater elevation.
- **Inlet structures**, such as concrete headwalls, may provide a more economical design by allowing the use of smaller entrance coefficients and, hence, smaller diameter culverts. When properly designed, they will also protect the embankment from erosion and eliminate the need for rock lining.
- In order to maintain the stability of roadway embankments, concrete headwalls, wingwalls, or tapered inlets and outlets may be required if **right-of-way or easement constraints** prohibit the culvert from extending to the toe of the embankment slopes. All inlet structures or headwalls installed in or near roadway embankments must be flush with and conforming to the slope of the embankment.
- **Debris barriers (trash racks)** are required on the inlets of all culverts that are over 60 feet in length and are 12 to 36 inches in diameter. This requirement also applies to the inlets of pipe systems. See Figure 5 - 6: Debris Barrier for a debris barrier detail. Exceptions are culverts on Type 1 or 2 streams.
- For culverts 18-inch diameter and larger, the receiving channel of the outlet shall be protected from erosion by **rock lining** specified in Table 5 - 6: Channel Protection, except the height shall be one foot above maximum tailwater elevation or one foot above the crown, whichever is higher.
- Closed depressions are required to have two outlets in the event one outlet clogs. This could be a second outlet pipe or an emergency spillway.

4.3 Open Channel Specifications

4.3.1 Natural Channels

Natural channels are defined as those that have occurred naturally due to the flow of surface waters, or those that, although originally constructed by human activity, have taken on the appearance of a natural channel including a stable route and biological community. They may

vary hydraulically along each channel reach and should be left in their natural condition, wherever feasible or required, in order to maintain natural hydrologic functions and wildlife habitat benefits from established vegetation.

4.3.2 Constructed Channels

Constructed channels are those constructed or maintained by human activity and include bank stabilization of natural channels. Constructed channels shall be either vegetation-lined, rock lined, or lined with appropriately bioengineered vegetation.

- **Vegetation-lined channels** are the most desirable of the constructed channels when properly designed and constructed. The vegetation stabilizes the slopes of the channel, controls erosion of the channel surface, and removes pollutants. The channel storage, low velocities, water quality benefits, and greenbelt multiple-use benefits create significant advantages over other constructed channels. The presence of vegetation in channels creates turbulence, which results in loss of energy and increased flow retardation; therefore, the design engineer must consider sediment deposition and scour, as well as flow capacity, when designing the channel. See A1000: Vegetation for examples of plants/seed mixes that may be appropriate for the vegetated channel.
- **Rock-lined channels** are necessary where a vegetative lining will not provide adequate protection from erosive velocities. They may be constructed with riprap, gabions, or slope mattress linings. The rock lining increases the turbulence, resulting in a loss of energy and increased flow retardation. Rock lining also permits a higher design velocity and therefore a steeper design slope than in grass-lined channels. Rock linings are also used for erosion control at culvert and stormwater system outlets, sharp channel bends, channel confluences, and locally steepened channel sections.
- **Bioengineered vegetation lining** is a desirable alternative to the conventional methods of rock armoring. *Soil bioengineering* is a highly specialized science that uses living plants and plant parts to stabilize eroded or damaged land. Properly designed bioengineering systems are capable of providing a measure of immediate soil protection and mechanical reinforcement. As the plants grow they produce vegetative protective cover and a root reinforcing matrix in the soil mantle. This root reinforcement serves several purposes:
    a. The developed anchor roots provide both shear and tensile strength to the soil, thereby providing protection from the frictional shear and tensile velocity components to the soil mantle during the time when flows are receding and pore pressure is high in the saturated bank.
    b. The root mat provides a living filter in the soil mantle that allows for the natural release of water after the high flows have receded.
    c. The combined root system exhibits active friction transfer along the length of the living roots. This consolidates soil particles in the bank and serves to protect the soil structure from collapsing and the stabilization measures from failing.

4.3.3 Open Channel Design Criteria

- **Open channels** shall be designed to provide required conveyance capacity while minimizing erosion and allowing for aesthetics, habitat preservation, and enhancement. See Section 3.4.4 Open Channel Design Events for open channel sizing criteria.
- **An access easement for maintenance** is required along all constructed channels located on private property. Required easement widths and building setback lines vary with channel top width.

- **Channel cross-section geometry** shall be trapezoidal, triangular, parabolic, or segmental. Side slopes shall be no steeper than 3:1 for vegetation-lined channels and 2:1 for rock-lined channels.
- **Vegetation-lined channels** shall have bottom slope gradients of 6% or less and a maximum velocity at design flow of 5 fps (see Table 5 - 6: Channel Protection).
- **Rock-lined channels or bank stabilization of natural channels** shall be used when design flow velocities exceed 5 feet per second. Rock stabilization shall be in accordance with Table 5 - 6: Channel Protection or stabilized with bioengineering methods as described above in “Constructed Channels”.

4.3.4 Open Channel Stabilization

4.3.4.1 Channel Protection

Open channels must be protected to avoid channel erosion. Table 5 - 6: Channel Protection describes protection types based upon velocity in the channel.

Table 5 - 6: Channel Protection

Velocity at Design Flow (fps)		Required Protection		
Greater than	Less than or equal to	Type of Protection	Thickness	Min. Height Above Design Water Surface
0	5	Grass lining or bioengineered lining	N/A	0.5 foot
5	8	Rock lining(1) or bioengineered lining	1 foot	1 foot
8	12	Riprap(2)	2 feet	2 feet
12	20	Slope mattress gabion, etc.	Varies	2 feet

(1) Rock Lining shall be reasonable well graded as follows:
Maximum stone size: 12 inches
Median stone size:8 inches
Minimum stone size:2 inches

(2) Riprap shall be reasonably well graded as follows:
Maximum stone size:24 inches
Median stone size:16 inches
Minimum stone size:4 inches

Note: Riprap sizing is governed by side slopes on channel, assumed to be approximately 3:1.

4.3.4.2 Riprap Design[1]

Proper riprap design requires the determination of the median size of stone, the thickness of the riprap layer, the gradation of stone sizes, and the selection of angular stones, which will interlock

1. From a paper prepared by M. Schaefer, Dam Safety Section, Washington State Department of Ecology.

when placed. Research by the U.S. Army Corps of Engineers has provided criteria for selecting the **median stone weight, W_{50}** (Figure 5 - 4: Mean Channel Velocity vs Medium Stone Weight (W50) and Equivalent Stone Diameter). If the riprap is to be used in a highly turbulent zone (such as at a culvert outfall, downstream of a stilling basin, at sharp changes in channel geometry, etc.), the median stone W_{50} should be increased from 200% to 600% depending on the severity of the locally high turbulence. The thickness of the riprap layer should generally be twice the **median stone diameter (D_{50})** or at least equivalent to the diameter of the maximum stone. The riprap should have a reasonably well-graded assortment of stone sizes within the following gradation:

$$1.25 \leq D_{max}/D_{50} \leq 1.50$$

$$D_{15}/D_{50} = 0.50$$

$$D_{min}/D_{50} = 0.25$$

Riprap Filter Design

Riprap should be underlain by a sand and gravel filter (or filter fabric) to keep the fine materials in the underlying channel bed from being washed through the voids in the riprap. Likewise, the filter material must be selected so that it is not washed through the voids in the riprap. Adequate filters can usually be provided by a reasonably well graded sand and gravel material where:

$$D_{15} < 5d_{85}$$

The variable d_{85} refers to the sieve opening through which 85% of the material being protected will pass, and D_{15} has the same interpretation for the filter material. A filter material with a D_{50} of 0.5 mm will protect any finer material including clay. Where very large riprap is used, it is sometimes necessary to use two filter layers between the material being protected and the riprap.

Example:

What embedded riprap design should be used to protect a streambank at a level culvert outfall where the outfall velocities in the vicinity of the downstream toe are expected to be about 8 fps.

From Figure 5 - 4: Mean Channel Velocity vs Medium Stone Weight (W50) and Equivalent Stone Diameter, W_{50} = 6.5 lbs, but since the downstream area below the outfall will be subjected to severe turbulence, increase W_{50} by 400% so that:

$$W_{50} = 26 \text{ lbs}, D_{50} = 8.0 \text{ inches}$$

The gradation of the riprap is shown in Figure 5 - 5: Riprap Gradation Curve, and the minimum thickness would be 1 foot (from Table 5 - 6: Channel Protection); however, 16 inches to 24 inches of riprap thickness would provide some additional insurance that the riprap will function properly in this highly turbulent area.

Figure 5 - 5: Riprap Gradation Curve shows that the gradation curve for ASTM C33, size number 57 coarse aggregate (used in concrete mixes), would meet the filter criteria. Applying the filter criteria to the coarse aggregate demonstrates that any underlying material whose gradation was coarser than that of concrete sand would be protected.

For additional information and procedures for specifying filters for riprap, refer to *the Army Corps of Engineers Manual EM 1110-2-1601, Hydraulic Design of Flood Control Channels*, Paragraph 14, “Riprap Protection.”

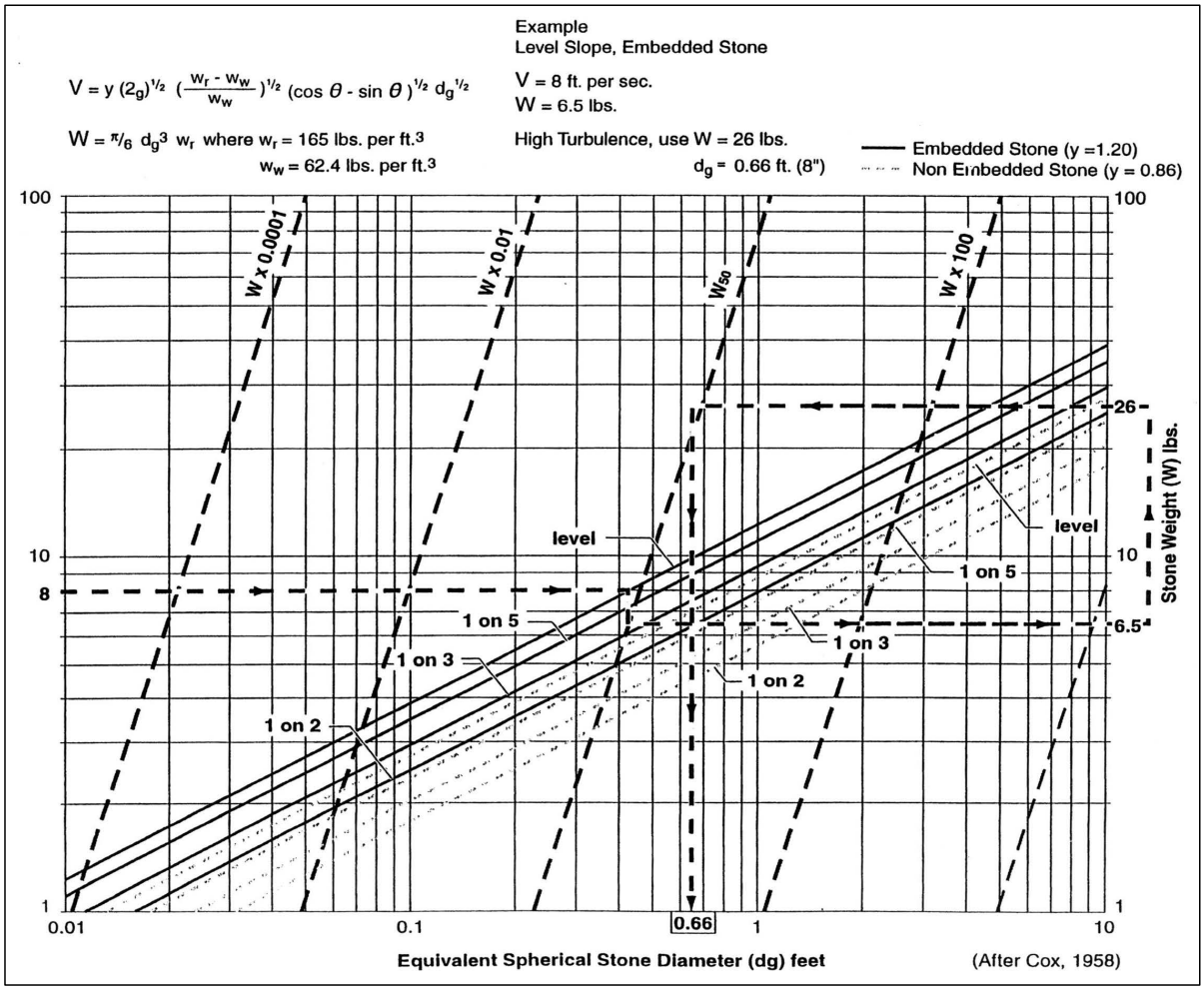

Figure 5 - 4: Mean Channel Velocity vs Medium Stone Weight (W50) and Equivalent Stone Diameter

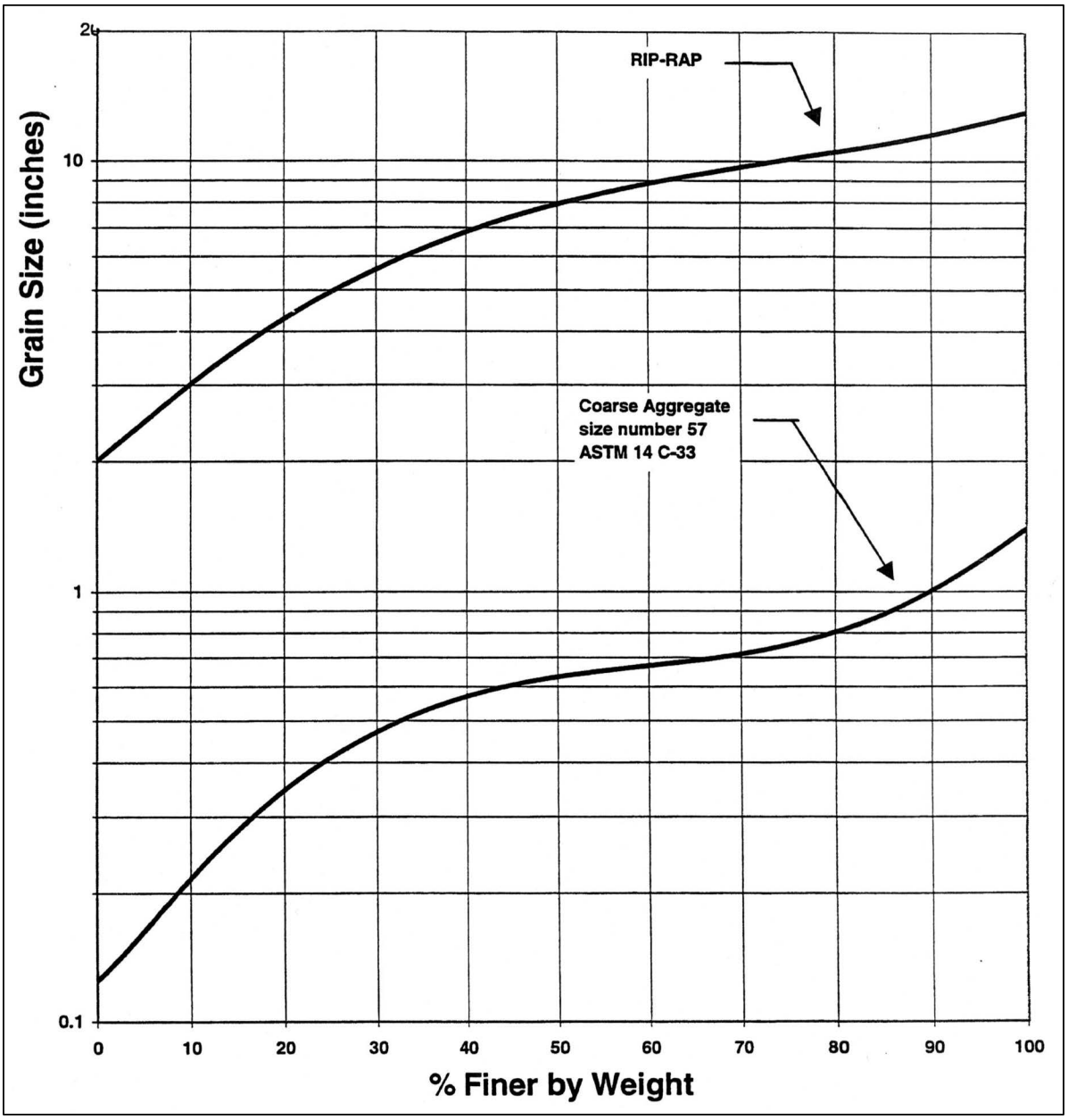

Figure 5 - 5: Riprap Gradation Curve

4.4 Structures

Structures to be installed in the public right-of-way, that will be publicly maintained, and/or privately owned but located within the right-of-way shall meet the requirements of the City of Tacoma Design Manual - tacoma.gov/government/departments/public-works/engineering/right-of-way-design-manual.

Conveyance system structures typically refers to catch basins and manholes.

Structure type and placement shall consider site use, constructability, accessibility, maintenance, and be designed to reduce or eliminate any localized flooding or pooling of stormwater. A basis for design may be required by the City of Tacoma to justify structure type and placement.

Standard details for all structure types must be shown on the plan set.

The following are criteria that shall be used for all projects. For public stormwater requirements see the City of Tacoma Design Manual:

- Structure size shall be determined by pipe diameter and orientation at the structure. A plan view of the junction structure, drawn to scale, will be required when more than four pipes enter the structure on the same plane, or if angles of approach and clearance between pipes is of concern. The plan view (and sections if necessary) must demonstrate that the minimum distance requirements between knockouts per the structure standards can be maintained.
- The maximum slope of ground surface for a radius of 5 feet around a catch basin grate shall be 3:1. The preferred slope is 5:1 to facilitate maintenance access.Catch basins and manholes shall be designed for H-20 loading at a minimum. Site use shall be considered when determining which loading to apply to a project..
- All catch basins, inlets, etc. shall be marked. The City of Tacoma has curb markers available for both public and private projects. Contact your City of Tacoma site inspectorto obtain curb markers for the project.
- Consideration shall be given when placing stormwater structures where buoyancy is a concern such as areas with year-long high groundwater inundation. A Washington State Licensed Professional Engineer is required to design measures to mitigate buoyancy.

4.5 System Connections

- Connections to the curb are discussed in Volume 5, Chapter 2 - Collect and Convey and connections to open channels are described in Volume 5, Section 4.3.
- It is recommended that connections to the conveyance system occur only at structures to accommodate long-term inspection and maintenance of the system.
- All connections shall be watertight. Specifications for connector type shall be provided and shown on the plan set.
- Connections will not be allowed to structures or pipes that are in disrepair. Replacement and/or rehabilitation of the existing structures and portions of existing pipe systems may be necessary to ensure a system that is fully functioning. The existing system shall be inspected prior to connections to ensure the system is in full working condition.
- To help minimize issues associated with backwater conditions, it is recommended to provide 0.1 foot of fall through structures. Pipes of different diameters should be aligned vertically in structures to match crowns.

- Stormwater from roofs shall not be connected to, or allowed to infiltrate into the footing drain system. Footing drains may connect to the roof drain system provided the following are met:
  - the connection of roof and footing drain discharge lines be a minimum of five feet horizontally from the building,
  - the footing drain invert elevation be a minimum of 6 inches above the roof invert elevation at the connection point, and
  - a yard drain, cleanout or other structure to allow for access and maintenance be installed at the connection points.

4.6 Debris Barriers

Trash racks on City-owned pipes are only required for culverts, pond outlet pipes or as otherwise directed by the City of Tacoma. Debris barriers (trash racks) are required on all pipes entering a pipe system. See Figure 5 - 6: Debris Barrier for required debris barriers on pipe ends outside of roadways and for requirements on pipe ends (culverts) projecting from driveways or roadway side slopes.

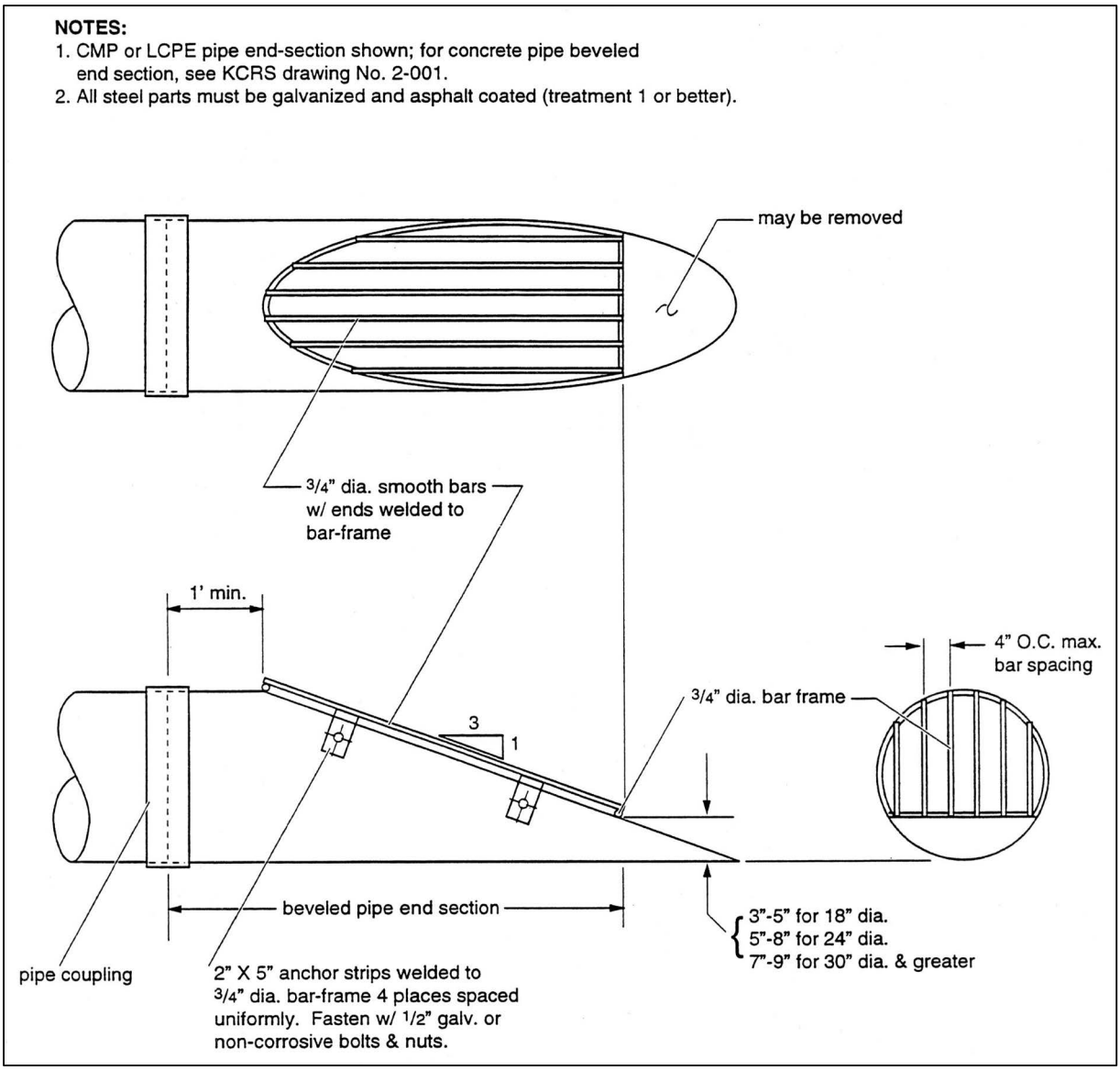

Figure 5 - 6: Debris Barrier

Chapter 5 Pump Systems

Pump systems are only allowed if it is determined that gravity systems are not feasible and as specifically approved in writing by the City of Tacoma. Feasibility of all other methods of gravity conveyance, infiltration and dispersion shall first be investigated and demonstrated to be infeasible in the following order of preference:

1. Infiltration of stormwater onsite.
2. Dispersion of stormwater on site.
3. Gravity connection to the City stormwater system.
4. Pumping to a gravity system.

5.1 Design Criteria

The pump system must convey, at a minimum, the peak volumetric flowrate calculated using a 10-minute timestep from a Type 1A, 25-year, 24-hour frequency storm using a single event model. Pump capacity plus system storage, must convey or store the 100-year, 24-hour frequency storm. An overflow must be provided for volumes exceeding the 100-year, 24-hour storm event and to serve in the event of a system failure. The overflow shall be to a safe, appropriate location

5.2 Pump Requirements

Proposed pump systems must meet the following minimum requirements:

- The gravity-flow components of the stormwater system to and from the pump system must be designed so that pump failure does not result in flooding of a building or emergency access or overflow to a location other than the natural discharge location for the project site.
- The pump system must have a dual pump (alternating) equipped with emergency back-up power OR a single pump may be provided without back-up power if the design provides the 100-year 24-hour storage volume.
- Pumps, wiring, and control systems shall be intrinsically safe per IBC requirements.
- All pump systems must be equipped with an external pump failure and high water alarm system.
- The pump system will serve only one lot or business owner.
- The pump system must be privately owned and maintained.
- The pump system shall not be used to circumvent any other City of Tacoma stormwater management requirements. Construction and operation of the pump system shall not violate any City of Tacoma requirements.
- All pump systems shall provide a transition from pressure line to gravity line prior to connection to the City system or curb. The transition shall be made at a cleanout or similar structure located on private property.

5.3 Additional Requirements

Private pumped stormwater systems will require the following additional items:

- Operations and Maintenance Manual describing the system itself and all required maintenance and operating instructions, including procedures to follow in the event of a power outage. All the requirements of Volume 2 - Documentation - Stormwater Site Plan (SSP), Construction Stormwater Pollution Prevention Plan (SWPPP) & Other Required Documents shall be included in the Operations and Maintenance manual.
- The property owner must enter into a Covenant and Easement Agreement with the City. The Covenant and Easement Agreement must be recorded to the property title with Pierce County.

All fees associated with preparing and recording documents and placing the Notice to Title shall be the responsibility of the applicant.

5.4 Submittal Requirements

The following information shall be provided for review:

- Plan view of proposed system
- Profile view of proposed system
- Detail of holding tank including pump on and off elevations
- Method of transition from pressure line to gravity line and location of transition from pressure line to gravity line
- Cut sheets and specifications for:
  - Pump (including pump performance curve)
  - Holding tank
  - Control panel
  - Audio visual alarm
- Engineering calculations, including:
  - System head loss calculations
  - Flowrate and volume as calculated from single event model using appropriate design event (see Chapter 3).
  - Appropriate flowrate and head characteristics plotted on the pump performance curve
  - Velocity calculations for the proposed diameter and type of pipe
  - Frequency and duration of pumping cycles
  - 100-year, 24-hour storage volume (if proposing a single pump)
- Operation and Maintenance Manual describing the system itself and all required maintenance and operating instructions, including procedures to follow in the event of a power outage. All requirements of Volume 2 - Documentation - Stormwater Site Plan (SSP), Construction Stormwater Pollution Prevention Plan (SWPPP) & Other Required Documents shall be included in the Operation and Maintenance Manual.

5.5 Sump Pumps

The above pump requirements do not apply to internal sump pumps. However, internal sump pumps **do require** a permit prior to connection to the City stormwater system.

- Sump pumps shall be sized to properly remove water from basements and crawl spaces.
- Sump pumps shall NOT be connected to the wastewater system.
- Consult the pump manufacturer or design engineer for appropriate sizing of a sump pump.
- Contaminated water shall not be discharged to the City stormwater or wastewater system.
- All pump systems shall provide a gravity break prior to discharge to the City system or curb.

The City of Tacoma may review pump installations and may require cut sheets, proposed layout, proposed connection to the City system, and sizing calculation.

VOLUME

6

Source Control Best Management Practices

How to Use this Volume

Minimum Requirement #3: Source Control - requires that all known, available, and reasonable source control BMPs are used to help prevent stormwater from contacting pollutants.

Source control BMPs are both operational and structural BMPs related to the use of the property and the potential pollutant sources of the property.

Source Control BMPs, contained in this Volume, shall be used in all areas in the City of Tacoma to reduce pollutants in stormwater. Every person/business/project/etc. is required to utilize source control BMPs. New development and redevelopment projects are required to plan for potential activities that may be associated with a project.

The use of the BMPs in this Volume also help to ensure compliance with Minimum Requirement #3: Source Control. The volume contains both Best Management Practices that are required (Required BMPs) and Best Management Practices that can be used (Recommended Additional BMPs) to ensure compliance with Minimum Requirement #3: Source Control. Minimum Requirement #3 requires the applicant to include relevant BMPs in the Stormwater Site Plan (SSP) Report. Volume 2 - Documentation - Stormwater Site Plan (SSP), Construction Stormwater Pollution Prevention Plan (SWPPP) & Other Required Documents describes the SSP components in detail.

There is a worksheet available on tacoma.org/stormwatermanual to help ensure appropriate BMPs are used on the site. For commercial, industrial, and multi-family projects, include this worksheet in the Stormwater Site Plan as applicable to the project.

Chapter 1 Source Control BMPs Applicable to All Sites

The following Best Management Practices shall be used at all commercial, multi-family, and industrial sites, as applicable:

BMP S100: Correcting Illicit Discharges to the Stormwater System

BMP S101: Labeling Stormwater Inlets

BMP S102: Formation of a Pollution Prevention Team

BMP S103: Preventive Maintenance / Good Housekeeping

BMP S104: Spill Prevention and Cleanup

BMP S105: Employee Training

BMP S106: Inspections

BMP S107: Record Keeping

1.1 BMP S100: Correcting Illicit Discharges to the Stormwater System

1.1.1 Applicability

This BMP applies to all properties. Illicit discharges are unpermitted wastewater or process wastewater discharges to the stormwater system or to surface water, rather than to a wastewater system, industrial process wastewater processing area, or other appropriate treatment. They can also include swimming pool water, filter backwash, cleaning solutions/washwaters, cooling water, etc. Experience has shown that illicit discharges are common, particularly in older buildings.

1.1.2 Required BMPs

- For all real properties, responsible parties must examine their plumbing systems to identify any potential illicit discharges. Review site plans, engineering drawings, or other sources of information for the plumbing systems on the property.
- If an illicit discharge is suspected, trace the source using an appropriate method such as visual reconnaissance, smoke test, flow test, dye test with a nontoxic dye, or closed circuit television (CCTV) inspection. These tests are to be performed by qualified personnel such as a plumbing contractor.

  Note: Contact City of Tacoma Environmental Compliance at (253) 502-2222 and the Washington State Department of Ecology prior to performing a dye test which may result in a discharge to a receiving water.
- If illicit connections are found, permanently plug or disconnect the connections.
- Eliminate prohibited discharges to the stormwater system, groundwater, or surface water.
- Convey illicit discharges to the wastewater system if allowed by the City of Tacoma.
- Obtain all necessary permits for altering or repairing side sewers and plumbing fixtures. Restrictions on certain types of discharges, particularly industrial process waters, may require pretreatment of discharges before they enter the wastewater system. It is the responsibility of the property owner or business operator to obtain the necessary permits and to replace the connection. Visit tacomapermits.org for information on the types of connection permits that may be required. Certain discharges may require Special Approved Discharge (SAD) permits - see tacoma.gov/government/departments/environmental-services/wastewater/fog-fats-oils-and-grease/

1.1.3 Recommended Additional BMPs

At commercial and industrial facilities, conduct a survey of wastewater discharge connections to the stormwater system and to surface water as follows:

- Conduct a field survey of buildings, particularly older buildings, and other industrial areas to locate stormwater inlets that receive stormwater from buildings and paved surfaces. Note where these discharge.
- During non-stormwater conditions, inspect each stormwater inlet for non-stormwater discharges. Record the locations of all non-stormwater discharges. Include all permitted discharges.
- If useful, prepare a map of each area. Show on the map the known location of the stormwater system, wastewater system, and permitted and unpermitted discharges. Aerial photos may be useful. Check records such as piping schematics to identify known side sewer connections and show these on the map. Consider using smoke, dye, or

chemical analysis tests to detect connections between two conveyance systems (e.g., process water and stormwater). If desirable, conduct TV inspections of the stormwater system and record the footage on videotape.

- Compare the observed locations of connections with the information on the map and revise the map accordingly. Note suspect connections that are inconsistent with the field survey.
- Identify all illicit connections to the stormwater system or to surface water and take the actions specified above as applicable

1.2 BMP S101: Labeling Stormwater Inlets

1.2.1 Applicability

This BMP applies to all properties that have stormwater inlets such as catch basins. This BMP also applies to stormwater inlets in the ROW. Waste materials dumped into stormwater inlets can have severe impacts on receiving waters. Posting notices regarding discharge prohibitions at stormwater inlets can prevent waste dumping. Stormwater inlet signs and stencils are highly visible source control BMPs that are typically placed directly adjacent to stormwater inlets.

1.2.2 Required BMPs

- Label all stormwater inlets to help prevent the improper disposal of pollutants.
  - Stormwater inlets at new development and redevelopment project sites shall be fully marked before final construction permit closeout.
  - Existing stormwater inlets that are not marked shall be marked as time allows and weather permits.
- Apply stormwater inlet markers adjacent to inlets where possible. If adherence of marker is not possible, stamp stormwater inlet grate or provide an alternate means of labeling.
  - Stormwater inlet markers shall be obtained from the City of Tacoma. Contact your City of Tacoma site inspector for markers.
- Apply stormwater inlet markers in weather appropriate for the adhesive to fully adhere.
- Place the marker in clear sight facing toward anyone approaching the inlet from either side.
- Use a brief statement and / or graphical icons to discourage illegal dumping. City provided stormwater inlet markers include these messages and graphical icons. Examples include:
  - “No Dumping - Drains to Stream"
  - “No Pollutants - Drains to Puget Sound"
  - “Dump No Waste - Drains to Lake"
  - “No Dumping - Puget Sound Starts Here"
- Replace inlet markers when they are no longer legible. Signage on top of curbs tends to weather and fade. Signage on face of curbs tends to be worn by contact with vehicle tires and sweeper brooms.
- When installing markers, temporarily block the stormwater inlet so that no pollutants are discharged from the labeling activities.

1.2.3 Recommended Additional BMPs

- Use a stormwater inlet marker and stamped grate to increase visibility of the message.
- Additionally label stormwater inlets with individual identifiers to assist in inspection and operation and maintenance activities.

1.3 BMP S102: Formation of a Pollution Prevention Team

1.3.1 Applicability

This BMP applies to commercial (including multi-family properties such as apartment buildings) and industrial properties and/or companies that manage those properties whether located onsite on a regular basis or not.

1.3.2 Required BMPs

The pollution prevention team should be responsible for implementing and maintaining all BMPs and treatment for the site. This team should be able to address any corrective actions needed on site to mitigate potential stormwater contamination. The team members should:

- Consist of those people who are familiar with the facility and its operations.
- Possess the knowledge and skills to assess conditions and activities that could impact stormwater quality at your facility, and who can evaluate the effectiveness of control measures.
- Assign pollution prevention team staff to be on duty on a daily basis to cover applicable facilities when those facilities are in operation.
- Have the primary responsibility for developing and overseeing facility activities necessary to comply with stormwater requirements.
- Have access to all applicable permit, monitoring, SWPPP, and other records.
- Be trained in the operation, maintenance and inspections of all BMPs and reporting procedures.
- Establish responsibilities for inspections, operation, maintenance, and emergencies.
- Regularly meet to review overall facility operations and BMP effectiveness.

1.4 BMP S103: Preventive Maintenance / Good Housekeeping

1.4.1 Applicability

Preventative maintenance and good housekeeping practices reduce the potential for stormwater to come into contact with pollutants and can reduce maintenance intervals for the stormwater and wastewater system.

1.4.2 Required BMPs

- Prevent the discharge of unpermitted liquid or solid wastes, process wastewater, and sewage to ground or surface water, or to the stormwater system that discharges to surface water, or to the ground. Conduct all oily parts cleaning, steam cleaning, or pressure washing of equipment or containers inside a building, or on an impervious contained area, such as a concrete pad. Direct contaminated stormwater from such an area to the wastewater system, or to other approved treatment. Pretreatment may be required, see https://tacoma.gov/government/departments/environmental-services/wastewater/fog-fats-oils-and-grease/ for additional information.
- Promptly contain and clean up solid and liquid pollutant leaks and spills including oils, solvents, fuels, and dust from manufacturing operations on an exposed soil, vegetation, or paved area.
- If a contaminated surface must be pressure washed, collect the resulting washwater for proper disposal (usually involves plugging stormwater inlets, or otherwise preventing discharge and pumping or vactoring up washwater, for discharge to wastewater system or for vactor truck transport to a wastewater treatment plant for disposal).
- Do not hose down pollutants from any area to the ground, into the stormwater system, or into receiving waters. Convey pollutants before discharge to a treatment system approved by the local jurisdiction.
- Sweep all appropriate surfaces with vacuum sweepers quarterly, or more frequently as needed, for the collection and disposal of dust and debris that could contaminate stormwater. Use mechanical sweepers, and manual sweeping as necessary to access areas that a vacuum sweeper can't reach to ensure that all surface contaminants are routinely removed.
- Do not pave over contaminated soil unless it has been determined that groundwater has not been and will not be contaminated by the soil. Call Ecology for assistance.
- Construct impervious areas that are compatible with the materials handled. Portland cement concrete, asphalt, or equivalent material may be considered.
- Use drip pans to collect leaks and spills from industrial/commercial equipment such as cranes at ship/boat building and repair facilities, log stackers, industrial parts, trucks and other vehicles stored outside.
- At industrial and commercial facilities, drain oil and fuel filters before disposal. Discard empty oil and fuel filters, oily rags, and other oily solid waste into appropriately closed and properly labeled containers, and in compliance with the Uniform Fire Code or International Building Code.
- For the storage of liquids, use containers, such as steel and plastic drums, that are rigid and durable, corrosion resistant to the weather and fluid content, non-absorbent, water tight, rodent-proof, and equipped with a close fitting cover.
- For the temporary storage of solid wastes contaminated with liquids or other potential polluted materials, use dumpsters, garbage cans, drums, and comparable containers,

which are durable, corrosion resistant, non-absorbent, non-leaking, and equipped with either a solid cover or screen cover to prevent littering. If covered with a screen, the container must be stored under a roof or other form of adequate cover.

- Where exposed to stormwater, use containers, piping, tubing, pumps, fittings, and valves that are appropriate for their intended use and for the contained liquid.
- Clean oils, debris, sludge, etc. from all stormwater facilities regularly, including catch basins, settling/detention basins, oil/water separators, boomed areas, and conveyance systems to prevent the contamination of stormwater. Contact the Washington State Department of Ecology's Hazardous Waste and Toxics Reduction Program for information on how handle potentially dangerous waste.
- Promptly repair or replace all substantially cracked or otherwise damaged paved secondary containment, high-intensity parking, and any other areas subject to stormwater and surface water, subjected to pollutant material leaks or spills. Promptly repair or replace all leaking connections, pipes, hoses, valves, etc., which can contaminate stormwater.
- Do not connect floor drains in potential pollutant source areas to the stormwater system, surface water, or to the ground.

1.4.3 Recommended Additional BMPs

- Where feasible, store potential stormwater pollutant materials inside a building or under a cover and/or containment.
- Minimize use of toxic cleaning solvents, such as chlorinated solvents, and other toxic chemicals.
- Use environmentally safe raw materials, products, additives, etc. such as substitutes for zinc used in rubber production.
- Recycle waste materials such as solvents, coolants, oils, degreasers, and batteries to the maximum extent feasible. Contact Ecology's Hazardous Waste & Toxics Reduction Program at https://ecology.wa.gov/About-us/Get-to-know-us/Our-Programs/Hazardous-Waste-Toxics-Reduction for recommendations on recycling or disposal of vehicle waste liquids and other waste materials.
- In uncovered areas, empty drip pans immediately after a spill or leak is collected.
- Use solid absorbents, e.g., clay and peat absorbents and rags for cleanup of liquid spills/ leaks, where practicable.
- Promptly repair/replace/reseal damaged paved areas at industrial facilities.
- Recycle materials, such as oils, solvents, and wood waste, to the maximum extent practicable.

Note: Evidence of stormwater contamination by oils and grease can include the presence of visible sheen, color, or turbidity in the runoff, or present or historical operational problems at the facility. Operators can use simple pH tests, for example with litmus or pH paper. These tests can screen for high or low pH levels (anything outside a 6.5-8.5 range) due to contamination in stormwater.

1.5 BMP S104: Spill Prevention and Cleanup

1.5.1 Applicability

This BMP applies to all spills and leaks that may happen on any parcel and in the ROW. Spills and leaks can damage public infrastructure, interfere with sewage treatment, and cause a threat to human health or the environment. Spills are often preventable if appropriate chemical and waste handling techniques are practiced effectively and the spill response plan is immediately implemented. Additional spill control requirements may be required based on the specific activity occurring on site.

1.5.2 Required BMPs

Spill Prevention

- Clearly label or mark all containers that contain potential pollutants.
- Store and transport liquid materials in appropriate containers with tight-fitting lids.
- Place drip pans underneath all containers, fittings, valves, and where materials are likely to spill or leak. Empty spill pans immediately after material is collected.
- Use tarpaulins, ground cloths, or drip pans in areas where materials are mixed, carried, and applied to capture any spilled materials.
- Train employees on the safe techniques for handling materials used on the site and to check for leaks and spills.

Spill Plan

See tacoma.gov/stormwatermanual for a template that can be used.

- Develop and implement a spill plan and update it annually or whenever there is a change in activities or staff responsible for spill cleanup. Post a written summary of the plan at areas with a high potential for spills, such as loading docks, product storage areas, waste storage areas, and near a phone. The spill plan may need to be posted at multiple locations.
- Describe the facility, including the owner's name, address, and telephone number; the nature of the facility activity; and the general types of chemicals and oils used at the facility.
- Designate spill response employees to be on-site during business activities. Provide a current list of the names and telephone numbers (home and office) of designated spill response employees who are responsible for implementing the spill plan.
- Provide a site plan showing the locations of storage areas for chemicals and oils, inlets/ catch basins, spill kits and other relevant infrastructure or materials information.
- Describe the emergency cleanup and disposal procedures. Note the location of all spill kits in the spill plan.
- List the names and telephone numbers of public agencies to contact in the event of a spill.
- Train key personnel in the implementation of the Spill Plan.

Spill Cleanup Kits

- Store all cleanup kits near areas with a high potential for spills so that they are easily accessible in the event of a spill. The contents of the spill kit must be appropriate to the

types and quantities of materials stored or otherwise used at the facility, and refilled when the materials are used. Spill kits must be located within 25 feet of all fueling/fuel transfer areas, including onboard mobile fuel trucks.

Note: Ecology recommends that the kit(s) include salvage drums or containers, such as high density polyethylene, polypropylene or polyethylene sheet-lined steel; polyethylene or equivalent disposal bags; an emergency response guidebook; safety gloves/clothes/equipment; shovels or other soil removal equipment; and oil containment booms and absorbent pads; all stored in an impervious. container.

Spill Cleanup and Proper Disposal of Waste

- Stop, contain, and clean up all spills immediately upon discovery.
- Implement the spill plan immediately.
- Contact the designated spill response employees.
- Block off and seal nearby inlets/catch basins to prevent materials from entering the stormwater system.
- Use the appropriate material to clean up the spill.
- Do not use emulsifiers or dispersants such as liquid detergents or degreasers unless disposed of properly. Emulsifiers and dispersants are not allowed to be used on surface water, or in a place where they may enter the stormwater system, surface waters, treatments systems, or the wastewater system.
- Immediately notify Ecology (https://ecology.wa.gov/Regulations-Permits/Reporting-requirements/Spills-If-you-spill) and the City of Tacoma at 311 if a spill has reached or may reach the wastewater or stormwater system, groundwater, or surface water. Notification must comply with state and federal spill reporting requirements.
- Do not wash absorbent material into interior floor drains or stormwater system inlets/ catch basins.
- Place used spill control materials in appropriate containers and dispose of according to regulations.

1.6 BMP S105: Employee Training

1.6.1 Applicability

This BMP applies to commercial (including multi-family properties such as apartment buildings) and industrial properties and/or companies that manage those properties whether located onsite on a regular basis or not.

1.6.2 Required BMPs

Train all employees that work in pollutant source areas about the following topics:

- Identifying Pollution Prevention Team Members.
- Identifying pollutant sources.
- Understanding pollutant control measures.
- Spill prevention and response.
- Emergency response procedures.
- Handling practices that are environmentally acceptable. Particularly those related to vehicle/equipment liquids such as fuels, and vehicle/equipment cleaning.

Additional specialized training may be needed for staff who will be responsible for handling hazardous materials.

1.7 BMP S106: Inspections

1.7.1 Applicability

This BMP applies to commercial (including multi-family properties such as apartment buildings) and industrial properties and/or companies that manage those properties whether located onsite on a regular basis or not. It is recommended that all other properties inspect their property at least monthly to asses and remedy potential sources of stormwater pollution.

1.7.2 Required BMPs

Qualified personnel shall conduct inspections monthly. Make and maintain a record of each inspection on-site. Inspections shall:

- Be conducted by someone familiar with the facility's site, operations, and BMPs.
- Verify the accuracy of the pollutant source descriptions in the SWPPP.
- Assess all BMPs that have been implemented for effectiveness and needed maintenance and locate areas where additional BMPs are needed.
- Reflect current conditions on the site.
- Include written observations of the presence of floating materials, suspended solids, oil and grease, discoloration, turbidity and odor in the stormwater discharges. In areas where acid or alkaline materials are handled or stored use a simple litmus or pH paper to identify those types of stormwater contaminants where needed.
- Eliminate or obtain a permit for unpermitted non-stormwater discharges to the stormwater system or receiving waters, such as process wastewater and vehicle/equipment washwater.
- Identify actions to address inspection deficiencies.

1.8 BMP S107: Record Keeping

1.8.1 Applicability

This BMP applies to commercial (including multi-family properties such as apartment buildings) and industrial properties and/or companies that manage those properties whether located onsite on a regular basis or not. It is recommended that all other properties keep records (such as inspection records) which may be useful in identifying any issues that might arise.

1.8.2 Required BMPs

See the applicable permit for specific record-keeping requirements and retention schedules for the following reports. At a minimum, retain the following reports for five years:

- Inspection reports which should include:
  - Time and date of the inspection
  - Locations inspected
  - Statement on status of compliance with the permit
  - Summary report of any remediation activities required
  - Name, title, and signature of person conducting the inspection
- Reports on spills of oil or hazardous substances in greater than Reportable Quantities (Code of Federal Regulations Title 40 Parts 302.4 and 117). Report spills of the following: antifreeze, oil, gasoline, or diesel fuel, that cause:
  - A violation of the State of Washington's Water Quality Standards.
  - A film or sheen upon or discoloration of the waters of the State or adjoining shorelines.
  - A sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines.

To report a spill or to determine if a spill is a substance of a Reportable Quantity, call the Washington State Department of Ecology at (360) 407-6300

In addition, call the Washington Emergency Management Division at 1-800-258-5990 or 1- 800-OILS-911 AND the National Response Center at 1-800-424-8802.

Also, refer to Focus on Emergency Spill Response (Ecology, 2009).

1.8.3 Recommended Additional BMPs

Maintain records of all related pollutant control and pollutant generating activities such as training, materials purchased, material use and disposal, maintenance performed, etc.

Chapter 2 BMPs for Commercial and Industrial Activities

2.1 Cleaning and Washing BMPs

BMP S108: Washing Best Management Practices for All Activities

BMP S109 Cleaning or Washing of Tools, Equipment, and Machinery

BMP S110: Cleaning or Washing of Cooking Equipment

BMP S111: Cleaning Building Structures and Related Equipment

BMP S112: Washing, Pressure Washing and Steam Cleaning of Vehicles

BMP S113: Dock Washing

2.1.1 BMP S108: Washing Best Management Practices for All Activities

2.1.1.1 Applicability

Washing BMPs encompass washing practices related to various washing activities.

2.1.1.2 Required BMPs for all washing activities

- Illicit connections to the stormwater system must be eliminated. See BMP S100: Correcting Illicit Discharges to the Stormwater System for additional information.
- Follow the guidance contained in the City of Tacoma Side Sewer and Sanitary Sewer Availability Manual as appropriate. The Side Sewer Manual is available at tacoma.gov/sidesewer and includes guidance for pretreatment and oil water separators when discharging to the wastewater system.
- For facilities with a dedicated wash pad, at a minimum the pad must be equipped with a catch basin/sediment trap that discharges through a tee outlet to the wastewater system. Discharges to the wastewater system must meet the discharge limits of TMC Chapter 12 before discharge is allowed. Sampling, testing, and pretreatment of the wastewater may be required to meet limits.
- Sweep or wipe surfaces prior to cleaning to remove excess sediment and pollutants before washing.
- Contact City of Tacoma Stormwater Management Program at ECInspections@tacoma.gov for assistance.
- Unless otherwise stated, discharge of washwater into the street, into receiving waterbodies, or into the stormwater system is prohibited. This includes any washwater generated from inside a building or from mobile cleaning operations, such as interior carpet cleaners.

2.1.1.3 Recommended BMPs for all washing activities

- Limit the amount of water used in washing activities.
- Recycle washwater when possible for subsequent washings.
- If soaps and detergents are allowed and used, use the least toxic cleaner capable of doing the job. Select non-phosphate detergents when possible.
- Cover and/or contain the cleaning activity inside a building to separate uncontaminated stormwater from the pollutant sources.

2.1.2 BMP S109 Cleaning or Washing of Tools, Equipment, and Machinery

2.1.2.1 Applicability

This activity applies to sites that clean any tools, equipment, or machinery such as saws, grinders, screens, lawn mowers, and other processing devices outside of buildings, and to sites engaged in pressure washing of engines, equipment, and portable objects.

Pollutant sources include toxic hydrocarbons, organic compounds, oils and greases, nutrients, heavy metals, pH, suspended solids, biochemical oxygen demand (BOD), and chemical oxygen demand (COD).

2.1.2.2 Required BMPs

- All washwater shall be discharged to the wastewater system.
  - Washwater may be used in a closed loop recycle system before ultimate disposal in the wastewater system.
  - Washwater can be temporarily stored before it is ultimately discharged to the wastewater system.
- Washwater shall not discharge to the stormwater system.

  See BMP S162: Well, Utility, Directional and Geotechnical Drilling for additional information.

- Pressure washing must be conducted in a designated area (such as a permanent or temporary wash pad) provided with some means of capturing the washwater, and stormwater run-on prevention. Permanent wash pads must drain to the wastewater system through an approved pretreatment device. See BMP S165: Cover the Activity with an Anchored Tarp or Plastic Sheet and BMP S166: Pave the Activity Area and Slope to a Sump, Holding Tank, or Oil/Water Separator for information on sumps (or holding tanks) and run-on prevention

2.1.3 BMP S110: Cleaning or Washing of Cooking Equipment

2.1.3.1 Applicability

This activity applies to businesses that clean cooking equipment such as grills, vent filters, exhaust hoods, grease traps, floors and floor mats.

Pollutants of concern consist of pH, oil and grease, nutrients, suspended solids, and biochemical oxygen demand (BOD).

2.1.3.2 Required BMPs

- Clean and wash cooking equipment indoors whenever possible.
- If washing cannot occur indoors, washing must take place on a designated wash pad.
- All washwater shall be discharged to the wastewater system.
  - Washwater may be used in a closed loop recycle system before ultimate disposal in the wastewater system.
  - Washwater can be temporarily stored before it is ultimately discharged to the wastewater system.
- Washwater shall not discharge to the stormwater system.
- Remove and properly dispose of greasy buildup on cooking equipment prior to washing.
- Install grease protection if required. See tacoma.gov/government/departments/environmental-services/wastewater/fog-fats-oils-and-grease/

2.1.3.3 Recommended Additional BMPs

- Discharge greasy washwater to the building's grease interceptor if one is available.
- If washing must take place outdoors, provide a cover over the designated wash pad.

2.1.4 BMP S111: Cleaning Building Structures and Related Equipment

2.1.4.1 Applicability

This activity applies to the washing of buildings, roofs, cooling towers, structures, sidewalks, and parking lots with low or high pressure water. This also includes removing graffiti.

Pollutants generated include heavy metals, pH, suspended solids, grit, paint chips, PCBs, and biochemical oxygen demand (BOD).

Between 1950 and 1980, PCBs were added to a range of building materials used on the exterior of industrial, commercial, government, and larger residential buildings to increase the material's longevity. Without proper precautions, PCBs from paint, caulk and other joint materials, sealants, roofing, and other items can be released into the environment and enter stormwater conveyances during building washing activities. Recent guidance for characterizing and abating PCBs in building materials recommends against washing PCB-containing materials on a building's exterior, and provides more detailed guidance on specific stormwater BMPs to apply when PCB-containing materials are or are assumed to be present.

2.1.4.2 Required BMPs

The preferred approach is to cover/contain the cleaning activity in order to separate uncontaminated stormwater from washwater sources and convey the washwater to the wastewater system. Washwater that is discharged to the wastewater system must first be filtered to remove solids. See below for specific information related to specific washing activities.

The Industrial Stormwater General Permit (ISGP) prohibits the discharge of process washwater which would include building structure and related equipment cleaning to groundwater or surface water. Stormwater that commingles with wastewater is considered process wastewater.

Facilities that are not covered under the ISGP that cannot follow the preferred approach of discharging to the wastewater system should contact the City of Tacoma Stormwater Management Program at ECInspections@tacoma.gov for guidance on the best BMP for their scenario. Discharges cannot harm downstream receiving waterbodies or groundwater. Note, the use of sumps, pumps, berms, etc. may be necessary to ensure discharge to the wastewater system.

The discharge of building washdown water to the stormwater system from structures suspected or confirmed to have PCB-containing materials is prohibited. Structures that have PCB-containing materials have special requirements – pressure washing may not be acceptable for those structures. Assess commercial structures (including industrial facilities and multi-story residential structures) constructed or renovated between 1950-1980 for PCB-containing materials consistent with Ecology Publication: How to Find and Address PCBs in Building Materials (https://apps.ecology.wa.gov/publications/summarypages/2204024.html) prior to building washdown. Single-family residential buildings are exempt from PCB assessment. Notify the City of Tacoma Stormwater Management Program at ECInspections@tacoma.gov when PCB-containing materials are or are likely to be present.

The City of Tacoma may require a Special Approved Discharge Permit for certain large or regularly scheduled cleaning projects. Visit https://tacoma.gov/government/departments/environmental-services/wastewater/wastewater-permits-and-manuals/ for additional information.

Washwater that is discharged to the wastewater system must first be filtered to remove solids.

Review Ecology's Publication: Disposal Options and Requirements for Polychlorinated Biphenyl Waste (https://apps.ecology.wa.gov/publications/documents/2404027.pdf) for information on how to properly dispose of PCB-containing materials.

Exterior Building Walls and Windows:

- All washwater that may contain oils, soaps, detergents, paint, or other pollutant shall discharge to the wastewater system.
  - Washwater may be used in a closed loop recycle system before ultimate disposal in the wastewater system.
  - Washwater can be temporarily stored before it is ultimately discharged to the wastewater system.
  - Washwater must be filtered to remove solids before discharge to the wastewater system.
- Washwater shall not discharge to the stormwater system except as follows:
  - Washwater that has no potential to contain oils, soaps, detergents, paint, PCBs, or other pollutants and where washwater is cold water can discharge to the stormwater system. Stormwater inlet protection per BMP C220: Stormwater System Inlet Protection shall be utilized for all inlets that may be impacted during the cleaning activity. This only applies to washing that is not suspected to contain PCBs.

Rooftop Equipment

Rooftop equipment includes but is not limited to exhaust fans and HVAC systems.

- All washwater shall be discharged to the wastewater system.
  - Washwater may be used in a closed loop recycle system before ultimate disposal in the wastewater system.
  - Washwater can be temporarily stored before it is ultimately discharged to the wastewater system.
  - Washwater must be filtered to remove solids before discharge to the wastewater system.
- Washwater shall not discharge to the stormwater system.

Parking Lots

- Because vacuum sweeping of surfaces is required per BMP S103: Preventive Maintenance / Good Housekeeping it is not likely that washing will be necessary on a regular basis. Consider the need to wash before conducting washing.
- Sweep before washing.
- All washwater shall be discharged to the wastewater system.
  - Washwater may be used in a closed loop recycle system before ultimate disposal in the wastewater system.
  - Washwater can be temporarily stored before it is ultimately discharged to the wastewater system.

    - Washwater must be filtered to remove solids before discharge to the wastewater system.
- Washwater shall not discharge to the stormwater system.

Sidewalks

- Sweep before washing.
- All washwater that may contain oils, soaps, detergents, paint, or other pollutant shall discharge to the wastewater system.
    - Washwater may be used in a closed loop recycle system before ultimate disposal in the wastewater system.
    - Washwater can be temporarily stored before it is ultimately discharged to the wastewater system.
    - Washwater must be filtered to remove solids before discharge to the wastewater system.
- Washwater shall not discharge to the stormwater system except as follows:
    - Washwater that has no potential to contain oils, soaps, detergents, paint, or other pollutants and where washwater is cold water can discharge to the stormwater system. Stormwater inlet protection per BMP C220: Stormwater System Inlet Protection shall be utilized for all inlets that may be impacted during the cleaning activity. This only applies to washing that is not suspected to contain PCBs.

Graffiti

- All washwater that may contain oils, soaps, detergents, paint, or other pollutant shall discharge to the wastewater system.
    - Washwater may be used in a closed loop recycle system before ultimate disposal in the wastewater system.
    - Washwater can be temporarily stored before it is ultimately discharged to the wastewater system.
    - Washwater must be filtered to remove solids before discharge to the wastewater system.
- Washwater shall not discharge to the stormwater system.
- Consider removal options that utilize minimal water.

2.1.5 BMP S112: Washing, Pressure Washing and Steam Cleaning of Vehicles

2.1.5.1 Applicability

This activity includes the washing of vehicles, aircraft, vessels/boats and construction vehicles such as backhoes., by low or high pressure water or steam and includes hand washing, scrubbing, sanding, etc. This also includes “charity” car washes at gas stations, religious organizations, and commercial parking lots.

Pollutants of concern from cleaning activities include oil and grease, suspended solids, heavy metals, pH, soluble organics, soaps, and detergents.

2.1.5.2 Required BMPs

General:

The preferred approach is to cover/contain the cleaning activity or conduct the activity inside a building in order to separate uncontaminated stormwater from washwater sources and convey the washwater to the wastewater system. Washwater that is discharged to the wastewater system must first be filtered to remove solids. See below for specific information related to specific washing activities.

The Industrial Stormwater General Permit (ISGP) prohibits the discharge of process washwater which would include building structure and related equipment cleaning to groundwater or surface water. Stormwater that commingles with wastewater is considered process wastewater.

Facilities that are not covered under the ISGP that cannot follow the preferred approach of discharging to the wastewater system should contact the City of Tacoma Stormwater Management Program at ECInspections@tacoma.gov for guidance on the best BMP for their scenario. Discharges cannot harm downstream receiving waterbodies or groundwater. Note, the use of sumps, pumps, berms, etc. may be necessary to ensure discharge to the wastewater system.

- Washwater shall be discharged to the wastewater system unless otherwise noted below.
- Two-step (acid – alkaline) washing is allowed if washwater rinsate is neutralized prior to discharging to the wastewater system.
- Contact City of Tacoma Stormwater Management Program at ECInspections@tacoma.gov for more information.

New and Used Car Dealer Lots:

- All washwater shall be discharged to the wastewater system.
    - Washwater may be used in a closed loop recycle system before ultimate disposal in the wastewater system.
    - Washwater can be temporarily stored before it is ultimately discharged to the wastewater system.
- Washwater shall not discharge to the stormwater system.
- Wash cars on a designated wash pad connected to the wastewater system.
    - Cars may be washed in their parking stalls provided:
        - soaps and detergents are not used,

- only cold water is used,
- stormwater inlets are plugged to ensure no discharge to the stormwater system, and
- all washwater is collected for disposal in the wastewater system.

Events Where Vehicle Washing May Occur:

This section applies to events where vehicles are being displayed and charity car washes.

- Evaluate the need to wash vehicles.
- All washwater shall be discharged to the wastewater system.
  - Washwater may be used in a closed loop recycle system before ultimate disposal in the wastewater system.
  - Washwater can be temporarily stored before it is ultimately discharged to the wastewater system.
- Washwater shall not discharge to the stormwater system.
- Wash vehicles on a designated wash pad connected to the wastewater system.
  - If a designated wash pad is not available, do not conduct washing activities.
  - Consider finding local car wash locations that participate in Charity Car Washes

RV, Truck, Auto Detailing, and Engine Washing Facilities

- All washwater shall be discharged to the wastewater system.
  - Washwater may be used in a closed loop recycle system before ultimate disposal in the wastewater system.
    - Washwater can be temporarily stored before it is ultimately discharged to the wastewater system.
- Washwater shall not discharge to the stormwater system.
- Wash vehicles on a designated wash pad connected to the wastewater system.

Boat Washing Facilities

- All washwater shall be discharged to the wastewater system.
  - Washwater may be used in a closed loop recycle system before ultimate disposal in the wastewater system.
  - Washwater can be temporarily stored before it is ultimately discharged to the wastewater system.
- Washwater shall not discharge to the stormwater system.
- Wash vehicles on a designated wash pad connected to the wastewater system.
- Visit Ecology's Green Boating website for additional information https://ecology.wa.gov/About-us/Get-involved/What-you-can-do/Washington-Waters-ours-to-protect/Clean-green-boating.

Mobile Vehicle Washing

This section applies to mobile vehicle and grocery cart washers conducting business in the City of Tacoma.

- Contact the City of Tacoma at (253) 591-5588 for the most up to date policies regarding mobile vehicle washing.
- All washwater shall be discharged to the wastewater system.
  - Washwater may be used in a closed loop recycle system before ultimate disposal in the wastewater system.
  - Washwater can be temporarily stored before it is ultimately discharged to the wastewater system.
- Washwater shall not discharge to the stormwater system.
- Wash vehicles/shopping carts on a designated wash pad connected to the wastewater system.
  - If a designated wash pad is not available:
    - Use a temporary wash pad, or
    - Wash ensuring the following:
      - soaps and detergents are not used,
      - only cold water is used,
      - stormwater inlets are plugged to ensure no discharge to the stormwater system, and
      - all washwater is collected for disposal in the wastewater system.

2.1.6 BMP S113: Dock Washing

2.1.6.1 Applicability

This BMP applies to all docks. Washing docks (or wharves, piers, floats, and boat ramps) can result in the discharge dirt, bird feces, soaps, and detergents that can be toxic to aquatic life, especially after they take on contaminants while cleaning. The BMPs in this section do not address dry docks, graving docks, or marine railway cleaning operations.

2.1.6.2 Required BMPs

Surface Preparation and Spot Cleaning

- Scoop and collect debris and bird feces.
- Sweep, capture, and dispose of debris from the dock as solid waste. Sweep or vacuum docks to minimize the need for chemical cleaners.
- During cleaning activities, if debris, substances, or wash water could enter receiving waterbodies through drains, temporarily block the drains and collect the water for proper disposal.
- Hose down the area if necessary and collect water as feasible.
- Try spot cleaning with water and a coarse cloth before using soaps or detergents.
- If a cleaner is needed for spot cleaning:
  - Mix it in a bucket and use it to scrub down only the areas that need extra attention.
  - Start with vinegar and baking soda and move to other options as needed. Spot clean using a rag if harsher cleaning products are needed.
  - Avoid or minimize the use of petroleum distillates, chlorinated solvents, and ammoniated cleaning agents.
  - Use degreasers or absorbent material to remove residual grease by hand and do not allow this material to enter surface water.
  - Keep cleaners in sealed containers. Keep cleaner containers closed securely when transporting between the shore and docks.
  - Properly dispose of the dirty bucket water.
- Minimize the scour impact of washwater to any exposed soil at the landward end(s) of the dock or below the dock. Place a tarp over exposed soil, plant vegetation, or put berms to contain eroded soil.

Dock Washing and Disposal

- To the extent practicable, collect any washwater generated from hosing down, pressure washing, or cleaning dock areas, and dispose of it properly.
- The following video, provided courtesy of the Port of Seattle, highlights the methods they have developed to collect wash water generated during dock washing.
- Video: Dock Scrubbing at Port of Seattle (YouTube Link): https://www.youtube.com/watch?v=7RBFdjC3K1Q
- Try pressure washing using light pressure. This uses less water and decreases the need for soap and scrubbing when washing the dock. Avoid using excessive pressure, which may damage the dock or send flakes of paint and other material into the water.

- Do not place any debris and substances resulting from cleaning activities in shoreline areas, riparian areas, or on adjacent land where these substances may erode into waters of the state.
- Where treated wood associated with the structure being washed are present, use non-abrasive methods and tools that, to the maximum extent practicable, minimize removal of the creosote or treated wood fibers when it removes marine growth from creosote or any other treated wood.
- Do not discharge removed marine growth to waters of the state where such marine growth would accumulate on the sea bed.
- Do not discharge emulsifiers, dispersants, solvents, or other toxic deleterious materials to waters of the state.

2.2 BMPs for Loading/Unloading and Storage of Materials

2.2.1 BMP S114: Loading and Unloading Areas for Liquid or Solid Material

2.2.1.1 Applicability

This BMP applies to commercial and industrial facilities that load/unload materials. Loading/ unloading of liquid and solid materials at industrial and commercial facilities is typically conducted at shipping and receiving, outside storage, fueling areas, etc. Materials transferred can include products, raw materials, intermediate products, waste materials, fuels, scrap metals, etc. Leaks and spills of fuels, oils, powders, organics, heavy metals, salts, acids, alkalis, etc. during transfer are potential causes of stormwater contamination. Spills from hydraulic line breaks are a common problem at loading docks.

2.2.1.2 Required BMPs

At All Loading/ Unloading Areas:

- Sweep loading/unloading areas frequently to remove accumulated material. Vacuum sweeping is also an acceptable method of removing accumulated material.
- Place drip pans or other appropriate temporary containment devices at locations where leaks or spills may occur such as hose connections, hose reels, and filler nozzles. Drip pans shall always be used when making and breaking connections (see Figure 6 - 1: Drip Pan). Check loading/unloading equipment such as valves, pumps, flanges, and connections regularly for leaks and repair as needed. Frequent monitoring of drip pans is required to ensure captured materials are not displaced by wind or rainwater.

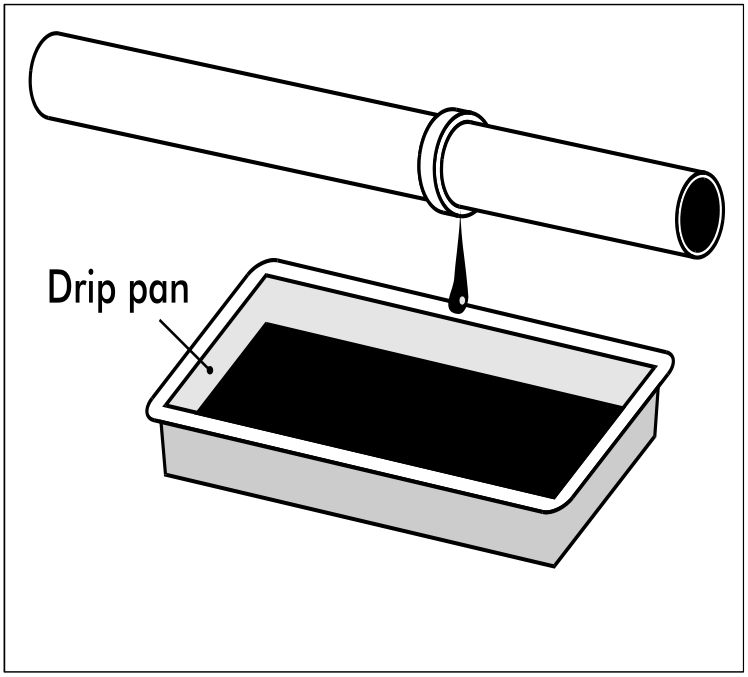

Figure 6 - 1: Drip Pan

- Washing loading/unloading areas must be conducted in such a way that all the runoff is collected for proper disposal. Refer to cleaning and washing BMPs for additional information.
- Conduct unloading or loading of solids and liquids in a manufacturing building or under a roof, lean-to, or other appropriate cover, consistent with Uniform Fire Code requirements and to the extent practicable.
- Berm, dike, and/or slope the loading/unloading area to prevent run-on of stormwater and to prevent the runoff or loss of any spilled material from the area.
- Place curbs along the edge, or slope the edge such that the stormwater can flow to an internal stormwater system that leads to an appropriate, approved treatment BMP. Large loading areas frequently are not curbed along the shoreline. As a result, stormwater passes directly off the paved surface into surface water.
- Pave and slope loading/unloading areas to prevent the pooling of water. The use of catch basins and stormwater lines within the interior of the paved area must be minimized as they will frequently be covered by material, or they shall be placed in designated “alleyways” that are not covered by material, containers, or equipment.

At Tanker Truck and Rail Transfer Areas to Above/Below-ground Storage Tanks:

- Prepare an "Operations Plan" that describes procedures for loading/unloading to minimize the risk of accidental spillage. Train the employees in its execution and post it or otherwise have it readily available to employees.
- Report spills of reportable quantities to the Washington State Department of Ecology. Visit: https://ecology.wa.gov/About-us/Get-involved/Report-an-environmental-issue/Report-a-spill for additional information on how to support spills.
- Prepare and implement an Emergency Spill Cleanup Plan for the facility (BMP S104: Spill Prevention and Cleanup) which includes the following BMPs:
  - Ensure the clean up of liquid/solid spills in the loading/unloading area immediately if a significant spill occurs, upon completion of the loading/unloading activity, or at the end of the working day.
  - Retain and maintain an appropriate oil spill cleanup kit on-site for rapid cleanup of material spills.
  - Ensure that an employee trained in spill containment and cleanup is present during loading/unloading.

At rail transfer areas, install a drip pan system as illustrated (see Figure 6 - 2: Drip Pan Within Rails) within the rails to collect spills/leaks from tank cars and hose connections, hose reels, and filler nozzles.

Loading/Unloading from/to Marine Vessels:

Facilities and procedures for the loading or unloading of petroleum products must comply with Coast Guard requirements.

Transfer of Small Quantities from Tanks and Containers:

Refer to BMP S118: Storage of Liquid, Food Waste or Dangerous Waste Containers for requirements on the transfer of small quantities from tanks and containers, respectively.

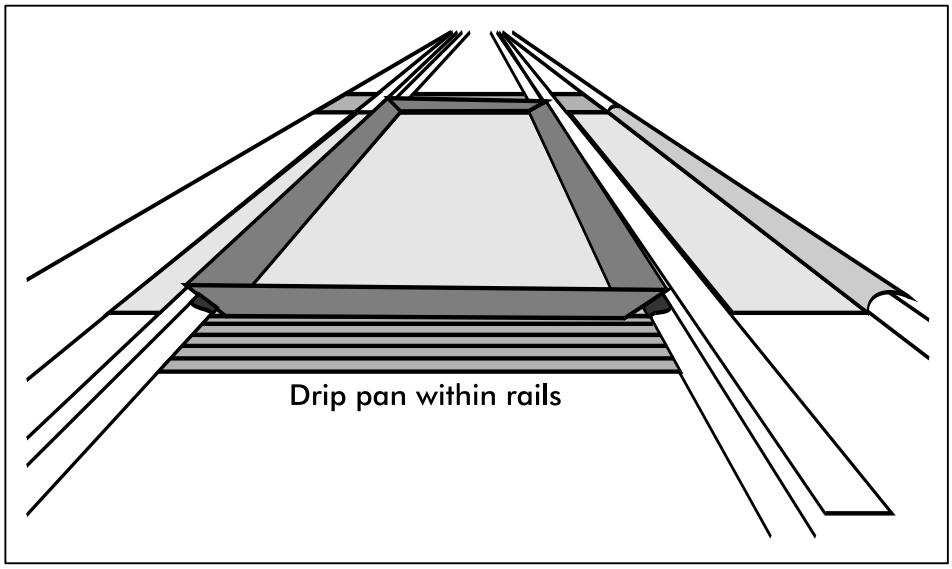

Figure 6 - 2: Drip Pan Within Rails

2.2.1.3 Recommended Additional BMPs

At All Loading/Unloading Areas

- Install an automatic shutoff system in the product transfer lines or other location that will minimize the release of product in the event of unanticipated off-loading interruption (e.g. coupling break, hose rupture, overfill, etc.).

At Loading and Unloading Docks:

- Install/maintain overhangs or door skirts that enclose the trailer end (see Figure 6 - 3: Loading Dock with Door Skirt and Figure 6 - 4: Loading Dock with Overhang) to prevent contact with rainwater.
- Design the loading/unloading area with berms, sloping, etc. to prevent the run-on of stormwater.
- Retain on-site the necessary materials for rapid cleanup of spills.

At Tanker Truck Transfer Areas to Above/Below-Ground Storage Tanks:

- Pave the area on which the transfer takes place. If any transferred liquid, such as gasoline, is reactive with asphalt, pave the area with Portland cement concrete.
- Slope, berm, or dike the transfer area to a dead-end sump, spill containment sump, spill control (SC) oil/water separator, or other spill control device. The minimum spill retention time should be 15 minutes at the highest fuel dispenser nozzle through-put rate or the peak volumetric flowrate using a 10-minute timestep from a Typa 1A, 6-month, 24-hour storm using a single event model over the surface of the containment pad, whichever is greater. The volume of the spill containment sump should be a minimum of 50 gallons with an adequate grit sedimentation volume.

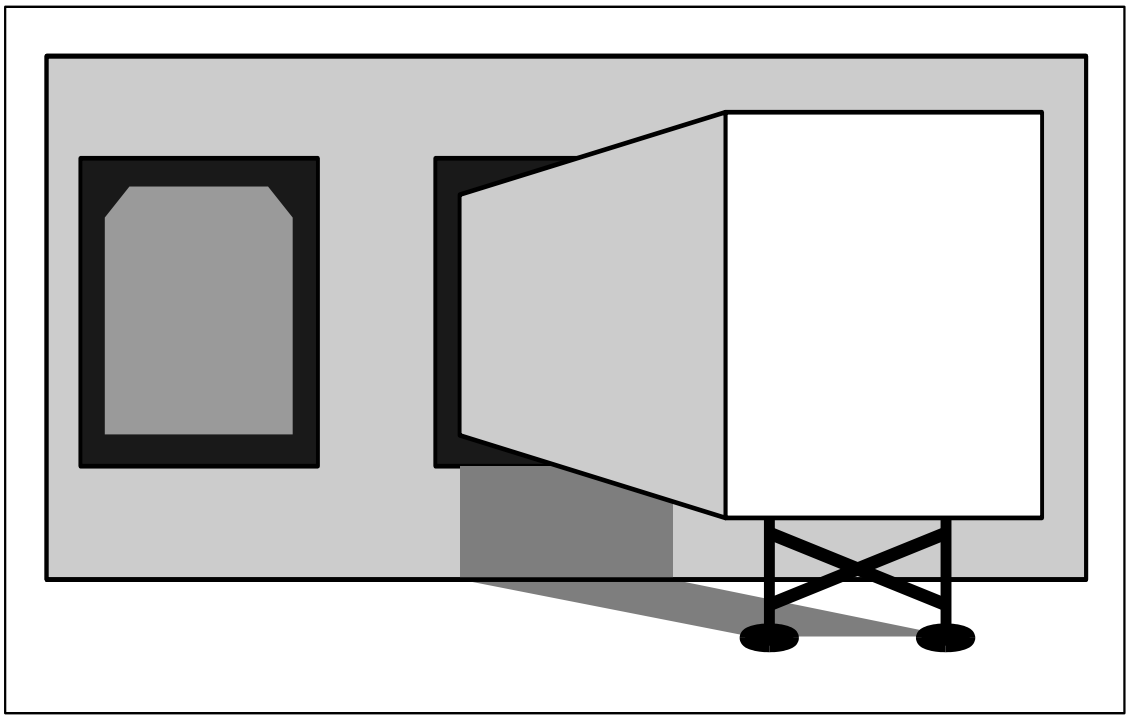

Figure 6 - 3: Loading Dock with Door Skirt

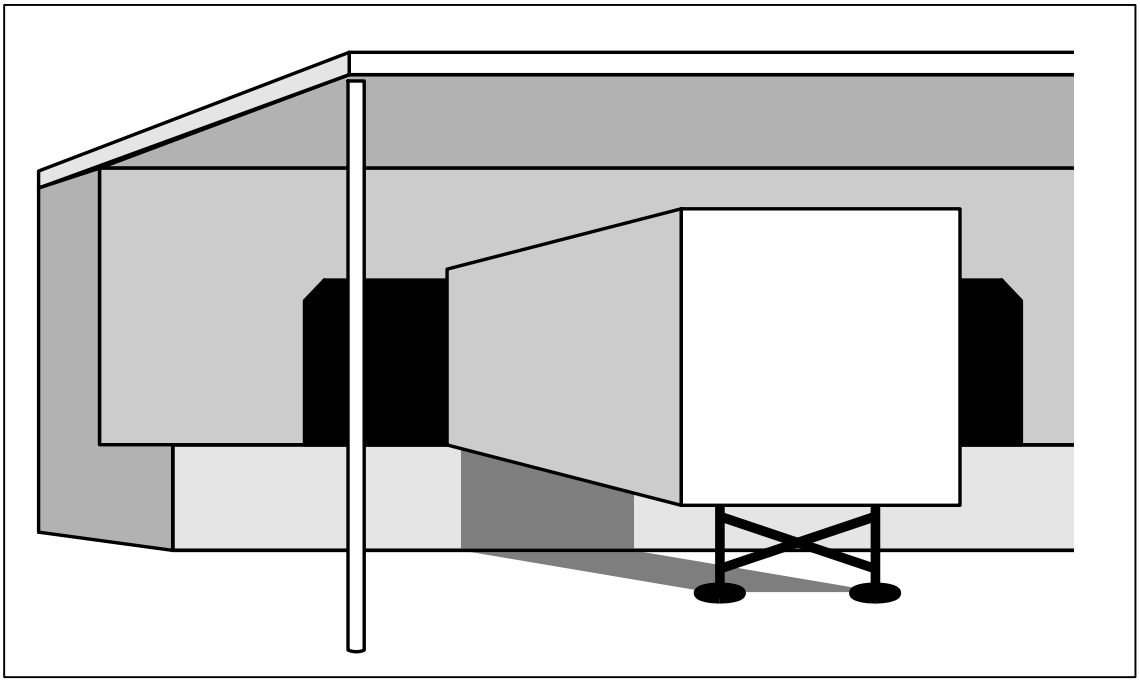

Figure 6 - 4: Loading Dock with Overhang

2.2.2 BMP S115: Storage or Transfer (Outside) of Solid Raw Materials, By-Products or Finished Products

2.2.2.1 Applicability

This BMP applies to properties that store or transfer materials. Solid raw materials, by-products, or products such as gravel, sand, salts, topsoil, compost, logs, sawdust, wood chips, lumber and other building materials, concrete, and metal products are typically stored outside in large piles, stacks, etc. at commercial or industrial establishments. Contact of outside bulk materials with stormwater can cause leachate and/or erosion of the stored materials. Contaminants may include TSS, BOD, organics, and dissolved salts (sodium, calcium, magnesium chloride, etc).

2.2.2.2 Required BMPs

- Do not hose down the contained stockpile area to the street, into a stormwater inlet, or receiving water.
- If the facility will be storing dangerous wastes or contaminated soils additional federal, state, or local permits may be required. Contact the City of Tacoma Stormwater Management Program at ECInspections@tacoma.gov to see if additional measures are necessary for controlling pollution.
- Choose one of the following:
  - Store materials inside a building or on a paved and bermed covered area.
  - Place temporary plastic sheeting (polyethylene, polypropolene, hypalon, or equivalent) over the materials.
  - Place materials on an uncovered paved area designed to prevent stormwater run-on from being contaminated and collect and convey contaminated stormwater to an appropriate treatment facility.

  For large uncovered areas, site perimeter measures may be necessary to ensure stormwater run-on is not contaminated and contaminated stormwater is collected and conveyed to an appropriate treatment facility.

2.2.2.3 Recommended Additional BMPs

- If and when feasible, collect and recycle water-soluble materials (leachates) to the stockpile.
- Stock cleanup materials such as brooms, dustpans, and vacuum sweepers near the storage area.

2.2.3 BMP S116: Storage of Dry Pesticides and Fertilizers

2.2.3.1 Applicability

This BMP applies to sites that store pesticides and fertilizers. Pesticides such as pentachlorophenol, carbamates, and organometallics can be released to the environment as a result of container leaks and outside storage of pesticide-contaminated materials and equipment. Inappropriate management of pesticides or fertilizers can result in stormwater contamination. Runoff contaminated by pesticides and fertilizers can severely degrade streams and lakes and adversely affect fish and other aquatic life.

2.2.3.2 Required BMPs

- Store pesticides and fertilizers in enclosed impervious containment areas to prevent precipitation from contacting the pesticides and fertilizers and to ensure unauthorized personnel do not have access to the pesticides and fertilizers.
- Containers and bags must be covered, intact, and off the ground.
- Store all material so that it cannot come into contact with water.
- Immediately clean up any spilled fertilizer or pesticides.
- Keep pesticide and fertilizer contaminated waste materials in designated covered and contained areas, and dispose of properly.
- Store and maintain spill cleanup materials near the storage area.
- Sweep paved storage areas as needed. Collect and dispose of spilled materials. Do not hose down the area.
- Do not discharge pesticide contaminated stormwater or spills/leaks of pesticides to the stormwater or wastewater system. Contaminated stormwater must be collected and disposed of properly. Unused or spilled/leaked pesticides must be disposed of according to the label.
- Comply with WAC 16-228-1220 and Chapter 16-229 WAC.

2.2.4 BMP S117: Storage of Solid Wastes and Food Wastes

2.2.4.1 Applicability

This activity applies to all properties in the City of Tacoma that store solid waste outdoors, including ordinary garbage.

Pollutants of concern include toxic organic compounds, oils and greases, heavy metals, nutrients, suspended solids, chemical oxygen demand (COD), and biochemical oxygen demand (BOD).

2.2.4.2 Required BMPs

- Per Tacoma Municipal Code 12.09, the collection and disposal of solid waste within the City of Tacoma is compulsory and universal. All occupied properties pay monthly solid waste service rates.
- Call or email Solid Waste Management with any questions regarding Solid Waste Management at (253) 502-2100 or solidwaste@tacoma.gov. Storing certain types of solid waste may require additional permits from the Tacoma Pierce County Health Department or Washington State Department of Ecology.
- All solid and food wastes must be stored in suitable containers. Piling of wastes without any cover is prohibited. Containers are either provided by Solid Waste Management or must be reviewed and approved by Solid Waste Management.
- Per Tacoma Municipal Code 12.09, the collection and disposal of solid waste within the City of Tacoma is compulsory and universal. All occupied properties pay monthly solid waste service rates.
- Trash compactors,dumpsters, and/or any trash containers with a combined solid waste container volume greater than 1 cubic yard, not to include containers designated for recycling or yard waste, that have food or liquid bearing waste (including ordinary garbage) must be placed on a pad with a drain to the wastewater system. Trash compactor hydraulic reservoirs or hoses shall be contained within the perimeter of the drainage pad. To help control the release of sewer gases from area drains in solid waste storage areas during dry weather, it is strongly recommended that the design include a downturned elbow, capped tee (tee oriented horizontally with the cap at the top end), drain trap seal or similar on the pipe outlet in the sump. The size of the pad shall be as small as feasible while still containing the containers and graded such that minimal stormwater enters the wastewater system. Where feasible, covers shall be provided to minimize stormwater contributions.
- Storage containers and compactors must be checked for leaks and broken seals and replaced if they are leaking, corroded, or otherwise deteriorating.
- A minimum of three feet of clearance must be maintained between a trash compactor or dumpster and any other storage containers kept in the storage area or trash enclosure. Alternatively, these storage containers can be kept in separate enclosures.
- Storage containers must have leak-proof lids or be covered by some other means. Lids must be kept closed at all times. Contact Solid Waste Management at (253) 502-2100 if containers are damaged in any way for a replacement container.
- Do not completely fill containers of waste fats, oil and grease. Leave a minimum of four inches of freeboard to prevent spills when the containers are moved or handled for recycling.
- Employees must be trained to frequently check storage containers for leaks and to ensure that the lids are on tightly.

- The waste storage area must be swept or otherwise cleaned frequently to collect all loose solids for proper disposal in a storage container. Do not hose the area to collect or clean solids. All solids must be swept and properly disposed of before hosing area.
- If containers are cleaned, all rinse water from cleaning must be disposed of in a wastewater or septic system.
- Inspect regularly and clean out catch basins on the property that receive water from waste storage area. See BMP S109 Cleaning or Washing of Tools, Equipment, and Machinery for details on catch basin cleaning.
- Store containers such that wind will not be able to knock them over.

2.2.4.3 Recommended Additional BMPs

The following BMPs are not required, but can provide additional pollution protection:

- Upsize the storage container if the amount of waste accumulated appears to frequently exceed the capacity of the storage container.
- Locate drain to the wastewater system at one end or side of the enclosure to ease cleaning the drain.
- In enclosures with drains to the wastewater system, provide an area for washing floor mats.
- Recycle and use the food waste bins as much as possible. See tacoma.gov/solidwaste for information about What Goes Where. The Recycle Coach App is a good source as well.

2.2.5 BMP S118: Storage of Liquid, Food Waste or Dangerous Waste Containers

2.2.5.1 Applicability

This BMP applies to properties that store waste containers. Steel and plastic drums with volumetric capacities of 55 gallons or less are typically used at industrial facilities for storage of liquids and powders. The BMPs specified below apply to container(s) located outside a building used for temporary storage of accumulated food wastes, vegetable or animal grease, used oil, liquid feedstock cleaning chemicals, or Dangerous Wastes (liquid or solid), unless the business is permitted by Ecology to store the wastes. Leaks and spills of pollutant materials during handling and storage are the primary sources of pollutants. Oil and grease, acid/alkali pH, BOD, and metals are potential pollutant constituents.

2.2.5.2 Required BMPs

- Place tight-fitting lids on all containers. Provide adequate freeboard/headspace.
- Label all containers appropriately. Store containers so that the labels are clearly visible.
- Place drip pans beneath all mounted container taps and at all potential drip and spill locations during filling and unloading of containers.
- Inspect container storage areas regularly for corrosion, structural failure, spills, leaks, overfills, and failure of piping systems. Check containers daily for leaks/spills. Replace containers, secure lids, and replace and tighten bungs in drums, as needed.
- Empty drums containing residues should be stored to prevent stormwater from entering the drum closures. Cover or tilt drums to prevent stormwater from accumulating on the top of the empty drums and around drum closures.
- Store containers that do not contain free liquids in a designated sloped area with the containers elevated or otherwise protected from stormwater run-on. Comply with the local fire code.
- Drums stored in an area where unauthorized persons may gain access must be secured in a manner that prevents accidental spillage, pilferage, or any unauthorized use (see Figure 6 - 6: Locking System for Drum Lid).
- If the material is a Dangerous Waste, the business owner must comply with any additional TPCHD or Ecology requirements. Please contact the Department of Ecology at 360-407-6300 and the TPCHD at 253-798-6047 for specific requirements and permitting information
- Storage of reactive, ignitable, or flammable liquids must comply with the strictest local zoning code, local fire code, the Uniform Fire Code (UFC), UFC standards, or the National Electric Code.
- Cover dumpsters or keep them under cover, such as a lean-to, to prevent the entry of stormwater. Replace or repair leaking garbage dumpsters.
- Collect and discharge liquid from dumpsters and/or dumpster pads to the wastewater system. Keep dumpster lids closed. Install waterproof liners.
- Keep containers with Dangerous Waste, food waste or other potential pollutant liquids inside a building unless this is impracticable due to site constraints or Uniform Fire Code requirements.
- Store containers in a designated area that is covered, bermed, or diked; paved; and impervious in order to contain leaks and spills (see Figure 6 - 7: Covered and Bermed

Containment Area). The secondary containment shall be sloped to drain into a dead-end sump for the collection of leaks and small spills.

- For liquid wastes, surround the containers with a dike as illustrated in Figure 6 - 7: Covered and Bermed Containment Area. The dike must be of sufficient height to provide a volume of either 10 percent of the total enclosed container volume or 110 percent of the volume contained in the largest container, whichever is greater, or, if a single container, 110 percent of the volume of that container.
- Where material is temporarily stored in drums, a containment system can be used, as illustrated, in lieu of the above system (see Figure 6 - 5: Secondary Containment Vessel).
- Place containers mounted for direct removal of a liquid chemical for use by employees inside a containment area as described above. Use a drip pan during liquid transfer (see Figure 6 - 8: Mounted Container).
- If a storage area is to be used on-site for less than 30 days, a portable temporary secondary system as shown in Figure 6 - 5: Secondary Containment Vessel can be used.

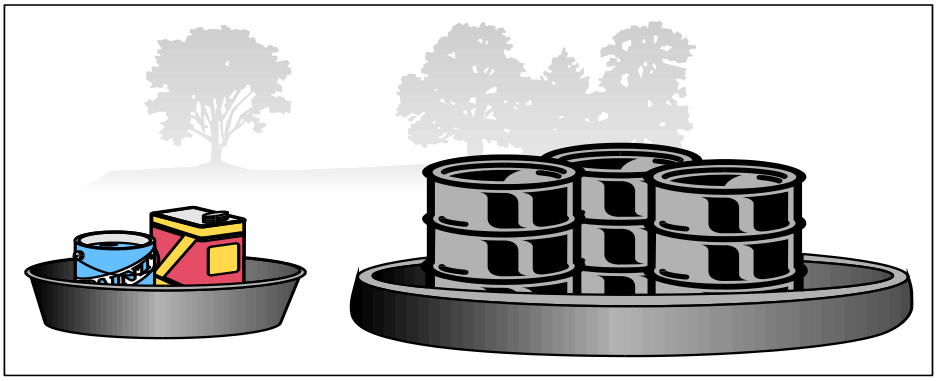

Figure 6 - 5: Secondary Containment Vessel

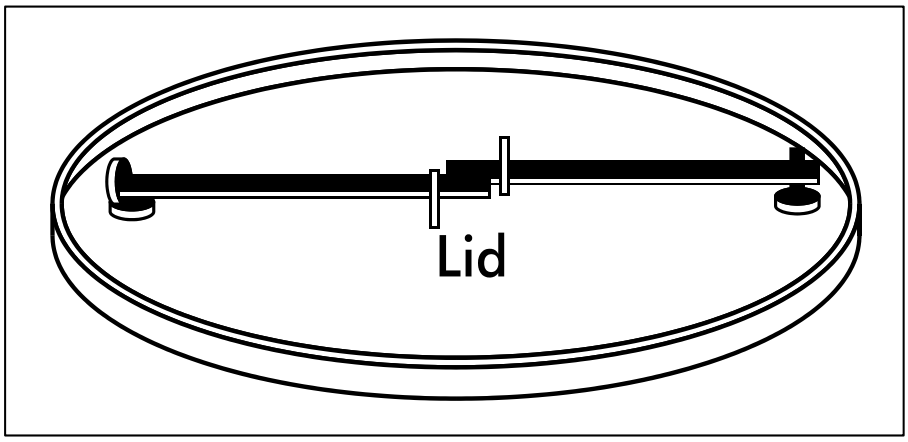

Figure 6 - 6: Locking System for Drum Lid

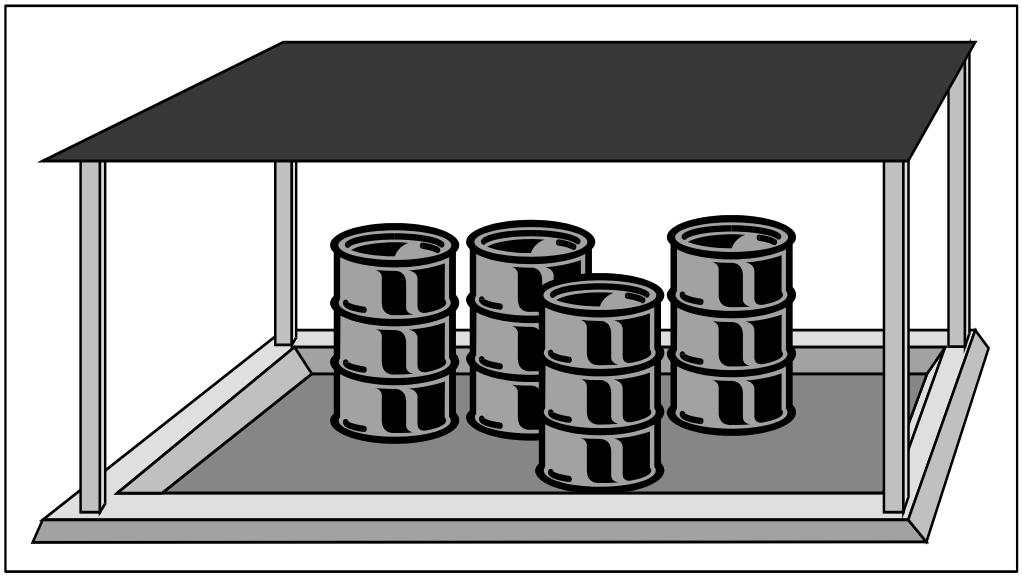

Figure 6 - 7: Covered and Bermed Containment Area

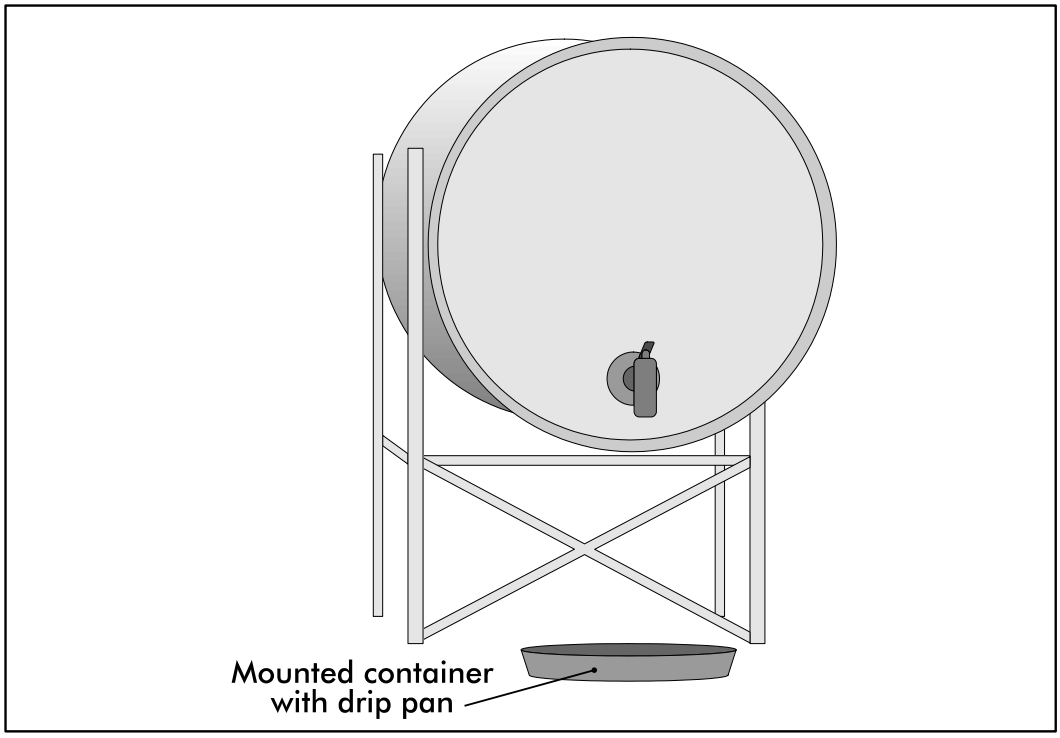

Figure 6 - 8: Mounted Container

2.2.6 BMP S119: Storage of Liquids in Above-Ground Tanks

2.2.6.1 Applicability

This BMP applies to sites that store liquids in above-ground tanks. Above-ground tanks containing liquids (excluding uncontaminated water) may be equipped with a valved drain, vent, pump, and bottom hose connection. These tanks are commonly associated with chemical and petroleum facilities and standby generators (see Figure 6 - 9: Above-Ground Tank Storage and Figure 6 - 10: Standby Generator). These tanks may be heated with steam heat exchangers equipped with steam traps. Leaks and spills can occur at connections and during liquid transfer. Oil and grease, organics, acids, alkalis, and heavy metals in tank water and condensate drainage can also cause stormwater contamination at storage tanks.

2.2.6.2 Required BMPs

- Locate tanks on an impervious surface (Portland cement or equivalent) surrounded by dikes/walls that provide secondary containment, or use double-walled tanks.
- Feed and return lines from double-walled tanks shall be double walled or entirely enclosed within the utility corridor.
- Secondary containment must provide containment volume of either 10% of the total enclosed tank volume or 110% of the volume contained in the largest tank (whichever is greater).
- Slope the secondary containment area to a drain.
    - The drain shall either be connected to the wastewater system or the stormwater system.
        - Secondary containment under cover shall discharge to the wastewater system with appropriate pretreatment if required (see tacoma.gov/government/departments/environmental-services/wastewater/wastewater-permits-and-manuals/ for additional information about the Pretreatment Program).
        - Uncovered secondary containment shall discharge to a sumped outlet equipped with a shutoff valve. The shutoff valve shall be normally closed. Before opening the valve, water shall be evaluated to determine if it is contaminated and if the water should be discharged to a stormwater treatment BMP, to the wastewater system (with appropriate pretreatment) or can be discharged directly into the stormwater system. Evidence of contamination includes visible oil sheen, color, turbidity, and/or pH.
- Inspect the containment area and tanks regularly for evidence of leaks/spills, cracks and corrosion. Replace/repair tanks and/or tank components if they show signs of wear.
- Develop a spill plan per BMP S104: Spill Prevention and Cleanup.
- Place drip pans beneath all mounted taps and drip/spill locations during filling/unloading of tanks. Valved drain tubing may be needed in mounted drip pans.
- Sweep and clean tank storage areas regularly.
- All installations shall comply with local fire codes.

- Protect tanks that might be exposed to traffic with bollards, jersey barriers, or walls. Bollards shall be at least 4 feet high, at least 3 feet from the tank, and no more than 4 feet apart. Paint bollards yellow (or similar) for ease of visibility.
- Include tank overfill protection to minimize risk of spillage during loading.
- Provide at least 5 feet of space between the tanks and any enclosures.
- Tank water and condensate discharge are considered process wastewater that may need a separate NPDES Permit or approval and possible pretreatment before discharging to the wastewater system.
- Loading racks and transfer areas associated with tank farms shall provide spill containment and treatment sized to encompass the largest vessel (trailer, rail car, intermodal tank) using the area.

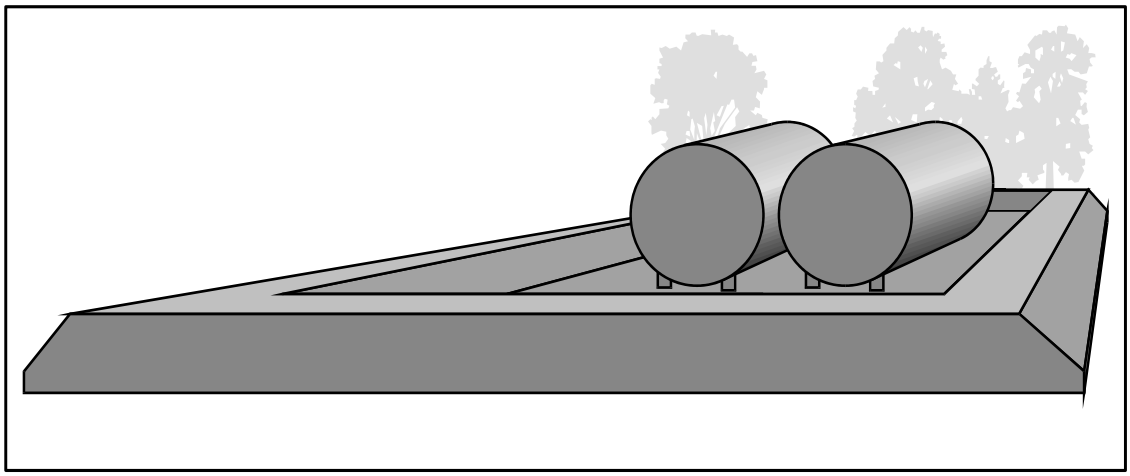

Figure 6 - 9: Above-Ground Tank Storage

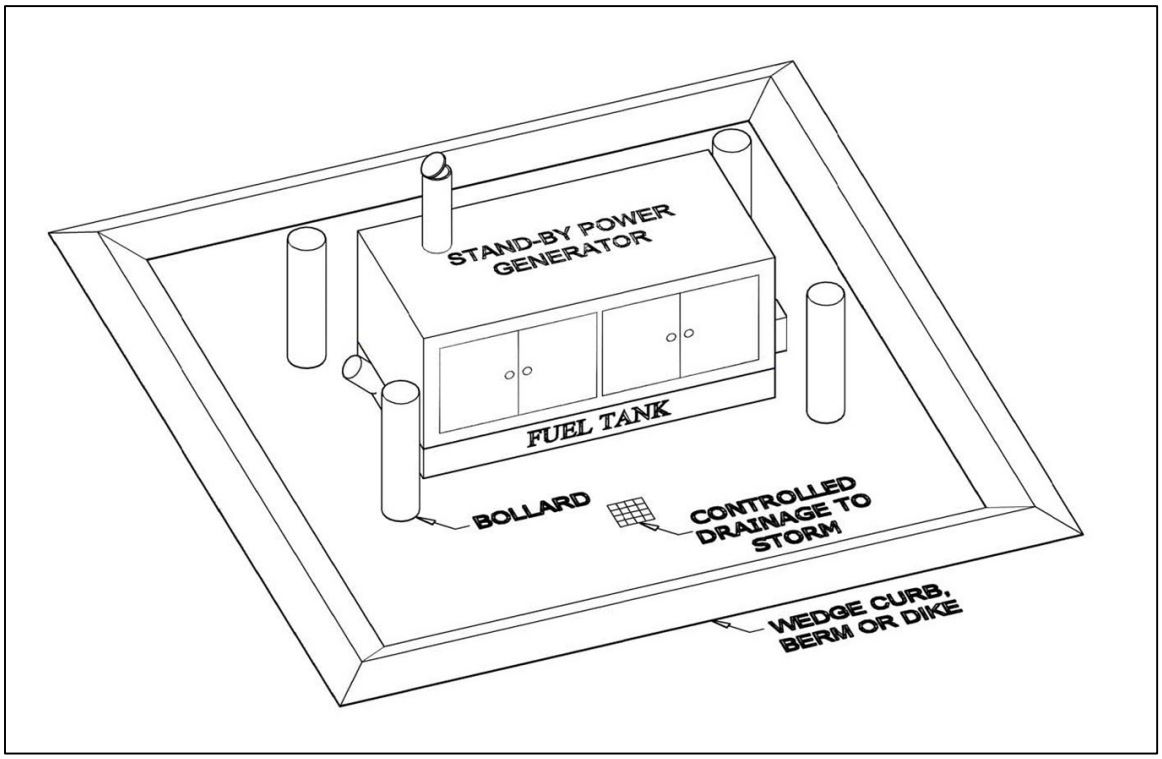

Figure 6 - 10: Standby Generator

2.2.7 BMP S120: Temporary Storage or Processing of Fruits or Vegetables

2.2.7.1 Applicability

This activity applies to businesses that temporarily store fruits and vegetables outdoors prior to or after processing or sale, or that crush, cut, or shred fruits or vegetables for wines, frozen juices, and other food and beverage products. These businesses may include farmers markets, fruit and vegetable stands, and fruit and vegetable processors. Nutrients and soil washing off of fruit and vegetables can have a detrimental effect on receiving waters.

Pollutants of concern include nutrients, suspended solids, biochemical oxygen demand (BOD), and color.

2.2.7.2 Required BMPs

- Educate employees on the benefits of keeping a clean storage area.
- Keep fruits, vegetables, and grains stored outside for longer than a day in plastic bins or in bins lined with plastic. The edge of the plastic liner should be higher than the amount of fruit stored or should drape over the side of the bin.
- Dispose of rotten fruit, vegetables, and grains in a timely manner (typically one week).
- Make sure all outside materials that have the potential to leach or spill to the stormwater system are covered, contained, or moved to an indoor location. For fruits, vegetables, and grains stored outside for a week or more, cover with a tarp or other waterproof material. Make sure covering are secured from wind.
- Minimize the use of water when cleaning produce to avoid excess runoff.
- Sweep or shovel storage and processing areas daily to collect dirt and fruit and vegetable fragments for proper disposal. Keep hosing to a minimum.
- Keep cleanup materials, such as brooms and dustpans, near the storage area.
- If a holding tank is used for storage of wastewater, pump out the contents before the tank is full and dispose of wastewater into wastewater system. Disposal may require a City of Tacoma Pretreatment or Special Approved Discharge Permit - contact Stormwater Management Program at ECInspections@tacoma.gov for additional information.
- Enclose the processing area in a building or shed, or cover the area and slope or berm to prevent run-on. Alternatively provide a designated pad that discharges to the wastewater system.

2.2.7.3 Recommended Additional BMPs

- Cover outdoor storage areas

2.2.8 BMP S121: Parking and Storage for Vehicles and Equipment

2.2.8.1 Applicability

This BMP applies to properties where cars are parked. Parked vehicles at public and commercial parking lots and garages, such as retail stores, fleet vehicle (including rent-a-car lots and car dealerships), equipment sale and rental parking lots, and parking lot driveways, can be sources of toxic hydrocarbons and other organic compounds, oils and greases, metals, and suspended solids.

2.2.8.2 Required BMPs

- If washing of a parking lot is conducted, discharge the washwater to the wastewater system (if allowed by the City of Tacoma) or other approved wastewater treatment system, or collect it for off-site disposal.
- Do not hose down the area to the stormwater system or receiving water. Sweep (vacuum sweeping is preferred) parking lots, storage areas, and driveways regularly to collect dirt, waste, and debris.
- Clean vehicle and equipment leaks and spills immediately.
- Place drip plans below leaking vehicles (including inoperable vehicles and equipment) in a manner that catches leaks or spills, including employee vehicles. Drip pans must be managed to prevent overfilling. Dispose of contents properly.
- New and redevelopment sites may be required to provide stormwater treatment BMPs if thresholds are met. See Minimum Requirement #6: Stormwater Treatment.
- Covered floors of parking garages with drains must drain to the wastewater system through an approved oil/water separator. Uncovered floors must be routed to the stormwater system through an approved treatment device.

2.2.8.3 Recommended Additional BMPs

- Encourage employees to repair leaking personal vehicles.
- Encourage employees to carpool or use public transit.
- Encourage customers to use public transit by rewarding valid transit pass holders with discounts.

2.3 Fueling

2.3.1 BMP S122: Fueling at Dedicated Stations

2.3.1.1 Applicability

This BMP applies to facilities that have onsite fueling areas. A fueling station is a facility dedicated to the transfer of fuels from a stationary pumping station to mobile vehicles or equipment. It includes above or underground fuel storage facilities. In addition to general service gas stations, fueling may also occur at 24-hour convenience stores, construction sites, warehouses, car washes, manufacturing establishments, port facilities, and businesses with fleet vehicles. Typically, stormwater contamination at fueling stations is caused by leaks/spills of fuels, lube oils, radiator coolants, and vehicle washwater.

2.3.1.2 Required BMPs

- Stormwater from fuel islands shall not discharge to the stormwater system.
- Follow the guidance contained in the City of Tacoma Side Sewer and Sanitary Sewer Availability Manual as appropriate. The Side Sewer Manual is available at tacoma.gov/sidesewer and includes guidance for pretreatment and oil water separators when discharging to the wastewater system. This manual includes information for both covered and uncovered fuel islands.
- Prepare an emergency spill response and cleanup plan.
- Train employees on the proper use of fuel dispensers and on the spill plan.
- Have a designated trained person on site or on call at all times to promptly and properly implement the spill plan and cleanup all spills.
- If the fueling station is unattended by a trained person during operating hours, the spill plan must be visible to all customers and untrained employees at the station, and the spill kit must be accessible and fully stocked.
- The person conducting the fuel transfer must be present at the fueling pump during fuel transfer.
- Keep suitable cleanup materials, such as dry absorbent materials, onsite to allow prompt cleanup of a spill.
- Do not use dispersants to clean up spills or sheen unless the dispersants can be removed for appropriate disposal following application. Dispersants cannot be used for on-water spills. Dispersants cannot enter the stormwater or wastewater system.
- Post signs in accordance with the requirements of the Uniform Fire Code or International Fire Code.
- Ensure the automatic shut-off on the fuel nozzle is properly functioning.

2.3.2 BMP S123: Mobile Fueling of Vehicles and Heavy Equipment

2.3.2.1 Applicability

This BMP applies to activities where mobile fueling may occur. This may occur on individual properties or within the ROW. Mobile fueling, also known as fleet fueling, wet fueling, or wet hosing, is the practice of filling fuel tanks of vehicles by tank trucks that are driven to the yards or sites where the vehicles to be fueled are located. Mobile fueling, also known as fleet fueling, wet fueling, or wet hosing, is the practice of filling fuel tanks of vehicles by tank trucks that are driven to the yards or sites where the vehicles to be fueled are located. Mobile fueling is only conducted using diesel fuel, as mobile fueling of gasoline is prohibited. Diesel fuel is considered a Class II Combustible Liquid, whereas gasoline is considered a Flammable Liquid.

Historically mobile fueling has been conducted for off-road vehicles that are operated for extended periods of time in remote areas. This includes construction sites, logging operations, and farms. Mobile fueling of on-road vehicles is also conducted commercially in the State of Washington.

2.3.2.2 Required BMPs

Organizations and individuals conducting mobile fueling operations must implement the following BMPs. The operating procedures for the driver/operator shall be simple, clear, effective and their implementation verified by the organization that will potentially be liable for environmental and third party damage.

- Ensure that all mobile fueling operations are approved and permitted by Tacoma Fire Prevention Bureau and comply with local and Washington State fire codes. Visit tacoma.gov/government/departments/fire/code-inspections-permits/for additional information.
- Fueling locations that are in close proximity to sensitive aquifers, designated wetlands, wetland buffers, or other waters of the State, require approval by the City of Tacoma to ensure compliance with additional local requirements. Ensure compliance with TMC 3.10.
- Ensure compliance with all 49 CFR 178 requirements for all fuel delivery vehicles or containers. Documentation from a Department of Transportation (DOT) Registered Inspector shall be proof of compliance.
- Ensure the presence and the constant observation/monitoring by the driver/operator at the fuel transfer location at all times during fuel transfer and ensure that the following procedures are implemented at the fuel transfer locations:
    - Locate the point of fueling:
        - At least 25 feet from the nearest stormwater inlet, or
        - Inside an impervious containment area with a volumetric holding capacity equal to or greater than 110 percent of the receiving tank volume, or
        - Place an impervious cover over the stormwater inlet to ensure no inflow of spilled or leaked fuel.

      A cover is not needed if there is an approved City of Tacoma (including Tacoma Fire Department) spill control separator. Potential spill/leak conveyance surfaces must be impervious and in good repair

  - Place a drip pan or an absorbent pad under each fueling location prior to and during all dispensing operations. The pan (must be liquid tight) and the absorbent pad must have a capacity of 5 gallons. Spills retained in the drip pan or the pad need not be reported.
  - Handle and operate fuel transfer hoses and nozzle, drip pan(s), and absorbent pads to prevent spills/leaks of fuel from reaching the ground, stormwater system, and receiving waters.
  - Do not extend the fueling hoses across a traffic lane without fluorescent traffic cones, or equivalent devices.
  - Remove the fill nozzle and cease filling when the automatic shut-off valve engages. Do not allow automatic shutoff fueling nozzles to be locked in the open position.
  - Do not “top off” the equipment receiving fuel.
- Provide the driver/operator of the fueling vehicle with:
  - Adequate headlamps, flashlights or other mobile lighting to view fill openings with poor accessibility. Consult with the Tacoma Fire Department for additional lighting requirements.
  - Two-way communication with home base.
- Train the driver/operator annually in spill prevention, reporting and cleanup measures and emergency procedures. Make all employees aware of the significant liability associated with fuel spills.
- The fueling operation procedures shall be properly signed and dated by the responsible manager, distributed to the operators, retained in the organization files, and made available in the event an authorized government agency requests a review.
- Ensure that the Tacoma Fire Department (911) and the Ecology Southwest Regional Office are immediately notified in the event of any spill entering surface or groundwaters, including catch basins. Establish a 24-hour “call down list” to ensure the rapid and proper notification of management and government officials should any amount of product be spilled on-site. Keep the list in a protected but readily accessible location in the mobile fueling truck. The “call down list” shall also pre-identify spill response contractors available in the area to ensure the rapid removal of significant product spillage into the environment.
- Maintain a minimum of the following spill clean-up materials in all fueling vehicles, that are readily available for use:
  - Non-water absorbents (pads, pillows, sump skimmers) capable of absorbing 15 gallons of diesel fuel;
  - A stormwater system inlet plug or cover kit;
  - A non-water absorbent containment boom of a minimum 10 feet in length with a 12-gallon absorbent capacity;
  - A non-metallic shovel; and
  - Two, five-gallon buckets with lids.
  - Loose granular absorbent material capable of absorbing a minimum of 5 gallons of diesel. Use only non-water absorbing materials, such as peat moss, during wet weather conditions.

- Use automatic shutoff nozzles for dispensing the fuel. Replace automatic shut-off nozzles as recommended by the manufacturer.
- Maintain and replace equipment on fueling vehicles, particularly hoses and nozzles, at established intervals to prevent failures.
- Do not overfill tanks. Allow room for heat expansion of fuel during warm weather.
- Include the following fuel transfer site components:
  - Automatic fuel transfer shut-off nozzles; and
  - An adequate lighting system at the filling point.
- Immediately remove and properly dispose of soils with visible surface contamination to prevent the spread of chemicals to groundwater or receiving water.
- Do not use dispersants to clean up spills or sheen unless properly removed of for disposal following application. Dispersants cannot enter the stormwater or wastewater system.

2.3.3 BMP S124: In-Water and Over-Water Fueling

2.3.3.1 Applicability

BMPs in this section apply to businesses and public agencies that operate a facility used for the transfer of fuels from a stationary pumping station to vehicles or equipment in water. This type of fueling station includes aboveground or underground fuel storage facilities, which may be permanent or temporary. Fueling stations include facilities such as, but not limited to, commercial gasoline stations, port facilities, marinas, private fleet fueling stations, and boatyards.

Typically, stormwater contamination at fueling stations is caused by leaks or spills of fuels, lubrication oils, and fuel additives. These materials contain organic compounds, oil and greases, and metals that can be harmful to humans and aquatic life.

Most fuel dock spills are small and result from overfilling boat fuel tanks, burps from air vent lines, and drips from the pump nozzle as it is being returned to the pump.

2.3.3.2 Required BMPs for Fuel Docks

General

- Facilities and procedures for the loading or unloading of petroleum products must comply with U.S. Coast Guard requirements. Refer to specifications in Coast Guard Requirements for Marine Transfer of Petroleum Products.

Training and Fueling Dock Supervision

- Train staff on proper fueling procedures. Document training and maintain records.
- Have a trained employee supervise the fuel dock during fueling activities.
- Do not allow self-service on a marina dock without some means of controlling the dock activity. According to NFPA 30A: Code for Motor Fuel Dispensing Facilities and Repair Garages, each facility must have an attendant on duty to supervise, observe, and "control" the operation when open for business. This can be done via camera, intercom, and shutoff abilities in the office. However, this can lead to complacency and nothing can replace having an attendant on the dock to attend to emergencies when they occur. (NFPA, 2012)

Fueling Dock Setup, Maintenance, and Inspection

- Install a tank and leak detection monitoring system that shuts off the pump and fuel line when a leak is sensed.
- Install personal watercraft floats at fuel docks to stabilize personal watercraft/jet skis while refueling.
- Provide a spill containment equipment storage area where materials are easily accessible and clearly marked.
- Use automatic shut-off nozzles and promote the use of "whistles" and fuel/air separators on air vents or tank stems of inboard fuel tanks to reduce the amount of fuel spilled into receiving waters during fueling of boats.
- Post readable refueling directions, BMPs, and emergency protocols.
- Always have a "Spills Aren't Slick" sign with emergency spill reporting numbers clearly visible. Marinas on land leased from the Washington Department of Natural Resources (DNR) are required to post these signs.

- Display "No Smoking" signs on fuel docks.
- Create a regular inspection, maintenance, and replacement schedule for fuel hoses, pipes, and tanks. Have staff walk the dock fuel lines from dispenser to tank to look for signs of leakage at joints and determine hose condition from end to end.

Fueling Practices

- Discourage operators from "topping off" (no more than 90% capacity). Fuel expands and can slosh out of the vent when temperatures rise or waters become choppy.
- When handing over the nozzle, wrap an absorbent pad around the nozzle end or plug inside the nozzle end to prevent fuel in the nozzle from spilling.
- Have the boat operator place an absorbent pad or suction cup bottle under the vent(s) to capture fuel spurts from the vent.
- Never block open the fuel nozzle trigger and always disable hands-free clips to ensure the boater remains with the nozzle to prevent overfilling. Hands-free clips are not allowed in Washington, per WAC 296-24-33015.
- Always keep the nozzle tip pointing up and hang the nozzle vertically when not in use.
- During fueling operations, visually monitor the liquid level indicator to prevent the tank from being overfilled.
- The maximum amount of product received must not exceed 95 percent capacity of the receiving tank.

Spill cleanup

- See BMP S104: Spill Prevention and Cleanup.
- Manage petroleum-contaminated booms, pads, and absorbents in a designated collection container and properly dispose of these materials. (See BMP S118: Storage of Liquid, Food Waste or Dangerous Waste Containers).
- Ensure customers do not use soaps in the event of a spill. Use oil absorbent booms or pads instead.

2.3.3.3 Required BMPs for Fueling by Portable Container

- Have boats fuel on shore or at a fuel dock rather than transport fuel from an upland facility to the boats. Only use hand-held fueling containers or "jerry cans" when necessary or when on shore or at dock fueling is not practical.
- Always refill portable fuel containers on the pavement or dock to ensure a good electrical ground. While the deck of the boat may seem stable, static electricity can build up and cause a spark.
- On the dock, put an absorbent pad under the container and wrap an absorbent pad around the fuel fill - this can easily be done by putting a hole in the pad.
- Ensure the nozzle stays in contact with the tank opening.
- When transferring fuel from a portable can, use a fuel siphon with a shut-off feature. If a siphon is not available, a nozzle/spout with a shut off is a good alternative.
- Since fueling boats with a portable container can take time, make sure the container is comfortable to carry, hold, and balance.
- Use a high flow funnel. Funnels can help prevent spills by making a larger opening for fueling.

- Place a plug of absorbent pad or paper towel in the nozzle when not in use to capture any extra drops that accumulate.
- Fuel slowly and pour deliberately, and watch the container (especially the nozzle mechanism) for signs of wear.
- Store portable fuel tanks out of direct sunlight and keep in a cool, dry place to minimize condensation.

2.4 Building and Vehicle Maintenance

2.4.1 BMP S125: Vehicle Maintenance Activities

2.4.1.1 Applicability

This activity applies to businesses and public agencies where fuel filters, engine oil, and other fluids such as battery acid, coolants, and transmission and brake fluids are removed and replaced in vehicles and equipment. It also applies to mobile vehicle maintenance operations, such as at construction sites.

Pollutants of concern include toxic hydrocarbons, toxic organic compounds, oils and greases, pH, and heavy metals.

2.4.1.2 Required BMPs

- Inspect all incoming vehicles, parts, and equipment stored temporarily outside, for leaks.
- Conduct all maintenance and repair of vehicles indoors or on a covered containment pad that is sloped to prevent run-on and is connected to the wastewater system.
- If the vehicle staging area is separate from the vehicle maintenance and repair area, convey stormwater from vehicle staging area to the wastewater system. For the vehicle staging area only, if discharge to the wastewater system is not possible or not allowed, discharge stormwater through an oil water separator followed by a basic treatment BMP to the stormwater system.
- Employees must be educated about the need for careful handling of automotive fluids. Employees at businesses or agencies who routinely change or handle these fluids must be trained in spill response and cleanup procedures.
- Remove batteries and liquids from vehicles and equipment in designated areas designed to prevent stormwater contamination. Store cracked batteries in a covered non-leaking secondary containment system. Do not pour any liquids into stormwater inlets.
- Empty fuel and fuel filters before disposal. Ensure no fuel enters stormwater inlets.
- Spill cleanup materials, such as rags and absorbent materials, must always be kept close at hand when changing oil and other fluids. Soiled rags and other cleanup material must be properly disposed of or cleaned and reused.
- Floor drains inside buildings shall connect to the wastewater system, be routed through an appropriately sized oil/water separator, and shall be approved by the City.
- Do not hose down the maintenance/repair area. Instead, sweep the area weekly to collect dirt, and wipe up spills with rags and other absorbent materials.
- A bermed tarp, ground cloth, or drip pans must be used beneath the vehicle or equipment to capture all spills and drips. The collected drips and spills must be recycled or disposed of properly. See BMP S163: Proper Disposal for disposal options.
- Recycle oil, antifreeze, batteries, and air conditioning coolant.
- If engine washing is to be performed, then appropriate pretreatment will be required. Contact the City of Tacoma Stormwater Management Program at ECInspections@tacoma.gov for their requirements.

2.4.1.3 Recommended Additional BMPs

The following BMPs are not required, but can provide additional pollution prevention.

- Drain all fluids from wrecked vehicles and car parts upon arrival. Recover air conditioning gases.
- Use reusable cloth rags to clean up drips and small spills instead of disposables: these can be professionally laundered and reused. Do not attempt to launder these at home or at a coin-op laundry.
- Use absorbent pillows or booms in or around stormwater system inlets and catch basins to absorb oil and fuel.
- Maintain vehicles under cover where possible.

2.4.2 BMP S126: Demolition

2.4.2.1 Applicability

This activity applies to removal of existing buildings or other structures by controlled explosions, wrecking balls, or manual methods, and subsequent clearing of the rubble. The loose debris can contaminate stormwater. Pollutants of concern include toxic organic compounds, (such as PCBs), hazardous wastes (such as asbestos), high PH, heavy metals, , and suspended solids.

PCBs were added to building materials before 1980 (such as caulk and other sealants, joint materials, paint, siding, roofing, and others), and now with age and weathering are at greater risk of being dislodged during demolition and renovation activities. Particles containing PCBs can be washed into the stormwater, contaminating the conveyance system and downstream water bodies, if not properly managed. PCB-containing building materials were more often used in public buildings such as schools, hospitals, universities, fire houses, police stations, government offices, military sites, as well as privately owned commercial and large multi-unit residential buildings. Recently, guidance has been developed for characterizing and abating PCBs in building materials that will undergo demolition or renovation (Ecology, 2024). The user should refer to this document (How to Find Address PCBs in Building Materials available at https://apps.ecology.wa.gov/publications/summarypages/2204024.html) for more details on preventing PCBs from entering stormwater.

Additional regulations regarding PCBs may apply, including but not limited to the federal Toxic Substances Control Act (TSCA). For more information, refer to the U.S. EPA's guidance for PCBs at the following web address: https://www.epa.gov/pcbs

2.4.2.2 Required BMPs

- Follow Ecology's guidance document How to Find and Address PCBs in Building Materials (https://apps.ecology.wa.gov/publications/summarypages/2204024.html) for PCB-containing building materials undergoing demolition or renovation. Handling of PCB-containing materials can be found in Ecology's guidance document: "Disposal Options and Requirements for Polychlorinated Biphenyl Waste".
- Review Ecology’s Publication: Disposal Options and Requirements for Polychlorinated Biphenyl Waste (https://apps.ecology.wa.gov/publications/documents/2404027.pdf) for information on how to properly dispose of PCB-containing materials.
- Educate employees about the need to control site activities to prevent stormwater pollution. Train employees in spill cleanup procedures.
- Identify and properly abandon all utility connections such as wastewater, gas, fuel lines and tanks.
- Identify, remove, and properly dispose of hazardous substances before beginning demolition activities. Remove and properly dispose of any additional hazardous substances found during demolition as soon as they are identified.
- Keep debris containers, dumpsters, and debris piles covered.
- Cover stormwater inlets to prevent dirty stormwater from entering the stormwater system.
    - Place the covers at the beginning of the workday.
    - Collect and properly dispose of the accumulated material before removing the covers at the end of the workday.
    - Use dikes, berms, or other methods to protect overland discharge paths from contaminated stormwater.

    - Clean brushes and tools covered with water-based paints in sinks connected to the wastewater system or in portable containers that are disposed of in the wastewater system.

- Use dust control methods as described in BMP S140: Dust Control at Disturbed Land Areas and Unpaved Roadways and Parking Lots and BMP S141: Dust Control at Manufacturing Sites.
- See City of Tacoma Policy ESD16-1 - Use of Reclaimed Asphalt Pavement Millings and Recycled Concrete Aggregate for information on the use of reclaimed asphalt pavement millings and recycled concrete aggregate. The policy is available at tacoma.gov/stormwatermanual.
- Street gutters, sidewalks, driveways, and other paved surfaces in the immediate area of the demolition must be swept at the end of each work day to collect and properly dispose of loose debris and garbage.
- Sweep areas that show accumulation of materials. Vacuum sweeping is also an acceptable method of removing accumulated material.
- To prevent PCBs in building materials from entering stormwater during the demolition planning/preparation phase (i.e. prior to active demolition), routinely visually survey the areas where PCB-containing building materials are likely to exist to check that they have remained intact. If weathering (e.g. flaking, peeling) becomes noticeably worse as demolition planning continues, consider installing BMPs to prevent runoff containing PCBs from entering the stormwater conveyance system, such as:
    - install catch basin filter inserts
    - dry sweep adjacent hard surfaces
    - prevent washwater or irrigation water from coming into contact with the PCB-containing building materials
    - educate landscaping and maintenance staff about avoiding the use of leaf blowers around the building.

2.4.2.3 Recommended Additional BMPs

The following BMPs are not required, but can provide additional pollution protection:

- If possible, a screen or wall should be constructed to prevent stray building materials and dust from escaping the area during demolition.
- Schedule demolition to take place at a dry time of the year.

2.4.3 BMP S127: Building, Repair, Remodeling and Construction

2.4.3.1 Applicability

This activity refers to activities associated with construction of buildings and other structures, remodeling of existing buildings and houses, and general exterior building repair work. Pollutants of concern include toxic hydrocarbons, hazardous wasters, toxic organics (such as PCBs), suspended solids, heavy metals, pH, oils, and greases.

PCBs were added to building materials before 1980 (such as caulk and other sealants, joint materials, paint, siding, roofing, and others), and now with age and weathering are at greater risk of being dislodged during demolition and renovation activities. Particles containing PCBs can be washed into the stormwater, contaminating the conveyance system and downstream water bodies, if not properly managed. Prior to 1980, PCB-containing building materials were more often used in public buildings such as schools, hospitals, universities, fire houses, police stations, government offices, military sites, as well as privately owned commercial and large multi-unit residential buildings. Recently, guidance has been developed for characterizing and abating PCBs in building materials that will undergo demolition or renovation (Ecology, 2024). The user should refer to this document for more details on preventing PCBs from entering stormwater.

2.4.3.2 Required BMPs

The following BMPs or equivalent measures are required of all businesses engaged in building repair, remodeling, and construction:

- Identify, remove, and properly dispose of hazardous substances from the building or structure before beginning repair or remodeling activities that could expose them to stormwater. Hazardous substances include PCBs, asbestos, lead paint, mercury switches, and electronic waste.
- Follow Ecology's guidance document How to Find and Address PCBs in Building Materials for PCB-containing building materials undergoing demolition or renovation.
- Employees must be educated about the need to control site activities to prevent stormwater pollution, and also must be trained in spill cleanup procedures. This includes training maintenance and landscaping employees working around buidlings with exterior PCB-containing materials.
- Spill cleanup materials, appropriate to the chemicals being used on site, must be available at the work site at all times.
- The work site must be cleaned up at the end of each work day, with materials such as solvents put away indoors or covered and secured so that vandals will not have access to them.
- When removing suspected PCB-containing materials, avoid working in high wind conditions or take extra precautions when working in wind strong enough to move dust and debris. This could include constructing a wind screen of plastic at the edge of the groundcover to keep dust and debris from spreading.
- The area must be swept daily to collect loose litter, paint chips, grit, and dirt. Use a filtered vacuum to collect material that may be hard to sweep such as fine dust or materials on a drop cloth.
- Use a HEPA vacuum below painted walls, caulking seams, windows, doors, downspouts, and any specific exterior features known or suspected of containing PCBs.

- Absolutely no substance can be dumped on pavement, the ground, or in or toward stormwater inlets, curbs, or receiving waterbodies, regardless of its content, unless it is only clean water.
- Place drop cloths, where space and access permits, before beginning wood treating activities. Use drip pans in areas where drips are likely to occur if the area cannot be protected with a drop cloth.
- Bermed ground or drop cloths must be used underneath scraping and sandblasting work. Ground cloths, buckets, or tubs must also be used anywhere that work materials are laid down.
- Cover stormwater inlets to prevent dirty stormwater from entering the stormwater system.
  - Place the covers at the beginning of the workday.
  - Collect and properly dispose of the accumulated material before removing the covers at the end of the workday.
  - Use dikes, berms, or other methods to protect overland discharge paths from contaminated stormwater.
- Tools and brushes covered with non-water-based finishes or other materials must be cleaned in a manner that enables collection of used solvents for recycling or proper disposal. See BMP S102: Formation of a Pollution Prevention Team for disposal options.
- Clean brushes and tools covered with water-based paints in sinks connected to the wastewater system or in portable containers that are disposed of in the wastewater system.
- Clean all tools and brushes in a manner such that any material from the cleaning operation can be collected for proper disposal.
- Use dust control methods as described in BMP S140: Dust Control at Disturbed Land Areas and Unpaved Roadways and Parking Lots and BMP S141: Dust Control at Manufacturing Sites.
- Prevent PCB-containing dust and solids from entering stormwater and stormwater conveyances.
- Notify the City of Tacoma Stormwater Management Program at ECInspections@tacoma.gov when PCB-containing materials are, or are likely to be present. They may be able to prioritize street sweeping and/or stormwater system cleaning in the area.
- Review Ecology's Publication: Disposal Options and Requirements for Polychlorinated Biphenyl Waste (https://apps.ecology.wa.gov/publications/documents/2404027.pdf) for information on how to properly dispose of PCB-containing materials.

2.4.3.3 Recommended Additional BMPs

The following BMPs are not required, but can provide additional pollution protection:

- Recycle materials whenever possible.
- Perform work in dry weather when possible. If work must take place in wet weather, provide cover for activities when possible.
- Use tools and work methods that generate the least dust and heat. Consider using manual tools as they generate less fine dust and heat.

2.4.4 BMP S128: Roofs and Building Drains

2.4.4.1 Applicability

This BMP applies to roofs and their associated gutters and downspouts. This BMP applies to commercial (including multi-family such as apartment buildings) and industrial buildings and roofed structures. Stormwater runoff from roofs and sides of manufacturing and commercial buildings can be sources of pollutants caused by leaching of roofing materials, paints, caulking, building vents, and other air emission sources. Vapors and entrained liquid and solid droplets/ particles have been identified as potential pollutants in roof/building runoff. Metals, solvents, acidic/alkaline pH, BOD, PCBs, and organics are some of the pollutant constituents identified.

Ecology has also researched the characterization and abatement of PCBs in building materials before demolition or renovation (Ecology, 2024). The user should refer to that guidance document for more details on preventing PCBs from entering stormwater from buildings that have, or likely have, PCB-containing materials on roofs and building exteriors like siding, joint materials (caulk), paint, and other potential sources.

2.4.4.2 Required BMPs

- Bare galvanized metal shall not be used for materials that convey stormwater, such as roofs, canopies, siding, gutters, downspouts, roof drains, and pipes. See Volume 5 - Stormwater Conveyance Design and Protection for acceptable pipe types. Any galvanized materials shall have an inert, non-leachable finish, such as a baked enamel, fluorocarbon paint (such as Kynar® or Hylar®), factory-applied epoxy, pure aluminum, or asphalt coating. Acrylic paint, polyester paint, field-applied, and part zinc (such as Galvalume®) coatings are not acceptable. Review the Washington State Department of Ecology Publication: Suggested Practices to Reduce Zinc Concentrations in Industrial Stormwater Discharges (Ecology, 2008)
- If leachates and/or emissions from buildings are suspected sources of stormwater pollutants, sample and analyze the stormwater from the building to determine the pollutants of concern. Use the information to help determine the most appropriate BMP.
- If PCBs in external building materials are suspected, assess the building materials and report findings consistent with the guidance in How to Find and Address PCBs in Building Materials (https://apps.ecology.wa.gov/publications/summarypages/2204024.html).
- If a roof/building stormwater pollutant source is identified, implement appropriate source control measures such as air pollution control equipment, selection of materials, operational changes, material recycle, process changes, removal/abatement, etc.
- Sweep the area routinely to remove any residual pollutants.
- Review Ecology's Publication: Disposal Options and Requirements for Polychlorinated Biphenyl Waste (https://apps.ecology.wa.gov/publications/documents/2404027.pdf) for information on how to properly dispose of PCB-containing materials.
- Treat stormwater from roofs to the appropriate level. Metals Treatment BMPs as described in Volume 4, Section 1.1.2.3 can be used. Some facilities regulated by the Industrial Stormwater General Permit, or the City of Tacoma, may have requirements that cannot be achieved with Metals Treatment BMPs. In these cases, additional treatment measures may be required. A treatment method for meeting stringent requirements such as Chitosan-Enhanced Sand Filtration may be appropriate.

2.4.5 BMP S129: Roof Vents

2.4.5.1 Applicability

This activity applies to processes that vent emissions to the roof and/or the accumulation of pollutants on roofs. Processes of special concern are stone cutting, metal grinding, spray painting, paint stripping, galvanizing and electroplating. Pollutants from these processes may build up on roofs and may pollute stormwater from roofs.

2.4.5.2 Required BMPs

- Identify processes that are vented and may contribute pollutants to the roof. Pollutants of concern include and are not limited to:
  - Metal dust
  - Grease from food preparation
  - Solvents
  - Hydrocarbons
  - Fines
  - Stone dust
- Look for chemical deposition around vents, pipes, and other surfaces.
- Install and maintain appropriate source control measures such as air pollution control equipment (filters, scrubbers, and other treatment). (City of San José Environmental Services, 2004)
  - Check that your scrubber solution is appropriate for the chemistry of the fumes.
  - Install vent covers and drip pans where there are none.
  - Prevent leaks in pipe fittings and containment vessels with routine maintenance.
- Consider instituting operational or process changes to reduce pollution.
- If proper installation and maintenance of air pollution control equipment does not prevent pollutant fallout on your roof, additional treatment of the roof runoff may be necessary.
  - Install/provide appropriate devices for roof runoff before it is discharged off site. This may include stormwater treatment BMPs or structural stormwater treatment systems.
- Maintain air filters and pollution control equipment on a regular basis to ensure they are working properly. (The smell of odors from outside the building indicates that the pollution control equipment may need maintenance or evaluation.)
- When cleaning accumulated emissions from roof tops, collect the washwater and loose materials using a sump pump, wet vacuum or similar device. Discharge the collected runoff to the wastewater system after approval by the City of Tacoma - Environmental Services, or have a waste disposal company remove it. A Special Approved Discharge Permit may be required - visit tacoma.gov/government/departments/environmental-services/wastewater/wastewater-permits-and-manuals/ for additional information.

2.5 Manufacturing, Painting, and Concrete Production

2.5.1 BMP S130: Manufacturing Operations – Outside

2.5.1.1 Applicability

This BMP applies to any property where manufacturing operations take place outside, have taken place outside, or where operations inside may affect outside areas. Manufacturing pollutant sources include outside process areas, stack emissions, and areas where manufacturing activity has taken place in the past and significant pollutant materials remain and are exposed to stormwater.

2.5.1.2 Required BMPs

- Sweep paved areas regularly, as needed, to prevent contamination of stormwater. Vacuum sweeping is preferred.
- Alter the activity by eliminating or minimizing the contamination of stormwater.
- Enclose the activity. If possible, enclose the manufacturing activity in a building.
- Cover the activity and connect floor drains to the wastewater system, if approved by the City of Tacoma. See BMP S164: Cover the Activity with a Roof or Awning. Berm or slope the floor as needed to prevent discharge of pollutants to outside areas.
- Isolate and segregate pollutants, as feasible. Convey the segregated pollutants to a wastewater system, process treatment, or dead-end sump, depending on available methods and applicable permit requirements.

2.5.2 BMP S131: Manufacturing and Post-Processing of Metal Products

2.5.2.1 Applicability

This activity applies to businesses such as mills, foundries, and fabricators that manufacture or post-process metal products. A variety of activities such as machining, grinding, soldering, cutting, welding, quenching, cooling, and rinsing may take place. These businesses may be required to obtain a National Pollutant Discharge Elimination System (NPDES) permit from the Department of Ecology or an Industrial Wastewater Discharge Permit from the City of Tacoma.

- Contact the Washington State Department of Ecology at 360-407-7541 for questions related to NPDES Industrial Stormwater Permitting.
- Contact the City of Tacoma Stormwater Management Program at ECInspections@tacoma.gov to determine if a City of Tacoma Industrial Wastewater Discharge Permit is necessary.

Note: Painting, finishing and coating of metal products is covered under BMP S132: Painting, Finishing and Coating of Vehicles, Boats, Buildings and Equipment.

Pollutants of concern include toxic organic compounds, heavy metals, oils and greases, pH, suspended solids, and biological oxygen demand (BOD).

2.5.2.2 Required BMPs

The following BMPs or equivalent measures are required of all businesses engaged in metals manufacturing or post-processing:

- Eliminate illicit connections to the stormwater system. See BMP S100: Correcting Illicit Discharges to the Stormwater System for detailed information on identifying and eliminating illicit connections.
- Process wastewater (including contact cooling water, filter backwash, cooling tower blowdown, and stormwater from activity areas must discharge to the wastewater system.
- The activity area must be swept at the end of each work day to collect and dispose of metal fragments and product residues properly. See BMP S163: Proper Disposal for disposal alternatives.

2.5.2.3 Recommended Additional BMPs

The following BMPs are not required but can provide additional pollution protection:

- Limit the amount of water used in quenching and rinsing. Recycle used water where possible.
- Cover the activity area to prevent rain from contacting the process and reduce the amount of contaminated stormwater.
- Use a catch basin filter or screen basket insert to capture stray metal particles.
- Implement a program to track purchase and consumption of lubricants, solvents, and additives. Check with operating managers for an explanation if consumption increases. Recommend actions if significant equipment leaks or spills are identified.
- Utilize any additional BMPs which are applicable for materials storage and maintenance activities in your shop.

2.5.3 BMP S132: Painting, Finishing and Coating of Vehicles, Boats, Buildings and Equipment

2.5.3.1 Applicability

This BMP applies activities that involve painting, finishing, and coating of vehicles, boats, buildings, and equipment. Surface preparation and the application of paints, finishes, and/or coatings to vehicles, boats, buildings, and/or equipment outdoors can be sources of pollutants. Potential pollutants include organic compounds, oils and greases, heavy metals, and suspended solids.

2.5.3.2 Required BMPs

- Train employees in the careful application of paints, finishes, and coatings to reduce misuse and over spray. Use ground or drop cloths or temporary berms underneath outdoor painting, scraping, sandblasting work, and properly clean and temporarily store collected debris daily.
- Do not conduct spraying, blasting, or sanding activities over open water or where wind may blow paint into water.
- Wipe up spills with rags and other absorbent materials immediately. Do not hose down the area to the street, the stormwater system, or into receiving waterbodies.
- On dock areas, sweep or vacuum rather than hose down debris. Collect any hose water generated and convey to appropriate treatment and disposal.
- Use stormwater inlet protection if dust, grit, washwater, or other pollutants may escape the work area and enter a stormwater inlet. The containment device(s) must be in place at the beginning of the workday. Collect contaminated runoff and solids and properly dispose of such wastes before removing the containment device(s) at the end of the workday.
- Use a ground cloth, pail, drum, drip pan, tarpaulin, or other protective device (e.g. plastic wading pool) for activities such as paint mixing and tool cleaning outside or where spills can contaminate stormwater.
- Properly dispose of all wastes and prevent all uncontrolled releases to the air, ground, or water.
- Clean brushes and tools covered with water-based paints in sinks connected to the wastewater system. Do not dump pollutants collected in portable containers into the street, ditch, stormwater inlet, or receiving waterbody.
- Clean brushes and tools covered with non-water-based paints, finishes, or other materials in a manner that allows collection of used solvents (e.g., paint thinner, turpentine, xylol, etc.) for recycling or proper disposal.
- Store toxic materials under cover (tarp, etc.) during precipitation events and when not in use to prevent contact with stormwater.
- Enclose and/or contain all work while using a spray gun or conducting sand blasting and in compliance with applicable air pollution control, OSHA, and WISHA requirements. Do not conduct outside spraying, grit blasting, or sanding activities during windy conditions which render containment ineffective.

2.5.3.3 Recommended Additional BMPs

- Recycle paint, paint thinner, solvents, pressure washer water, and any other recyclable materials.

- Use efficient spray equipment such as electrostatic, air-atomized, high volume/low pressure, or gravity feed spray equipment.
- Purchase recycled paints, paint thinner, solvents, and other products if feasible.

2.5.4 BMP S133: Concrete and Asphalt Mixing and Production at Stationary Sites

2.5.4.1 Applicability

This activity applies to businesses and agencies that mix raw materials onsite to produce concrete or asphalt. It also applies to subsequent uses such as pouring concrete structures and making other concrete or asphalt products. Requirements for stockpiling of raw materials are covered under BMP S115: Storage or Transfer (Outside) of Solid Raw Materials, By-Products or Finished Products.

Pollutants of concern include toxic hydrocarbons, toxic organic compounds, oils and greases, heavy metals, and pH.

2.5.4.2 Required BMPs

The following BMPs or equivalent measures are required of sites active in concrete and asphalt mixing and production:

- Eliminate all illicit connections to the stormwater system. See BMP S100: Correcting Illicit Discharges to the Stormwater System for a detailed discussion on identifying and eliminating these connections.
- All process water from production, pouring, and equipment cleaning must be discharged to a dead-end sump, a process water treatment system, connected to the wastewater system, or recycled. Never wash fresh concrete or concrete mixer washout into streets, stormwater systems, streams, or other water bodies.
- Production and pouring areas must be protected from stormwater run-on. See BMP S167: Surround the Activity Area with a Curb, Dike, or Berm or Elevate the Activity for methods of run-on protection.
- Cover the production area for prevention of stormwater run-on. See BMP S164: Cover the Activity with a Roof or Awning and BMP S167: Surround the Activity Area with a Curb, Dike, or Berm or Elevate the Activity for information on covers and run-on prevention.
- Use absorbent materials or catch basin filters in and around stormwater system inlets and catch basins to filter out contaminants.
- Contact the Washington State Department of Ecology at 360-407-6400 to determine if an NPDES Sand and Gravel General Permit is required for your site.
- Sweep areas that show accumulation of materials. Vacuum sweeping is also an acceptable method of removing accumulated material.

2.5.4.3 Recommended Additional BMPs

The following BMPs are not required, but can provide additional pollution protection:

- The production and pouring area should be swept at the end of each work day to collect loose chunks of aggregate and raw materials for recycling or proper disposal. See BMP S102: Formation of a Pollution Prevention Team for disposal options.
- Asphalt plants should use an oil/water separator to treat stormwater. See Volume 4 - Best Management Practices Library, for more information.
- Pave the mixing, production, and pouring areas. A sump drain in these areas is probably not advisable due to potential clogging problems, but could be used in a curing area. Sweep these areas to remove loose aggregate and recycle or dispose of properly.

2.6 Streets, Parking Lots, and Utility

2.6.1 BMP S134: De-Icing and Anti-Icing Operations

2.6.1.1 Applicability

This BMP applies to any property or ROW that uses de-icers or anti-icers. Deicing and/or anti-icing compounds are used on highways, streets, and sidewalks to control ice and snow. Typically ethylene glycol and propylene glycol are deicers used on aircraft. Deicers commonly used on highways, streets and sidewalks include calcium magnesium acetate (CMA), calcium chloride, magnesium chloride, sodium chloride, urea, and potassium acetate. The deicing and anti-icing compounds become pollutants when they are conveyed to the stormwater system or receiving waterbodies after application. Leaks and spills of these chemicals can also occur during their handling and storage.

2.6.1.2 Required BMPs

- Select de-icers and anti-icers that cause the least adverse environmental impact. Apply only as needed using minimum quantities. Consider the Pacific Northwest Snowfighters Qualified Product List when selecting roadway de-icers and anti-icers.
- Where feasible and practicable, use roadway deicers, such as calcium magnesium acetate, potassium acetate, or similar materials that cause less adverse environmental impact than urea and sodium chloride.
- Store and transfer de/anti-icing materials on an impervious containment pad in accordance with BMP S115: Storage or Transfer (Outside) of Solid Raw Materials, By-Products or Finished Products.
- Sweep/clean up accumulated de/anti-icing materials and grit from roads as soon as possible after the road surface clears.

2.6.1.3 Recommended Additional BMPs

- Intensify roadway cleaning in early spring to help remove particulates from road surfaces.
- Include limits on toxic metals in the specifications for de/anti-icers.
- Additional guidance can be found in the Regional Road Maintenance - Endangered Species Act (ESA) program guidelines.
- State guidelines contain additional information for de-icing activities at airports.

2.6.2 BMP S135: Streets

2.6.2.1 Applicability

This BMP applies to the general and enhanced maintenance of all streets. Streets are a source of many contaminates including lawn clippings, sediment, vehicle liquids, tire wear residue, heavy metals, animal wastes, lawn chemicals, paint, and combustion by-products. See BMP L633: Permeable Pavements for additional requirements that may be specific to maintaining permeable surfaces.

2.6.2.2 Required BMPs

- Conduct efficient street sweeping to minimize the contamination of stormwater. Do not wash contaminants from street into stormwater inlets or into receiving waters. Properly dispose of all street sweeping material.
- If washing must be conducted, sweep streets first to remove larger particles. Ensure dirty water does not enter the stormwater system or receiving waterbody.
- Use drip pans or absorbents wherever concrete, asphalt, asphalt emulsion, paint product, and drips are likely to spill, such as beneath discharge locations from equipment.
- Cover and contain nearby stormwater inlets to keep runoff from entering the stormwater system.
- Collect and contain all solids, slurry, and rinse water. Do not allow these to enter gutters, stormwater inlets, or conveyance ditches or onto the paved surface of a roadway or driveway.
- Designate an area onsite for washing hand tools and collect that water for disposal.
- Do not use diesel fuel for cleaning or prepping asphalt tools and equipment.
- Store all fuel, paint, and other products on secondary containment.
- Conduct paint striping operations during dry weather.

2.6.2.3 Recommended Additional BMPs

- Conduct sweeping at optimal frequencies. Optimal frequencies are those scheduled sweeping intervals that produce the most cost-effective annual reduction of pollutants normally found in stormwater and can vary depending on land use, traffic volume, and rainfall patterns.
- Train operators in those factors that result in optimal pollutant removal. These factors include sweeper speed, brush adjustment and rotation rate, sweeping pattern, maneuvering around parked vehicles, and interim storage and disposal methods.
- Minimize the amount of water applied for dust control to avoid washing pollutants into the stormwater system.
- Consider the use of periodic parking restrictions and public notification in residential areas to ensure the sweeper’s ability to sweep along the curb.
- Establish procedures for prompt sweeping, removal, and disposal of spill clean-up materials and debris from special events that will generate higher than normal loadings.
- Disposal of street sweeping solids must comply with state solid waste regulations. Additional guidance can be found in the Regional Road Maintenance – Endangered Species Act (ESA) program guidelines.
- Inform citizens about the importance of eliminating yard debris, oil, and other wastes in street gutters in order to reduce street pollutant sources.

- When encountering questionable sweeping waste contact the City of Tacoma Stormwater Management Program at ECInspections@tacoma.gov for guidance.

2.6.3 BMP S136: Utility Corridors (including Power Pole Corridors) and Utility Vaults

2.6.3.1 Applicability

This BMP applies to the construction and maintenance of utility corridors such as pipeline and overhead power corridors and associated facilities. This BMP also applies to the maintenance of utilities including both above and below ground and utility vaults. Utility corridors and vaults may be a source of sediment, oil and grease, BOD, organics, PCBs, pesticides, and heavy metals. Utility vaults can be a source of debris, oils and grease, or other contaminants.

2.6.3.2 Required BMPs

- When water or sediments are removed from utility vaults, determine whether contaminants might be present before disposing of the water and sediments.
  - This includes inspecting for the presence of oil or sheen, and determining from records or testing if the transformers contain PCBs.
  - If records or tests indicate that the sediment or water are contaminated above applicable levels, manage contaminants in accordance with applicable federal and state regulations, including the federal PCB rules (40 CFR 761) and the state MTCA cleanup regulations (Chapter 173-340 WAC).
  - Water removed from the vaults can be discharged in accordance with the federal 40 CFR 761.79, and state regulations (Chapter 173-201A WAC and Chapter 173-200 WAC), or via the wastewater system if the requirements, including applicable permits, for such a discharge are met. Visit tacoma.gov/government/departments/environmental-services/wastewater/wastewater-permits-and-manuals/ for additional information about discharges to the wastewater system.
- Ensure any spills are immediately cleaned
- Minimize the amount of herbicides and other pesticides used to maintain access roads and facilities.
- When removing water or sediments from electric transformer vaults, determine the presence of contaminants before disposing of the water and sediments.
  - This includes inspecting for the presence of oil or sheen, and determining from records or testing if the transformers contain PCBs.
  - If records or tests indicate that the sediments or water are contaminated above applicable levels, manage these media in accordance with applicable federal and state regulations, including the federal PCB rules (40 CFR 761) and the state MTCA cleanup regulations (Chapter 173-340 WAC).
  - Water removed from the vaults can be discharged in accordance with the federal 40 CFR 761.79, and state regulations (Chapter 173-201A WAC and Chapter 173-200 WAC), or to the wastewater system with appropriate pretreatment if necessary.
- Clean all spills immediately.
- Stabilize access roads or areas of bare ground with gravel, crushed rock, or another method to prevent erosion. Use and manage vegetation to minimize bare ground/soils that may be susceptible to erosion.
- Provide maintenance practices to prevent stormwater from accumulating and draining across and/or onto roadways. Convey stormwater through roadside ditches and culverts.

The road should be crowned, outsloped, water barred, or otherwise left in a condition not conducive to erosion. Appropriately maintaining grassy roadside ditches discharging to surface waters is an effective way of removing some pollutants associated with sediments carried by stormwater.

- Maintain ditches and culverts at an appropriate frequency to ensure that plugging and flooding across the roadbed, with resulting overflow erosion, does not occur.
- Apply the appropriate BMPs in this Volume for the storage of waste materials that can contaminate stormwater.

2.6.3.3 Recommended Additional BMPs

- When selecting utility poles for a specific location, consider the potential environmental effects of the pole or poles during storage, handling, and end-use, as well as its cost, safety, efficacy, and expected life. Use wood products treated with chemical preservatives made in accordance with generally accepted industry standards such as the American Wood Preservers Association Standards (see http://www.awpa.com/standards/). Consider alternative materials or technologies if placing poles in or near an environmentally sensitive area, such as a wetland or a drinking water well. Alternative technologies include poles constructed with material(s) other than wood such as fiberglass composites, metal, or concrete. Consider other technologies and materials, such as sleeves or caissons for wood poles, when they are determined to be practicable and available.
- As soon as practicable remove all litter from wire cutting/replacing operations.
- Implement temporary erosion and sediment control in areas cleared of trees and vegetation and during the construction of new roads.

2.6.4 BMP S137: Maintenance of Ditches and Culverts

2.6.4.1 Applicability

This BMP applies to the maintenance of all ditches and culverts that are specifically designed for or that can transport stormwater. Common road debris including litter, eroded soil, oils, vegetative particles, and heavy metals can be sources of stormwater pollutants.

2.6.4.2 Required BMPs

- Inspect roadside ditches and culverts regularly, as needed, to identify sediment accumulations and localized erosion.
- Clean ditches and culverts on a regular basis, as needed. Ditches shall be kept free of rubbish and debris.
- Vegetation in ditches often prevents erosion and cleanses runoff waters. Remove vegetation only when flow is blocked or excess sediments have accumulated. Conduct ditch maintenance (seeding and harvesting) in late spring and/or early fall, where possible. Consider leaving segments of undisturbed vegetation to provide natural filtration.
- In the area between the edge of the pavement and the bottom of the ditch, commonly known as the “bare earth zone,” use grass vegetation, wherever possible. Vegetation shall be established from the edge of the pavement if possible, or at least from the top of the slope of the ditch.
- Diversion ditches on top of cut slopes that are constructed to prevent slope erosion by intercepting stormwater and surface water must be maintained to retain their diversion shape and capability.
- Do not leave ditch cleanings on the roadway surfaces. Promptly sweep dirt and debris remaining on the pavement as needed and at the completion of ditch cleaning operations.
- Roadside ditch cleanings not contaminated by spills or other releases and not associated with a stormwater treatment system such as a bioswale may be screened to remove litter and separated into soil and vegetative matter (leaves, grass, needles, branches, etc.). The soil fraction may be handled as ‘clean soils’ and the vegetative matter can be composted or disposed of in a municipal waste landfill.
- Roadside ditch cleanings contaminated by spills or other releases known or suspected to contain dangerous waste must be handled following the Dangerous Waste Regulations (Chapter 173-303 WAC) unless testing determines it is not dangerous waste. Specific cleanup standards are set forth in the Model Toxics Control Act (Chapter 70.105D RCW) and Regulations (Chapter 173-340 WAC). Disposal shall also comply with the Washington State Department of Ecology Stormwater Management Manual for Western Washington - Appendix IV-B: Management of Street Waste Solids and Liquids.
- Inspect culverts on a regular basis for scour or sedimentation at the inlet and outlet, and repair as necessary. Give priority to those culverts conveying perennial and/or salmon-bearing streams and culverts near streams in areas of high sediment load, such as those near subdivisions during construction.
- Do not apply fertilizers, herbicides, or pesticides in ditches.
- Use temporary erosion and sediment control BMPs or revegetate as necessary to prevent erosion during ditch maintenance.

2.6.4.3 Recommended Additional BMPs

- Install biofiltration swales and filter strips to treat roadside runoff wherever practicable and use engineered topsoils wherever necessary to maintain adequate vegetation. These systems can improve infiltration and stormwater pollutant control upstream of roadside ditches. Refer to Volume 4 - Best Management Practices Library of this manual for additional information about biofiltration swales and filter strips.
- Additional guidance can be found in the Regional Road Maintenance - Endangered Species Act (ESA) program guidelines.

2.6.5 BMP S138: Water Reservoir, Transmission Mainline, Wellhead, and Hydrant Flushing Activities

2.6.5.1 Applicability

This BMP applies to activities that handle operations of water infrastructure. Construction and operation of drinking water infrastructure, as well as emergency response activities, can generate sediments, rust, turbidity and suspended solids, bacteria, and chlorinated water. Flushing of the water delivery system is necessary to maintain drinking water quality and ensure public health. Flushing activities can result in increased flows in downstream conveyances. These high flows may cause flooding and create erosion in downstream channels.

2.6.5.2 Required BMPs

- Remove solids from downstream curbs and gutters before flushing water. Use erosion and sediment control protection.
- Do not over apply dechlorination agents.
- Conduct flushing on dry days when possible.
- Untreated hyperchlorinated water cannot be discharged to the street, stormwater system, or receiving waters. Discharge shall be directed to the wastewater system. A Special Approved Discharge Permit may be required, see tacoma.gov/government/departments/environmental-services/wastewater/wastewater-permits-and-manuals/
- Alternatively, non-emergency discharges of de-chlorinated potable water such as hydrant flushing may go to the stormwater system at prior approved flow rates provided the following limits are met:
  - Chlorine residual 0.1 ppm
  - pH6.5 – 8.5
  - Turbidity 10 NTU

  A Special Approved Discharge Permit may be required. Contact the City of Tacoma - Asset Management at (253) 591-5588 to determine appropriate flowrates for discharge.
- Evaluation of the receiving conveyance system for capacity and/or obstructions may be required.
- A Special Approved Discharge Permit may be required for draining and flushing reservoirs, standpipes, wellheads, and transmission lines. Notification, monitoring, reporting, flow control measures, and other special conditions may apply. Visit tacoma.gov/government/departments/environmental-services/wastewater/wastewater-permits-and-manuals/ for additional information.
- Significant releases of water can have a detrimental effect on the storm and sanitary transmission system as well as receiving waters. Notification of these releases must be promptly made to Environmental Services by calling the 24-hour Operations Center at 253-591-5595.
- Clean impacted Right-of Way and/or stormwater systems to prevent migration of silt and sediments.

2.6.5.3 Recommended Additional BMPs

- During emergency repairs and activities, such as mainline breaks, erosion control measures shall be taken as practicable. Use of sandbags, check dams, plastic sheeting,

pumps, and other erosion control measures should be employed to minimize erosion as much as possible.

- Excavation de-watering should be managed to minimize downstream environmental impacts. Use of vactor trucks, diverting flow to grassy areas, filter bags, and retention ponds should be employed.

2.6.6 BMP S139: Stormwater System Maintenance

2.6.6.1 Applicability

This BMP applies to all properties and ROW that have stormwater systems. Components of the stormwater system include gutters, downspouts, catch basins, stormwater pipes, onsite stormwater management BMPs, stormwater treatment BMPs, and flow control BMPs. Contaminants such as excess sediment, oils, hydrocarbons and sediment can be found in parts of the stormwater system.

2.6.6.2 Required BMPs

- Properly maintain all portions of the stormwater system.
- Conduct maintenance activities in a way that does not negatively affect the downstream stormwater system. Utilize Temporary Erosion and Sediment Control BMPs as necessary.
- Maintain Onsite Stormwater Management BMPs, Stormwater Treatment BMPs, and Flow Control BMPs per the onsite Operation and Maintenance Manual. If an O&M Manual does not exist, create one per the operation and maintenance procedures in Volume 4.
- Inspect and clean treatment BMPs, conveyance systems, and catch basins as needed, and determine necessary O&M improvements.
- Promptly repair any deterioration threatening the structural integrity of stormwater facilities. These include replacement of clean-out gates, catch basin lids, and rock in emergency spillways.
- Regularly remove debris and sludge from BMPs and properly dispose per BMP S162: Well, Utility, Directional and Geotechnical Drilling.
- Clean catch basins when the depth of deposits reaches 60 percent of the sump depth as measured from the bottom of basin to the invert of the lowest pipe into or out of the basin. However, in no case should there be less than six inches clearance from the debris surface to the invert of the lowest pipe. Some catch basins (for example, WSDOT's Catch Basin Type 1L (WSDOT, 2011)) may have as little as 12 inches sediment storage below the invert. These catch basins need frequent inspection and cleaning to prevent scouring. Where these catch basins are part of a stormwater collection and treatment system, the system owner/operator may choose to concentrate maintenance efforts on downstream control devices as part of a systems approach.
- Properly dispose of all solids, polluted material, and stagnant water collected through system cleaning. Do not decant water back into the stormwater system from eductor trucks or vacuum equipment since there may be residual contaminants in the cleaning equipment. Do not jet material downstream into the public stormwater system.
- Remove woody debris from the catch basin as frequently as needed to ensure proper operation of the catch basin.
- Post warning signs; "Dump No Waste - Drains to Groundwater," "Streams," "Lakes," or emboss on or adjacent to all stormwater system inlets where possible.
- Dispose of sediment and liquids from catch basins at a decant facility. Disposal shall also comply with the Washington State Department of Ecology Stormwater Management Manual for Western Washington - Appendix IV-B: Management of Street Waste Solids and Liquids.

2.7 Dust and Erosion Control

2.7.1 BMP S140: Dust Control at Disturbed Land Areas and Unpaved Roadways and Parking Lots

2.7.1.1 Applicability

This BMP applies to all properties and ROW with disturbed land areas, unpaved driving surfaces, and parking lots that may create dust. Dust can cause air and water pollution problems particularly at demolition sites, disturbed land areas, and unpaved roadways and parking lots.

2.7.1.2 Required BMPs

- Sprinkle or wet down soil or dust with water as long as it does not result in runoff or a wastewater discharge. Minimize the amount of water to avoid washing pollutants into the stormwater system. At active construction sites, street sweeping shall be performed prior to washing the street.
- Use only local and/or state government approved dust suppressant chemicals such as those listed in Ecology Publication #96-433, “Techniques for Dust Prevention and Suppression.”
- Avoid excessive and repeated applications of dust suppressant chemicals. Time the application of dust suppressants to avoid or minimize their wash-off by rainfall or human activity such as irrigation.
- Use stormwater containment to prevent the conveyance of solids and sediment into the stormwater system or receiving waters.
- The use of motor oil or other oils for dust control is prohibited. Care shall be taken when using lignin derivatives and other high BOD chemicals in excavations or areas easily accessible to surface water or groundwater.
- Consult with the Ecology Southwest Regional Office at 360-407-6300 on discharge permit requirements if the dust suppression process results in a wastewater discharge to the ground, groundwater, stormwater system, or surface water.
- Contact the Puget Sound Clean Air Agency to see if additional permits are required and to obtain information about additional BMPs for dust control. Visit: pscleanair.gov for additional information.
- Protect stormwater inlets during application of dust suppressants.
- Install inlet protection in stormwater inlets to collect sediment and debris. Maintain inlet protection regularly to prevent clogging.

2.7.1.3 Recommended Additional BMPs for Roadways and Other Trafficked Areas

- Consider limiting use of off-road recreational vehicles on dust generating land.
- Consider paving unpaved permanent roads, approaches, exits, access lanes, and other trafficked areas at municipal, commercial, and industrial areas.
- Consider paving or stabilizing shoulders of paved roads with gravel, vegetation, or City of Tacoma approved chemicals.
- Encourage use of alternate paved routes, if available.
- Vacuum or wet sweep fine dirt and skid control materials from paved roads soon after winter weather ends or as needed.

- Consider using traction sand that is pre-washed to reduce dust emissions.

2.7.1.4 Recommended Additional BMPs for Dust Generating Areas

- Prepare a dust control plan. Helpful references include Control of Open Fugitive Dust Sources (Cowherd et al., 1988) and Fugitive Dust Background Document and Technical Information Document for Best Available Control Measures (EPA-450/2-92-004).
- Limit exposure of soil (dust source) as much as feasible.
- Stabilize dust-generating soil by growing and maintaining vegetation, mulching, topsoiling, and/or applying stone, sand, or gravel.
- Apply windbreaks in the soil such as trees, board fences, tarp curtains, bales of hay, etc.
- Cover dust-generating piles with wind-impervious fabric, or equivalent material.

Additional information on dust control can be found in Volume 3 - Construction Site Stormwater Best Management Practices of this manual.

2.7.2 BMP S141: Dust Control at Manufacturing Sites

2.7.2.1 Applicability

This BMP applies to properties where product manufacturing or other processes may create dust. Industrial material handling activities can generate considerable amounts of dust that is typically removed using exhaust systems. This can generate air emissions that can contaminate stormwater. Dusts can be generated at cement and concrete product mixing facilities, foundries, and wherever powdered materials are handled. Particulate materials that are of concern to air pollution control agencies include grain dust, sawdust, coal, gravel, crushed rock, cement, and boiler fly ash. The objective of this BMP is to reduce the stormwater pollutants caused by dust generation and control.

2.7.2.2 Required BMPs

- Clean building roofs, powder material handling equipment, and vehicles that can be sources of stormwater pollutants as needed to remove accumulated dust and residue.
- Regularly sweep dust accumulation areas that can contaminate stormwater. Sweeping shall be conducted using vacuum filter equipment to minimize dust generation and to ensure optimal dust removal.
- Minimize the amount of water used for dust control to avoid washing pollutants into the stormwater system.
- Contact the Puget Sound Clean Air Agency to see if additional permits are required and to obtain information about additional BMPs for dust control. Visit: pscleanair.gov for additional information.
- Use dust filtration/collection systems such as bag house filters, cyclone separators, etc. to control vented dust emissions that could contaminate stormwater. Monitor rooftops for possible accumulation of material and take appropriate measures to ensure material cannot enter the stormwater system.
- Maintain dust collection devices on a regular basis.

2.7.2.3 Recommended Additional BMPs

- In manufacturing operations, train employees to carefully handle powders to prevent generation of dust.
- Use approved dust suppressants such as those listed in Methods for Dust Control (Ecology, 2016b). Some products cannot be used in close proximity to receiving waters. Ensure only appropriate products are used.
- Use stormwater treatment BMPs as necessary. Refer to Volume 4 - Best Management Practices Library.

2.7.3 BMP S142: Soil Erosion and Sediment Control at Commercial and Industrial Sites

2.7.3.1 Applicability

This BMP applies to properties whose operations may cause erosion. Industrial activities on soil areas, exposed and disturbed soils, steep grades, etc. can be sources of sediments that can contaminate stormwater.

2.7.3.2 Required BMPs

- Limit the exposure of erodible soil.
- Stabilize entrances/exits to prevent track-out.
- Stabilize or cover erodible soil to prevent erosion. Cover practice options include:
  - Use vegetative cover such as grass, trees, shrubs, or erodible soil areas.
  - Cover exposed areas with mats such as clear plastic, jute, or synthetic fiber. See BMP C122: Nets and Blankets and BMP C123: Plastic Covering.
  - Preserve natural vegetation including grass, trees, shrubs, and vines when possible. See BMP C101: Preserving Natural Vegetation.
- If stabilizing or covering the erodible soil is not possible, then structural controls must be implemented which might include:
  - Vegetated swales
  - BMP C200: Interceptor Dike and Swale
  - BMP C233: Silt Fence
  - BMP C207: Check Dams
  - BMP C232: Gravel Filter Berm
  - Sedimentation Basin
  - Proper Grading
  - Paving

2.8 Vegetation Maintenance

2.8.1 BMP S143: Landscaping and Lawn/Vegetation Management

2.8.1.1 Applicability

This BMP applies to all properties and areas of the ROW that have landscaping and/or lawn areas. Landscaping can include grading, soil transfer, vegetation removal, pesticide and fertilizer application, and watering. Stormwater contaminants include toxic organic compounds, heavy metals, oils, total suspended solids, coliform bacteria, fertilizers, and pesticides.

Lawn and vegetation management can include control of objectionable weeds, insects, mold, bacteria, and other pests with chemical pesticides and is conducted commercially at commercial, industrial, and residential sites. Examples include weed control on golf course lawns, access roads, and utility corridors and during landscaping; sap stain and insect control on lumber and logs; rooftop moss removal; killing nuisance rodents; fungicide application to patio decks; and residential lawn/plant care. Toxic pesticides such as pentachlorophenol, carbamates, and organometallics can be released to the environment by leaching and dripping from treated parts, container leaks, product misuse, and outside storage of pesticide contaminated materials and equipment. Poor management of the vegetation, poor application of pesticides or fertilizers, and non-targeted irrigation water or overwatering can cause appreciable stormwater contamination.

2.8.1.2 Required BMPs

- Install engineered soil/landscape systems to improve the infiltration and regulation of stormwater in landscaped areas. Apply BMP L613: Post-Construction Soil Quality and Depth BMPs as required per Minimum Requirement #5: Onsite Stormwater Management.
- Do not dispose of collected vegetation into wetlands, waterways or the stormwater system.
- Select the right plants for the planting location based on proposed use, available maintenance, soil conditions, sun exposure, water availability, height, site factors, and space available.
- Ensure that plants selected for planting are not on the noxious weed list. The Washington State Noxious Weed List can be found at: https://www.nwcb.wa.gov/printable-noxious-weed-list
- Do not blow vegetation or other debris into the stormwater system.
- Dispose of collected vegetation such as grass clippings, leaves, and sticks by composting or recycling.
- Use manual and/or mechanical methods of vegetation removal (pincer-type weeding tools, flame weeders, or hot water weeders as appropriate) rather than applying herbicides, where practical.
- Use at least an 8" topsoil layer with at least 8% organic matter to provide a sufficient vegetation-growing medium.
    - Organic material is at the least water-soluble form of nutrients that can be added to the soil. Composted organic matter generally releases only between 2 and 10 percent of its total nitrogen annually, and this release corresponds closely to the plant growth

cycle. Return natural plant debris and mulch to the soil, to continue recycling nutrients indefinitely.

- Select the appropriate turfgrass mixture for the climate and soil type.
  - Certain tall fescues and rye grasses resist insect attack because the symbiotic endophytic fungi found naturally in their tissues repel or kill common leaf and stem-eating lawn insects.
    - The fungus causes no known adverse effects to the host plant or to humans.
    - Tall fescues and rye grasses do not repel root-feeding lawn pests such as Crane Fly larvae.
    - Tall fescues and rye grasses are toxic to ruminants such as cattle and sheep.
  - Endophytic grasses are commercially available; use them in areas such as parks or golf courses where grazing does not occur.
  - Local agricultural or gardening resources such as the Washington State University Extension office can offer advice on which types of grass are best suited to the area and soil type.
- Use the following seeding and planting BMPs, or equivalent BMPs, to obtain information on grass mixtures, temporary and permanent seeding procedures, maintenance of a recently planted area, and fertilizer application rates: BMP C120: Temporary and Permanent Seeding, BMP C121: Mulching, BMP C123: Plastic Covering, and BMP C124: Sodding.
- Adjusting the soil properties of the subject site can assist in selection of desired plant species. Consult a soil restoration specialist for site-specific conditions.

2.8.1.3 Recommended Additional BMPs

- Conduct mulch-mowing whenever practicable.
- Use native plants in landscaping. Native plants do not require extensive fertilizer or pesticide applications. Native plants may also require less water.
- Till a topsoil mix or composted organic material into the soil to create a well-mixed transition layer that encourages deeper root systems and drought-resistant plants.
- Apply an annual topdressing application of 3/8" compost. Amending existing landscapes and turf systems by increasing the percent organic matter and depth of topsoil can:
  - Substantially improve the permeability of the soil.
  - Increase the disease and drought resistance of the vegetation.
  - Reduce the demand for fertilizers and pesticides.
- Disinfect gardening tools after pruning diseased plants to prevent the spread of disease.
- Prune trees and shrubs in a manner appropriate for each species.
- If specific plants have a high mortality rate, assess the cause and replace with another more appropriate species.

- When working around and below mature trees, follow the most current American National Standards Institute (ANSI) ANSI A300 standards and Internationl Society of Arboriculture BMPs to the extent practicable.
- Monitor tree support systems (stakes, guys, etc.).
  - Repair and adjust as needed to provide support and prevent tree damage.
  - Remove tree supports after one growing season or maximum of 1 year.
  - Backfill stake holes after removal.
- When continued, regular pruning (more than one time during the growing season) is required to maintain visual sight lines for safety or clearance along a walk or dive, consider relocating the plant to a more appropriate location.
- Make reasonable attempts to remove and dispose of Class C noxious weeds.
- Reseed bare turf areas until the vegetation fully covers the ground surface.
- Watch for and respond to new occurrences of especially aggressive weeds such as Himalayan blackberry, Japanese knotweed, morning glory, English ivy, and red canary grass to avoid invasion.
- Plant and protect trees.
- Aerate lawns regularly in areas of heavy use where the soil tends to become compacted. Conduct aeration while the grasses in the lawn are growing most vigorously. Remove layers of thatch greater than ¾" deep.
- Set the mowing height at the highest acceptable level and mow at times and intervals designed to minimize stress on the turf. Generally mowing only 1/3 of the grass blade height will prevent stressing turf.
  - Mowing is a stress-creating activity for turfgrass.
  - Grass decreases its productivity when mowed too short and there is less growth of roots and rhizomes. The turf becomes less tolerant of environmental stresses, more disease prone and more reliant on outside means such as pesticides, fertilizers, and irrigation.

2.8.2 BMP S144: Pesticides and Integrated Pest Management

2.8.2.1 Applicability

This BMP applies to any property or ROW that may be required to use pesticides. Pesticides include herbicides, rodenticides, insecticides, and fungicides. Pesticides are used for weed control, insect control, rodent control, and moss removal among other things. Pesticides can be a source of pentachorophenol, carbamates, organometallics, and sediment.

2.8.2.2 Required BMPs

- Train employees on proper application of pesticides and disposal practices.
- Follow manufacturers' application guidelines and label requirements.
- Do not apply pesticides in quantities that exceed the limits on the product's Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) label. Avoid excessive application of chemical.
- Conduct spray applications during weather conditions as specified in the label requirements and applicable local and state regulations. Do not apply during rain or immediately before expected rain (unless the label directs such timing).
- Clean up any spilled pesticides immediately. Do not hose into the street, into a stormwater system or into a receiving waterbody.
- Remove weeds/vegetation in conveyance ditches, stormwater facilities, and other components of the stormwater system by hand or other mechanical means and only use pesticides as a last resort.
- Flag all sensitive areas including wells, creeks, and wetlands prior to spraying.
- Post notices and delineate the spray area prior to the application, as required by the local jurisdiction, or by Ecology.
- Refer to BMP S143: Landscaping and Lawn/Vegetation Management and use pesticides only as a last resort.
- Conduct any pest control activity at the life stage when the pest is most vulnerable. For example, if it is necessary to use a Bacillus thuringiens application to control tent caterpillars, apply it to the material before the caterpillars cocoon or it will be ineffective. Any method used should be site-specific and not used wholesale over a wide area.
- Mix pesticides and clean the application equipment under cover in an area where accidental spills will not enter surface water or groundwater, and will not contaminate the soil.
- The pesticide application equipment must be capable of immediate shutoff in the event of an emergency.
- Implement a pesticide-use plan and include at a minimum:
    - A list of selected pesticides and their specific uses.
    - Brands and formulations of the pesticides.
    - Application methods and quantities to be used.
    - Equipment use and maintenance procedures.
    - Safety, storage, and disposal methods.
    - Monitoring, record keeping, and public notice procedures. All procedures shall conform to the requirements of Chapter 17.21 RCW and Chapter 16-228 WAC.

- Develop and implement an Integrated Pest Management (IPM) program if pests are present. The following steps are adapted from (Daar, 1992).
  - Step One: Correctly identify problem pests and understand their life cycle.
    - Learn more about the pest.
    - Observe it and pay attention to any damage that may be occurring.
    - Learn about the life cycle.
    - Many pests are only a problem during certain seasons, or can only be treated effectively in certain phases of the life cycle.
  - Step Two: Establish tolerance thresholds for pests.
    - Decide on the level of infestation that must be exceeded before treatment needs to be considered. Pest populations under this threshold should be monitored but don't need treatment.
  - Step Three: Monitor to detect and prevent pest problems.
    - Monitor regularly to anticipate and prevent major pest outbreaks.
    - Conduct a visual evaluation of the lawn or landscape's condition. Take a few minutes before mowing to walk around and look for problems.
    - Keep a notebook, record when and where a problem occurs, then monitor for it at about the same time in future years.
    - Specific monitoring techniques can be used in the appropriate season for some potential problem pests, such as European crane fly.
  - Step Four: Modify the maintenance program to promote healthy plants and discourage pests.
    - Review your landscape maintenance practices to see if they can be modified to prevent or reduce the problem.
    - A healthy landscape is resistant to most pest problems. Lawn aeration and overseeding along with proper mowing height, fertilization, and irrigation will help the grass out-compete weeds.
    - Correcting drainage problems and letting soil dry out between waterings in the summer may reduce the number of crane-fly larvae that survive.
  - Step Five: If pests exceed the tolerance thresholds:
    - Consider the most effective management options concurrent with reducing impacts to the environment. This may mean chemical pesticides are the best option in some circumstances.
    - Consider the use of physical, mechanical, or biological controls.
    - Study to determine what products are available and choose a product that is the least toxic and has the least non-target impact.
  - Step Six: Evaluate and record the effectiveness of the control, and modify maintenance practices to support lawn or landscape recovery and prevent recurrence.

- Keep records!
- Note when, where, and what symptoms occurred, or when monitoring revealed a potential pest problem.
- Note what controls were applied and when, and the effectiveness of the control.
- Monitor next year for the same problems.

2.8.2.3 Recommended Additional BMPs

- Choose the least toxic pesticide available that is capable of reducing the infestation to acceptable levels. The pesticide should readily degrade in the environment and/or have properties that strongly bind it to the soil.
- Choose pesticides categorized by EPA as reduced risk. For example, the herbicide imazamox.
- When possible, apply pesticides during the dry season so that the pesticide residue is degraded prior to the next rain event.
- If possible, do not spray pesticides within 100 feet of waterbodies. Spraying pesticides within 100 feet of receiving waterbodies including any portions of the stormwater system that lead to receiving waterbodies may have additional regulatory requirements beyond just following the pesticide product label. Additional requirements may include:
  - Obtaining a permit from the Washington State Department of Ecology - https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Aquatic-pesticide-permits.
  - Obtaining Washington State Department of Agriculture Applicator's License - https://agr.wa.gov/services/licenses-permits-and-certificates/pesticide-license-and-recertification.
  - Using an aquatic labeled pesticide and adjuvant.
- Use manual pest control strategies such as physically scraping moss from rooftops, high-pressure sprayers to remove moss, and rodent traps.
- Consider alternatives to the use of pesticides such as covering or harvesting weeds, substitute vegetative growth, and manual weed control/moss removal.
- Consider the use of soil amendments, such as compost, that are known to control some common diseases in plants, such as Pythium root rot, ashy stem blight, and parasitic nematodes.
- Once a pesticide is applied, evaluate its effectiveness for possible improvement. Records should be kept showing the effectiveness of the pesticides applied.
- Follow the FIFRA label requirements for disposal. If the FIFRA label does not have disposal requirements the rinseate from equipment cleaning and/or triple-rinsing of pesticide containers should be used as product or recycled into product.
- Develop an adaptive management plan and annual evaluation procedure including: (adapted from (Daar, 1992))
  - A review of the effectiveness of pesticide applications.
  - Impact on buffers and sensitive areas, including potable wells. If individual or public potable wells are located in the proximity of commercial pesticide applications, contact the regional Ecology hydrogeologist to determine if additional pesticide application control measures are necessary.

- Public concerns.
- Recent toxicological information on pesticides used/proposed for use.

2.8.2.4 Additional Information

- For more information, refer to the Pesticide Information Center Online (PICOL) Databases at https://picol.cahnrs.wsu.edu/.
- Washington pesticide law requires most businesses that commercially apply pesticides to the property of another to be licensed as a Commercial Applicator from the Washington State Department of Agriculture.

2.8.3 BMP S145: Fertilizer Application

2.8.3.1 Applicability

This BMP applies to any property or portion of the ROW that may use fertilizers are part of vegetation management. Poor application of fertilizers can cause appreciable stormwater contamination. Fertilizers can leach phosphorous, nitrogen, and coliform bacteria. Fertilizers can contribute to algae blooms, increase nutrient concentrations, and deplete oxygen in receiving waters.

2.8.3.2 Required BMPs

- Apply the minimum amount of slow-release fertilizer necessary to achieve successful plant establishment.
- Do not fertilize when the soil is dry or during a drought.
- Never apply fertilizers if it is raining or about to rain.
- Do not apply fertilizers within three days prior to predicted rainfall. The longer the period between fertilizer application and either rainfall or irrigation, the less likely that stormwater will be contaminated by fertilizer.
- Determine the proper fertilizer application for the types of soil and vegetation involved.
- Follow manufacturers' recommendations and label directions.
- Train employees on the proper use and application of fertilizers.
- Keep fertilizer granules off impervious surfaces. Clean up any spills immediately. Do not wash spilled fertilizer into the street, into the stormwater system, or into receiving waterbodies.
- If possible, do not fertilize areas within 100 feet of water bodies including wetlands, ponds, and streams.
- Avoid fertilizer applications in stormwater ditches, stormwater facilities, and other components of the stormwater system.
- In areas that drain to sensitive waterbodies, do not apply fertilizer.
- Use slow release fertilizers such as methylene urea, isobutylidene, or resin coated fertilizers when appropriate, generally in the spring. Use of slow release fertilizers is especially important in areas with sandy or gravelly soils.
- Apply fertilizers in amounts appropriate for the target vegetation and at the time of year that minimizes losses to surface water and groundwater.
- Time the fertilizer application to periods of maximum plant uptake. Ecology generally recommends application in the fall and spring, although Washington State University turf specialists recommend four fertilizer applications per year.
- Do not use turf fertilizers containing phosphorous unless a soil sample analysis taken within the past 36 months indicates the soil of the established lawn is deficient in phosphorus. For more information about restrictions on turf fertilizers containing phosphorus, see the following website: https://agr.wa.gov/departments/pesticides-and-fertilizers/fertilizers/fertilizers-containing-phosphorus

2.8.3.3 Recommended Additional BMPs

- Test soils to determine the correct fertilizer application rates.

- Evaluation of soil nutrient levels through regular testing ensures the best possible efficiency and economy of fertilization.
- Fertilization needs vary by site depending on plant, soil, and climatic conditions.
- Choose organic fertilizers when possible.
- For details on soils testing, contact the local Conservation District, a soils testing professional, or a Washington State University Extension office.

2.8.4 BMP S146: Irrigation

2.8.4.1 Applicability

This BMP applies to any properties or ROW areas that use irrigation. Irrigation consists of discharges from irrigation water lines, landscape irrigation, and lawn or garden watering. Excessive watering can lead to discharges of chlorinated potable water into the stormwater system; it can also cause erosion; and negatively affect plant health. Improper irrigation can encourage pest problems, leach nutrients, and make a lawn completely dependent on artificial watering. Mosquito breeding habitats may form through excessive watering.

2.8.4.2 Required BMPs

- Irrigate with the minimum amount of water needed. Never water at rates that exceed the infiltration rate of the soil.
- Maintain all irrigation systems so that irrigation water is applied evenly and where it is needed.
- Ensure sprinkler systems do not overspray vegetated areas resulting in excess water discharging into the stormwater system.
- Inspect irrigated areas for excess watering. Adjust watering times and schedules to ensure that the appropriate amount of water is being used to minimize runoff. Consider factors such as soil structure, grade, time of year, and type of plant material in determining the proper amounts of water for a specific area.
- Inspect irrigated areas regularly for signs of erosion and / or discharge.
- Place sprinkler systems appropriately so that water is not being sprayed on impervious surfaces instead of vegetation.
- Repair broken or leaking sprinkler nozzles as soon as possible.
- Appropriately irrigate lawns based on the species planted, the available water holding capacity of the soil, and the efficiency of the irrigation system.
    - The depth from which a plant normally extracts water depends on the rooting depth of the plant. Appropriately irrigated lawn grasses normally root in the top 6 to 12 inches of soil; lawns irrigated on a daily basis often root only in the top 1 inch of soil.
- Do not irrigate plants during or immediately after fertilizer application. The longer the period between fertilizer application and irrigation, the less likely that stormwater will be contaminated by fertilizer.
- Do not irrigate plants during or immediately after pesticide application (unless the pesticide label directs such timing).
- Reduce frequency and / or intensity of watering as appropriate for the wet season (October 1 to April 30).
- Place irrigation systems to ensure that plants receive water where they need it. For example, do not place irrigation systems downgradient of plant's root zones on hillsides.

2.8.4.3 Recommended Additional BMPs

- Add a tree bag or slow-release watering device (e.g., bucket with a perforated bottom) for watering newly installed trees when irrigation system is not present.
- Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist.
- Use soaker hoses or spot water with a shower type wand when an irrigation system is not present.

    - Pulse water to enhance soil absorption, when feasible.
    - Pre-moisten soil to break surface tension of dry or hydrophobic soils/mulch, followed by several more passes. With this method, each pass increases soil absorption and allows more water to infiltrate prior to runoff.
- Identify trigger mechanisms for drought-stress (e.g., leaf wilt, leaf senescence, etc.) of different species and water immediately after initial signs of stress appear.
- Water during drought conditions or more often if necessary to maintain plant cover.
- Adjust irrigation frequency / intensity as appropriate after plant establishment.
- Annually inspect irrigation systems to ensure:
    - That there are no blockages of sprayer nozzles.
    - Sprayer nozzles are rotating as appropriate.
    - Sprayer systems are still aligned with the plant locations and root zones.
- Consult with the local water utility, Conservation District, or Cooperative Extension office to help determine optimum irrigation practices.
- Do not use chemigation and fertigation in irrigation systems. This will help avoid over application of pesticides and fertilizers.

2.9 Animal Related

2.9.1 BMP S147: Commercial Animal Handling Areas

2.9.1.1 Applicability

This BMP applies to properties that handle animals as part of their business practice. These may include businesses such as kennels, animal day care services, and veterinarians. Racetracks, kennels, fenced pens, veterinarians, and businesses that provide boarding services for horses, dogs, cats, etc. can generate pollutants from activities such as manure deposits, animal washing, grazing, and any other animal handling activity that could contaminate stormwater. Pollutants can include coliform bacteria, nutrients, total suspended solids, and animal-related pharmaceuticals. Kennels shall be as defined in TMC 17.03.

2.9.1.2 Required BMPs

- Regularly scoop, sweep and clean animal keeping areas to collect and properly dispose of droppings, uneaten food, and other potential stormwater contaminants.
- Do not hose down to the stormwater system or receiving waters those areas that contain potential stormwater contaminants.
- Contaminated water, including washwater, must go to the wastewater system. An animal fur/hair interceptor may be required.
- If animals are kept in unpaved and uncovered areas, the ground must either have vegetative cover or some other type of ground cover, such as mulch.
- If animals are not leashed or in cages, the area where animals are kept must be surrounded by a fence or other devices to prevent animals from moving away from the controlled area where BMPs are used.
- Uncovered outdoor runs shall not be connected to the wastewater system unless approved by the City of Tacoma. Cover outdoor areas when possible.
- Unused pet pharmaceuticals shall not be discharged to the stormwater system or wastewater system. See https://www.tpchd.org/healthy-places/waste-management/secure-medicine-return for additional information on the safe disposal of medicine.
- Where areas need to be disinfected, use an unsaturated mop to spot clean the areas. Do not allow wastewater runoff to enter the stormwater system.
- Do not stockpile animal waste. Store in covered containers that do not allow contact with stormwater.

2.9.2 BMP S148: Goose Waste

2.9.2.1 Applicability

This BMP applies to areas of chronic accumulation of goose waste that may impact the stormwater system. Goose waste deposited near water or in water can contribute nutrients and algae growth. Goose feces may contain pathogens and contribute to the spread of diseases. Swimmers itch (schistosome or cercarial dermatitis) is caused by a parasite that can be spread by goose droppings, but does not mature or reproduce in humans.

2.9.2.2 Required BMPs

- If possible, pick up goose waste using shovels, brooms, rakes, power sweepers, and trash cans. Properly dispose of goose waste in the garbage.
- Do not blow, sweep, or wash goose waste into waterways or the stormwater system.
- Regularly clean goose waste from areas of chronic deposition where deterrence measures are impractical.
- Do not feed wild geese or any other wild animals.
- In recreational areas post signs discouraging the feeding of geese and other wild animals.

2.9.2.3 Recommended Additional BMPs

- Change the habitat from goose friendly to goose resistant. Reduce lawn areas and increase the height of shoreline vegetation (tall grass, shrubs); as geese are reluctant to walk through tall vegetation.
- Create a natural geese barrier. 20 to 100 feet of herbaceous vegetation at least 3 feet in height to discourage geese. A narrow, winding path through the plantings will allow for beach access, while preventing geese from having a direct line of sight through the planted area.
- Make bank slopes steeper than 4:1 to discourage geese by preventing a clear view of the bank top and potential predators or separate the beach from the grass with a few steep steps, which makes the ascent too difficult for most geese.
- Narrow ponds to limit takeoff and landing opportunities.
- Where space is limited use one or two rows of shrub plantings combined with a fence. Fences can be made from woven wire, poultry netting, plastic netting, plastic snow fencing, monofilament line, or electrified wire. Fences should be at least 24 inches tall (3 feet may be better), firmly constructed, and installed to prevent the geese from walking around the ends. Lower openings should be no larger than 4 inches from the ground to prevent goslings from walking under or through the fence.
- Construct a grid of wire or line above the water's surface to prevent geese from flying into a pond that they have been accustomed to using. The grid should be one to two feet above the water surface, but may be taller if humans need access to the area under the grid. There should be no more than five feet of space between grid lines. To prevent geese from walking under the grid install a perimeter fence. Regularly monitor the grid for holes, trapped wildlife, and sagging.
- Canada geese are protected under federal and state law and a hunting license and open season are required to hunt them. Where lethal control of Canada geese is necessary outside of hunting seasons, it should be carried out only after the above nonlethal control techniques have proven unsuccessful and only under permits issued by the U.S. Fish and Wildlife Service. Currently, the only agency permitted for lethal removal is the U.S.

Department of Agriculture's Wildlife Services. Lethal control techniques include legal hunting, shooting out of season by permit, egg destruction by permit, and euthanasia of adults by government officials.

- Scare geese away when they are around. Geese often learn quickly to ignore scare devices that are not a real physical danger. Vary the use, timing, and location of tactics. Take advantage of geese being fearful of new objects. Examples of harassment and scare tactics:
  - Dog patrols: Hire a professional dog handler whose dog is trained for bird management. When directed by a handler, dogs are the method of choice for large open areas and results are often immediate. After an aggressive initial use (several times a day for one or two weeks), geese get tired of being harassed and will use adjacent areas instead.
  - Eyespot Balloons: Large, helium-filled balloons with large eye-like images can be used to deter geese. Tether balloons on a 20 to 40 foot monofilament line attached to a stake or heavy object. Locate balloons where they will not tangle with trees or utility lines.
  - Flags and Streamers: Use simple plastic flags mounted on tall poles or mylar tape to make 6-foot streamers attached to the top of 8 foot long poles. Flags and streamers work best in areas where there is steady wind.
  - Scarecrows: Effective in areas where geese view humans as dangerous predators. For maximum effect, the arms and legs should move in the wind, use bright colors, and large eyes. Large, blow-up toy snakes are reported to work as a type of scarecrow.
  - Noisemakers: Devices that make a loud bang such as propane cannons, blanks, and whistle bombs can scare geese. Making the noise as soon as geese arrive and persistence are the keys to success when using these devices. Consult noise ordinances and other permitting authorities (such as the local police department) before using.
  - Lasers: Relatively low-power, long-wavelength lasers provide an effective means of dispersing geese under low light conditions. The birds view the light as a physical object or predator coming toward them and generally fly away to escape. Never aim lasers in the direction of people, roads, or aircraft.
- Geese's favorite food is new shoots of grass. Low lying grass also allows easy access to the water for protection from predators. Let grass grow to six inches or taller. Stop fertilizing and watering the lawn to reduce the palatability of the lawn.
- Minimize open sight lines for geese to less than 30 feet.
- Plant shrubs or trees along ponds to limit takeoff and landing opportunities.
- Refer to: http://www.humanesociety.org/assets/pdfs/wild_neighbors/canada_goose_guide.pdf and https://wdfw.wa.gov/sites/default/files/2020-10/pacific_northwest_goose_management_aug2017.pdf for additional information.

2.9.3 BMP S149: Pet Waste

2.9.3.1 Applicability

This BMP applies to pet owners, property managers, and environmental stewards. Pets and pet-care can generate pollutants from waste, animal washing, and cage or kennel cleaning. Pet waste that washes into lakes, streams or Puget Sound begins to decay, using up oxygen and releasing ammonia. Low oxygen levels and ammonia combined with warm water can kill fish. Pet waste also contains nutrients that encourage weed and algae growth, and contribute to low oxygen and high pH in waters we use for swimming, boating and fishing. Most importantly, pet waste can carry viruses and bacteria that could cause disease and lead to beach or shellfish harvesting closures.

2.9.3.2 Recommended BMPs for Pet Owners

- Regularly pick up and dispose of pet waste deposited on walks and at home.
- Put pet waste in a securely closed bag and deposit it in the trash. Do not place pet waste in yard waste containers because pet waste may carry diseases, and composting may not kill disease-causing organisms.
- Pet waste is prohibited from being placed in the Brown Yard Waste Bins provided by the City of Tacoma.
- Do not compost or use pet waste as fertilizer. Harmful bacteria, worms, and parasites that can transmit disease can live in the soil for years even after the solid portion of the pet waste has dissolved.
- Do not dispose of unused pet pharmaceuticals in to a stormwater inlet, on the ground, in a toilet, or down a sink. See https://www.tpchd.org/healthy-places/waste-management/secure-medicine-return for information on pharmaceutical disposal.
- When cleaning out cages and kennels, dispose of wash water down the toilet or a mop sink.
- Bathe pets indoors or in a manner that wash water won't be discharged to the stormwater system, the road, ditches, or surface waters.

2.9.3.3 Recommended BMPs for Recreation Areas and Multi-Family Properties

- Post signs at recreation areas and multi-family properties (that allow pets) reminding residents and visitors to pick up after their pets.
- Carefully consider the placement of pet waste stations at recreation sites and near multi-family properties that allow pets. Choose locations convenient for dog walkers to pick up a bag at the start of their walk and locations for them to dispose of it at mid-walk or at the end of their walk.
- Check pet waste stations on a regular basis to keep pet waste bags stocked and disposal stations empty. Consider signage to keep regular trash out of pet waste disposal stations to avoid filling them too quickly. Make sure pet waste disposal stations have a cover to keep out water.
- See BMP S150: Rooftop Dog Runs for properties with rooftop dog areas.

2.9.4 BMP S150: Rooftop Dog Runs

2.9.4.1 Applicability

This BMP applies to properties that provide uncovered rooftop or above ground plaza dog runs as an amenity to properties. Dog runs are typically constructed with artificial turf and other dog-friendly amenities and may include sprinklers to wash down areas.

2.9.4.2 Required BMPs

- Prevent stormwater from the dog run from discharging into the stormwater system.
- Stormwater from the dog run shall discharge to the building wastewater system.
    - A maximum of 200 square feet can discharge to the wastewater system. Areas over 200 square feet shall be covered.

2.10 Other

2.10.1 BMP S151: Log Sorting and Handling

2.10.1.1 Applicability

This BMP applies to businesses that store, sort, and handle logs for production into wood or paper products. Log yards are paved or unpaved areas where logs are transferred, sorted, debarked, cut, and stored to prepare them for shipment or for the production of dimensional lumber, plywood, chips, poles, or other products. Log yards are generally maintained at sawmills, shipping ports, and pulp mills. Typical pollutants include oil and grease, BOD, settleable solids, total suspended solids (including soil), high and low pH, heavy metals, pesticides, wood-based debris, and leachate.

Truck traffic to and from these facilities can track sediment onto roadways. An aggressive sweeping program is recommended to ensure sediment does not reach the storm system.

The following are pollutant sources:

- Log storage, rollout, sorting, scaling, and cutting areas
- Log and liquid loading areas
- Log sprinkling
- Debarking, bark bin, and conveyor areas
- Bark, ash, sawdust and wood debris piles, and other solid wastes
- Metal salvage areas
- Truck, rail, ship, stacker, and loader access areas
- Log trucks, stackers, loaders, forklifts, and other heavy equipment
- Maintenance shops and parking areas
- Cleaning areas for vehicles, parts, and equipment
- Storage and handling areas for hydraulic oils, lubricants, fuels, paints, liquid wastes, and other liquid materials
- Pesticide usage for log preservation and surface protection
- Application of herbicides for weed control
- Contaminated soil resulting from leaks or spills of fluids

2.10.1.2 Washington State Department of Ecology Industrial Permit Requirements

Industries with log yards or areas where logs are sorted or loaded are required to obtain coverage under the Industrial Stormwater General Permit for discharges of stormwater associated with industrial activities. The permit requires preparation and on-site retention of Stormwater Pollution Prevention Plans (SWPPP). The SWPPP must identify operational, source control, erosion and sediment control, and, if necessary, treatment BMPs. Required and recommended operational, source control, and treatment BMPs are presented in detail in Industrial Stormwater General Permit Implementation Manual for Log Yards (Ecology Publication Number 04-10-031, Water Quality Program, Revised December 2016). It is recommended that all log yard facilities obtain a copy of this document.

2.10.2 BMP S152: Wood Treatment Areas

2.10.2.1 Applicability

Wood treatment includes both anti-staining and wood preserving using pressure processes or by dipping or spraying. Wood preservatives and anti-staining chemical additives can include petroleum products, pesticides and heavy metals.

Pollutant sources include drips of condensate or preservative after pressurized treatment, product washwater (in the treatment or storage areas), spills and leaks from process equipment and preservative tanks, fugitive emissions from vapors in the process, blowouts and emergency pressure releases, and kick-back from lumber (phenomenon where preservative leaks as it returns to normal pressure). Potential pollutants typically include the wood treating chemicals, BOD, suspended solids, oil and grease, benzene, toluene, ethylbenzene, phenol, chlorophenols, nitrophenols, heavy metals, and PAH, depending on the chemical additive used.

2.10.2.2 Required BMPs

Wood treatment facilities are required to obtain either an Industrial Stormwater General Permit or a separate individual discharge permit from the Washington State Department of Ecology. These permit may have specific required source control that must be followed.

- Use dedicated equipment for treatment activities to prevent the tracking of treatment chemicals to other areas on the site.
- Eliminate non-process traffic on the drip pad. Scrub down non-dedicated lift trucks on the drip pad.
- Immediately remove, contain, and properly dispose of soils with visible surface contamination (green soil) to prevent the spread of chemicals to groundwater and to surfaces waters.
- If incidental drippage is discovered in the storage yard, relocate the wood to a concrete chemical containment structure until it is drip free.
- Cover and/or enclose, and contain with impervious surfaces, all wood treatment equipment and drip pads. Slope and drain areas around dip tanks, spray booths, retorts, and any other process equipment in a manner that allows return of treatment chemicals to the wood treatment process.
- Cover storage areas for freshly treated wood to prevent contact of treated wood products with stormwater. Keep clean stormwater away from process water. Convey all process water to an approved treatment system.
- Seal any holes or cracks in the asphalt areas that are subject to wood treatment chemical contamination.
- Elevate stored and/or treated wood products to prevent contact with stormwater run-on and runoff.
- Place dipped lumber over the dip tank, or on an inclined ramp for a minimum of 30 minutes to allow excess chemicals to drip back to the dip tank.
- Freshly treated lumber from dip tanks or retorts must be placed on a containment area until drippage has ceased prior to placement in outside storage areas.

2.10.2.3 Recommended Additional BMPs

- Consider using preservative chemicals that do not adversely affect receiving waters.

2.10.3 BMP S153: Color Events

2.10.3.1 Applicability

This BMP applies to color events. Color events are charity, religious, or commercial events that involve the use of powdered (typically cornstarch based) and/or liquid dyes. Because they typically occur outside, there is a high likelihood of the color material entering the stormwater system and surface water unless measures are taken to prevent these illicit discharges from occurring.

"Biodegradable" and "non-toxic" do NOT mean that a substance can go into the stormwater system or water bodies. The dye material can harm aquatic organisms by altering water quality and chemistry. State and Federal environmental laws require local jurisdictions to prohibit non-stormwater discharges to the stormwater system. Dye material and any wash water are prohibited discharges.

2.10.3.2 Required BMPs

Pre-Event

- Create a map of your event that includes the following:
  - Event route.
  - Nearby streams, lakes, and ponds.
  - Start and finish areas.
  - Color application stations / areas.
  - Stormwater system inlets and open stormwater system features (e.g., ditches, swales, bioretention, rain gardens) at the color application, start and finish areas.
- Create a Pollution Plan that details:
  - Measures taken to ensure that NO dye material, either during or after the event, will enter the stormwater system.
  - How all dye material will be removed and disposed of.
  - What will happen in the event of rain (including addressing localized flooding, runoff, and collection of the stormwater).
  - The emergency number for the City of Tacoma Environmental Compliance - (253) 502-2222 in case dye material does enter the stormwater system or receiving waterbody.
- Use handheld brooms to complete the initial cleanup of paved surfaces. Follow with use of a vacuum sweeper truck on roads.
- Contract with a commercial street sweeping firm to clean paved surfaces. Have a storm drain cleaning contractor on-call for discharges to the stormwater system or emergency clean-up if necessary.
- Ensure that the commercial street sweeping firm has a plan in place for the proper disposal of sweepings from the event and associated air filters.
- Ensure that all clean-up will be completed prior to the next forecasted rainfall, or no later than 24-hours after the race event, and that the contractor will have enough equipment and staff on hand for the clean-up.

- Request a copy of the dye product's SDS (Safety Data Sheet) from the manufacturer or supplier. Review the SDS for potential safety and environmental hazards.
- Comply with The City of Tacoma Special Event Permit requirements for stormwater pollution prevention. With the permit application, provide:
  - Copies of the map
  - Pollution prevention plan
  - Commercial cleaning contract
  - Dye SDSs
  - Names and contact information of the event officials for both during and after the event.

Preventing Pollutants from Entering the stormwater system and Waterbodies

- Protect stormwater inlets by using berms, covering the stormwater system inlets, and using catch basin covers.
- Use care when removing berms, covers, and tarps to ensure no dye enters the stormwater system.
- Prohibit participants from throwing dye within 100 feet of any stream or other surface waterbody.
- Prohibit participants from throwing dye within 100 feet of any open stormwater feature (e.g,. ditch, swale, bioretention, rain garden, detention pond)
- Set up color stations at least 100 feet away from any surface water or open stormwater feature.
- The route, start, finish, and color application stations must be at least 100' away from any permeable pavement or the permeable pavement must be completely covered.
- If the event will be held on a small, contained area, cordon off the area and place enough covers on the ground to cover the entire site. If possible, contain the color application to grassy areas where ground covers are unnecessary.

Event Cleanup

- Dry off tarps and stained wet pavement with towels or absorbent pads.
- Use brooms or street sweepers to clean up paved areas. The fineness of the material may require sweepers with dust control systems.
- Do not use blowers to move dye material.
- Do not use hoses or pressure washers to rinse excess dye off of tarps, sidewalks or paved areas. If it becomes necessary to use water to clean surfaces, all the water must be collected and disposed of in the wastewater system. A Special Approved Discharge Permit may be required, see: tacoma.gov/government/departments/environmental-services/wastewater/wastewater-permits-and-manuals/ for additional information.
- Call the City of Tacoma Environmental Compliance at (253) 502-2222 immediately (24/7) if any colored water enters the stormwater system or receiving waterbody.
- Dispose of the collected sweeping materials, cleaning materials, and air filters appropriately.
- All litter and debris must be picked up and properly disposed of.

- All clean-up must be done within 24-hours of the race event.

2.10.4 BMP S154: Farmer’s Markets

2.10.4.1 Applicability

This BMP applies to farmer's markets. Potential sources of pollutants include food waste, oil and grease, water that has come into contact with food, waste from equipment washing, and other typical garbage items. Examples of waste sources include: ice and water that has come into contact with food (either in produce washing or temperature regulation), cooking equipment washwater, and hand washing centers.

2.10.4.2 Required BMPs

- Dispose of wastewater into the wastewater system. Wastewater shall not be disposed in the stormwater system. Either transport wastewater back to regular place of business for proper disposal, at the disposal site approved by the Tacoma/Pierce County Health Department as part of the food handling permit, or at the event’s designated wastewater disposal sink.
- Fats, grease and oils shall not be disposed in the stormwater or wastewater system. Recycle cooking oils or secure for proper disposal.
- Clean flower water may be disposed into nearby grassy areas. Do not dispose of flower water directly into stormwater system inlets.
- Food carts and mobile food vendors must obtain and follow the requirements of a mobile food vendor permit as issued by the Tacoma/Pierce County Health Department.

2.10.5 BMP S155: Nurseries and Greenhouses

2.10.5.1 Applicability

These BMPs are for use by commercial container plant, greenhouse grown, and cut foliage production operations. Common practices at nurseries and greenhouses can cause elevated levels of phosphorus, nitrogen, sediment, bacteria, and organic material which can contribute to the degradation of water quality.

2.10.5.2 Required BMPs

- Establish nursery composting areas, soil storage, and mixing areas at least 100 feet away from any receiving waterbody and as far away as possible from the stormwater system.
- Do not dispose of collected vegetation into receiving waterbodies or the stormwater system.
- Do not blow, sweep, or otherwise allow vegetation or other debris into the stormwater system.
- Regularly clean up spilled potting soil to prevent its movement, especially if fertilizers and pesticides are incorporated. (Haver, 2014)
- Use soil mixing and layering techniques with composted organic material to reduce herbicide use and watering.
- Utilize soil incorporated with fertilizers and / or pesticides immediately; do not store for extended periods. (Haver, 2014)
- Cover soil storage and compost storage piles. Refer to BMP S115: Storage or Transfer (Outside) of Solid Raw Materials, By-Products or Finished Products.
- Dispose of pathogen-laced potting substrate and diseased plants appropriately.
- Place plants on gravel, geotextile, or weed cloth to allow infiltration and minimize erosion, including inside greenhouse structures. (Haver, 2014)
- Properly reuse, recycle, or dispose of used polyfilm, containers, and other plastic-based products so that they do not collect stormwater. (FDACS, 2014)
- Evaluate and manage irrigation to reduce runoff, sediment transport, and erosion.
    - Place irrigation inputs to keep moisture primarily in the plant's root zone. This will significantly reduce nutrient related impacts from fertilizers. (FDACS, 2014)
    - Avoid over-irrigating. This may exceed the soil's water-holding capacity and lead to runoff or leaching. (FDACS, 2014)
    - Consider and adjust as needed the uniformity of application, the amount of water retained within the potting substrate, and the amount of water that enters containers compared to that which exits the containers and / or falls between containers. (FDACS, 2014)
    - Consolidate containers and turn off irrigation in areas not in production. This may require individual on / off valves at each sprinkler head. (Haver, 2014)
    - Based on the stage of plant growth, space containers and flats as close as possible to minimize the amount of irrigation water that falls between containers. (FDACS, 2014)
    - Group plants of similar irrigation needs together. (FDACS, 2014)

  - Consider minimizing water losses by using cyclic irrigation (multiple applications of small amounts). (FDACS, 2014)
  - Consider using sub-irrigation systems (e.g. capillary mat, ebb-and-flow benches, and trays or benches with liners); these systems can conserve water and reduce nutrient loss, particularly when nutrients are supplied in irrigation water that is reused. (FDACS, 2014)
  - Refer to BMP S146: Irrigation for additional BMP considerations.
- Refer to BMP S145: Fertilizer Application and BMP S144: Pesticides and Integrated Pest Management.
- Use windbreaks or other means (e.g. pot in pot) to minimize plant blowover (FDACS, 2014).
- Cover potting areas with a permanent structure to minimize movement of loose soil. Use a temporary structure if a permanent structure is not feasible (Haver, 2014).
- Control runoff from central potting locations that have a watering station used to irrigate plants immediately after potting. Either:
  - Collect runoff in a small basin and reuse the runoff.
  - Or, route runoff through an onsite vegetative treatment area.
  - Or, use a graveled area and allow runoff to infiltrate. Graveled area should not be a parking space or heavily compacted area.
- Surround soil storage and compost storage areas with a berm or wattles.
- Utilize a synthetic (geotextile) groundcover material to stabilize disturbed areas and prevent erosion in areas where vegetative cover is not an option (FDACS, 2014).
- In areas with a large amount of foot traffic, use appropriate aggregate such as rock and gravel for stabilization (FDACS, 2014).
- Store potting substrate that contains fertilizer in a dedicated area with an impermeable base. If the storage area is not under a roof to protect it from rainfall, manage runoff by directing it to a stormwater treatment area (FDACS, 2014).

2.10.6 BMP S156: Recyclers and Scrap Yards

2.10.6.1 Applicability

This BMP applies to businesses that reclaim various materials for resale or for scrap, such as vehicles and vehicle/ equipment parts, construction materials, metals, computers, appliances, beverage containers, and papers.

Potential sources of pollutants include paper, plastic, metal scrap debris, engines, transmissions, radiators, batteries, and other materials that contain fluids or are contaminated with fluids. Other pollutant sources include leachate from metal components, contaminated soil, and the erosion of soil. Activities that can generate pollutants include the transfer, dismantling, and crushing of vehicles and scrap metal; the transfer and removal of fluids; maintenance and cleaning of vehicles, parts, and equipment; and storage of fluids, parts for resale, solid wastes, scrap parts, and materials, equipment and vehicles that contain fluids, generally in uncovered areas.

Potential pollutants typically found at vehicle recycle and scrap yards include oil and grease, ethylene and propylene glycol, total suspended solids, BOD, heavy metals, and acidic pH.

2.10.6.2 Required BMPs

- For facilities subject to Ecology's Industrial Stormwater General Permit refer to: Vehicle and Metal Recyclers: A Guide for Implementing the Industrial Stormwater General National Pollutant Discharge Elimination System Permit Requirements (Ecology Publication Number 94-146, Water Quality Program, Revised March 2011). Apply the BMPs in that guidance document to scrap material recycling facilities depending on the pollutant sources existing at those facilities.
- Check incoming scrap materials, vehicles, and equipment for potential fluid contents and batteries.
- Drain and transfer fluids from vehicles and other equipment only in a designated area with a waste collection system or over drip pans.
- Remove batteries and store on the ground in a leak proof container and under cover.
- Cover and raise any materials that may contaminate stormwater. A tarp and pallet are acceptable.
- Cover and contain stockpiles of any material that has the potential to contaminate stormwater.
- All containers used to store fluids must comply with secondary containment requirements. Storage of flammable and combustible materials must comply with the appropriate Fire Codes.
- Inspect storage areas regularly and promptly clean up any leaks, spills, or contamination.
- Sweep scrap storage areas as needed. Do not hose down anything into the street, into the stormwater system, or into receiving waterbodies.
- Keep spill cleanup materials in a location known to all. Ensure that employees are familiar with the site's spill control plan and/or proper spill cleanup procedures.

2.10.6.3 Recommended Additional BMPs

- Install catch basin inserts to collect excess sediment and debris if necessary. Inspect and maintain catch basin inserts to ensure they are working correctly.

- Conduct automobile/vehicle metal-shredding inside enclosed buildings with HEPA air filtration systems to prevent the fugitive release of heavy metals and other potentially hazardous materials into the air.

2.10.7 BMP S157: Commercial Composting

2.10.7.1 Applicability

Commercial compost facilities operating outside without cover require large areas to decompose wastes and other feedstocks. These facilities should be designed to separate stormwater from leachate (i.e., industrial wastewater) to the greatest extent possible. When stormwater is allowed to contact any active composting areas, including waste receiving and processing areas, it becomes leachate. Pollutants in leachate include nutrients, biochemical oxygen demand (BOD), organics, coliform bacteria, acidic pH, color, and suspended solids. Stormwater at a compost facility consists of runoff from areas at the facility that are not associated with active processing and curing, such as product storage areas, vehicle maintenance areas, and access roads.

2.10.7.2 Required BMPs

This BMP applies to commercial composting facilities. Commercial composting facilities are required to be covered under an Individual NPDES Permit and may require an Industrial Wastewater Discharge Permit from the City of Tacoma.

- Commercial composting facilities shall comply with WAC 173-350-220, Composting Facilities.
- See Siting and Operating Composting Facilities in Washington State: Good Management Practices (Ecology Publication Number 11-07-005, Revised July 2013) for common sense actions that can be implemented at a facility to help run a successful program.
- See Ecology's Organic Materials Management page for the most up-to-date information: https://ecology.wa.gov/Waste-Toxics/Reducing-recycling-waste/Organic-materials.
- All composting facilities shall obtain the appropriate state and local permits.
- Visit tacomapermits.org for additional information on required City of Tacoma permits.
- Visit https://ecology.wa.gov/Water-Shorelines/Water-quality/Water-quality-permits for additional information on required state water quality permits.
- Visit the Tacoma-Pierce County Health Department for information about additional permits that may be required: https://www.tpchd.org/i-want-to/contact-us
- Screen incoming wastes for dangerous materials and solid wastes. These materials may not be accepted for composting and must be properly disposed of.
- Locate composting areas on impervious surfaces.
- Drain all leachate from composting operations to a wastewater system, holding tank, or onsite treatment system. Leachate may not go to the stormwater system or groundwater.
- Collect the leachate with a dike or berm, or with intercepting drains placed on the down slope side of the compost area.
- Do not allow run-on into the composting area.
- Clean up debris from yard areas as needed to prevent stormwater contamination

2.10.7.3 Recommended Additional BMPs

- Review the Washington State Department of Ecology (Ecology) publication which contains guidance for common practices that a facility can adopt to help run a successful program: Siting and Operating Composting Facilities in Washington State: Good Management Practices. This document is available at: https://fortress.wa.gov/ecy/publications/summarypages/1107005.html

- Review Ecology's Organic Materials Management Rules and Laws page for the information concerning composting facilities: https://ecology.wa.gov/Waste-Toxics/Reducing-recycling-waste/Organic-materials.
- Install catch basin inserts to collect excess sediment and debris if necessary. Inspect and maintain catch basin inserts to ensure they are working correctly.
- Locate stored residues in areas designed to collect leachate and limit storage time to prevent degradation and generation of leachate.

2.10.8 BMP S158: Commercial Printing Operations

2.10.8.1 Applicability

This BMP applies to commercial printing businesses. Materials used in the printing process include inorganic and organic acids, resins, solvents, polyester film, developers, alcohol, vinyl lacquer, dyes, acetates, and polymers. Waste products may include waste inks and ink sludge, resins, photographic chemicals, solvents, acid and alkaline solutions, chlorides, chromium, zinc, lead, spent formaldehyde, silver, plasticizers, and used lubricating oils. As the printing operations are conducted indoors, the only likely points of potential contact with stormwater are the outside temporary waste material storage area and area where chemicals are offloaded at external unloading bays. Pollutants can include TSS, pH, heavy metals, oil and grease, and COD.

2.10.8.2 Required BMPs

- Discharge process wastewaters to the wastewater system (if approved by the City of Tacoma) or to an approved process wastewater treatment system. Contact the City of Tacoma Stormwater Management Program at ECInspections@tacoma.gov for discharge requirements.
- Do not discharge process wastes or wastewaters into the stormwater system.
- Determine whether any of these wastes qualify for regulation as dangerous wastes and dispose of them accordingly.
- Store raw materials or waste materials that could contaminate stormwater in covered and contained areas.
- Train all employees in pollution prevention, spill response, spill reporting, and environmentally acceptable materials handling procedures.
- Store materials in proper, appropriately labeled containers. Identify and label all chemical substances.
- Wash printing press without solvents if feasible. If solvent cleaning is required use a solvent with a low VOC content. Don't evaporate ink cleanup trays to the outside atmosphere.
- Place cleanup sludges into a properly labeled container with a tight lid, designate the sludge, and dispose properly. It is the responsibility of the generator to designate waste as hazardous waste and provide supporting information.

For additional information see the Washington State Department of Ecology publication: Environmental Management and Pollution Prevention: A Guide for Lithographic Printers (Publication 94-139) - available at https://ecology.wa.gov/About-us/Online-tools-publications/Publications-forms.

2.10.9 BMP S159: Boat Building, Mooring, Maintenance and Repair

2.10.9.1 Applicability

This BMP applies to properties that build, moor, and maintain boats. Sources of pollutants at boat and ship building, repair, and maintenance facilities at boatyards, shipyards, ports, and marinas include pressure washing, surface preparation, paint removal, sanding, painting, engine maintenance and repairs, and material handling and storage, if conducted outdoors. Potential pollutants include spent abrasive grits, solvents, oils, ethylene glycol, washwater, paint over-spray, cleaners/detergents, paint chips, scrap metal, welding rods, resins, glass fibers, dust, and miscellaneous trash. Pollutant constituents include TSS, oil and grease, organics, copper, lead, tin, and zinc.

Washington State Department of Ecology Permitting Requirements

Ecology's statewide Boatyard General Permit applies to boatyards that discharge stormwater from areas with industrial activities to the ground, a surface waterbody, or a stormwater system. The permit also regulated wastewater (such as from pressure washing). Visit https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Boatyard-general-permit to determine if a Boatyard General Permit is required. Large boatyards and shipyard may be covered under a separate individual permit.

2.10.9.2 Required BMPs

- Maintenance and repair activities that can be moved on-shore must be moved accordingly. This action reduces some of the potential for direct pollution impact on waterbodies.
- Do not perform extensive repair, modification, surface preparation or coating while the boat is in the water to the extent feasible. If minor work must be done with the boat in water, use fixed platforms with appropriate plastic or tarpaulin barriers as work surfaces and for containment when performing work on a vessel in the water to prevent blast material or paint overspray from contacting stormwater or surface water.
- Use plastic or tarpaulin barriers beneath the hull and between the hull and dry dock walls to contain and collect waste and spent materials. Clean and sweep regularly to remove debris.
- Enclose, cover, or contain blasting and sanding activities to the maximum extent practicable to prevent abrasives, dust, and paint chips, from reaching the stormwater system or receiving waterbody. Use plywood and/or plastic sheeting to cover open areas between decks when sandblasting.
- Direct any contaminated water associated with the activity to a collection system sump for settling and/or additional treatment.
- Store cracked batteries in covered secondary containment.
- Immediately repair or replace leaking connections, valves, pipes, hoses, and other equipment that may cause stormwater contamination.
- Use drip pains, drop cloths, tarpaulins, or other protective devices in all paint mixing and solvent operations.
- Maintain automatic bilge pumps to ensure waste material is not accidently pumped to the stormwater system.

- Do not dump or pour waste materials into drains that connect to the stormwater system or directly to the surface water. Plug floor drains that connect to the stormwater system or surface water while work is being performed.
- Uncontained spray painting, blasting and sanding activities are not allowed over open water.
- Outside spray painting, blasting, and sanding activities are not allowed during windy conditions.
- Do not burn paint and/or use spray guns on topsides or above decks.
- Immediately clean all spills that could reach the stormwater system or surface water.
- Locate spill kits so they are readily accessible on all piers and docks.
- Collect spent abrasives regularly and store under cover to await proper disposal.
- Dispose of greasy rags, oil filters, air filters, batteries, zinc anodes, spent coolant, and degreasers properly.
- Drain oil filters before disposal or recycling.
- Bilge water must be collected for proper disposal rather than discharged on land or water. See BMP S102: Formation of a Pollution Prevention Team for detail on disposal options. Several companies are available for bilge pumpout services. Use oil-absorbent pads to capture the oil in the bilge water before or during pumping. If pads are used, they must be recycled or properly disposed.
- Ballast water that has an oily sheen on the surface must be collected for proper disposal rather than discharged on land or water. See BMP S102: Formation of a Pollution Prevention Team for details on disposal options.
- Sewage from sanitary holding tanks on ships must be approved for discharge to the wastewater system. Contact the City of Tacoma Stormwater Management Program at ECInspections@tacoma.gov.
- Solid wastes from international vessels must be evaluated on a case-by-case basis. Contact the City of Tacoma Solid Waste Division at 253-591-5544 for assistance. Galley wastes may need to be taken to a United States Department of Agriculture Animal and Plant Health Inspection Service (APHIS) approved facility. For assistance, contact the local APHIS office during normal business hours at 206-553-2400 or 206-553-4406 after hours.
- Maintenance yard areas must be swept and cleaned, without hosing down the area, regularly. This prevents sandblasting materials, scrapings, paint chips, oils, and other loose debris from being carried away with stormwater. The collected materials must be disposed of properly. See BMP S102: Formation of a Pollution Prevention Team for disposal options.
- Docks and boat ramps must be swept regularly, and the collected materials must be disposed of properly. Dry docks must be swept before flooding.
- Paint and solvent mixing, fuel mixing and similar handling of liquids shall be performed on shore, or such that no spillage can occur directly into surface waterbodies.
- Routine cleanup materials such as oil-absorbent pads, brooms, dustpans, shop vacuums, mops, buckets, and sponges must be stocked near docks.
- When washing a boat in the water, use no soaps or detergents. Brush the hull with water only.

- Comply with BMP S125: Vehicle Maintenance Activities if engine repair and maintenance are conducted.
- In the event of an accidental discharge of oil or hazardous material into waters of the state or onto land with a potential for entry into state waters, immediately notify the yard, port, or marina owner or manager, the Department of Ecology, and the National Response Center at 1-800-424-8802 (24-hour). If the spill can reach or has reached marine waters, contact the U.S. Coast Guard at 206-217-6232.

2.10.9.3 Recommended Additional BMPs

The following BMPs are not required but can provide additional pollution protection:

- Boat construction and structural repair activities should be covered.
- Materials such as paints, tools, and ground cloths should be stored indoors or in a covered area when not in use.
- Select the least toxic anti-fouling paint available.
- Boat interiors should be routinely cleaned, with proper disposal of collected materials, so that accumulations of water drained from the boat's interior are not contaminated.
- Use sanders that have dust containment bags or use vacuum sanders, and avoid sanding in windy conditions.
- All used oil should be recycled if feasible. Most marinas now offer used oil recycling services. To dispose of filters, let drain 24 hours, then double wrap in plastic and dispose in the regular garbage, or take them to the Tacoma Landfill Household Hazardous Waste facility for recycling. Pending state legislation may make disposal in the garbage illegal, so call the Hazardous Waste Line at 1-800-287-6429 for current information.
- Check with marinas for other BMPs they have developed.
- Use stormwater treatment BMPs as necessary for the pollutants of concern. Refer to Volume 4 for information about stormwater treatment BMPs.
- Use clean, green boating practices. See https://ecology.wa.gov/About-us/Get-involved/What-you-can-do/Washington-Waters-ours-to-protect/Clean-green-boating for additional information.

2.10.10 BMP S160: Swimming Pools, Spas, Hot Tubs, and Fountains

2.10.10.1 Applicability

This activity applies to all swimming pools, spas, hot tubs, and fountains used for recreational and/or decorative purposes that may use chemicals and/or are heated including Tacoma-Pierce County Health Department (TPCHD) regulated facilities. Pools at single-family residences are covered in Chapter 3 of this volume. Commercial pool and spa cleaning services must follow the required BMPs for all pools serviced.

Pollutants of concern include nutrients, suspended solids, chlorine, pH, and chemical oxygen demand (COD).

2.10.10.2 Required BMPs

- Clean the pool, spa, hot tub, or fountain regularly. Maintain the filtration system and water chemistry. Regular maintenance will limit the need to drain the facility.
- Store chemicals inside a building.
- Properly dispose of spent chemicals. Do not dump or pour any chemicals into the stormwater system or receiving waters.
- When the facility needs to be drained, drain all water to the wastewater system when feasible. This may require the use of a pump. A Special Approved Discharge Permit may be required - see tacoma.gov/government/departments/environmental-services/wastewater/wastewater-permits-and-manuals/ for additional information.
- If discharge to the wastewater system is not possible, discharge to the stormwater system may be possible provided discharge water is:
  - Dechlorinated/debromiated to 0.1 ppm or less.
  - Free from sodium chloride
  - pH-adjusted
  - Reoxygenated if necessary
  - Free of color, dirt, suds, or algae
  - Free of filter media
  - Free of acid cleaning wastes
  - Thermally controlled to prevent an increase in temperature of the receiving water.
  - Volumetrically and velocity controlled to prevent resuspension of sediments
- Ensure the pool, spa, hot tub, or fountain system is free of leaks and operates within the design parameters.
- Do not connect the pool, spa, hot tub, or fountain system to the stormwater system.
- Backwash from pool filters cannot be discharged onto the ground, into the street, into the stormwater system, into receiving waterbodies, or into septic systems.
- Diatomaceous earth used in pool filters cannot be discharged onto the ground, into the street, into the stormwater system, into receiving waterbodies, or into septic systems.

2.10.10.3 Recommended Additional BMP

- Hire a professional pool-draining service to collect all pool water for offsite disposal.

2.10.11 BMP S161: Railroad Yards

2.10.11.1 Applicability

This BMP applies to railroad yards. Pollutant sources can include drips/leaks of vehicle fluids and cargo onto the railroad bed; human waste disposal; litter; locomotive/railcar/equipment cleaning; fueling; outside material storage; the erosion and loss of soil particles from the railroad bed; maintenance and repair activities at railroad terminals, switching yards, and maintenance yards; and herbicides used for vegetation management. Waste materials can include waste oil, solvents, degreasers, antifreeze solutions, radiator flush, acids, brake fluids, dust, soiled rags, oil filters, sulfuric acid and battery sludges, machine chips with residual machining oil, and toxic fluids/solids lost during transit. Potential pollutants include oil and grease, TSS, BOD, organics, pesticides, and metals.

2.10.11.2 Required BMPs

- Implement the applicable BMPs in this chapter depending on the pollutant generating activities/sources at a railroad yard facility.
- Do not allow toilets to discharge to outside areas while a train is in transit or at the station. Pumpout facilities shall be used to service train toilets.
- Use drip and track pans at hose/pipe connections during liquid transfer and other leak-prone areas.
- During maintenance do not discard debris or waste liquids along the tracks or in railroad yards.
- When undergoing routine maintenance, discharge locomotive cooling systems only after the locomotive has stopped and at a location where the coolant can be collected, managed, and then disposed of properly.
- During maintenance, do not discard debris or waste liquids along the tracks or in railroad yards.
- Handle wastes generated from large-scale equipment cleaning, such as locomotive, track equipment, or axle cleaning operations, properly to avoid harming the environment and to comply with state and federal environmental regulations.
- Store any metal scrap generated from metal punching or other mechanical operations out of contact with stormwater.
- Do not dump, drain, or allow the discharge of any water-based coolant from multi-punch presses into the stormwater system.
- Place track mats under each rail/flange lubricator that is in service where track mats can be safely installed and maintained without danger to rolling stock or personnel.
- Select cost-effective rail/flange lubricant that provides safe and effective rail operation while considering adverse environmental impact. Consider both the chemical composition of the lubricant and the likelihood of transfer off of the rail during rain events.
- Inspect and replace track mats, as necessary. Routinely inspect all track mats for tears or saturation, and replace as necessary.
- Install spill containment pans/trays or track mat at designated locomotive and railcar maintenance facilities and fixed fueling areas, to reduce environmental impacts from potential spills under locomotives and other track equipment. Direct spill containment pans/trays to an oil / water separator where feasible for treatment or collect spilled chemicals for proper disposal.

- During locomotive fueling operations use drip pans or secondary containment to capture any fuel or oil seepage.
- Install track mats at designated Engine Tie-Up and/or outdoor locomotive parking locations (e.g., service tracks) located in SWPP permitted areas where locomotives are unattended and idle for extended periods of time.
- Do not conduct heavy/major locomotive engine repairs on the rail line. Conduct heavy/ major engine repairs at an established railroad maintenance facility.
- Store creosote-treated railroad ties in locations that reduce the potential to impact stormwater.
- In areas subjected to leaks/spills of oils or other chemicals, convey stormwater to appropriate treatment such as the wastewater system with appropriate pretreament, or, to BMP T1200a: API (Baffle Type) Separators, BMP T1200b: Coalescing Plate (CP) Separators, or other treatment as approved by the City of Tacoma.
- Promptly clean up all spilled materials.

2.10.11.3 Recommended Additional BMPs

- At each rail/flange lubricator that is in service use rain sensors to adjust the lubrication cycle accordingly to limit the amount of lubricant exposed to stormwater.

2.10.12 BMP S162: Well, Utility, Directional and Geotechnical Drilling

2.10.12.1 Applicability

This BMP applies to drilling water wells and utilities, environmental protection and monitoring wells, and geotechnical borings that use machinery in the drilling. It does not apply to the use of devices such as hand augers, or for large structural drilling such as drilled shafts.

Drilling activities can expose soil and contaminated soil. These activities may cause the discharge of stormwater contaminated with sediments and other contaminates. This risk increases when drilling in areas with contaminated soils.

2.10.12.2 Required BMPs

- When drilling in areas of known or suspected soil contamination, test and characterize soil cuttings and accumulated sediment to determine proper management and disposal methods. If applicable, generator knowledge may be used to characterize the soil cuttings and accumulated sediment.
- Obtain permits for drilling activities, and for clearing and grading the access routes and the work site.
- Protect environmentally sensitive areas (streams, wetlands, floodplains, floodways, erosion hazards, and landslide hazards) within the area of influence of the work site.
- Mitigate potential impacts to surrounding areas and/or the stormwater system.
- For horizontal directional drilling, take measures to capture and contain drilling fluids and slurry.
- Equip the driller to quickly respond to unusual conditions that may arise.
- Locate and prepare access roadways to minimize the amount of excavation and the potential for erosion.
- Contain accumulated uncontaminated water and sediment on site and pump into a storage tank or direct through a geotextile filtration system (or equivalent system) before discharging to the surrounding ground surface. Contaminants may include, but are not limited to, hydraulic fluids, contaminants in the soil and/or groundwater, polymers, and other drilling fluid additives.
- Keep all sediment-laden water out of the stormwater system and receiving waterbodies. If sediment-laden water does escape from the immediate drilling location, block flow to any nearby waterways or catch basins using fabric, inlet protections, sand bags, erosion fences, or other similar methods. Immediately notify Ecology and the local jurisdiction if sediment-laden water impacts the stormwater system or receiving waterbodies.
- Divert any concentrated flows of water into the site using sandbags or check dams up-slope from the site.
- Dispose of soil cuttings and accumulated sediment appropriately. If cuttings or other soils disturbed in the drilling process are to be temporarily stockpiled on site, they must be covered and surrounded by a berm or filter device. See BMP S115: Storage or Transfer (Outside) of Solid Raw Materials, By-Products or Finished Products.
- Stabilize exposed soils at the end of the job, using mulch or other erosion control measures. See BMP S142: Soil Erosion and Sediment Control at Commercial and Industrial Sites.
- Contain spent drilling slurry on site and allow it to dewater, or haul to an appropriate, approved disposal site.

- Restore disturbed areas with mulch (see BMP C121: Mulching) and seeding or hydroseeding (see BMP C120: Temporary and Permanent Seeding).

2.11 Proper Disposal

2.11.1 BMP S163: Proper Disposal

2.11.1.1 Applicability

This BMP applies to anyone disposing of any liquid or solid waste.

2.11.1.2 Required BMPs

- Do not dispose of any waste into the street, stormwater system, or receiving waterbodies.
- Limit activities that produce waste to the maximum extent practicable. Consider why the activity is occurring and if it needs to occur.
- Categorize waste and dispose of according to type.

Liquid Wastes

- Non-hazardous liquid wastes (including contaminated stormwater and process wastewater) can generally be discharged to the wastewater system. Discharges to the wastewater system may require pretreatment and/or a Special Approved Discharge Permit. All non-domestic users are required to complete a User Survey to characterize the wastewater discharges. See: tacoma.gov/government/departments/environmental-services/wastewater/wastewater-permits-and-manuals/ for additional information. TMC Chapter 12 defines materials that are prohibited from entering the wastewater system.
- Certain liquids can also be recycled and reused in various processes. Whenever possible, reuse liquids.
- There may be cases when liquid wastes must be stored in a holding tank before discharge to the wastewater system. In these cases, monitor and maintain holding tanks to ensure no overfill or leaks.

Solid Wastes

- See BMP S117: Storage of Solid Wastes and Food Wastes.
- Hazardous wastes must be managed appropriately according to State and Federal regulations.

2.12 Structural BMPs

2.12.1 BMP S164: Cover the Activity with a Roof or Awning

In many cases, a simple roof or awning will protect the activity from coming into contact with stormwater, and usually at a lower cost than a complete building. These structures may require building permits to construct. Visit tacomapermits.org for additional information.

The area of the roof cover shall be sufficient to prevent any precipitation from reaching the covered materials. Provisions shall be made to prevent stormwater run-on into the covered area. The installation of sumps or drains to the wastewater system may also be necessary. Roof drains shall discharge outside and be directed away from the covered area. Examples of these types of structures are shown in Figure 6 - 11: Examples of Covered Activities.

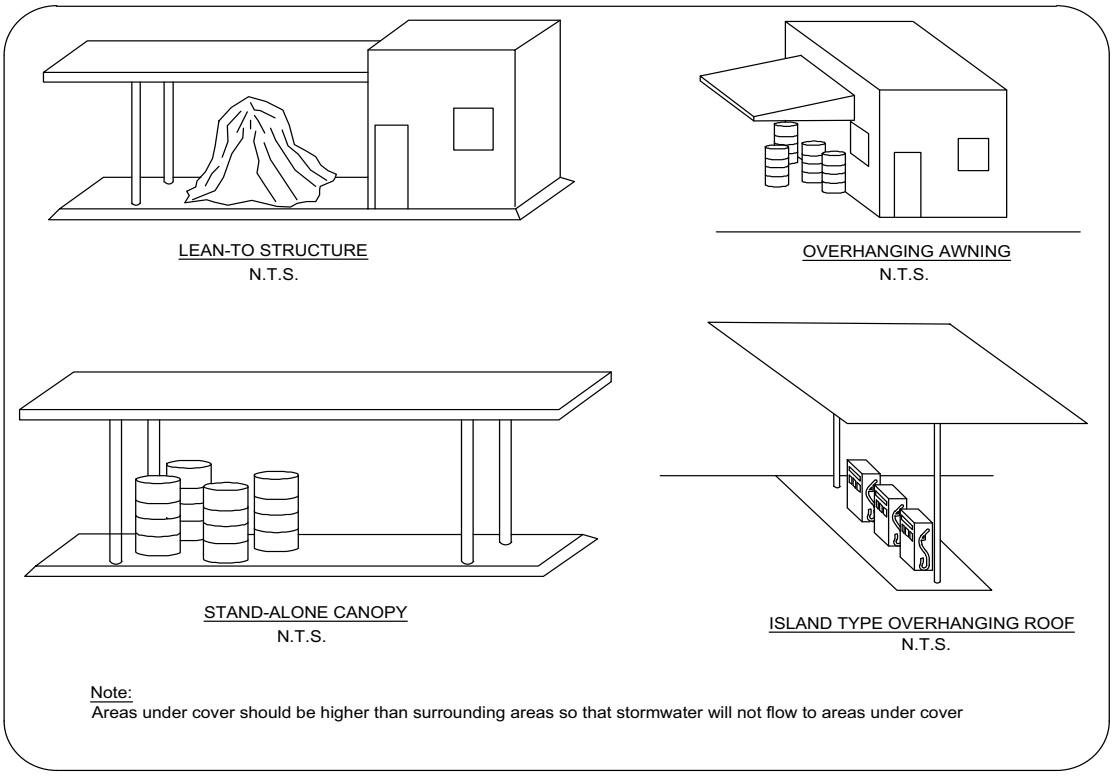

Figure 6 - 11: Examples of Covered Activities

2.12.2 BMP S165: Cover the Activity with an Anchored Tarp or Plastic Sheet

Some activities, such as stockpiling of small amounts raw materials, can be effectively covered with a sturdy tarp or heavy plastic sheet made of impermeable material. Weights such as bricks, tires, or sandbags should be used to anchor the cover in place. Run-on shall be prevented from reaching the activity or material. Stormwater run-off from the cover shall be directed away from the stockpile and work zone, and if uncontaminated, directed to the stormwater collection system. The tarp must be inspected daily to ensure that no holes or gaps are present in the tarp coverage. An example of this type of cover is shown in Figure 6 - 12: Tarp Covering.

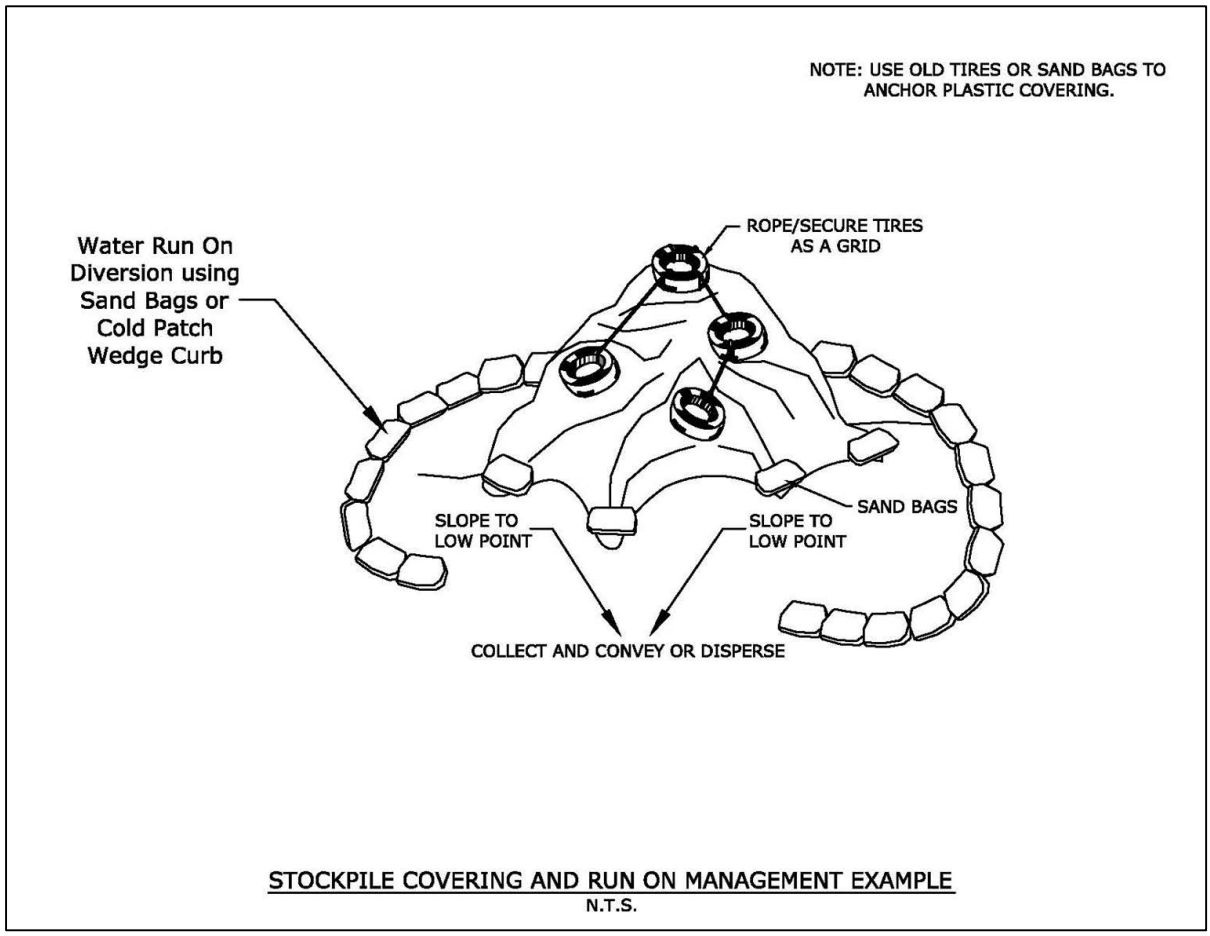

Figure 6 - 12: Tarp Covering

2.12.3 BMP S166: Pave the Activity Area and Slope to a Sump, Holding Tank, or Oil/Water Separator

This BMP applies to several activities that cannot be covered effectively. It is particularly suited to activities with the potential for leaks and spills, but that otherwise do not generate excessive amounts of polluted runoff. The activity area shall be paved and sloped to a central collection point. A sump, holding tank, or oil/water separator (Figure 6 - 13: Paved Area with Sump Drain) serves to provide spill containment until the liquids can be pumped out and properly disposed. The minimum volume for the sump shall be equivalent to the volume generated by the anticipated activity plus rain water. Sizing justification shall be included in design submittals. Discharge to the wastewater system may be appropriate in some instances. A Utility Connection Permit with approval from the City of Tacoma is required before connecting any areas to the private wastewater system or the public wastewater system. See tacomapermits.org for additional information.

To prevent run-on, the area should be enclosed with a berm, curb, or dike. Frequent inspections of the sump, holding tank, or oil/water separator are necessary. Inspections and maintenance shall be recorded in a log. Commercial services that pump sumps and holding tanks are listed in the Yellow Pages of the phone directory under Environmental and Ecological Services.

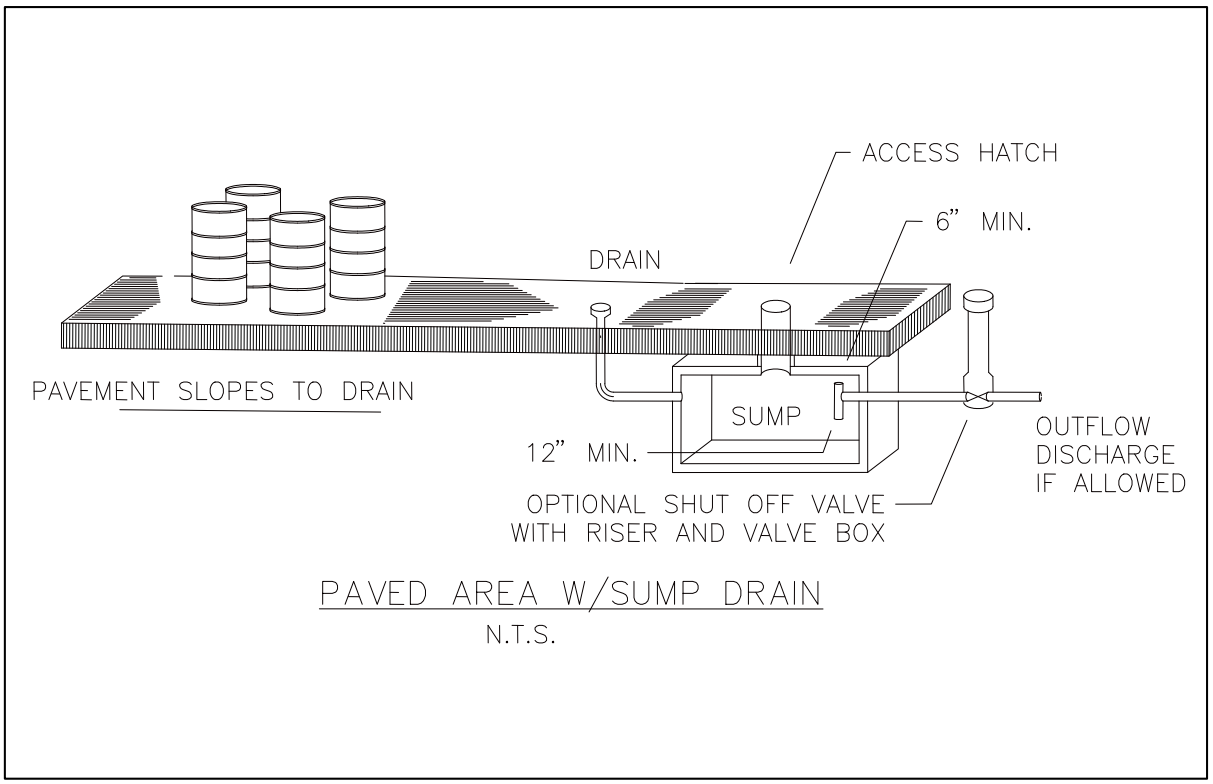

Figure 6 - 13: Paved Area with Sump Drain

2.12.4 BMP S167: Surround the Activity Area with a Curb, Dike, or Berm or Elevate the Activity

This set of BMP options can be an effective means for prevention of stormwater run-on to an activity area. In addition, a curb, berm, or dike can be used for containment of spills in the activity area, or for containment of contaminated water. Generally, a containment BMP is most applicable to spill control situations; that is, sites where runoff is relatively clean, but occasional spills may occur.

If a curb, berm, or dike is used for runoff containment, and other containment sizing regulations (such as fire codes, Environmental Protection Agency, Department of Ecology or Tacoma-Pierce County Health Department restrictions) do not apply, the containment volume shall be 100% of the volume of the largest tank within the containment area is contained or 110% of the volume of the largest tank, whichever is greater.

Impervious containment may consist of membrane lined soil enclosures, containment pallets, plastic pools, mortar mixing tubs, and water troughs. See Figure 6 - 14: Containment Types.

Regular inspections of the containment area and proper management of any collected stormwater is required.

Development of a spill plan may be necessary for storage of liquids.

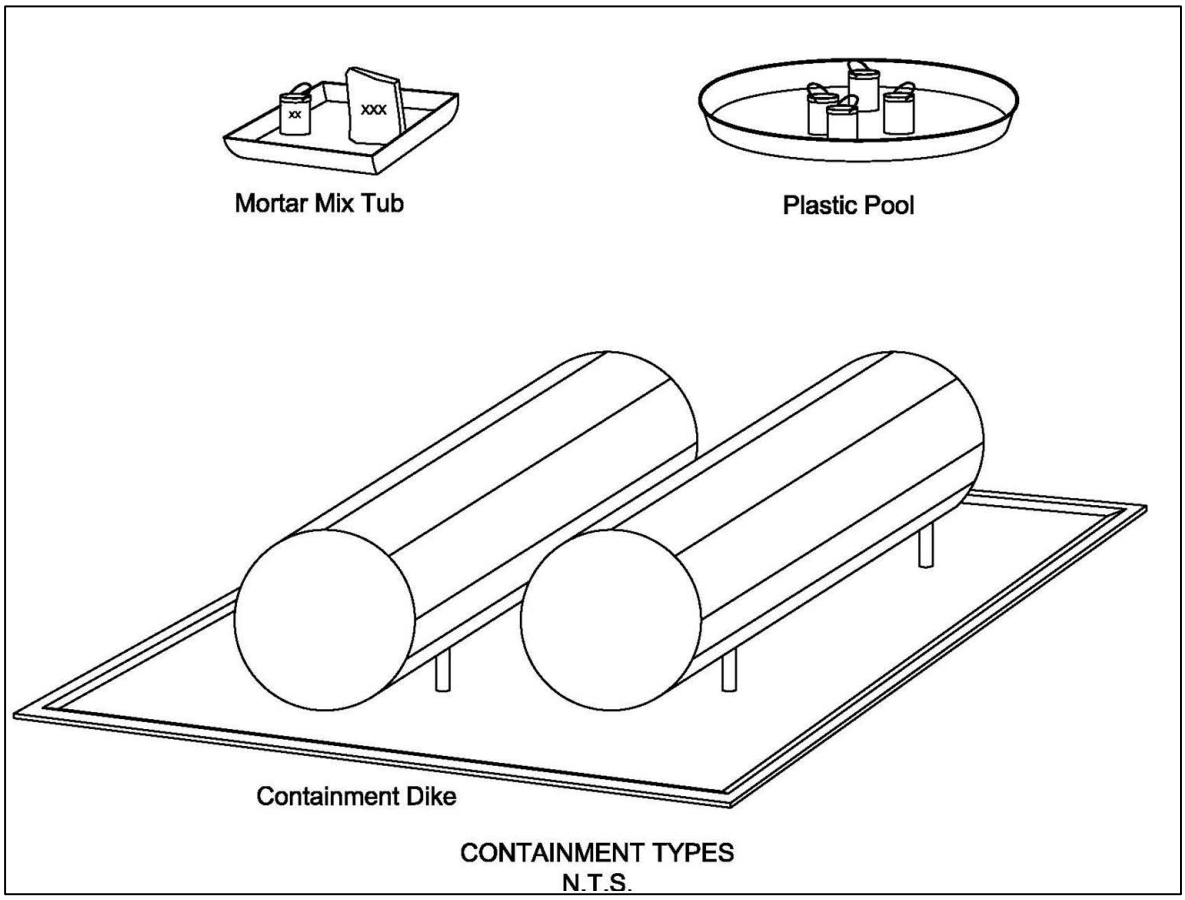

Figure 6 - 14: Containment Types

Chapter 3 BMP S168: BMPs for Homeowners

3.1 Applicability

This BMP applies to all single family homeowners in the City of Tacoma. There may be additional BMPs within Volume 6 - Source Control Best Management Practices that apply to your property. The BMPs in this section are intended to cover typical use of single family homes and are actions that should be taken when performing the associated activities.

3.1.1 Washing

Washing activities might include washing tools, buckets, dishes, automobiles, bicycles, boats, windows, siding, and any other washing activity.

- All washwater must drain to the wastewater system. For a typical single family home this means that washing cannot occur outside the home unless all washwater can be collected for disposal into the wastewater system.
- Wash items inside in a sink that drains to the wastewater system when possible.
- Remove any grease and oil before washing. Properly dispose of oils and grease.
- Sweep or otherwise wipe down items to remove the bulk of dirt of grit. Properly dispose of any removed material in the trash.
- Take automobiles and boats to a commercial carwash.
- Do not wash any material into the street.
- Do not pour any washwater into the street, into a stormwater inlet, or into a surface water.

3.1.2 General Home Maintenance

- Maintenance activities might include things like painting and fixing household items.
- Obtain appropriate City of Tacoma Permits for large maintenance projects. See tacomapermits.org to see if a permit is required for the type of maintenance being performed.
- Conduct maintenance in such a way that no pollutants will enter the street, a stormwater inlet or a surface water.
- Regularly sweep or vacuum. Properly dispose of debris in the trash.
- Do not pour or dispose of anything into the street, a stormwater inlet, or a surface water.
- Dispose of waste materials at the end of each day.

3.1.3 Automobile and Bicycle Maintenance

- When possible conduct all vehicle and bike maintenance activities indoors or undercover.
- If maintenance cannot be conducted indoors or undercover, place a tarp over the activity and place drip pads under the area to ensure no pollutants reach the ground.
- Recycle all oils, antifreeze, solvents, and batteries. The Household Hazardous Waste facility at the Tacoma Recovery and Transfer Center accepts many items that may be associated with vehicle maintenance. See: tacoma.gov/solidwaste for additional information.

- Never dump new or used automotive fluids or solvents on the ground, into the street, into a stormwater inlet, or into surface waters.
- Do not mix wastes. Always keep your wastes in separate containers which are properly labeled and store them under cover.
- Fix leaks to ensure materials stay off the streets and out of the stormwater system and local waterways.

3.1.4 Solid Waste, Recycling, and Yard Waste

- City of Tacoma residents shall use the City of Tacoma Solid Waste Management waste containers. The containers shall have lids that can fully close and be free from damage. If the containers are damaged contact Solid Waste. See: tacoma.gov/solidwaste or call (253) 502-2100 for questions about Setout Guidelines, damaged containers, and what can go into each container.
- For bulky items use Tacoma Call-2-Haul program. See tacoma.gov/solidwaste for additional information. Do not let bulky items sit outside for extended period of time unless they are covered by a tarp.
- Do not blow yard waste into the street, into a stormwater inlet, or into a surface water. Collect all yard waste and dispose in the yard waste bin (brown bin).
- BMP S117 - Storage of Solid Wastes and Food Wastes may apply if the combined solid waste container volume is greater than one cubic yard. See BMP S117 for additional information.

3.1.5 Vegetation Management

- Use natural yard care practices to the maximum extent practicable. These include practices such as planting appropriate vegetation for the site, building healthy soil by using compost amendments, watering sparingly, eliminating or minimizing the use of fertilizers, pesticides, and herbicides, and mowing grass higher.
- Store yard care tools and amendments inside and under cover.
- Do not dispose of yard clippings in the street, into a stormwater inlet, or into a surface water. Collect all yard waste and dispose in the yard waste bin.
- Do not apply moss removal powders or chemicals if there is a chance of rain within 1 week of application. Remove excess chemicals and moss by use of vacuum or sweeper. If pressure washing is used, all washwater must be collected and discharged to the wastewater system. Washwater shall not discharge onto the ground, into a stormwater inlet, into the street, or into a surface water.

3.1.6 Swimming Pools, Hot Tubs, and Fountains

- Clean the pool, spa, hot tub, or fountain regularly. Maintain the filtration system and water chemistry. Regular maintenance will limit the need to drain the facility.
- Store chemicals inside a building or in a container under cover.
- Properly dispose of spent chemicals. Do not dump or pour any chemicals into the stormwater system or receiving waters.
- When the facility needs to be drained, drain all water to the wastewater system when feasible. This may require the use of a pump. A Special Approved Discharge Permit may be required - see tacoma.gov/government/departments/environmental-services/wastewater/wastewater-permits-and-manuals/ for additional information.

- If discharge to the wastewater system is not possible, discharge to the stormwater system may be possible provided discharge water is:
  - Dechlorinated/debromiated to 0.1 ppm or less.
  - Free from sodium chloride
  - pH-adjusted
  - Reoxygenated if necessary
  - Free of color, dirt, suds, or algae
  - Free of filter media
  - Free of acid cleaning wastes
  - Thermally controlled to prevent an increase in temperature of the receiving water.
  - Volumetrically and velocity controlled to prevent resuspension of sediments
- Ensure the pool, spa, hot tub, or fountain system is free of leaks and operates within the design parameters.
- Do not connect the pool, spa, hot tub, or fountain system to the stormwater system.

3.1.7 Material Storage

- Store all materials indoors or under cover. Materials left outside can degrade and pollutants can enter the stormwater system.

3.1.8 Roofs and Building Drains

- Bare galvanized metal shall not used for materials that convey stormwater, such as roofs, canopies, siding, gutters, downspouts, roof drains and pipes. Any galvanized materials shall have an inert, non-leachable finish. Acrylic paint, polyester paint, field-applied, and part zinc coating area not acceptable.

Glossary

The following terms are provided for reference and use with this manual. The definitions contained within this glossary are intended solely for the purposes of this document. They are context-specific and may not align with definitions used in other documents, standards, or publications. No inference should be made regarding their applicability outside this context. They shall be superseded by any other definitions for these terms adopted by ordinance, unless they are defined in a Washington State WAC or RCW, or are used and defined as part of the Minimum Requirements for all new development and redevelopment.

AASHTO classification	The official classification of soil materials and soil aggregate mixtures for highway construction, used by the American Association of State Highway and Transportation Officials.
Absorption	The penetration of a substance into or through another, such as when water fills the voids of soil.
Adjustment	A variation in the application of a Minimum Requirement to a particular project. Adjustments provide equivalent environmental protection.
Adsorption	The adhesion of a substance to the surface of a solid or liquid; often used to extract pollutants by causing them to be attached to such adsorbents as activated carbon or silica gel. Hydrophobic, or water-repulsing adsorbents, are used to extract oil from waterways when oil spills occur. Heavy metals such as zinc and lead often adsorb onto sediment particles.
Aeration	The process of being supplied or impregnated with air. In waste treatment, the process used to foster biological and chemical purification. In soils, the process by which air in the soil is replenished by air from the atmosphere. In a well aerated soil, the soil air is similar in composition to the atmosphere above the soil. Poorly aerated soils usually contain a much higher percentage of carbon dioxide and a correspondingly lower percentage of oxygen.
Aerobic	Living or active only in the presence of free (dissolved or molecular) oxygen.
Aerobic bacteria	Bacteria that require the presence of free oxygen for their metabolic processes.
Algae	Primitive plants, many microscopic, containing chlorophyll and forming the base of the food chain in aquatic environments. Some species may create a nuisance when environmental conditions are suitable for prolific growth.
Algal bloom	Proliferation of living algae on the surface of lakes, streams or ponds; often stimulated by phosphate over-enrichment. Algal blooms reduce the oxygen available to other aquatic organisms.

American Public Works Association (APWA)	The Washington State Chapter of the American Public Works Association.
Anadromous	Fish that grow to maturity in the ocean and return to rivers for spawning.
Anaerobic	Living or active in the absence of oxygen.
Anaerobic bacteria	Bacteria that do not require the presence of free or dissolved oxygen for metabolism.
Antecedent moisture condition	The degree of wetness of a watershed or within the soil at the beginning of a storm.
Applicant	The person who has applied for a City of Tacoma Permit or is submitting plans for approval (ex. when a Permit is not needed but plan review is required).
Appurtenances	Machinery, appliances, or auxiliary structures attached to a main structure, but not considered an integral part thereof, for the purpose of enabling it to function.
Aquatic Life Use	Aquatic life uses are based upon the presence of, or intent to provide protection for: • char spawning and rearing, • core summer salmonid habitat, • salmonid spawning, rearing, and migration, • salmonid rearing and migration only, • non-anadromous interior redband trout, • indigenous warm water species, • all indigenous fish and nonfish aquatic species. In the City of Tacoma, all freshwater bodies shall be considered to have an aquatic life use. See Volume 1, Minimum Requirement #6 to determine what treatment type applies to the project.
Aquifer	A geologic stratum containing groundwater that can be withdrawn and used for human purposes.
Arterial	A road or street with the primary purpose of efficient movement of people and goods. See TMC 11 for classified arterials in the City of Tacoma.
As-built drawings	Engineering plans which have been revised to reflect all changes to the plans which occurred during construction.

Average daily traffic (ADT)	The volume of traffic passing a point or segment of a roadway, in both directions, during a period of time, divided by the number of days in the period and factored to represent an estimate of traffic volume for an average day of the year. ADT counts must be estimated using the Trip Generation Manual published by the Institute of Transportation Engineers or a traffic study prepared by a licensed engineer in the state of Washington or a transportation specialist with expertise in traffic volume estimation. ADT counts shall be made for the design life of the project. For project sites with seasonal or varied use, the highest period of expected traffic impacts should be evaluated.
Background	A description of pollutant levels arising from natural sources, and not due to human activities.
Backwater	Water upstream from an obstruction which is deeper than it would normally be without the obstruction.
Baffle	A device to check, deflect, or regulate flow.
Base flood	A flood having a one percent chance of being equaled or exceeded in any given year. This is also referred to as the 100-year flood.
Base flood elevation	The water surface elevation of the base flood. It shall be referenced to the National Geodetic Vertical Datum of 1929 (NGVD). For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey Website at http:// www.ngs.noaa.gov/
Baseflow	Portion of flow that comes from groundwater.
Baseline sample	A sample collected during dry-weather flow (i.e., it does not consist of runoff from a specific precipitation event).
Basic treatment	Treatment of stormwater using a Stormwater Treatment BMP chosen and sized to meet the basic treatment performance goal.
Basic treatment performance goal	The intent of a Stormater Treatment BMP to achieve 80% removal of total suspended solids for influent concentrations that are greater than 100 mg/l, but less than 200 mg/l. For influent concentrations greater than 200 mg/l, a higher treatment goal may be appropriate. For influent concentrations less than 100 mg/l, the BMP is intended to achieve an effluent goal of 20 mg/l total suspended solids.
Basin	An area draining to a particular outfall.
Bedrock	The more or less solid rock in place either on or beneath the surface of the earth. It may be soft, medium, or hard and have a smooth or irregular surface.
Bench	A relatively level step excavated into earth material on which fill is to be placed.

Beneficial uses	Uses of waters of the State, which include but are not limited to: use for domestic, stock watering, industrial, commercial, agricultural, irrigation, mining, fish and wildlife maintenance and enhancement, recreation, generation of electric power and preservation of environmental and aesthetic values, and all other uses compatible with the enjoyment of the public waters of the State.
Berm	A constructed barrier of compacted earth, rock, or gravel. In a stormwater facility, a berm may serve as a vertical divider typically built up from the bottom.
Best available science	The technical provisions in this manual represent common provisions for the protection of waters of the state from adverse impacts of urban stormwater. Implementation of these provisions is necessary to minimize project-specific and cumulative impacts on waters of the state. This manual reflects the best available science and practices related to protection of water quality. The manual will incorporate new information as it becomes available and allow alternative practices that provide equal or greater protection for waters of the state.
Best management practice (BMP)	The schedules of activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices, that when used singly or in combination, prevent or reduce the release of pollutants and other adverse impacts to waters of Washington State.
Biochemical oxygen demand (BOD)	An indirect measure of the concentration of biologically degradable materials present in organic wastes. The amount of free oxygen utilized by aerobic organisms when allowed to attack the organic material in an aerobically maintained environment at a specified temperature (20°C) for a specific time period (5 days), and thus stated as BOD5. It is expressed in milligrams of oxygen utilized per liter of liquid waste volume (mg/l) or in milligrams of oxygen per kilogram of waste solution (mg/kg = ppm = parts per million parts). Also called biological oxygen demand.
Biodegradable	Capable of being readily broken down by biological means, especially by microbial action. Microbial action includes the combined effect of bacteria, fungus, flagellates, amoebae, ciliates, and nematodes. Degradation can be rapid or may take many years depending upon such factors as available oxygen and moisture.
Bioengineering	The combination of biological, mechanical, and ecological concepts (and methods) to control erosion and stabilize soil through the use of vegetation or in combination with construction materials.

Biofilter	A designed treatment facility using a combined soil and vegetation system for filtration, infiltration, adsorption, and biological uptake of pollutants in stormwater when runoff flows over and through. Vegetation growing in these facilities acts as both a physical filter which causes gravity settling of particulates by regulating velocity of flow, and also as a biological sink when direct uptake of dissolved pollutants occurs. The former mechanism is probably the most important in western Washington where the period of major runoff coincides with the period of lowest biological activity.
Biofiltration	The process of reducing pollutant concentrations in water by filtering the polluted water through biological materials.
Biological control	A method of controlling pest organisms by means of introduced or naturally occurring predatory organisms, sterilization, the use of inhibiting hormones, or other means, rather than by mechanical or chemical means.
Bioretention	Engineered facilities that store and treat stormwater by passing it through a specified soil profile, and either retain or detain the treated stormwater for full infiltration or flow attenuation.
Biosolids	Municipal sewage sludge that is a primarily organic, semisolid product resulting from the wastewater treatment process, that can be beneficially recycled and meets all applicable requirements under Chapter 173-308 WAC. Biosolids include a material derived from biosolids and septic tank sludge, also known as septage, that can be beneficially recycled and meets all applicable requirements under Chapter 173-308 WAC. For the purposes of Chapter 173-308 WAC, semisolid products include biosolids or products derived from biosolids ranging in character from mostly liquid to fully dried solids.
Bituminous surface treatment	A temporary surface treatment provided to control dust and assist in the control of erosion. An unimproved roadway that receives this treatment does not meet the City of Tacoma Standard Roadway Design. When upgrading from bituminous surface treatment to asphalt or concrete, the surface is considered a new impervious surfaces.
Bollard	A post (may or may not be removable) used to prevent vehicular access.
Breast height	See Diameter at Breast Height.
Buffer	The area adjacent to a critical or sensitive area for which location and limits are described by federal, state, or local jurisdictions and intent is ensuring protection of the critical area by separating incompatible use from the critical or sensitive area.

Building setback line (BSBL)	A line measured parallel to a property, easement, stormwater facility, or buffer boundary, that delineates the area (defined by the distance of separation) where buildings or other obstructions are prohibited (including decks, patios, outbuildings, or overhangs beyond 18 inches). Wooden or chain link fences and landscaping are allowable within a building setback line. In this manual the minimum building setback line shall be 5 feet.
Catch basin	A chamber or well, usually built at the curb line of a street, for the admission of stormwater or surface water to the stormwater system, having at its base a sediment sump designed to retain grit and detritus below the point of overflow.
Cation Exchange Capacity (CEC)	The degree to which a soil can absorb and exchange cations, at a given pH. Typically defined in milliequivalents per 100 grams of soil (meq/100 g soil). Soil found to have a CEC of 5 meq at pH 7 will have CEC <5 meq when pH <7.
Certified Erosion and Sediment Control Lead (CESCL)	An individual who is knowledgeable in the principles and practices of erosion and sediment control. The CESCL must have the skills to assess: the site conditions and construction activities that could impact the quality of the stormwater; and the effectiveness of erosion and sediment control measures used to control the quality of stormwater discharges. The CESCL must have current certification through an approved erosion and sediment control training program that meets the minimum training standards established by Ecology. See BMP C160: Certified Erosion and Sediment Control Lead for more information.
Certified Professional in Erosion and Sediment Control (CPESC)	An individual who has educational training, expertise and experience in controlling erosion and sedimentation, and has met certification standards. The CPESC shall have a current certification through a program approved by Ecology.
Channel	A feature that conveys stormwater and surface water and is open to the air.
Channel, constructed	Channels constructed (or reconstructed natural channels) to convey stormwater and surface water.
Channel, natural	Channels that convey stormwater and surface water and have existed long enough to establish a stable route and/or biological community.
Channel stabilization	Erosion prevention and stabilization of velocity distribution in a channel using vegetation, jetties, drops, revetments, and/or other measures.
Channelization	Alteration of a stream channel by widening, deepening, straightening, cleaning, or paving certain areas which changes characteristics.

Check dam	Small dam constructed in a gully, swale, or other small watercourse to decrease the streamflow velocity, minimize channel scour, and promote deposition of sediment.
Chemical oxygen demand (COD)	A measure of the amount of oxygen required to oxidize organic and oxidizable inorganic compounds in water. The COD test, like the BOD test, is used to determine the degree of pollution in water.
Chip Seal	In the City of Tacoma, chip sealing is a maintenance practice currently used to extend the life of existing asphalt or concrete roadways. The practice involves applying asphalt emulsion and chip rock to the existing asphalt or concrete section. On roadways that have received a chip seal maintenance application, when overlaying with asphalt or concrete, the overlain sections of roadway will not be considered new or replaced impervious surfaces and will not be counted toward the project thresholds.
City Block	A City block shall be defined by existing arterial or residential roads. A City block shall not be defined by alleys.
Cleared Areas	An area where vegetation has been removed by manual, mechanical, or chemical means.
Clearing	The destruction and removal of vegetation by manual, mechanical, or chemical methods.
Closed depression	An area which is low-lying and either has no, or such a limited, outlet that during storm events the area acts as a retention basin.
Cohesion	The capacity of a soil to resist shearing stress, exclusive of functional resistance.
Coliform bacteria	Microorganisms common in the intestinal tracts of man and other warm-blooded animals; all the aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C. Used as an indicator of bacterial pollution.
Commercial agriculture	Those activities conducted on lands defined in RCW 84.34.020(2), and activities involved in the production of crops or livestock for commercial trade. An activity ceases to be considered commercial agriculture when the area on which it is conducted is proposed for conversion to a nonagricultural use or has lain idle for more than five (5) years, unless the idle land is registered in a federal or state soils conservation program, or unless the activity is maintenance of irrigation ditches, laterals, canals, or conveyance ditches related to an existing and ongoing agricultural activity.
Commercial	Not considered residential, industrial or road-related. Multifamily is considered commercial where the term commercial is used throughout this document.

Common Plan of Development or Sale

A site where multiple separate and distinct construction activities may be taking place at different times on different schedules and/or by different contractors, but still under a single plan. Examples include:

1. Phased projects and projects with multiple filings or lots, even if the separate phases or filings/lots will be constructed under separate contract or by separate owners (e.g., a plat or short plat where lots are sold to separate builders).
2. A development plan that may be phased over multiple years, but is still under a consistent plan for long-term development.
3. New development or redevelopment in contiguous areas that may be unrelated but still under the same contract, such as construction of a building extension and a new parking lot at the same facility.
4. New development or redevelopment on contiguous lots that are not associated with a land use action, that are owned by a single entity, even if construction on the lots will not occur at the same time.
5. New development or redevelopment on non-contiguous lots that are located on the same City block and discharge to the same threshold discharge area, owned by a single entity, even if construction will not occur at the same time.
6. New development or redevelopment on linear projects such as roads, pipelines, or utilities.

If the project is part of a common plan of development or sale, the disturbed area of the entire plan must be used to determine permit requirements. Conveyances into different ownership for the ostensible purpose of avoiding more comprehensive stormwater review and requirements, or where an innocent conveyance has this effect, may be considered to be part of a Common Plan of Development or Sale and reviewed by the City of Tacoma for cumulative impacts.

Compaction

The densification, settlement, or packing of soil in such a way that permeability of the soil is reduced. Compaction effectively shifts the performance of a hydrologic group to a lower permeability hydrologic group. For example, a group B hydrologic soil can be compacted and be effectively converted to a group C hydrologic soil in the way it performs in regard to runoff.

Compaction may also refer to the densification of a fill by mechanical means.

Compost	Organic material that has undergone biological degradation and transformation under controlled conditions designed to promote aerobic decomposition at a solid waste facility in compliance with the requirements of Chapter 173-350 WAC, or biosolids composted in compliance with Chapter 173-308 WAC. Composting is a form of organic material recycling. Natural decay of organic solid waste under uncontrolled conditions does not result in composted material. (Note: Various BMPs have restrictions on the percentage of biosolids in compost or do not allow biosolids in compost.)
Composting	The biological degradation and transformation of organic solid waste under controlled conditions designed to promote aerobic decomposition. Natural decay of organic solid waste under uncontrolled conditions is not composting.
Conservation district	A public organization created under state enabling law as a special-purpose district to develop and carry out a program of soil, water, and related resource conservation, use, and development within its boundaries, usually a subdivision of state government with a local governing body and always with limited authority. Often called a soil conservation district or a soil and water conservation district.
Constructed wetland	Artificial wetlands created where wetlands do not currently exist for managing stormwater discharges. Constructed wetlands are considered part of the stormwater system.
Construction Stormwater Pollution Prevention Plan (SWPPP)	A document that describes the potential for pollution problems on a construction project and explains and illustrates the measures to be taken on the construction site to control those problems.
Contour	An imaginary line on the surface of the earth connecting points of the same elevation.
Contributing area	The geographical limits of an area that provides stormwater and surface water to a common location such as an outlet, discharge location, or stormwater facility.
Converted vegetation (areas)	The surfaces on a project site where native vegetation, pasture, scrub/shrub, uncultivated vegetation, or unmaintained non-native vegetation (e.g., Himalayan blackberries, scotch broom) are converted to lawn or landscaped areas, or where native vegetation is converted to pasture.
Conveyance	A mechanism for transporting water from one point to another, including pipes, ditches, and channels.

Conveyance system	The stormwater system components, both natural and artificial, which collect, contain, and provide for the flow of surface and stormwater from the highest points on the land down to a receiving waterbody. The natural elements of the conveyance system include natural channels, streams, rivers, lakes, and wetlands. The artificial elements of the conveyance system include gutters, ditches, pipes, channels, and most retention/detention facilities.
Critical Areas	At a minimum, areas which include wetlands, stream corridors, areas with a critical recharging effect on aquifers used for potable water, fish and wildlife habitat conservation areas, frequently flooded areas, geologically hazardous areas, including unstable slopes, and associated areas and ecosystems.
Critical root zone (CRZ)	An area equal to 1-foot radius from the base of the tree's trunk for each 1-inch of the tree's diameter at 4.5 feet above grade (diameter at breast height).
Crown (pipe)	The highest point of the internal surface of the transverse cross section of a pipe.
Crown (tree)	The upper part of the tree, measured from the lowest branch, including all the branches and foliage.
Culvert	Pipe or concrete box structure that conveys stormwater or surface water under a roadway or embankment. Typically with no catchbasins or manholes along its length.
Cut	Portion of land surface or area from which earth has been removed or will be removed by excavating; the depth below original ground surface to excavated surface.
Cut-and-fill	Process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas.
Cut slope	A slope formed by excavating overlying material to connect the original ground surface with a lower ground surface created by the excavation. A cut slope is distinguished from a bermed slope, which is constructed by importing soil to create the slope.
Dangerous waste	According to RCW 70.105.010, any discarded, useless, unwanted, or abandoned substances, including, but not limited to, certain pesticides, or any residues or containers of such substances that are disposed of in such quantity or concentration as to pose a substantial, present, or potential hazard to human health, wildlife, or the environment. These wastes may have short-lived, toxic properties that may cause death, injury, or illness or have mutagenic, teratogenic, or carcinogenic properties; or be corrosive, explosive, flammable; or may generate pressure through decomposition or other means. See also Hazardous waste.
Dead storage	The volume available in a depression below an elevation that could allow discharge from that depression.

Deciduous	A tree that sheds foliage at the end of the growing season.
Dedication of land	Refers to setting aside a portion of a property for a specific use or function.
Degradation	(Biological or chemical) The breakdown of complex organic or other chemical compounds into simpler substances, usually less harmful than the original compound, as with the degradation of a persistent pesticide. (Geological) Wearing down by erosion. (Water) The lowering of the water quality of a watercourse by an increase in the pollutant loading.
Degraded wetland	A wetland (community) whose functions and values have been reduced as a result of human activities. For example, a wetland in which the vegetation, soils, and/or hydrology have been adversely altered, resulting in lost or reduced functions and values; generally, implies topographic isolation; hydrologic alterations such as hydroperiod alteration (increased or decreased quantity of water), diking, channelization, and/or outlet modification; soils alterations such as presence of fill, soil removal, and/or compaction; accumulation of toxicants in the biotic or abiotic components of the wetland; and/or low plant species richness with dominance by invasive weedy species.
Depressional wetland	A wetland where the elevation of the surface within the wetland is lower than the surrounding landscape. These wetlands often pond water at the surface but they can also be saturated without surface ponding
Design engineer	The Washington State Licensed Professional Engineer who prepares the analysis, design, and engineering plans for an applicant's permit or approval submittal.
Design storm	A prescribed hyetograph or precipitation distribution and the total precipitation amount (for a specific duration recurrence frequency) used to estimate runoff for a hypothetical storm of interest or concern for the purposes of analyzing existing stormwater flow characteristics, designing stormwater systems or assessing other impacts of a proposed project on the flow of surface water.
Design storm frequency	The anticipated period in years that will elapse, based on the average probability of storms in the design region, before a storm of a given intensity and/or total volume will recur. Thus a 10-year storm can be expected to occur on the average once every 10 years; the same storm has a 10% chance of occurring each year. Facilities designed to handle flows that occur under such storm conditions would be expected to be surcharged by any storms of greater amount or intensity.
Detention	The release of stormwater runoff from the site at a slower rate than it is collected by the stormwater facility system, the difference being held in temporary storage.

Detention	An above or below ground facility, such as a pond or tank, that temporarily stores stormwater runoff and subsequently releases it at a slower rate than it is collected by the drainage facility system. There is little or no infiltration of stored stormwater.
Detention time	The theoretical time required to displace the contents of a stormwater treatment facility at a given rate of discharge (volume divided by rate of discharge).
Determination of Nonsignificance (DNS)	The written decision by the responsible official of the lead agency that a proposal is not likely to have a significant adverse environmental impact, and therefore an EIS is not required.
Development	Means new development, redevelopment, or both. See definitions for each.
Diameter at breast height (DBH)	Diameter of the tree trunk from 4.5 feet above the ground.
Direct discharge	Stormwater that discharges directly from a pipe into a waterbody. The Minimum Requirements are based upon the first receiving waterbody encountered along the discharge path whether or not the discharge is direct or indirect.
Discharge	Runoff leaving a site via overland flow, built conveyance systems, or infiltration facilities. A hydraulic rate of flow, specifically fluid flow; a volume of fluid passing a point per unit of time, commonly expressed as cubic feet per second, cubic meters per second, gallons per minute, gallons per day, or millions of gallons per day.
Discharge location	The location where runoff leaves a site or stormwater system.
Dispersion	Release of surface and stormwater runoff from a drainage facility system such that the flow spreads over a wide area and is located so as not to allow flow to concentrate anywhere upstream of a conveyance channel with erodible underlying granular soils.
Disturb	See Land Disturbing Activity
Ditch	A natural or artificial channel used for the purposes of conveying stormwater and surface waters. A ditch top width is less than 10 feet at design flow.
Drain	A buried pipe or other conduit (closed drain).
Drain (To)	To provide channels, such as open ditches or closed drains, so that excess water can be removed by surface flow or by internal flow. To lose water (from the soil) by percolation.
Drainage	Stormwater and surface water related.

Drainage, Soil

As a natural condition of the soil, soil drainage refers to the frequency and duration of periods when the soil is free of saturation; for example, in well-drained soils the water is removed readily but not rapidly; in poorly drained soils the root zone is waterlogged for long periods unless artificially drained, and the roots of ordinary crop plants cannot get enough oxygen; in excessively drained soils the water is removed so completely that most crop plants suffer from lack of water. Strictly speaking, excessively drained soils are a result of excessive runoff due to steep slopes or low available water-holding capacity due to small amounts of silt and clay in the soil material. The following classes are used to express soil drainage:

- Well drained - Excess water drains away rapidly and no mottling occurs within 36 inches of the surface.
- Moderately well drained - Water is removed from the soil somewhat slowly, resulting in small but significant periods of wetness. Mottling occurs between 18 and 36 inches.
- Somewhat poorly drained - Water is removed from the soil slowly enough to keep it wet for significant periods but not all of the time. Mottling occurs between 8 and 18 inches.
- Poorly drained - Water is removed so slowly that the soil is wet for a large part of the time. Mottling occurs between 0 and 8 inches.

Very poorly drained - Water is removed so slowly that the water table remains at or near the surface for the greater part of the time. There may also be periods of surface ponding. The soil has a black to gray surface layer with mottles up to the surface.

Drawdown

Lowering of the water surface (in open channel flow), water table or piezometric surface (in groundwater flow) resulting from a withdrawal of water.

Dripline

The area on the ground below the tree in which the boundary is designated by an imaginary line defined by the edge of the tree’s branch spread.

Drywell

An underground structure that disposes unwanted water. A drywell receives water from entry pipes located at the top of the facility. Typically, drywells are deeper than they are wide and they typically do not contain perforated pipe to distribute water evenly.

Earth material

Any rock, natural soil or fill and/or any combination thereof. Earth material shall not be considered topsoil used for landscape purposes. Topsoil used for landscaped purposes shall comply with ASTM D 5268 specifications. Engineered soil/landscape systems are also defined independently.

Easement

The legal right to use a parcel or portion of land for a particular purpose. It does not include fee ownership, but may restrict the owners use of the land.

Effective Impervious Surface	Those impervious surfaces that are connected via sheet flow or discrete conveyance to a stormwater system. -Impervious surfaces are considered ineffective if: • The runoff is fully dispersed in accordance with BMP L614 – Full Dispersion, or • Residential Roof Runoff is infiltrated in accordance with BMPL602: Downspout Full Infiltration Systems, or • All runoff from the impervious surface is infiltrated (i.e. approved continuous runoff modeling methods indicate the entire runoff file is infiltrated).
Embankment	A structure of earth, gravel, or similar material raised to form a pond bank or foundation for a road.
Emergent plants	Aquatic plants that are rooted in the sediment but whose leaves are at or above the water surface. These wetland plants often have high habitat value for wildlife and waterfowl, and can aid in pollutant uptake.
Emergency spillway	A channel used to safely convey flood discharges in excess of the capacity of the principal spillway.
Emerging technology	Stormwater treatment technologies that are currently being evaluated for performance or have been evaluated for performance and have achieved a use level designation following the Technology Assessment Protocol – Ecology (TAPE).
Energy dissipater	Any means by which the total energy of flowing water is reduced. In stormwater design, they are usually mechanisms that reduce velocity prior to, or at, discharge from an outfall in order to prevent erosion. They include rock splash pads, drop manholes, concrete stilling basins or baffles, and check dams.
Energy gradient	The slope of the specific energy line (i.e., the sum of the potential and velocity heads).
Engineer of Record	The Washington State Licensed Professional Engineer who seals the final engineering specifications, reports, drawings, plans, design information, and calculations.

Engineered soil/ landscape system

This is a self-sustaining soil and plant system that simultaneously supports plant growth, soil microbes, water infiltration, nutrient and pollutant adsorption, sediment and pollutant biofiltration, water interflow, and pollution decomposition. The system shall be protected from compaction and erosion. The system shall be planted and/or mulched as part of the installation. This definition is not to be used for engineered soils if used for treatment.

The engineered soil/plant system shall have the following characteristics:

- Be protected from compaction and erosion.
- Have a plant system to support a sustained soil quality.
- Possess permeability characteristics of not less than 6.0, 2.0, and 0.6 inches/hour for hydrologic soil groups A, B, and C, respectively (per ASTM D 3385). D is less than 0.6 inches/ hour.
- Possess minimum percent organic matter of 12, 14, 16, and 18 percent (dry-weight basis) for hydrologic soil groups A, B, C, and D, respectively (per ASTM D 2974).

Engineering plan

A plan prepared and stamped by a Washington State Licensed Professional Engineer.

Enhancement

To raise value, desirability, or attractiveness of an environment associated with surface water.

Ephemeral wetland

Wetlands that temporarily hold water in the spring and early summer or after heavy rains. Periodically, these wetlands dry up, often in mid to late summer.

Erodible or leachable materials

Wastes, chemicals, or other substances that measurably alter the physical or chemical characteristics of runoff when exposed to rainfall. Examples include erodible soils that are stockpiled, uncovered process wastes, manure, fertilizers, oily substances, ashes, kiln dust, and materials that contribute to garbage dumpster leakage.

Erosion

The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. Also, detachment and movement of soil or rock fragments by water, wind, ice, or gravity. The following terms are used to describe different types of water erosion:

- **Accelerated erosion** - Erosion much more rapid than normal or geologic erosion, primarily as a result of the influence of the activities of man or, in some cases, of the animals or natural catastrophes that expose bare surfaces (e.g., overgrazing, fires).
- **Geological erosion** - The normal or natural erosion caused by geological processes acting over long geologic periods and resulting in the wearing away of mountains, the building up of floodplains, coastal plains, etc. Synonymous with natural erosion.
- **Gully erosion** - The erosion process whereby water accumulates in narrow channels and, over short periods, removes the soil from this narrow area to considerable depths, ranging from 1 to 2 feet to as much as 75 to 100 feet.
- **Natural erosion** - Wearing away of the earth's surface by water, ice, or other natural agents under natural environmental conditions of climate, vegetation, etc., undisturbed by man. Synonymous with geological erosion.
- **Rill erosion** - An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently disturbed and exposed soils. See Rill.
- **Sheet erosion** - The removal of a fairly uniform layer of soil from the land surface by runoff.
- **Splash erosion** - The spattering of small soil particles caused by the impact of raindrops on wet soils. The loosened and spattered particles may or may not be subsequently removed by surface runoff.

Erosion and sediment control

Any temporary or permanent measures taken to reduce erosion; control siltation and sedimentation; and ensure that sediment-laden water does not leave the site.

Erosion and sediment control facility

A component of the stormwater system designed to hold water for a period of time to allow sediment contained in the surface and stormwater runoff directed to the facility to settle out , filter, or change chemically so as to improve the quality of the runoff.

Estuarine wetland

Wetlands where salt tolerant plant species dominate and the water regime is influenced by tidal action. The wetlands are usually partially enclosed by land with open, or partially obstructed access to open saline water. Salinity is greater than 0.5 ppt.

Evapotranspiration

The collective term for the processes of evaporation and plant transpiration by which water is returned to the atmosphere.

Evergreen	A tree having foliage that persists and remains green throughout the year.
Excavation	The mechanical removal of earth material.
Exception	Relief from the application of a Minimum Requirement to a project.
Existing land cover condition, also existing site condition	The impervious surfaces, drainage systems, land cover, native vegetation, and soils that exist at a site prior to any changes associated with achieving the proposed development conditions. For a phased project, the proposed development condition is the final built condition not an interim condition created for construction related purposes (for example if an early grade and fill permit allows for gravel surfacing but the ultimate plan is construction of a building, the existing condition would not be the gravel surface but the surface that existed before that gravel surface was installed.) If sites have impervious areas and drainage systems that were built without approved permits, the existing condition is defined as those that existed prior 1995 (the year of the first Municipal Stormwater Permit issued to the City). Existing conditions may be verified using aerial photography or other records.
Existing hard surfaces	The hard surfaces, that exist at a site prior to any changes associated with achieving the proposed development conditions. For a phased project, the proposed development condition is the final built condition not an interim condition created for construction related purposes (for example if an early grade and fill permit allows for gravel surfacing but the ultimate plan is construction of a building, the existing condition would not be the gravel surface but the surface that existed before that gravel surface was installed.) If sites have hard surfaces that were built without approved permits, the existing condition is defined as those that existed prior 1995 (the year of the first Municipal Stormwater Permit issued to the City). Existing conditions may be verified using aerial photography or other records.
Fertilizer	Any material or mixture used to supply one or more of the essential plant nutrient elements.
Fill	A deposit of earth material placed by artificial means.
Filter fabric	A woven or non-woven, water-permeable material generally made of synthetic products such as polypropylene and used in stormwater management and erosion and sediment control applications to trap sediment or prevent the clogging of aggregates by fine soil particles.
Filter strip	A grassy area with gentle slopes that treats stormwater runoff from adjacent paved areas before it concentrates into a discrete channel or is discharged via sheet flow.
Final Stabilization	The completion of all soil disturbing activities at the site and the establishment of a permanent vegetative cover or equivalent permanent stabilization measure (pavement, riprap) which will prevent erosion.

Fish-Bearing stream	Tacoma has the authority to declare a stream as fish-bearing based on readily available data. According to WAC 222-16-030: Type S, F, and Np waters are fish habitat streams. Until these fish habitat water type maps are available, an interim water typing system applies (see WAC 222-16-031): Type 1, 2, 3, and 4 waters are fish habitat streams.
Flocculation	The process by which suspended colloidal or very fine particles are assembled into larger masses or floccules which eventually settle out of suspension. This process occurs naturally but can also be caused through the use of such chemicals as alum.
Flood	An overflow or inundation that comes from a river or any other source, including (but not limited to) streams, tides, wave action, conveyance systems, or excess rainfall. Any relatively high stream flow overtopping the natural or artificial banks in any reach of a stream.
Flood control	Methods or facilities for reducing flood flows and the extent of flooding.
Flood fringe	That portion of the floodplain outside of the floodway which is covered by floodwaters during the base flood; it is generally associated with slower moving or standing water rather than rapidly flowing water.
Flood hazard areas	Those areas subject to inundation by the base flood. Includes, but is not limited to streams, lakes, wetlands, and closed depressions.
Floodplain	The total area subject to inundation by a flood including the flood fringe and floodway.
Floodway	The channel of the river or stream and those portions of the adjoining floodplains that are reasonably required to carry and discharge the base flood flow. The portions of the adjoining floodplains which are considered to be "reasonably required" is defined by flood hazard regulations.
Flow control based perfomance standard	A performance standard that is based on the volume and/or velocity of flow, which must be met by using Flow Control BMPs. Examples of Flow Control based performance standards are: The LID Performance Standard in Volume 1, Section 1.3.5 MR#5: On-Site Stormwater Management The Flow Control Performance Standard in Volume 1, Section 1.3.7.4 MR#7: Flow Control Hydroperiod protection requirements in Volume 1, Section 1.3.8 MR#8: Wetlands Protection

Flow Control Exempt Threshold Discharge Area

A threshold discharge area (TDA) is flow control exempt if stormwater from that TDA discharges directly or indirectly to saltwater bodies or the Puyallup River (if located outside the City of Tacoma limits see Appendix I-A of Ecology's 2024 Stormwater Management Manual for Western Washington) and all the following restrictions are met:

- Direct discharges to the saltwater body or Puyallup River does not result in the diversion of drainage from any perennial stream classified as Types 1, 2, 3, or 4 in the State of Washington Interim Water Typing System, or Types "S", "F", or "Np" in the Permanent Water Typing System, or from any category I, II, or III wetland.

- If flow splitters or conveyance elements are applied to route natural runoff volumes from the TDA to any downstream Type 5 stream or category IV wetland, then:
  - Design of the flow splitters or conveyance elements must be based on approved continuous simulation modeling analysis. The design must assure that flows delivered to Type 5 stream reaches will approximate, but in no case exceed, durations ranging from 50% of the 2-year to the 50-year peak flow.
  - Flow splitters and conveyance elements that deliver flows to category IV wetlands must also be designed using approved continuous simulation modeling to preserve pre-project wetland hydrologic conditions unless specifically waived or exempted by regulatory agencies with permitting jurisdiction.
- Stormwater and surface water from the TDA must discharge to a conveyance system that is comprised entirely of artificial conveyance elements (e.g., pipes, ditches, outfall protection) and extends to the ordinary high water mark (of the mean higher high water mark for tidally influenced exempt receiving waters) of the exempt receiving water. To avoid construction activities in sensitive areas, an alternative to extending the conveyance system to the ordinary high water mark is to ensure that flows are properly dispersed before reaching the buffer zone of the sensitive or critical area.

- The conveyance system between the TDA and the exempt receiving water shall have sufficient hydraulic capacity to convey discharges from future build-out conditions (under current zoning) from contributing areas of the Site, and the existing conditions from contributing off-site areas.

- Any erodible elements of the artificial conveyance system must be adequately stabilized to prevent erosion under the conditions noted above.

Flow Control Exempt Waterbody

A project is flow control exempt if stormwater from that project discharges directly or indirectly to saltwater bodies, or the Puyallup River (if located outside the City of Tacoma limits see Appendix I-A of Ecology's 2024 Stormwater Management Manual for Western Washington) and all the following restrictions are met:

- Direct discharge to the saltwater body, or the Puyallup River does not result in the diversion of stormwater and surface water from any perennial stream classified as Types 1, 2, 3, or 4 in the State of Washington Interim Water Typing System, or Types "S", "F", or "Np" in the Permanent Water Typing System, or from any category I, II, or III wetland.
- If flow splitters or conveyance elements are applied to route natural runoff volumes from the project to any downstream Type 5 stream or category IV wetland, then:
  - Design of the flow splitters or conveyance elements must be based on approved continuous simulation modeling analysis. The design must assure that flows delivered to Type 5 stream reaches will approximate, but in no case exceed, durations ranging from 50% of the 2-year to the 50-year peak flow.
  - Flow splitters and conveyance elements that deliver flows to category IV wetlands must also be designed using approved continuous simulation modeling to preserve pre-project wetland hydrologic conditions unless specifically waived or exempted by regulatory agencies with permitting jurisdiction.
- Stormwater and surface water from the project (or TDA) must discharge to a conveyance system that is comprised entirely of artificial conveyance elements (e.g., pipes, ditches, outfall protection) and extends to the ordinary high water water mark (of the mean higher high water mark for tidally influenced exempt receiving waters) of the exempt receiving water. To avoid construction activities in sensitive areas, an alternative to extending the conveyance system to the ordinary high water mark is to ensure that flows are properly dispersed before reaching the buffer zone of the sensitive or critical area.
- The conveyance system between the project and the exempt receiving water shall have sufficient hydraulic capacity to convey discharges from future build-out conditions (under current zoning) from contributing areas of the Site, and the existing conditions from contributing off-site areas.
- Any erodible elements of the artificial conveyance system must be adequately stabilized to prevent erosion under the conditions noted above.

Flow control facility A stormwater facility designed to mitigate the impacts of increased surface and stormwater flowrates generated by development. Flow control facilities are designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and/or infiltration into the ground, or to hold runoff for a short period of time, releasing it to the conveyance system at a controlled rate.

Flow duration The aggregate time that peak flows are at or above a particular flowrate of interest. For example, the amount of time that peak flows are at or above 50% of the 2-year peak flowrate for a period of record.

Flow frequency The inverse of the probability that the flow will be equaled or exceeded in any given year (the exceedance probability). For example, if the exceedance probability is 0.01 or 1 in 100, that flow is referred to as the 100-year flow.

Flowpath The route that stormwater runoff follows between two points of interest.

Footing drain Also called a foundation drain, is a pipe or trench system located on the outer face of the building foundation wall installed to collect stormwater and surface waters away from the building.

Forebay An easily maintained, extra storage area provided near an inlet of a BMP to trap incoming sediments before they accumulate in a pond or wetland BMP.

Forest practice Any activity conducted on or directly pertaining to forest land and relating to growing, harvesting, or processing timber, including but not limited to:

- Road and trail construction.
- Harvesting, final and intermediate.
- Precommercial thinning.
- Reforestation.
- Fertilization.
- Prevention and suppression of diseases and insects.
- Salvage of trees.
- Brush control.

Freeboard The vertical distance between the design water surface elevation and the elevation of the crest of the facility

Frequently flooded areas The 100-year floodplain designations of the Federal Emergency Management Agency and the National Flood Insurance Program or as defined by the local government.

Frequency of storm (design storm frequency)	The anticipated period in years that will elapse, based on average probability of storms in the design region, before a storm of a given intensity and/or total volume will recur; thus a 10-year storm can be expected to occur on the average once every 10 years. Conveyance or facilities designed to handle flows that occur under such storm conditions would be expected to be surcharged by any storms of greater amount or intensity.
Fully Stabilized	See Final Stabilization
Gabion	A rectangular or cylindrical wire mesh cage (a chicken wire basket) filled with rock and used as a protecting agent, revetment, etc., against erosion. Soft gabions, often used in streambank stabilization, are made of geotextiles filled with dirt, in between which cuttings are placed.
Gage or gauge	A device for registering precipitation, water level, discharge, velocity, pressure, temperature, etc. Also, a measure of the thickness of metal; e.g., diameter of wire, wall thickness of steel pipe.
Geologically hazardous areas	Areas that, because of their susceptibility to erosion, sliding, earthquake, or other geological events, are not suited to the siting of commercial, residential, or industrial development consistent with public health or safety concerns.
Grade	The slope of a road, channel, or natural ground. The finished surface of a canal bed, roadbed, top of embankment, or bottom of excavation; any surface prepared for the support of construction such as paving or the laying of a conduit.
Grade (To)	To finish the surface of a canal bed, roadbed, top of embankment or bottom of excavation.
Gradient terrace	An earth embankment or a ridge-and-channel constructed with suitable spacing and an acceptable grade to reduce erosion damage by intercepting surface runoff and conducting it to a stable outlet at a stable nonerosive velocity.
Grassed waterway	A natural or constructed waterway, usually broad and shallow, covered with erosion-resistant grasses, used to conduct surface water from an area at a reduced flowrate. See also biofilter.
Groundwater	Water in a saturated zone or stratum beneath the land surface or below a surface waterbody.
Groundwater Protection Area	A geographic area that is by or close by a surrounding community and nontransient noncommunity water system, that uses groundwater as a source of drinking water (40 C.F.R. 144.87) and other sensitive groundwater areas critical to protecting underground sources of drinking water from contamination; such as sole source aquifers, highly productive aquifers supplying private wells, critical aquifer recharge areas and/or other state and local areas determined by state and local governments.

Groundwater recharge	Inflow to a groundwater reservoir.
Groundwater table	The free surface of the groundwater, that surface subject to atmospheric pressure under the ground, generally rising and falling with the season, the rate of withdrawal, the rate of restoration, and other conditions. It is seldom static.
Gully	A channel caused by the concentrated flow of surface and stormwater runoff over unprotected erodible land.
Habitat	The specific area or environment in which a particular type of plant or animal lives. An organism's habitat must provide all of the basic requirements for life and should be protected from harmful biological, chemical, and physical alterations.
Hardpan	A cemented or compacted and often clay-like layer of soil that is impenetrable by roots. Also known as glacial till.
Hard Surface	An impervious surface, a permeable pavement or a vegetated roof.
Hazardous Subtance	Any liquid, solid, gas, or sludge, including any material, substance, product, commodity, or waste, regardless of quantity, that exhibits any of the physical, chemical, or biological properties described in WAC 173-303-090 or WAC 173-303-100. See also Dangerous waste.
Hazardous Waste	According to RCW 70.105.010, all dangerous and extremely hazardous waste, including substances composed of both radioactive and hazardous components. See also Dangerous waste.
Head (hydraulics)	The height of water above any plane of reference. The energy, either kinetic or potential, possessed by each unit weight of a liquid, expressed as the vertical height through which a unit weight would have to fall to release the average energy possessed. Used in various compound terms such as pressure head, velocity head, and head loss.
Head loss	Energy loss due to friction, eddies, changes in velocity, or direction of flow.
Heavy metals	Metals of high specific gravity, present in municipal and industrial wastes, that pose long-term environmental hazards. Such metals include antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, thallium, and zinc.
High-ADT roadways and parking areas	Any road with average daily traffic (ADT) > 30,000 vehicles; and parking areas with either more than 100 trip ends per 1,000 square feet of gross building area or > 300 total trip ends are high-use traffic areas. Examples include commercial buildings with a frequent turnover of customers and other visitors.

High-use site A site that typically generates high concentrations of oil due to high traffic turnover or the frequent transfer of oil and/or other petroleum products. High-use sites include:

- An area of a commercial or industrial site subject to an expected average daily traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area or 300 total trips ends per day;
- An area of a commercial or industrial site subject to petroleum storage and transfer in excess of 1,500 gallons per year, not including routinely delivered heating oil;
- An area of a commercial or industrial site subject to parking, storage or maintenance of 25 or more vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.);
- A road intersection with a measured ADT count of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use.

Highway A main public road connecting towns and cities.

Hog fuel See wood-based mulch.

Hydraulic Conductivity The quality of saturated soil that enables water or air to move through it. Also known as permeability coefficient.

Hydraulic gradient Slope of the potential head relative to a fixed datum.

Hydrodynamics The science involving the energy and forces acting on water or other liquids and the resulting impact on the motion of the liquid.

Hydrograph A graph of runoff rate, inflow rate or discharge rate, past a specific point over time.

Hydrologic cycle The circuit of water movement from the atmosphere to the earth and return to the atmosphere through various stages or processes as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.

Hydrologic Soil Groups

A soil characteristic classification system defined by the U.S. Soil Conservation Service in which a soil may be categorized into one of four soil groups (A, B, C, or D) based upon infiltration rate and other properties.

Type A: Low runoff potential. Soils having high infiltration rates, even when thoroughly wetted, and consisting chiefly of deep, well drained to excessively drained sands or gravels. These soils have a high rate of water transmission.

Type B: Moderately low runoff potential. Soils having moderate infiltration rates when thoroughly wetted, and consisting chiefly of moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Type C: Moderately high runoff potential. Soils having slow infiltration rates when thoroughly wetted, and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine textures. These soils have a slow rate of water transmission.

Type D: High runoff potential. Soils having very slow infiltration rates when thoroughly wetted, and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a hardpan, till, or clay layer at or near the surface, soils with a compacted subgrade at or near the surface, and shallow soils or nearly impervious material. These soils have a very slow rate of water transmission.[1]

[1] Vladimir Novotny and Harvey Olem. *Water Quality Prevention, Identification, and Management of Diffuse Pollution,* Van Nostrand Reinhold: New York, 1994, p. 109.

Hydrology

The science of the behavior of water in the atmosphere, on the surface of the earth, and underground.

Hydroperiod

A seasonal occurrence of flooding and/or soil saturation; it encompasses depth, frequency, duration, and seasonal pattern of inundation.

Hyetograph

A graph of percentages of total precipitation for a series of time steps representing the total time in which precipitation occurs.

Illicit discharge

Any spill or direct or indirect discharge to the stormwater system, groundwater, or receiving waters that is not composed entirely of stormwater or of non-stormwater discharges as allowed in Tacoma Municipal Code Chapter 12.

Impaired waters

Water bodies that do not fully support their beneficial uses.

Impervious

Not allowing penetration.

Impervious surface A surface area which either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development. A surface area which causes water to run off the surface in greater quantities or at an increased rate of flow from the flow present under natural conditions prior to development. Common impervious surfaces include, but are not limited to, rooftops, walkways, patios, driveways, parking lots or storage areas, concrete or asphalt paving, gravel roads, packed earthen materials, and oiled, macadam or other surfaces which similarly impede the natural infiltration of stormwater.

Open, uncovered retention/detention facilities shall not be considered as impervious surfaces for the purposes of determining whether the thresholds for application of minimum requirements are exceeded. Open, uncovered retention/detention facilities shall be considered impervious surfaces for purposes of runoff modeling.

When an underdrain is used below an artificial turf surface, that surface shall be considered (and modeled) as impervious surface.

Impoundment A natural or artificial containment for surface water.

Improvements The term “improvements” may refer to existing improvements or improvement projects.

Existing improvements include streets (with or without curbs or gutters), sidewalks, crosswalks, parking lots, water mains, sanitary and storm sewers, drainage facilities, street trees and other appropriate items.

Improvement projects replace paved or other impervious areas with a better surface, and/or in a way that enhances the traffic-carrying capacity of a road or parking area and/or improves safety.

Indirect connections Stormwater discharges that do not discharge directly into a waterbody, but travel through other conveyance systems before reaching that waterbody.

Indirect discharge Stormwater that discharges indirectly to a waterbody. This typically means the stormwater has entered a conveyance system before discharging into that waterbody. The Minimum Requirements are based upon the first receiving waterbody encountered along the discharge path whether or not the discharge is direct or indirect.

Industrial activities	Material handling, transportation, or storage; manufacturing; maintenance; treatment; or disposal. Areas with industrial activities include plant yards, access roads and rail lines used by carriers of raw materials, manufactured products, waste material, or by-products; material handling sites; refuse sites; sites used for the application or disposal of process waste waters; sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas for raw materials, and intermediate and finished products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to stormwater.
Industrial sites	Those sites zoned industrial or with industrial activities. These include areas that manufacture, process, or store raw materials.
Infiltration	Means the downward movement of water from the surface to the subsoil.
Infiltration facility (or system)	A stormwater facility designed to use the hydrologic process of surface and stormwater runoff soaking into the ground, commonly referred to as a percolation, to dispose of surface and stormwater runoff.
Infiltration rate	The rate, usually expressed in inches/hour, at which water moves downward (percolates) through the soil profile. Short-term infiltration rates may be inferred from soil analysis or texture or derived from field measurements. Long-term infiltration rates are affected by variability in soils and subsurface conditions at the site, the effectiveness of pretreatment or influent control, and the degree of long-term maintenance of the infiltration facility. The short-term infiltration rate is sometimes referred to as the native infiltration rate. The long-term infiltration rate is sometimes referred to as the design infiltration rate as it takes into account safety factors that should be considered in design.
Ingress/egress	The points of access to and from a property.
Inlet	A form of connection between surface of the ground and an above or below ground stormwater system for the admission of surface and stormwater runoff.
Insecticide	A substance, usually chemical, that is used to kill insects.
Integrated Pest Management (IPM)	A natural, long-term ecologically based approach to controlling pest populations.
Interception (Hydraulics)	The process by which precipitation is caught and held by foliage, twigs, and branches of trees, shrubs, and other vegetation. Often used for "interception loss" or the amount of water evaporated from the precipitation intercepted.

Interflow	That portion of rainfall that infiltrates into the soil and moves laterally through the upper soil horizons until intercepted by a stream channel or until it returns to the surface for example, in a roadside ditch, wetland, spring or seep. Interflow is a function of the soil system depth, permeability, and water-holding capacity.
Intermittent stream	A stream or portion of a stream that flows only in direct response to precipitation. It receives little or no water from springs and no long-continued supply from melting snow or other sources. It is dry for a large part of the year, ordinarily more than three months.
Invasive plant species	As defined in Tacoma Municipal Code 13, a plant species that has negative environmental, economical, recreational, and/or public health impacts that overcome native plants or ornamental landscaping for resources.
Invasive Species	Nonnative organisms whose introduction causes or is likely to cause economic or environmental harm or harm to human, animal or plant health.
Invert	The lowest point on the inside of a pipe.
Invert elevation	The vertical elevation of the pipe invert.
Lag time	The interval between the center of mass of the storm precipitation and the peak flow of the resultant runoff.
Lake	A natural area permanently inundated by water in excess of two meters deep and greater than 20 acres in size as measured at the ordinary high water marks.
Lake Fringe Wetland	Wetlands that are on the water side of the Ordinary High Water Mark (OHWM) of lakes where the area of open water next to a vegetated wetland is larger than 20 ac (8ha), and more than 6.6 feet deep over 30% of the open water areas.
Land disturbing activities	Any activity that results in a change in the existing soil cover (both vegetative and non-vegetative) and/or existing soil topography. Land disturbing activities include, but are not limited to clearing, grading, filling, and excavation. Compaction that is associated with stabilization of structures and road construction shall also be considered a land disturbing activity. Vegetation maintenance practices, including landscape maintenance and gardening, are not considered land disturbing activity if conducted according to established standards and procedures. Stormwater BMP/facility maintenance is not considered land disturbing activity if conducted according to established standards and procedures.
Landscape unit	An area of land that has a specified boundary used for planning purposes that defines an area of interrelated physical, chemical, and biological processes. A watershed or drainage basin is a common type of landscape unit. A ground-water aquifer is another type of landscape unit.

Landscaped Areas	Vegetation, including but not limited to, annuals, woody and herbaceous perennials such as shrubs, vines, or trees that are regularly and/or systematically maintained through a combination of pruning, mowing, watering, trimming, fertilizing, and other activities. Landscaped areas are typically used for aesthetic purposes. Rockscaped areas are considered landscaped areas.
Landslide	Episodic downslope movement of a mass of soil or rock that includes but is not limited to rockfalls, slumps, mudflows, and earthflows. For the purpose of these rules, snow avalanches are considered to be a special case of landsliding.
Landslide hazard areas	Those areas subject to a severe risk of landslide.
Lawn Areas	An area of land planted with grasses or other durable plants which are maintained at a short height and used for aesthetic and/or recreational purposes. The definition also includes turf surfaces, artificial lawn surfaces, and artificial turf surfaces. When an underdrain is used below an artificial turf surface, that surface shall be considered (and modeled) as impervious surface.
Leachable materials	Those substances that, when exposed to rainfall, measurably alter the physical or chemical characteristics of the rainfall runoff. Examples include erodible soils, uncovered process wastes, manure, fertilizers, oil substances, ashes, kiln dust, and materials contributing to garbage dumpster leakage.
Leachate	Any liquid that in passing through matter, extracts solutes, suspended solids or any other component of the material through which it has passed.
Leaching	Removal of the more soluble materials from the soil or other material by percolating waters.
Legume	A member of the legume or pulse family, Leguminosae, one of the most important and widely distributed plant families. The fruit is a "legume" or pod. Includes many valuable food and forage species, such as peas, beans, clovers, alfalfas, sweet clovers, and vetches. Practically all legumes are nitrogen-fixing plants.
Level spreader	A device used to spread out stormwater runoff uniformly over the ground surface as sheet flow (i.e., not through channels). The purpose of level spreaders is to prevent concentrated, erosive flows from occurring, and to enhance infiltration.
Local government	Any county, city, town, or special purpose district having its own incorporated government for local affairs.
Local jurisdiction	Any county, city, town, or special-purpose district having its own incorporated government for local affairs.

Low-ADT roadways and parking areas	Urban roads with average daily traffic (ADT) fewer than 7,500 vehicles, rural roads and freeways with ADT < 15,000 vehicles, and parking areas with both < 40 trip ends per 1,000 square feet of gross building area and < 100 total trip ends per day are considered low-use traffic areas. Examples include most residential parking and employee-only parking areas for small office parks or other commercial buildings. Urban roads are located within designated Urban Growth Management Areas; rural roads are located outside designated Urban Growth Management Areas. Freeways may be located either inside or outside Urban Growth Management Areas.
Low impact development	A stormwater and land use management strategy that strives to mimic predisturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration by emphasizing conservation, use of onsite natural features, site planning, and distributed stormwater management practices that are integrated into a project design.
Low Impact Development Best Management Practices (LID BMPs)	Distributed stormwater management practices, integrated into a project design, that emphasize predisturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration. LID BMPs include, but are not limited to, bioretention, rain gardens, permeable pavements, roof downspout infiltration and dispersion, perforated stub-outs, dispersion, soil quality and depth, minimal excavation foundations, vegetated roofs, and water reuse.
Low Impact Development Principles	Land use management strategies that emphasize conservation, use of onsite natural features, and site planning to minimize impervious surfaces, native vegetation loss and stormwater runoff.
Low permeability liner	A layer of earthen material, concrete, or a geomembrane.
Maintenance	Repair and maintenance includes activities conducted on currently serviceable structures, facilities, and equipment that involves no expansion or use beyond that previously existing and results in no significant adverse hydrologic impact. It includes those usual activities taken to prevent a decline, lapse, or cessation in the use of structures and systems and includes replacement of dysfunctioning facilities, including cases where environmental permits require replacing an existing structure with a different type structure, as long as the functioning characteristics of the original structure are not changed. For example, replacing a collapsed, fish blocking, round culvert with a new box culvert under the same span, or width, of roadway. For stormwater facilities, maintenance includes assessment to ensure ongoing proper operation, removal of built up pollutants (i.e., sediments), replacement of failed or failing treatment media, and other actions taken to correct deficits as identified in the maintenance standards, Volume 4. See exemptions for Pavement Maintenance, Volume 1.

Manning's equation

An equation used to predict the velocity of water flow in an open channel or pipelines:

$$V = \frac{1.486 R^{2/3} S^{1/2}}{n}$$

where:

V is the mean velocity of flow in feet per second

R is the hydraulic radius in feet

S is the slope of the energy gradient or, for assumed uniform flow, the slope of the channel in feet per foot; and

n is Manning's roughness coefficient or retardance factor of the channel lining.

Mature tree

A tree that has achieved at least 75% of its full canopy growth or a tree that is over 15 years of age.

Mature tree spread

Crown diameter at maturity.

Maximum Extent Practicable (MEP)

Refers to paragraph 402(p)(3)(B)(iii) of the federal Clean Water Act which reads as follows: Permits for discharges from municipal storm sewers shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques, and system design and engineering methods, and other such provisions as the Administrator or the State determines appropriate for the control of such pollutants.

Mean annual water level fluctuation

Derived as follows:

1. Measure the maximum water level (e.g., with a crest stage gage, Reinelt and Horner 1990) and the existing water level at the time of the site visit (e.g., with a staff gage) on at least eight occasions spread through a year.
2. Take the difference of the maximum and existing water level on each occasion and divide by the number of occasions.

Mean depth

Average depth; cross-sectional area of a stream or channel divided by its surface or top width.

Mean velocity

The average velocity of a stream flowing in a channel or conduit at a given cross-section or in a given reach. It is equal to the discharge divided by the cross-sectional area of the reach.

Metals

Elements, such as mercury, lead, nickel, zinc and cadmium, which are of environmental concern because they do not degrade over time. Although many are necessary nutrients, they are sometimes magnified in the food chain, and they can be toxic to life in high enough concentrations. They are also referred to as heavy metals.

Microbes The lower trophic levels of the soil food web. They are normally considered to include bacteria, fungi, flagellates, amoebae, ciliates, and nematodes. These in turn support the higher trophic levels, such as mites and earthworms. Together they are the basic life forms that are necessary for plant growth. Soil microbes also function to bioremediate pollutants such as petroleum, nutrients, and pathogens.

Mitigation To lessen known impacts to the environment. Mitigation should be conducted in the following order of preference:

1. Avoiding the impact altogether by not taking a certain action or part of an action;
2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts;
3. Rectifying the impact by repairing, rehabilitating or restoring the affected environment;
4. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and
5. Compensating for the impact by replacing, enhancing, or providing substitute resources or environments.

Modification A change to a design standard that is not considered an Exception or Adjustment.

Modified wetland A wetland whose physical, hydrological, or water quality characteristics have been purposefully altered for a management purpose, such as by dredging, filling, forebay construction, and inlet or outlet control.

Monitor To systematically and repeatedly measure something in order to track changes.

Monitoring The collection of data by various methods for the purposes of understanding natural systems and features, evaluating the impacts of development proposals on such systems, and assessing the performance of mitigation measures imposed as conditions of development.

Mulch	A layer of organic material or aggregate applied to the surface of soil. Its purpose is any or all of the following: • To conserve soil moisture or temperature • To improve the fertility and health of the soil • To reduce weed growth • To hold fertilizer, seed, and soil in place. • To enhance aesthetics of the facility. Types of mulch include: chipped site vegetation, compost, hydromulch, wood-based mulch or wood straw, wood strand, straw, and aggregate.
Multi-family	When there are 4 or more residential dwelling units on a single parcel of land. Multi-family is considered commercial where the term commercial is used throughout this document.
NGVD	National Geodetic Vertical Datum.
National Pollutant Discharge Elimination System (NPDES)	The part of the federal Clean Water Act, which requires point source dischargers to obtain permits. These permits are referred to as NPDES permits and, in Washington State, are administered by the Washington State Department of Ecology.
Native Growth Protection Easement (NGPE)	An easement granted for the protection of native vegetation within a sensitive area or its associated buffer. The NGPE shall be recorded on the appropriate documents of title and filed with the County Assessor.
Native Soil	The soil that is present before any construction associated with the project begins on the site.
Native Soil Infiltration Rate	The infiltration rate of the soil that is present before construction associated with the project begins on the site.
Native vegetation	Vegetation comprised of plant species, other than noxious weeds, that are indigenous to the coastal region of the Pacific Northwest and which reasonably could have been expected to naturally occur on the site. Examples include trees such as Douglas fir, Western Hemlock, Western Red Cedar, Alder, Big-leaf Maple, and Vine Maple; shrubs such as willow, elderberry, salmonberry and salal; and herbaceous plants such as sword fern, foam flower, and fireweed.
Natural Area	Land on which the existing plants arose naturally, or were planted intentionally to mimic natural processes.
Natural conditions	Surface water quality present before any human-caused pollution. When estimating natural conditions in the headwaters of a disturbed watershed, it may be necessary to use the less disturbed conditions of a neighboring or similar watershed as a reference condition.

Natural location

The location of those channels, swales, and other non-artificial conveyance systems as defined by the first documented topographic contours existing for the subject property, either from maps or photographs, or such other means as appropriate. Based upon site geology and the infiltration capability of the underlying soils, there may be no discernible surface discharge.

New development

- Land Disturbing Activities, including Class IV – general forest practices that are conversions from timber land to other uses
- Structural development, including construction or installation of a building or other structure.
- Creation of hard surfaces
- Subdivision, short subdivision, and binding site plans as defined and applied in Chapter 58.17 RCW.
- Site Plan Approval per Tacoma Municipal Code 13.

Projects meeting the definition of redevelopment shall not be considered new development

New Hard Surface

A surface that is:

- upgraded from dirt to: gravel, bituminous surface treatment (“chip seal”), asphalt, concrete, permeable pavement, a structure with a vegetated roof, or an impervious structure; or
- upgraded from gravel to: bituminous surface treatment, asphalt, concrete, permeable pavement, a structure with a vegetated roof, or an impervious structure; or
- upgraded from bituminous surface treatment to: asphalt, concrete, permeable pavement, a structure with a vegetated roof, or an impervious structure.

Note that if asphalt or concrete has been overlaid by a chip seal or bituminous surface treatment, the existing condition should be considered as asphalt or concrete.

Asphalt or concrete overlays will not be considered a new or replaced impervious surface and will not be counted toward project thresholds provided the characteristics of the roadway are not changed, the capacity is not increased, and the area of coverage is not expanded. Overlaying permeable or pervious pavements with traditional (non-permeable) asphalt or concrete will be considered a new impervious surface, and the stormwater mitigation provided by the overlain permeable surface shall be replaced.

New Impervious Surface

A surface that is:

- changed from a pervious surface to an impervious surface; or
- upgraded from dirt to: gravel, a bituminous surface treatment, asphalt, concrete, or an impervious structure; or
- upgraded from gravel to: bituminous surface treatment, asphalt, concrete, or an impervious structure; or
- upgraded from bituminous surface treatment to: asphalt, concrete, or an impervious structure.

Note that if asphalt or concrete has been overlaid by a chip seal or bituminous surface treatment, the existing condition should be considered as asphalt or concrete.

Asphalt or concrete overlays will not be considered a new or replaced impervious surface and will not be counted toward project thresholds provided the characteristics of the roadway are not changed, the capacity is not increased, and the area of coverage is not expanded. Overlaying permeable or pervious pavements with traditional (non-permeable) asphalt or concrete will be considered a new impervious surface, and the stormwater mitigation provided by the overlain permeable surface shall be replaced.

Nitrogen, Available

Usually ammonium, nitrite, and nitrate ions, and certain simple amines available for plant growth. A small fraction of organic or total nitrogen in the soil is available at any time.

Nonendangerment standard

Activities that prevent the movement of fluid containing any contaminant into the groundwater if the contaminant may cause a violation of the Water Quality Standards for groundwaters of the state of Washington, Chapter 173-200 WAC, or may cause health concerns.

Non-fish-bearing stream

According to WAC 222-16-030: Type Ns waters are nonfish habitat streams. Until fish habitat water type maps are available, an interim water typing system applies (see WAC 222-16-031): Type 5 waters are nonfish habitiat streams.

Nonpoint source pollution

Pollution that enters a waterbody from diffuse origins on the watershed and does not result from discernible, confined, or discrete conveyances.

Nonpollution-generating surface

A surface considered to be an insignificant source of pollutants in stormwater and/or a surface that is not defined as a pollution-generating surface.

Nutrients

Essential chemicals needed by plants and animals for growth. Excessive amounts of nutrients can lead to degradation of water quality and algal blooms. Some nutrients can be toxic at high concentrations.

Off-line facilities	Stormwater facilities to which stormwater runoff is restricted to some maximum flowrate or volume by a flow-splitter.
Offsite	Any area lying upstream of the site that drains onto the site and any area lying downstream of the site to which the site drains.
Oil	Oil of any kind or any form, including, but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil.
Oil Mat	A surface treatment that creates a permanent unyielding non-skid roadway similar to asphalt or concrete and is considered a City of Tacoma Standard Roadway Design. When overlaying an oil mat surface with asphalt or concrete, the surface will not be considered a new or replaced surface and will not count toward the project thresholds. See Volume 1, Section 1.1.2 for Pavement Maintenance Exemptions.
Oil/water separator	A vault, usually underground, designed to provide a quiescent environment to separate oil from water.
On-line facilities	Stormwater facilities which receive all of the stormwater runoff from a contributing area. Flows above the water quality design flowrate or volume are passed through at a lower percent removal efficiency.
Onsite	The entire property that includes any proposed development.
Onsite Stormwater Management BMPs	Development and mitigation techniques that serve to infiltrate, disperse, and retain stormwater runoff on a project site.
Operational BMPs	Operational BMPs are a type of Source Control BMP. They are schedules of activities, prohibition of practices, and other managerial practices to prevent or reduce pollutants from entering stormwater. Operational BMPs include formation of a pollution prevention team, good housekeeping, preventive maintenance procedures, spill prevention and clean-up, employee training, inspections of pollutant sources and BMPs, and record keeping. They can also include process changes, raw material/product changes, and recycling wastes.

Ordinary high water mark

The term ordinary high water mark means the line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank; shelving; changes in the character of soil destruction on terrestrial vegetation, or the presence of litter and debris; or other appropriate means that consider the characteristics of the surrounding area.

The ordinary high water mark will be found by examining the bed and banks of a stream and ascertaining where the presence and action of waters are so common and usual, and so long maintained in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland, in respect to vegetation. In any area where the ordinary high water mark cannot be found, the line of mean high water shall substitute. In any area where neither can be found, the channel bank shall be substituted. In braided channels and alluvial fans, the ordinary high water mark or substitute shall be measured so as to include the entire stream feature.

Organic matter

Organic matter as decomposed animal or vegetable matter. It is measured by ASTM D 2974. Organic matter is an important reservoir of carbon and a dynamic component of soil and the carbon cycle. It improves soil and plant efficiency by improving soil physical properties including infiltration capability, aeration, and other structural characteristics. It contains the nutrients, microbes, and higher-form soil food web organisms necessary for plant growth. The maturity of organic matter is a measure of its beneficial properties. Raw organic matter can release water-soluble nutrients (similar to chemical fertilizer). Beneficial organic matter has undergone a humification process either naturally in the environment or through a composting process.

Orifice

An opening with closed perimeter, usually sharp-edged, and of regular form in a plate, wall, or partition through which water may flow, generally used for the purpose of measurement or control of water.

Outfall

A point source as defined by 40 CFR 122.2 at the point where a discharge leaves the Permittee's MS4 and enters a surface receiving waterbody or surface receiving waters. Outfall does not include pipes, tunnels, or other conveyances which connect segments of the same stream or other surface waters and are used to convey primarily surface waters (i.e., culverts).

Outlet

Point of water disposal from a stream, river, lake, tidewater, or artificial conveyance system.

Outlet channel

A waterway constructed or altered primarily to carry water from artificial structures, such as terraces, tile lines, and diversions.

Outwash soils

Soils formed from highly permeable sands and gravels.

Overflow

A channel or device that allows that portion of flow above the design flowrate to discharge downstream.

Overlay	Placement of an additional layer of asphalt or concrete over existing asphalt or concrete. An overlay can be done when the existing asphalt or concrete is in overall good condition with minor problem areas (e.g, severe cracking, crumbling, sinking, or wavy).
Overtopping	To flow over the limits of a containment or conveyance element.
Particle Size	The effective diameter of a particle as measured by sedimentation, sieving, or micrometric methods.
Pasture	Land (typically grass) used for domestic grazing animals.
Pavement Preservation	A program employing a network level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety and meet motorist expectations. Pavement preservation includes pavement maintenance activities (such as crack sealing, chip sealing, concrete joint sealing), minor rehabilitation activities (such as grind and overlay, overlay), and routine or corrective maintenance activities (such as pothole patching, square patching, overlays, maintenance of pavement markings).
Peak discharge	The maximum instantaneous rate of flow during a storm, usually in reference to a specific design storm event.
Peat Wetland	Unique, irreplaceable bogs and fens that can exhibit pH in a wide range from highly acidic to alkaline.
Percolation	The movement of water through soil.
Perennial stream	A stream reach that does not go dry during a year of normal precipitation: the elevation of the water table is always above the bottom of the stream channel during a year of normal precipitation.
Perennial Wetland	Wetlands where at least a portion of their area has permanent surface water (i.e., flooded or inundated throughout the year), in a normal water year or wetter.
Permeable pavement	Pervious concrete, porous asphalt, permeable pavers, permeable interlocking concrete pavements, or other forms of pervious or porous paving material intended to allow passage of water through the pavement section. It often includes an aggregate base that provides structural support and acts as a stormwater reservoir.
Permeable soils	Soil materials with a sufficiently rapid infiltration rate so as to greatly reduce or eliminate surface and stormwater runoff. These soils are generally classified as SCS hydrologic soil types A and B.
Person	Any individual, partnership, co-partnership, firm, company, association, joint stock company, trust, estate, society, corporation, group, government, governmental agency or other legal entity, or their legal representatives, agents or assigns. This definition includes all federal, state, and local government entities.

Pervious surface	Any surface material that allows stormwater to infiltrate into the ground. Examples include lawn, landscape, pasture, native vegetation areas, and permeable pavements.
Pesticide	A general term used to describe any substance - usually chemical - used to destroy or control organisms; includes herbicides, insecticides, algicides, fungicides, and others. Many of these substances are manufactured and are not naturally found in the environment. Others, such as pyrethrum, are natural toxins that are extracted from plants and animals.
pH	The negative logarithm of the effective hydrogen ion concentration or hydrogen activity in gram equivalents per liter used in expressing both acidity and alkalinity on a scale whose values run from 0 to 14, with 7 representing neutrality, numbers less than 7 increasing acidity and numbers greater than 7 increasing alkalinity.
Physiographic	Characteristics of the natural physical environment (including hills).
Plat	A map or representation of a subdivision showing the division of a tract or parcel of land into lots, blocks, streets, or other divisions and dedications.
Point discharge	The release of collected and/or concentrated surface and stormwater runoff from a pipe, culvert, or channel.
Point of compliance	The location at which compliance with a discharge performance standard or a receiving water quality standard is measured.
Polishing	Additional treatment of a waste stream that has already received one or more stages of treatment by other means.
Pollution	Contamination or other alteration of the physical, chemical, or biological properties, of waters of the state, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive or other substance into any waters of the state as will or is likely to create a nuisance or render such waters harmful, detrimental or injurious to the public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish or other aquatic life.
Pollution-generating hard surface (PGHS)	Those hard surfaces considered to be a significant source of pollutants in stormwater runoff. PGHS includes permeable pavement subject to vehicular use. See the listing of surfaces under pollution generating impervious surfaces.

Pollution-generating impervious surface (PGIS)

Those impervious surfaces considered to be a significant source of pollutants in stormwater runoff. Such surfaces include:

- those which are subject to vehicular use (as further defined in the glossary);
- those which are subject to industrial activities (as further defined in the glossary);
- those which are subject to storage of erodible or leachable materials, wastes, or chemicals, and which receive direct rainfall or the run-on or blow-in of rainfall;
- metal roofs unless they are coated with an inert, non-leachable material;
- roofs that are subject to venting significant amounts of dusts, mists, or fumes from manufacturing, commercial, or other indoor activities.
- Artificial turf with underdrains.

Pollution-generating pervious surface (PGPS)

Any non-impervious surface subject to any of the following:

- vehicular use (as further defined in the glossary);
- industrial activities (as further defined in the glossary);
- storage of erodible or leachable materials, wastes, or chemicals, and which receive direct rainfall or the run-on or blow-in of rainfall;
- use of pesticides and fertilizers; or
- loss of soil.

Artificial turf of any kind without an underdrain system is also considered to be PGPS.

Typical PGPS include permeable pavements subject to vehicular use, lawn and landscaped areas including: golf courses, parks, cemeteries, and sports fields (natural and artificial turf). Artificial turf of any kind without an underdrain is considered PGPS.

Predeveloped Condition

The native vegetation and soils that existed at a site prior to the influence of Euro-American settlement. The predeveloped condition shall be assumed to be forested land cover unless reasonable, historic information is provided that indicates the site was prairie prior to settlement.

Preservation maintenance

A preservation or maintenance project is defined as preserving/ protecting infrastructure by rehabilitating or replacing existing structures to maintain operational and structural integrity, and for the safe and efficient operation of the facility. Traffic area maintenance projects do not increase the traffic-carrying capacity of a roadway or parking area.

Pretreatment

Function performed by a BMP to remove at least 50% of total suspended solids.

Priority peat systems Unique, irreplaceable fens that can exhibit water pH in a wide range from highly acidic to alkaline, including fens typified by Sphagnum species, Ledum groenlandicum (Labrador tea), Drosera rotundifolia (sundew), and Vaccinium oxycoccos (bog cranberry); marl fens; estuarine peat deposits; and other moss peat systems with relatively diverse, undisturbed flora and fauna. Bog is the common name for peat systems having the Sphagnum association described, but this term applies strictly only to systems that receive water income from precipitation exclusively.

Process wastewater The used water and solids from an industrial source. This water should be directed to a treatment facility and kept separate from the stormwater generated from the site.

Project

Any proposed action to alter or develop a site. The proposed action of a permit application or an approval which requires stormwater mitigation review.

Projects can be defined by:

- Common Plans of Development (definition in glossary)
- Land Use Actions, excluding Boundary Line Adjustments (BLAs)
- New development or redevelopment on contiguous or non-contiguous parcels that are permitted under a single permit number or that are part of a subdivision regardless of ownership.
- Other City departmental conditions and review (e.g. offsite improvements are imposed on multiple parcels)

Single Family/Duplex Projects can be defined by:

- Land Use Actions, excluding Boundary Line Adjustments
- New development or redevelopment on contiguous or non-contiguous parcels that are permitted under a single permit number or that are part of a subdivision regardless of ownership.
- Other City departmental conditions and review (e.g. offsite improvements are imposed on multiple parcels)

Land use actions that would affect if a proposed development is a project include, without limitation, plats, short plats, site specific rezones, wetland development permits, conditional use permits, shoreline development permits, and SEPA, if the intent of those land use actions is to develop the affected parcel, parcels or right of way. All other land use permits may create a project depending upon the project scope proposed in the land use action.

Conveyances into different ownership for the ostensible purpose of avoiding more comprehensive stormwater review and requirements, or where an innocent conveyance has this effect, may be considered to be part of a project and reviewed by the City of Tacoma for cumulative impacts.

The City of Tacoma reserves the right to make the final determination of what is considered to be the project. The City will consider other activities that occurred on a site over time when determining what is considered the overall project to ensure Minimum Requirements are being appropriately applied due to when and how applications are received. Note, if work occurred on a site and stormwater mitigation was required but did not occur, those surfaces will be required to be incorporated into the project to ensure appropriate mitigation.

Project site	That portion of a property, properties, and right of way subject to land disturbing activities, new hard surfaces, or replaced hard surfaces. On-site and associated off-site improvements shall be added together when determining if a project site exceeds a threshold. The City of Tacoma reserves the right to make the final determination of the project site.
Properly Functioning Soil System (PFSS)	Equivalent to engineered soil/landscape system. This can also be a natural system that has not been disturbed or modified.
Proposed development condition	The impervious surfaces, drainage systems, land cover, native vegetation, and soils that are proposed to exist at the site at the completion of the project (complete build-out).
Puget Sound basin	Puget Sound south of Admiralty Inlet (including Hood Canal and Saratoga Passage); the waters north to the Canadian border, including portions of the Strait of Georgia; the Strait of Juan de Fuca south of the Canadian border; and all the lands draining into these waters as mapped in Water Resources Inventory Areas numbers 1 through 19, set forth in WAC 173-500-040.
Qualified personnel	Someone who has had professional training in the aspects of stormwater management for which they are responsible and are under the functional control of the Permittee. Qualified Personnel may be staff members, contractors, or trained volunteers with professional certification. Permittees may train and certify volunteers.
Rain Garden	A non-engineered shallow landscaped depression, with compost-amended native soils and adapted plants. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas, and to allow stormwater to pass through the amended soil profile. Refer to the Rain Garden Handbook for Western Washington Homeowners for additional information, http://raingarden.wsu.edu. See BMP L601: Rain Gardens.
Rare, threatened, endangered, or sensitive species	Plant or animal species that are regionally relatively uncommon, are nearing endangered status, or whose existence is in jeopardy and is usually restricted to highly specific habitats. Threatened, endangered, or sensitive species are officially listed by federal and state authorities, whereas rare species are unofficial species of concern that fit the above definitions.
Rational method	A means of computing stormwater flowrates (Q) by use of the formula Q = CIA, where C is a coefficient describing the physical contributing area, I is the rainfall intensity and A is the area.
Reach	A length of channel with uniform characteristics.

Receiving waterbody or Receiving waters

Bodies of surface water to which runoff is discharged via a point source or via sheet flow. Groundwater to which runoff is directed by infiltration.

Additional guidance for new development and redevelopment projects:

- An MS4 is not considered a receiving water. Examples of receiving waters include (but are not limited to) lakes, rivers, streams, wetlands, creeks, and groundwater.
- The project proponent must determine the FIRST receiving water encountered by the discharge(s) from the project site. This is the receiving water that must be considered when determining stormwater requirements per the Minimum Requirements.
- Determining the receiving water that each discharge from the project ultimately reaches is a fundamental step of the stormwater design for the project. The receiving water must be determined in order to evaluate the appropriate levels of protection (i.e. which Minimum Requirements apply, and what types of BMPs are appropriate to comply with those Minimum Requirements). There are no distance thresholds that would negate the need to determine the receiving water for the project.

Recharge

The addition of water to the zone of saturation (i.e., an aquifer).

Recommended BMPs

As used for compliance with Minimum Requirement #3 - Source Control, recommended BMPs (also called Recommended Additional BMPs) are those BMPs that are not expected to be mandatory by local governments at new development and redevelopment sites. However, they may improve pollutant control efficiency, and may provide a more comprehensive and environmentally effective stormwater management program.

Redevelopment

On a site that is already substantially developed (has 35% or more of existing hard surface coverage - when determining percentage only include those areas that are buildable):

- The creation or addition of hard surfaces;
- The expansion of a building footprint or addition or replacement of a structure;
- Structural development including construction, installation or expansion of a building or other structure;
- Replacement of hard surface that is not part of a routine maintenance activity; and
- Land disturbing activities

Regional	An action (here, for stormwater management purposes) that involves more than one discrete property.
Regional stormwater facility	A stormwater facility designed to provide stormwater treatment or flow control for a large region or portion of a basin or subbasin.
Rehabilitation	The manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural or historic hydrologic functions and processes of a degraded wetland. Rehabilitation results in a gain in wetland function but does not result in a gain in wetland area.
Release rate	The computed peak rate of surface and stormwater runoff from a site.
Removed impervious surface	Areas where the impervious surface covering (i.e. building, pavement, gravel, etc.) has been removed, the soil has been amended in accordance with the BMP L613: Post Construction Soil Quality and Depth and the area is left as a permanent pervious surface (landscaping, natural areas) and planted with native vegetation including evergreen trees. Removed impervious surfaces are not required to be added to the impervious area totals to determine compliance with Minimum Requirements #6, #7 and #8.
Replaced hard surface	For structures, the removal down to (i.e. exposing the top of) the foundation and/or slab and replacement. For other hard surfaces, the intentional removal down to (i.e. exposing the top of) bare soil or top of base course layer and replacement, including replacement as required for repairing the base course layer. On redevelopment sites, the construction of a structure over an existing asphalt or concrete surface will not be considered new or replaced hard surfaces and will not count toward project thresholds if the existing underlying asphalt or concrete surface remains in place and undisturbed. See exemptions for Pavement Maintenance, Volume 1, Section 1.1.2
Replaced impervious surface	For structures, the removal down to (i.e. exposing the top of) the foundation and/or slab and replacement. For other impervious surfaces, the intentional removal down to (i.e. exposing the top of) bare soil or top of base course layer and replacement, including replacement as required for repairing the base course layer. On redevelopment sites, the construction of a structure over an existing asphalt or concrete surface will not be considered new or replaced impervious surfaces and will not count toward project thresholds if the existing underlying asphalt or concrete surface remains in place and undisturbed. See exemptions for Pavement Maintenance, Volume 1, Section 1.1.2.
Replaced pollution-generating impervious surface	A replaced impervious surface that is a pollution-generating impervious surface.

Residential	For determining how Minimum Requirements apply, residential shall mean when there are less than 4 residential dwelling units on a single parcel of land. When used as a general descriptor such as residential roof or residential patio it means primarily used for long-term housing.
Restoration (wetland)	Actions performed to reestablish wetland functional characteristics and processes that have been lost by alterations, activities, or catastrophic events in an area that no longer meets the definition of a wetland.
Resurfacing	Also known as a grind and overlay where the existing asphalt or concrete surface is milled or ground down to remove the damaged surface. An asphalt or concrete overlay is then placed. If material must be removed to the top of the base course layer, the activity is considered replacement of a hard surface and subject to the Minimum Requirements as applicable for replaced surfaces.
Retention	The process of collecting and holding surface and stormwater runoff with no surface outflow.
Retention/detention facility (R/D)	A type of stormwater facility designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and/or infiltration into the ground; or to hold surface and stormwater runoff for a short period of time and then release it to the surface and stormwater management system.
Retrofitting	The renovation of an existing structure or facility to meet changed conditions or to improve performance.
Return frequency or recurrence interval	A statistical term for the average expected time interval between events (e.g. flows, floods, droughts, or rainfall) that equal or exceed given conditions.
Rhizome	A modified plant stem that grows horizontally underground.
Rill	A small intermittent watercourse with steep sides, usually only a few inches deep. Often rills are caused by an increase in surface water flow when soil is cleared of vegetation.
Riprap	A facing layer or protective mound of rocks placed to prevent erosion or sloughing of a structure or embankment due to flow of surface and stormwater runoff.
Riparian	Pertaining to the banks of streams, wetlands, lakes, or tidewater.
Riser	A vertical pipe extending from the bottom of a pond BMP that is used to control the discharge rate from a BMP for a specified design storm.

Riverine impounding wetland	Wetlands that retain surface water significantly longer than the duration of the flood event. Riverine impounded wetlands tend to hold water for more than a week after a flood event. These wetlands are found in a topographic depression on the valley floor, or in areas where natural or human made barriers to downstream flow occur.
Riverine wetlands	Riverine wetlands occur in valleys associated with streams or river channels. They lie in the active floodplains of a river, and have important hydrologic links to the water dynamics of the river or stream. The distinguishing characteristic of riverine wetlands in Washington is that they are frequently flooded by overbank flow from the stream or river.
Road Related Project	A project whose objective is the construction or maintenance of elements within the roadway section or right-of-way including the driving surface, sidewalks, bike paths, and pedestrian paths. Sidewalks, bike paths, and pedestrian paths must be associated with an abutting or adjacent driving surface. Roadway elements built as a requirement for onsite actions and permit issuance are not included in this category.
Road Prism	The area containing the road surface (including shoulders and curbs), cut slope and fill slope.
Rodenticide	A substance used to destroy rodents.
Runoff	Water originating from rainfall and other precipitation that is found in stormwater facilities, rivers, streams, springs, seeps, ponds, lakes and wetlands as well as shallow groundwater. As applied in this manual, it also means the portion of rainfall or other precipitation that becomes surface flow and interflow.
Salmonid	A member of the fish family Salmonidae. Chinook, coho, chum, sockeye and pink salmon; cutthroat, brook, brown, rainbow, and steelhead trout; Dolly Varden, kokanee, and char are examples of salmonid species.
Sand filter	An artificial depression or basin with a layer of sand or a sand layer within another facility that treats stormwater as it percolates through the sand and is discharged via a central collector pipe or allowed to infiltrate into the native soil.
Saturated hydraulic conductivity	The ability of a fluid to flow through a porous medium under saturated conditions, which is determined by the size and shape of the pore spaces in the medium and their degree of interconnection and by the viscosity of the fluid. Hydraulic conductivity can be expressed as the volume of fluid that will move during unit of time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow.

Secondary Permittee	An operator of a municipal separate stormwater which is not a city, town, or county. Secondary Permitees include special purpose districts, and other public entities that meet the criteria in Section S1.E.1 of the Washington State Department of Ecology Phase I Municipal Stormwater Permit.
Sensitive area	Any area designated by a federal, state, or local jurisdictions to have unique or important environmental characteristics that may require special additional protective measures. These areas include, but are not limited to, wetlands and their buffer zones, stream riparian areas, wellhead protection areas, and geologic hazard areas. See also Critical areas.
Scour	Erosion of channel banks due to excessive velocity of the flow of surface and stormwater runoff.
SCS (TR-20) Method	A single event hydrologic analysis technique for estimating runoff based on the curve number approach developed by the USDA Soil Conservation Service (SCS) – now called Natural Resource Conservation Service (NCRS).
Seasonal high groundwater	The highest annual groundwater elevation as determined by a Washington State Licensed Professional Engineer, Washington State Licensed Professional Geologist, a Certified Professional Soil Scientist, or a Washington State Licensed Onsite Wastewater Treatment System Designer. Refer to specific BMPs for the method(s) and professional that can be used to determine the seasonal high groundwater level.
Seasonal wetland	A wetland that has water above the soil surface for a period of time (usually between two months to less than one year) during and/or after the wettest season but in typical years dries to or below the soil surface in warmer, drier weather.
Sediment	Fragmented material that originates from weathering and erosion of rocks or unconsolidated deposits, and is transported by, suspended in, or deposited by water.
Sedimentation	The depositing or formation of sediment.
Settleable solids	Those suspended solids in stormwater that separate by settling when the stormwater is held in a quiescent condition for a specified time.
Sheet erosion	The relatively uniform removal of soil from an area without the development of conspicuous water channels.
Sheet flow	Runoff that flows over the ground surface as a thin, even layer, not concentrated in a channel.

Shoreline development

The proposed project as regulated by the Shoreline Management Act. Usually the construction over water or within a shoreline zone (generally 200 feet landward of the water) of structures such as buildings, piers, bulkheads, and breakwaters, including environmental alterations such as dredging and filling, or any project which interferes with public navigational rights on the surface waters.

Short circuiting

The passage of runoff through a BMP in less than the design treatment time.

Siltation

The process by which a river, lake, or other waterbody becomes clogged with sediment. Silt can clog gravel beds and prevent successful salmon spawning.

Site

The area defined by the legal boundaries of a parcel or parcels of land that is (are) subject to new development or redevelopment. For road projects, the length of the project site and the right-of-way boundaries define the site.

A Site may include multiple parcels and/or sections of right-of-way, if multiple parcels and/or sections of right-of-way are subject to the new development or redevelopment project.

Site appropriate development principles

Also known as Low Impact Development Principles are land use management strategies that emphasize conservation, use of onsite natural features, and site planning to minimize impervious surfaces, native vegetation loss, and stormwater runoff. Site appropriate development principles include:

- Minimization of land disturbance by fitting development to the natural terrain
- Minimization of land disturbance by confining construction to the smallest area feasible and away from critical areas
- Preservation of natural vegetation
- Locating impervious surfaces over less permeable soils
- Clustering buildings
- Minimizing impervious surfaces

Slope

Degree of deviation of a surface from the horizontal; measured as a numerical ratio, percent, or in degrees. Expressed as a ratio, the first number is the horizontal distance (run) and the second is the vertical distance (rise), as 2:1. A 2:1 slope is a 50 percent slope. Expressed in degrees, the slope is the angle from the horizontal plane, with a 90° slope being vertical (maximum) and 45° being a 1:1 or 100 percent slope.

Slope wetland	Slope wetlands occur on slopes where groundwater surfaces and begins running along the surface, or immediately below the surface. Water in these wetlands flows only in one direction (down the slope) and the gradient is steep enough that the water is not impounded. The downhill side of the wetland is always the point of lowest elevation in the wetland.
Sloughing	The sliding of overlying material. It is the same effect as caving, but it usually occurs when the bank or an underlying stratum is saturated or scoured.
Soil	The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants. See also topsoil, engineered soil/landscape system, and properly functioning soil system.
Soil disturbing activities	Activities affected by construction activity including clearing, grading, excavation, and any other activity that disturbs the surface of the land including ingress/egress from the site.
Soil group, hydrologic	A classification of soils by the Soil Conservation Service into four runoff potential groups. The groups range from A soils, which are very permeable and produce little or no runoff, to D soils, which are not very permeable and produce much more runoff.
Soil horizon	A layer of soil, approximately parallel to the surface, which has distinct characteristics produced by soil-forming factors.
Soil profile	A vertical section of the soil from the surface through all horizons, including C horizons.
Soil structure	The relation of particles or groups of particles which impart to the whole soil a characteristic manner of breaking; some types are crumb structure, block structure, platy structure, and columnar structure.
Soil permeability	The ease with which gases, liquids, or plant roots penetrate or pass through a layer of soil.
Soil stabilization	The use of measures such as rock lining, vegetation or other engineering structures to prevent the movement of soil when loads are applied to the soil.
Soil stratigraphy	The sequence, spacing, composition, and spatial distribution of sedimentary deposits and soil strata (layers).
Sorption	The physical or chemical binding of pollutants to sediment or organic particles.

Source control BMP	A structure or operation that is intended to prevent pollutants from coming into contact with stormwater through physical separation of areas or careful management of activities that are sources of pollutants. This manual separates source control BMPs into two types. *Structural source control BMPs* are physical, structural, or mechanical devices or facilities that are intended to prevent pollutants from entering stormwater. *Operational BMPs* are non-structural practices that prevent or reduce pollutants from entering stormwater. See Volume 6 for details.
Spill control device	A Tee section or turn down elbow designed to retain a limited volume of pollutant that floats on water, such as oil or antifreeze. Spill control devices are passive and must be cleaned-out for the spilled pollutant to actually be removed.
Spillway	A passage such as a paved or otherwise stabilized apron or channel for surplus water over or around a dam or similar obstruction. An open or closed channel, or both, used to convey excess water from a reservoir. It may contain gates, either manually or automatically controlled, to regulate the discharge of excess water.
Stage excursion	A post-project departure, either higher or lower, from the water depth existing under a given set of conditions in the pre-development state.
Stage-storage-discharge table	Relationship between the stage, or water surface elevation inside a stormwater BMP, and the available storage volume and discharge rates from the BMP. Available storage may include subsurface storage (e.g., storage within the voids of bioretention soil mix or aggregate reservoir layers), as well as surface ponding storage (e.g., surface ponding in a bioretention swale). Discharge may include infiltration to native soils, flow through underdrains, and/or flow-through overflow control structures, based on designs. The stage-storage-discharge table is developed by the designer for use in level-pool routing modeling to size LID BMPs.
Storm frequency	The time interval between major storms of predetermined intensity and volumes of runoff for which stormwater conveyance systems and other structures are designed and constructed to handle hydraulically without surcharging and backflooding, e.g., a 2-year, 10-year or 100-year storm.
Stormwater	That portion of precipitation, including snowmelt, that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, pipes and other features of a stormwater system into a receiving water or stormwater facility.
Stormwater and surface water	Water originating from rainfall and other precipitation, including shallow groundwater that is found in the stormwater system, rivers, streams, springs, seeps, ponds, lakes, and wetlands.
Stormwater system	Constructed and natural features which function together as a system to collect, convey, channel, hold, inhibit, retain, detain, infiltrate, divert, treat or filter stormwater and surface waters.

Stormwater facility	A component of the stormwater system constructed to perform a particular function such as onsite stormwater management, stormwater treatment, flow control, or conveyance.
Stormwater Inlet	An opening that connects stormwater and surface water from the ground surface to an underground or above-ground conveyance system.
Stormwater Management Manual for Western Washington (Stormwater Manual)	The manual prepared by Ecology which contains BMPs to prevent, control or treat pollution in stormwater and reduce other stormwater-related impacts to waters of the State. The Stormwater Manual is intended to provide guidance on measures necessary in western Washington to control the quantity and quality of stormwater runoff from new development and redevelopment. This manual is equivalent to the Ecology manual and must be used for projects located within the City of Tacoma.
Stormwater Site Plan (SSP)	A comprehensive report and drawing set containing all the technical information and analysis necessary to evaluate projects for compliance with the stormwater requirements.
Streams	Those areas where surface waters flow sufficiently to produce a defined channel or bed. Lands and waters contained within a channel which supports hydrophytes and where the substrate is predominantly undrained hydric soils, nonsoil and/or is saturated with water or covered by water each growing season. The channel or bed need not contain water year-round. This definition is not meant to include irrigation ditches, canals, stormwater runoff devices or other entirely artificial watercourses unless they are used to convey streams naturally occurring prior to construction. Those topographic features that resemble streams but have no defined channels (i.e. swales) shall be considered streams when hydrologic and hydraulic analyses done pursuant to a development proposal predict formation of a defined channel after development.
Structure	Any artificial item. Examples include catch basins, manholes, buildings, decks, etc.
Structural source control BMPs	Physical, structural, or mechanical devices or facilities that are intended to prevent pollutants from entering stormwater. Structural source control BMPs typically include: • Enclosing and/or covering the pollutant source (building or other enclosure, a roof over storage and working areas, temporary tarp, etc.). • Segregating the pollutant source to prevent run-on of stormwater, and to direct only contaminated stormwater to appropriate treatment BMPs.
Stub-out	A short length of pipe provided for future connection to the stormwater system.

Subbasin	A drainage area that drains to a water-course or waterbody named and noted on common maps and which is contained within a basin.
Subgrade	A layer of stone or soil used as the underlying base for a BMP or other facility.
Subsoil	The B horizons of soils with distinct profiles. In soils with weak profile development, the subsoil can be defined as the soil below the plowed soil (or its equivalent of surface soil), in which roots normally grow. Although a common term, it cannot be defined accurately. It has been carried over from early days when "soil" was conceived only as the plowed soil and that under it as the "subsoil."
Substrate	The natural soil base underlying a BMP.
Surcharge	The flow condition occurring in closed conduits when the hydraulic grade line is above the crown of the pipe.
Surface water	Waterbodies, such as creek, streams, rivers, lakes, wetlands, estuaries, and marine waters.
Surface waters of the state	All waters defined as “waters of the United States” in 40 CFR 122.2 that are within the boundaries of the state of Washington. This includes lakes, rivers, ponds, streams, inland waters, wetlands, ocean, bays, estuaries, sounds, and inlets.
Suspended solids	Organic or inorganic particles that are suspended in and carried by the water. The term includes sand, mud, and clay particles (and associated pollutants) as well as solids in stormwater.
Swale	A shallow conveyance with relatively gentle side slopes, generally with flow depths less than one foot.
Target surfaces	The new and replaced hard surfaces, converted vegetation areas, and land disturbed that are subject to the Minimum Requirements.
TMC	Tacoma Municipal Code
Terrace	An embankment or combination of an embankment and channel across a slope to control erosion by diverting or storing surface runoff instead of permitting it to flow uninterrupted down the slope.
Threshold Discharge Area	An area within a project site draining to a single natural or constructed discharge location or multiple natural or constructed discharge locations that converge within one-quarter mile downstream (as determined by the shortest flowpath). The examples in Figure G - 1: Threshold Discharge Area illustrate this definition. The purpose of this definition is to clarify how the thresholds of this manual are applied to project sites with multiple discharge locations.

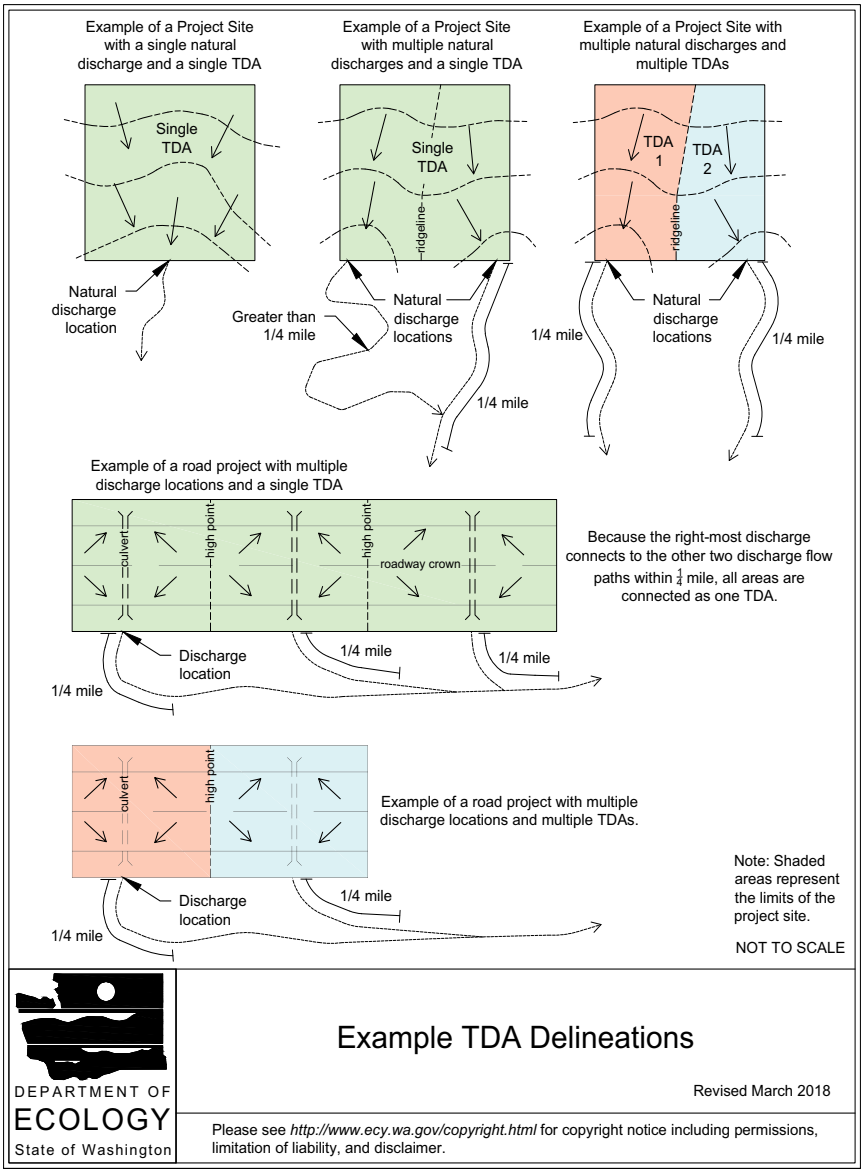

Figure G - 1: Threshold Discharge Area

Tightline A continuous length of pipe that conveys water from one point to another with no inlets or collection points in between.

Till A layer of poorly sorted soil deposited by glacial action that generally has very low infiltration rates.

Time of concentration The time period necessary for surface runoff to reach the outlet of a subbasin from the hydraulically most remote point in the contributing area.

Topography General term to include characteristics of the ground surface such as plains, hills, mountains, degree of relief, steepness of slopes, and other physiographic features.

Topsoil	The upper portion of a soil, usually dark colored and rich in organic material. It is more or less equivalent to the upper portion of an A horizon in an ABC soil.
Total dissolved solids	The dissolved salt loading in surface and subsurface waters.
Total impervious area (TIA)	The total area of surfaces on a developed site that inhibit infiltration of stormwater. The surfaces include, but are not limited to, conventional asphalt or concrete roads, driveways, parking lots, sidewalks, alleys, and rooftops.
Total Petroleum Hydrocarbons (TPH)	A large family of chemical compounds that come from crude oil. Two types important to stormwater include: • TPH-Gx: The qualitative and quantitative method (extended) for volatile (“gasoline”) petroleum products in water; and • TPH-Dx: The qualitative and quantitative method (extended) for semi-volatile (“diesel”) petroleum products in water.
Total solids	The solids in water, sewage, or other liquids, including the dissolved, filterable, and nonfilterable solids. The residue left when the moisture is evaporated and the remainder is dried at a specified temperature, usually 130°C.
Total suspended solids	That portion of the solids carried by stormwater that can be captured on a standard glass filter.
Total Maximum Daily Load (TMDL)	A calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant’s sources. A TMDL (also known as a Water Cleanup Plan) is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the State has designated. The calculation must also account for seasonable variation in water quality. Water quality standards are set by states, territories, and tribes. They identify the uses for each waterbody, for example, drinking water supply, contact recreation (swimming), and aquatic life support (fishing), and the scientific criteria to support those uses. The Clean Water Act, Section 303, establishes the water quality standards and TMDL programs.
Toxic	Poisonous, carcinogenic, or otherwise directly harmful to life.
Track-out	Material such as dirt, mud, and other debris that is deposited outside the project site by vehicles exiting a construction site or a commercial or industrial facility.
Tract	A legally created parcel of property designated for special nonresidential and noncommercial uses.
Transplanting	The process of relocating and planting an existing plant into a landscape. Note: Trees are considered plants.

Transportation safety improvement projects	Projects that improve motorized and/or nonmotorized user safety that do not enhance the traffic capacity of a roadway.
Trash rack	A structural device used to prevent debris from entering a spillway or other hydraulic structure.
Travel time	The estimated time for surface water to flow between two points of interest.
Treatment BMP	A BMP that is intended to remove pollutants from stormwater.
Treatment liner	A layer of soil that is designed to slow the rate of infiltration and provide sufficient pollutant removal so as to protect groundwater quality.
Treatment Soil	Existing or engineered combination of sands and organics that meet Site Suitability Criteria (SSC) for Stormwater Treatment.
Treatment train	A combination of two or more treatment facilities connected in series.
Trip ends	A single or one direction vehicle movement with either the origin or destination being the subject site. Projected trip end counts for the parking area are associated with the proposed land use. Trip end counts shall be estimated using the Trip Generation Manual published by the Institute of Transportation Engineers or a traffic study prepared by a licensed engineer in the state of Washington or a transportation specialist with expertise in traffic volume estimation. Trip end counts shall be made for the design year or expected life of the project (the intent is for treatment facilities to be added in the earliest period of disruptive construction). For project sites with seasonal or varied use, evaluate the highest period of expected traffic impacts.
Trunk main	Publically owned stormwater pipes with inside diameters and minimum slopes as follows: • 54" and greater at a slope greater than or equal to 0.5%
Turbidity	Dispersion or scattering of light in a liquid, caused by suspended solids and other factors; commonly used as a measure of suspended solids in a liquid.
Unconsolidated by glacial advance	Refers to those soil strata that were not overconsolidated (compacted by the weight of the sediment and ice) by the last glacial event. Typically, Qvr (Vashion Recessional Outwash) soils are considered to be unconsolidated by glacial advance whereas Qva (Vashon Advance Outwash) Soils are considered to be overconsolidated by glacial advance.

Uncultivated vegetation	Vegetation, including but not limited to, all annuals, woody and herbaceous perennials such as shrubs, vines or trees that are not regularly or systematically maintained through any combination of the following: pruning, mowing, watering, trimming, fertilizing and any other activity intended to ensure public safety and assist vegetation to achieve full environmental and landscape function.
Underdrain	Subsurface drainage system that is perforated, slotted or otherwise drilled that is designed to collect and remove excess water (stormwater, groundwater, etc.) Underdrains are not intended to to collect and distribute water into the subsurface.
Underground utilities	Underground lines which serve the public with various utilities. They are typically located in trenches. Dry utilities include such lines as telephone, cable, electric and gas lines. Wet utilities include stormwater conveyance pipes, fire lines, domestic water lines and wastewater pipes.
Unstable slopes	Those sloping areas of land which have in the past exhibited, are currently exhibiting, or will likely in the future exhibit, mass movement of earth.
Upgrade	The replacement of paved areas with a better surface or in a way that enhances the traffic capacity of the road.
U.S. EPA	The United States Environmental Protection Agency.
Variance	See Exception.
Vegetated flowpath	A flowpath consisting of well-established lawn or pasture, landscaping with well-established groundcover, native vegetation with natural groundcover, or an area that meets BMP L613: Post-Construction Soil Quality and Depth. The groundcover shall be dense enough to help disperse flows and to prevent erosion.
Vegetated roof	A vegetated rooftop, also known as a green roof, is a rooftop that is partially or completely covered with vegetation and a growing medium planted over a waterproofing membrane. The green roof will also contain a root repelling membrane and stormwater system.
Vegetation	As related to applicability of the Minimum Requirements, vegetation shall mean native vegetation, pasture, scrub/shrub, uncultivated vegetation, or unmaintained non-native vegetation (e.g., Himalayan blackberries, scotch broom).
Vegetation Maintenance	As related to pavement maintenance, vegetation maintenance includes caring for and controlling vegetation along roadways or paved surfaces to ensure vegetation does not damage the pavement surface or cause a safety concern. Vegetation maintenance may also include moss control and care and control of vegetation that is part of a permeable paver system.

Vehicular Use

Regular use of an impervious or pervious surface by motor vehicles. The following are subject to regular vehicular use:

- roads
- Un-vegetated road shoulders
- bike lanes within the traveled lane of a roadway
- driveways
- parking lots
- unrestricted access fire lanes
- vehicular equipment stoarge yards
- railway lines, including light rail elevated and non-elevated guideways/tracks, and
- airport runways and other surfaces intended for movement and/or storage of aircraft

The following are not considered subject to regular vehicular use:

- sidewalks not subject to drainage from roads for motor vehicles,
- paved bicycle pathways separated from and not subject to drainage from roads for motor vehicles,
- restricted access fire lanes, and infrequently used maintenance access roads of no more than once per day.

Waterbody

Surface waters including rivers, streams, lakes, marine waters, estuaries, and wetlands.

Water Level Fluctuation (WLF)

As related to Minimum Requirement #8 - Wetlands Protection, WLF is a defining characteristic of a wetland. WLF during a monitoring interval is as follows: Average base stage = (Instantaneous stage at beginning of interval + Instantaneous stage at end of interval)/2

Washington State Licensed Professional Engineer

A person who has met the necessary requirements to be licensed as a Professional Engineer in Washington State. Certain tasks may only be performed by a P.E. with a specialty license. It is the responsibility of every professional to know the limits of their licenses.

Washington State Licensed Professional Geologist

A person who has met the necessary requirements to be licensed as a Professional Geologist in Washington State. Certain tasks may only be performed by a P.G. with a specialty license. It is the responsibility of every professional to know the limits of their licenses.

Water quality

A term used to describe the chemical, physical, and biological characteristics off water, usually in respect to its suitability for a particular purpose.

Water quality standards	Minimum requirements of purity of water for various uses; for example, water for agricultural use in irrigation systems should not exceed specific levels of sodium bicarbonate, pH, total dissolved salts, etc. In Washington, the Department of Ecology sets water quality standards.
Watershed	The land area that drains into a stream, lake, or other body of water. An area of land that contributes runoff to one specific delivery point. Large watersheds may be composed of several smaller subwatersheds, each of which contributes runoff to different runoff locations that ultimately combine at a common delivery point or receiving water. The words watershed and basin are often used interchangeably.
Water table	The upper surface or top of the saturated portion of the soil or bedrock layer, indicates the uppermost extent of groundwater.
Weir	Device for measuring or regulating the flow of water.
Weir notch	The opening in a weir for the passage of water.
Wetland edge	Delineation of the wetland edge shall be based on the U.S. Army Corps of Engineers Wetlands Delineation Manual, Technical Report Y-87-1, U.S. Army Engineers Waterways Experiment Station, Vicksburg, Miss. (1987)
Wetland functions	The ecological (physical, chemical, and biological) processes or attributes of a wetland. Functions are often defined in terms of the processes that provide value to society, but they can also be defined based on processes that are not value based. Wetland functions include food chain support, provision of ecosystem diversity and fish and wildlife habitat, flood flow alteration, groundwater recharge and discharge, water quality improvement, and soil stabilization.
Wetland structure	The physical components of a wetland, both the abiotic (physical and chemical) and biotic (living).
Wetland values	Wetland processes or attributes that are valuable or beneficial to society (also see Functions). Wetland values include support of commercial and sport fish and wildlife species, protection of life and property from flooding, recreation, education, and aesthetic enhancement of human communities.

Wetlands	Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, including, but not limited to, irrigation and conveyance ditches, grass-lined swales, canals, stormwater treatment wetlands, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from nonwetland areas to mitigate the conversion of wetlands. (Waterbodies not included in the definition of wetlands as well as those mentioned in the definition are still waters of the state.)
Wetlands Functions	The ecological (physical, chemical, and biological) processes or attributes of a wetland without regard for their importance to society (see also values). Wetland functions include food chain support, provision of ecosystem diversity and fish and wildlife habitat, floodflow alteration, groundwater recharge and discharge, water quality improvement, and soil stabilization.
Wetponds and wetvaults	Stormwater facilities for stormwater treatment that contain permanent pools of water that are filled during the initial runoff from a storm event. They are designed to optimize water quality by providing retention time in order to settle out particles of fine sediment to which pollutants such as heavy metals absorb, and to allow biologic activity to occur that metabolizes nutrients and organic pollutants.
WWHM	Western Washington Hydrology Model. A continuous simulation model approved by the Washington State Department of Ecology for use with this manual.
Yard drain	A catch basin or similar structure used to collect and convey stormwater and surface water from lawn and landscaped areas of a site.