Stormwater Management Manual for Western Washington

July 2019

DEPARTMENT OF ECOLOGY
State of Washington

Publication Number 19-10-021

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Stormwater Management Manual for Western Washington

Volume I - What Requirements Apply to My Site?

Volume II - Construction Stormwater Pollution Prevention

Volume III - Choosing, Modeling, and Documenting Your BMPs

Volume IV - Source Control BMP Library

Volume V - Runoff Treatment, Flow Control, and LID BMP Library

Prepared by:

Washington State Department of Ecology
Water Quality Program

July 2019

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Accommodation Requests

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Executive Summary of the 2019 Revisions

The Stormwater Management Manual for Western Washington (SWMMWW) provides guidance on the measures necessary to control the quantity and quality of stormwater. Local municipalities use this manual to set stormwater requirements for new development and redevelopment projects. Land developers and development engineers use this manual to design permanent stormwater control plans, create construction stormwater pollution prevention plans, and determine stormwater infrastructure. Businesses use this manual to help design their stormwater pollution prevention plans.

The greatest use of the SWMMWW has been through National Pollutant Discharge Elimination System (NPDES) stormwater permits. The Municipal Stormwater General Permits for western Washington incorporate and reference the SWMMWW. The Industrial Stormwater General Permit, Construction Stormwater General Permit, Boatyard General Permit, and the Sand and Gravel General Permit reference the SWMMWW. Since 2005, Ecology has reissued or issued for the first time all of these NPDES stormwater permits. The 2019 revisions to the SWMMWW will continue to help permittees comply with these permits.

Types of Revisions

Usability Enhancements

The focus of the 2019 update was to enhance the usability, which will result in improved implementation of the stormwater permits that rely on this guidance. Enhancements include:

- Fully embracing the online user (maintain the interactive online format)
- Consolidating repetitive information
- Revising text for clarity
- Reordering sections for a better flow of concepts

Significant Changes

Ecology also identified the following changes that must be made in order to continue to provide the best guidance available:

1. **Continuous Simulation Modeling:** Text throughout the SWMMWW has been updated to require continuous simulation models that include:
    - The ability to directly model BMPs that may be used in LID applications, such as bioretention, permeable pavement, and green roofs.
    - 15-minute time steps.
    - Incorporation of the van Genuchten algorithm to model bioretention.
2. **Replaced Hard Surfaces Redevelopment Threshold:** The Minimum Requirement Thresholds for non-road related commercial or industrial redevelopment projects have been updated to require the project proponent to compare the value of the proposed improvements

to the value of the Project Site (the limits of disturbance) improvements, rather than the Site (the entire parcel) improvements.

3. **Equivalent Areas:** The Redevelopment Project Thresholds have been updated to allow a project proponent to provide Stormwater Management BMPs for an equivalent area. The equivalent area may be on-site, or off-site if the area drains to the same receiving water and the guidance for in-basin transfers is followed.

4. **Minimum Requirement 2:** The 13 Elements in I-3.4.2 MR2: Construction Stormwater Pollution Prevention Plan (SWPPP) have been updated to incorporate changes that were made to the 2015-2020 Construction Stormwater General Permit.

5. **Minimum Requirement 5:** I-3.4.5 MR5: On-Site Stormwater Management has been updated to require BMP T5.13: Post-Construction Soil Quality and Depth when choosing to use the LID Performance Standard to meet Minimum Requirement 5 for Minimum Requirement 1-5 projects.

6. **Minimum Requirement 7:** I-3.4.7 MR7: Flow Control has been updated to ensure that a TDA discharging to a marine waterbody meets all exemption requirements before it can be determined to be Flow Control exempt.

7. **Concrete Washout BMP:** BMP C154: Concrete Washout Area has been updated to clarify that auxiliary concrete truck components and small concrete handling equipment may be washed into formed areas awaiting concrete pour, while concrete truck drums must be washed either off-site or into a concrete washout area.

8. **Source Control BMPs:** Volume IV (Source Control BMP Library) has been updated with Source Control BMPs for activities not listed in previous versions of the manual. The new activities with Source Control BMPs are:

    - S434 BMPs for Dock Washing
    - S441 BMPs for Potable Water Line Flushing, Water Tank Maintenance, and Hydrant Testing
    - S435 BMPs for Pesticides and an Integrated Pest Management Program
    - S444 BMPs for the Storage of Dry Pesticides and Fertilizers
    - S449 BMPs for Nurseries and Greenhouses
    - S450 BMPs for Irrigation
    - S445 BMPs for Temporary Fruit Storage
    - S439 BMPs for In-Water and Over-Water Fueling
    - S436 BMPs for Color Events
    - S438 BMPs for Construction Demolition
    - S440 BMPs for Pet Waste
    - S442 BMPs for Labeling Storm Drain Inlets On Your Property

- S443 BMPs for Fertilizer Application
- S446 BMPs for Well, Utility, Directional and Geotechnical Drilling
- S447 BMPs for Roof Vents
- S451 BMPs for Building, Repair, Remodeling, Painting, and Construction
- S452 BMPs for Goose Waste

9. **Wetlands Guidance:** Appendix I-C: Wetland Protection Guidelines and I-3.4.8 MR8: Wetlands Protection have been updated to require monitoring and modeling of high value wetlands, if the project proponent has legal access to them. The 2014 wetland guidance is retained, but refined, for modeling requirements for lower value wetlands (and high value wetlands that the project proponent does not have legal access to).

Other Updates

Other updates include:

- Incorporation of UIC Program guidance. See I-4 UIC Program.
- Expanded guidance for regional facilities. See Appendix I-D: Regional Facilities.
- Guidance for stormwater control transfer programs. See Appendix I-E: Stormwater Control Transfer Program.

How to Find Corrections, Updates, and Additional Information

With a publication of this size and complexity there will inevitably be errors that must be corrected and clarifications that are needed. There will also be new information and technological updates.

Ecology intends to incorporate errata changes within the text of the interactive online version of the 2019 SWMMWW. Other updates, such as new technical information, FAQs, and/or training videos, may be posted as additional documents in the navigation pane of the interactive online manual, but will not be incorporated within the manual text until Ecology officially updates the publication.

Ecology will not use the interactive online version to make revisions in key policy areas – such as the thresholds and minimum requirements in Volume I. Please check the interactive online version periodically for corrections and updates.

Public Involvement Leading Up to the 2019 SWMMWW

Ecology provided public involvement opportunities and received public comments in preparation of the 2019 SWMMWW through individual user feedback, listening sessions, meetings with experts in selected fields, a preliminary draft public comment period, and a formal draft public comment period.

- **Individual User Feedback**

  Since the release of the 2014 SWMMWW, Ecology has collected feedback in the form of emails and phone calls from individual manual users. Ecology took note of common questions, and has provided clarification in the edits.

- **Listening Sessions**

  In the Spring of 2017, Ecology hosted listening sessions across western Washington to gather input for preparing to reissue the 2019 Municipal Stormwater permits and update the Manual. Participants largely agreed that the Manual update should not include substantial changes to the technical requirements, but were thankful for the efforts suggested by Ecology to enhance the usability of the manual.

- **Meetings With Experts**

  In a few cases, Ecology met with internal and external experts to discuss needed changes to the Manual. For example, Ecology held meetings to discuss the updates to Appendix I-C: Wetland Protection Guidelines.

- **Preliminary Draft Public Comment Period**

  In the Fall of 2017, Ecology provided a preliminary draft package of the 2019 SWMMWW for an informal public review. Ecology considered the comments received while finalizing the formal draft.

- **Formal Draft Public Comment Period**

  In the Summer of 2018, Ecology provided a formal draft package of the 2019 SWMMWW for a 120 day public comment period. Ecology considered the comments received during the comment period and made the final changes to the 2019 SWMMWW. Ecology has issued a response to comments with the final version of the 2019 SWMMWW.

Acknowledgments

Ecology gratefully acknowledges the valuable time, comments, and expertise provided by the people listed below who contributed to the 2019 Stormwater Management Manual for Western Washington (SWMMWW). Ecology is solely responsible for any errors, omissions, and final decisions related to the 2019 SWMMWW.

Acknowledgments

Name / Affiliation	Name / Affiliation
BCRA, Inc.	Master Builders Association of King and Snohomish Counties
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Dedications

Volume I is dedicated to Ed O'Brien. Ed worked for the Washington State Department of Ecology for 39 years. As a scientist, engineer, writer, and leader he created a clear vision for the protection of water quality for western Washington. His dedication to public service and to the goal of water quality protection continues to be an inspiration.

Volume II is dedicated to the memory of Ron Devitt. Ron was with Ecology from its earliest days. He will always be remembered by the many lives he touched both within the agency and outside of the agency, and for all the good he did for Washington State's environmental health. At Ron's retirement in May 2004, an award for "Excellence in the Field" was established in his name by the Water Quality Program.

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Cover Photos

Cover, clockwise from bottom:

- Spring blooms within a bioretention BMP in Clark County. Photo provided by Jane Tesner Kleiner, Clark County Public Works.
- A wheel wash in action at a Port of Vancouver construction site. Photo provided by Matt Graves, Port of Vancouver.
- An artistic spin on a stormwater facility that includes both permeable pavement and bioretention BMPs in Kitsap County. Photo provided by Chris May (with photo credit to Kitsap Biz Productions), Kitsap County Public Works.
- A street sweeper posing with an elevated debris tank at the Port of Vancouver. Photo provided by Matt Graves, Port of Vancouver.
- A herringbone pattern installation of permeable pavement in Pierce County. Photo provided by Dennis Dixon, Pierce County Planning & Public Works.
- A wetpond follows a tortuous path to maximize treatment potential at the Port of Vancouver. Photo provided by Matt Graves, Port of Vancouver.

Spine, top to bottom:

- A green roof installed on a residential outbuilding in Oak Harbor. Photo provided by Brad Gluth, City of Oak Harbor.

- A construction team works together to install a stormwater vault in Pierce County. Photo provided by Dennis Dixon, Pierce County Planning & Public Works.
- A bioretention overflow structure awaits its bounty in Clark County. Photo provided by Jane Tesner Kleiner, Clark County Public Works.

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Volume I

What Requirements Apply to My Site?

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Executive Summary of Volume I

Welcome to Volume I of Ecology's 2019 Stormwater Management Manual for Western Washington. Volume I introduces the measures necessary to control the quantity and quality of stormwater produced by new development and redevelopment. In this Volume you will find the following:

I-1 Introduction to Stormwater Management in Western Washington outlines objectives of the manual, including a summary of key research and science that identified challenges associated with stormwater. This chapter also includes an overview of the Best Management Practices (BMPs) that can be used to address these challenges.

I-2 Relationship of This Manual to Permits, Requirements, and Programs describes how the guidance of this manual relates to some important regulations.

I-3 Minimum Requirements for New Development and Redevelopment discusses in detail the minimum requirements for new development and redevelopment sites.

I-4 UIC Program provides guidance for Underground Injection Control (UIC) wells regulated under the UIC program.

Appendix I-A: Flow Control Exempt Receiving Waters lists the flow control-exempt waters that can receive stormwater discharges from new development and redevelopment sites without requiring Flow Control BMPs if all restrictions outlined in I-3.4.7 MR7: Flow Control are met.

Appendix I-B: Basin Plans describes the steps that jurisdictions may take to prepare a basin-wide plan to alter the minimum requirements.

Appendix I-C: Wetland Protection Guidelines provides guidance to protect downstream wetlands.

Appendix I-D: Regional Facilities describes how jurisdictions can use regional facilities to meet Minimum Requirements 5, 6, 7, 8 or some combination of these.

Appendix I-E: Stormwater Control Transfer Program describes how a jurisdiction can use watershed planning to help reach designated and existing beneficial uses.

Refer to Volumes II through V for information on the following:

Volume II focuses on managing stormwater impacts associated with construction activities. It discusses the need for pollution prevention for construction stormwater, details how to document construction BMPs in a construction stormwater pollution prevention plan, and includes information on how to implement construction stormwater BMPs.

Volume III provides guidance on how to choose, hydrologically model, and document stormwater BMPs in a stormwater site plan.

Volume IV contains a library of source control BMPs, categorized by types of activities.

Volume V contains a library of design criteria for BMPs that project proponents can use to meet I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.6 MR6: Runoff Treatment, and/or I-3.4.7 MR7: Flow Control.

I-1 Introduction to Stormwater Management in Western Washington

I-1.1 About This Manual

Objective of the Manual

The objective of this manual is to provide guidance on the measures necessary to control the quantity and quality of stormwater produced by new development and redevelopment. The goal of the measures are to comply with water quality standards and contribute to the protection of beneficial uses of the receiving waters. Application of appropriate Minimum Requirements (MRs) and Best Management Practices (BMPs) identified in this manual are necessary but sometimes insufficient measures to achieve these objectives. See I-1.3 Effects of Urbanization for further information about the impacts of development on water quality.

Water quality standards include:

- Chapter 173-200 of the Washington Administrative Code (WAC), Water Quality Standards for Groundwaters of the State of Washington
- Chapter 173-201A WAC, Water Quality Standards for Surface Waters of the State of Washington
- Chapter 173-204 WAC, Sediment Management Standards

Manual Content

This manual identifies Minimum Requirements for new development and redevelopment projects of all sizes, and provides guidance for preparing and implementing Stormwater Site Plans. These requirements are, in turn, satisfied by the application of BMPs from Volumes II, IV, and V. Projects that follow this approach will apply reasonable, technology-based BMPs and water quality-based BMPs to reduce the adverse impacts of stormwater.

This manual includes the following:

- *Guidance for applying Minimum Requirements (MRs) to new and redevelopment project sites.* MRs provide protection of receiving waters in a variety of ways, including preparation of Stormwater Site Plans, pollution prevention during the construction phase of a project, control of potential pollutant sources, treatment of runoff, control of stormwater flow volumes, protection of wetlands, and long-term operation and maintenance. The MRs applicable to a project vary depending on the type and size of the proposed project.
- *Guidance for designing and maintaining Best Management Practices (BMPs) that can be used to meet the MRs*. BMPs are schedules of activities, prohibitions of practices, maintenance procedures, managerial practices, or structural features that prevent or reduce pollutants or other adverse impacts to waters of Washington State. BMPs are divided into those for short-term control of stormwater from construction sites, and those addressing long-term

management of stormwater at developed sites. Long-term BMPs are further subdivided into those covering management of the volume and timing of stormwater flows (Flow Control), prevention of pollution from potential sources (Source Control), and treatment of runoff to remove sediment and other pollutants (Runoff Treatment).

- *Guidance on how to prepare and implement Stormwater Site Plans.* The Stormwater Site Plan is a comprehensive report that describes existing site conditions, explains development plans, examines potential off-site effects, identifies applicable Minimum Requirements, and proposes stormwater BMPs for both the construction phase and long-term stormwater management. The project proponent submits the Stormwater Site Plan to state and local permitting authorities with jurisdiction, who use the plan to evaluate a proposed project for compliance with stormwater requirements.

Manual Applicability

This manual is applicable to all types of land development – including residential, commercial, industrial, and roads. Manuals with a more-specific focus, such as WSDOT's Highway Runoff Manual (WSDOT, 2014), that have been determined to be equivalent to this manual, may provide more appropriate guidance to the intended audience.

More Stringent Requirements

Federal, state, and local permitting authorities with jurisdiction can require more stringent measures that are deemed necessary to meet locally established goals, state water quality standards, or other established natural resource or drainage objectives. Water cleanup plans or Total Maximum Daily Loads (TMDLs) may also identify more stringent measures needed to restore water quality in an impaired water body.

Use of This Manual For Retrofits

This manual can also help identify options for retrofitting BMPs into existing developed areas. Retrofitting BMPs into existing developed areas will be necessary in many cases to meet federal Clean Water Act and state Water Pollution Control Act (Chapter 90.48 RCW) requirements. The Puget Sound Action Agenda, described in I-2.3 The Action Agenda for Puget Sound, also includes prioritizing and implementing stormwater retrofits as one objective.

While the Washington State Department of Ecology (Ecology) has guidance for redevelopment, there is no specific guidance for retrofits outside of redevelopment. Application of BMPs from this manual is encouraged for retrofits. However, there can be site constraints that make the strict application of these BMPs as retrofits difficult. In these instances, the BMPs presented here can be modified using best professional judgment to provide reasonable improvements in stormwater management.

Exclusion of Conveyance Design

Design guidance for conveyance systems is not included in this manual. This topic is covered in standard engineering references.

I-1.2 Applicability to Western Washington

This manual applies to all of western Washington. This includes the area bounded on the south by the Columbia River, on the west by the Pacific Ocean, on the north by the Canadian border, and on the east by the Cascade Mountains crest. This manual also applies to those areas of Skamania and Cowlitz counties that lie east of the Cascade crest.

The following counties are included in the area described above:

- Clallum
- Clark
- Cowlitz
- Grays Harbor
- Island
- Jefferson
- King
- Kitsap
- Lewis
- Mason
- Pacific
- Pierce
- San Juan
- Skagit
- Skamania
- Snohomish
- Thurston
- Wahkiakum
- Whatcom

Original Manual Development and Expansion to Western Washington

The Ecology stormwater manual was originally developed in response to a directive of the Puget Sound Water Quality Management Plan (PSWQA, 1987 et seq.), now the Puget Sound Action Agenda (See I-2.3 The Action Agenda for Puget Sound). The Puget Sound Water Quality Authority (since replaced by the Puget Sound Partnership, PSP) 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. This manual was originally developed to meet this requirement. Ecology has found that the concepts developed for the Puget Sound Basin are applicable throughout western Washington.

I-1.3 Effects of Urbanization

Background Conditions

Prior to the Euro-American settlement, western Washington primarily was forested in alder, maple, fir, hemlock and cedar. The area's bountiful rainfall supported the forest and the many creeks, springs, ponds, lakes and wetlands. The forest system provided protection by intercepting rainfall in the canopy, reducing the possibility of erosion and the deposition of sediment in waterways. The trees and other vegetative cover evapotranspirated at least 40% of the rainfall. The forest duff layer absorbed large amounts of runoff, releasing it slowly to the streams through shallow ground water flow.

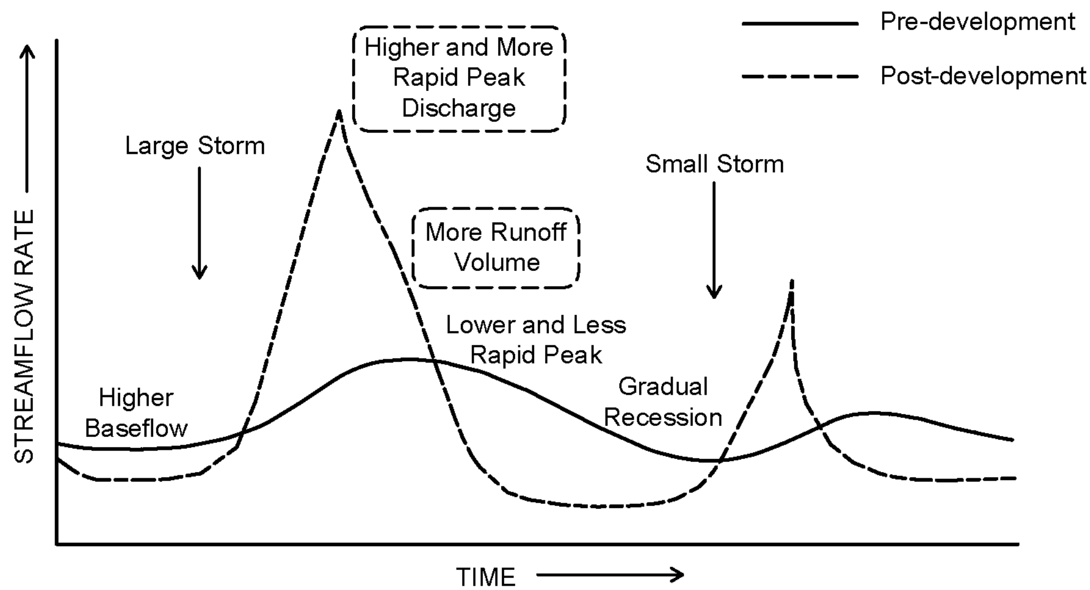
Hydrologic Changes

As settlement occurs and the population grows, trees are logged and land is cleared for the addition of impervious surfaces such as rooftops, roads, parking lots, and sidewalks. Maintained landscapes that have much higher runoff characteristics typically replace the natural vegetation. The natural soil structure is also lost due to grading and compaction during construction. Roads are cut through slopes and low spots are filled. Drainage patterns are irrevocably altered. All of this results in drastic changes in the natural hydrology, including:

- Increased volumetric flow rates of runoff
- Increased volume of runoff
- Decreased time for runoff to reach a natural receiving water
- Reduced ground water recharge
- Increased frequency and duration of high stream flows during and after wet weather
- Reduced stream flows during the dry season
- Wetlands inundation during and after wet weather
- Reduced wetlands water levels during the dry season
- Greater stream velocities

Figure I-1.1: Changes in Hydrology after Development (Schueler, 1987) illustrates some of these hydrologic changes. As a consequence of these hydrology changes, stream channels are eroded by high flows and can lose summertime base flows. Increased flooding occurs. Streams lose their hydraulic complexity. Habitat is degraded and receiving water species composition is altered as explained below.

Figure I-1.1: Changes in Hydrology after Development



(Schueler, 1987)

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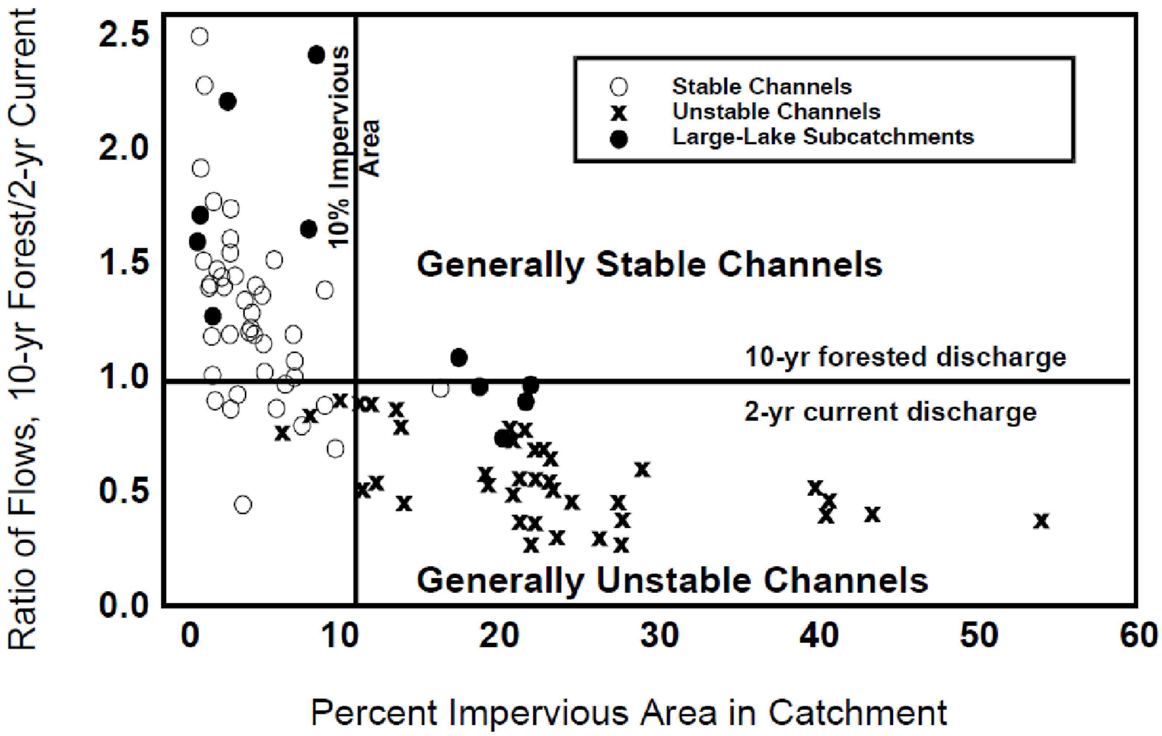
Changes in Hydrology after Development

Revised July 2016

Figure I-1.2: Channel Stability and Land Use: Hylebos, East Lake Sammamish, Issaquah Basins (Booth and Jackson, 1997) illustrates one observed relationship between the level of development in a basin (as measured by effective, not total, impervious area), the changes in the recurrence of modeled stream flows, and the resultant streambank instability and channel erosion. These data show that even a crude measure of stream degradation, “channel instability,” shows significant changes at relatively low levels of urban development. More sensitive measures, such as biological indicators, document degradation at even lower levels of human activity (see Biological Changes, below).

Figure I-1.2: Channel Stability and Land Use: Hylebos, East Lake Sammamish, Issaquah Basins



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Channel Stability and Land Use: Hylebos, East Lake Sammamish, Issaquah Basins

Revised June 2015

Water Quality Changes

Urbanization also causes an increase in the types and quantities of pollutants in surface and ground waters. Runoff from urban areas has been shown to contain many different types of pollutants, depending on the nature of the activities in those areas. Table I-1.1: Mean Concentrations of Selected Pollutants in Runoff from Different Land Uses, from an analysis of Oregon urban runoff water quality monitoring data collected from 1990 to 1996, shows mean concentrations for a limited number of pollutants from different land uses. (Strecker et al., 1997)

Table I-1.1: Mean Concentrations of Selected Pollutants in Runoff from Different Land Uses

Land Use	TSS	Total Cu	Total Zn	Dissolved Cu	Total P
	mg/l	mg/l	mg/l	mg/l	mg/l
In-pipe Industry	194	0.053	0.629	0.009	0.633
Instream Industry	102	0.024	0.274	0.007	0.509
Transportation	169	0.035	0.236	0.008	0.376
Commercial	92	0.032	0.168	0.009	0.391
Residential	64	0.014	0.108	0.006	0.365
Open	58	0.004	0.025	0.004	0.166
Note: In-pipe industry means the samples were taken in stormwater pipes. Instream industry means the samples were taken in streams flowing through industrial areas. Samples for all other categories were taken within stormwater pipes.					

The runoff from roads and highways is contaminated with pollutants from vehicles. Oil and grease, polynuclear aromatic hydrocarbons (PAH's), lead, zinc, copper, cadmium, as well as sediments (soil particles) and road salts are typical pollutants in road runoff.

Runoff from industrial areas typically contains even more types of heavy metals, sediments, and a broad range of man-made organic pollutants, including phthalates, PAH's, and other petroleum hydrocarbons.

Residential areas contribute the same road-based pollutants to runoff, as well as herbicides, pesticides, nutrients (from fertilizers), bacteria and viruses (from animal waste). All of these contaminants can seriously impair beneficial uses of receiving waters.

Regardless of the eventual land use conversion, the sediment load produced by a construction site can turn the receiving waters turbid and be deposited over the natural sediments of the receiving water.

The pollutants added by urbanization can be dissolved in the water column or can be attached to particulates that settle in streambeds, lakes, wetlands, or marine estuaries. A number of urban bays in

Puget Sound have contaminated sediments due to pollutants associated with particulates in stormwater runoff.

Urbanization also tends to cause changes in water temperature. Heated stormwater from impervious surfaces and exposed stormwater ponds discharges to streams with less riparian vegetation for shade. Urbanization also reduces ground water recharge, which reduces sources of cool ground water inputs to streams. In winter, stream temperatures may lower due to loss of riparian cover. There is also concern that the replacement of warmer ground water inputs with colder surface runoff during colder periods may have biological impacts.

Biological Changes

The hydrologic and water quality changes described above result in changes to the biological systems that were supported by the natural hydrologic system. In particular, aquatic life is greatly affected by urbanization. Habitats are drastically altered when a stream changes its physical configuration and substrate due to increased flows. Natural riffles, pools, gravel bars and other areas are altered or destroyed. These and other alterations produce a habitat structure that is very different from the one in which the resident aquatic life evolved. For example, spawning areas, particularly those of salmonids, are lost. Fine sediments imbed stream gravels and suffocate salmon redds. The complex food web is destroyed and replaced by a biological system that can tolerate the changes. However, that biological community is typically not as complex, is less desirable, and is unstable due to the ongoing rapid changes in the new hydrologic regime.

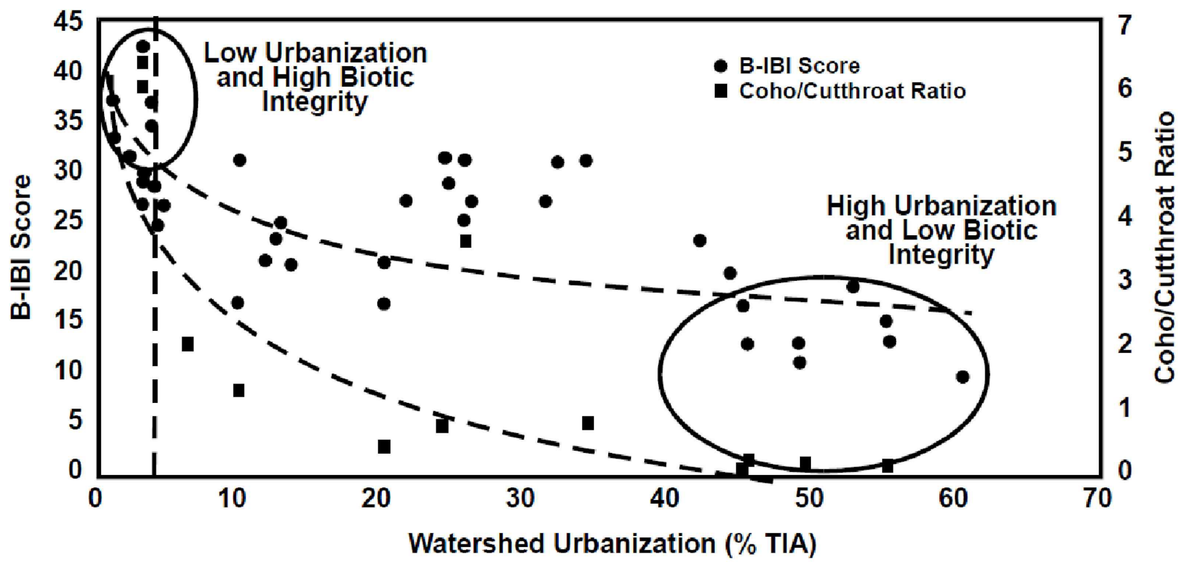
Significant and detectable changes in the biological community of Puget Sound lowland streams begin early in the urbanization process. (May et al., 1997) reported changes in the 5-10% total impervious area range of a watershed. Figure I-1.3: Relationship Between Basin Development and Biotic Integrity in Puget Sound Lowland Streams from (May et al., 1997) shows the relationship observed between the Benthic Index of Biotic Integrity (B-IBI) developed by (Kleindl, 1995) and (Karr, 1991), and the extent of watershed urbanization as estimated by the percentage of total impervious area (% TIA). Also shown in the figure is the correlation between the abundance ratio of juvenile coho salmon to cutthroat trout (Lucchetti and Fuerstenberg, 1993) and the extent of urbanization.

The biological communities in wetlands are also severely impacted and altered by the hydrological changes. Relatively small changes in the natural water elevation fluctuations can cause dramatic shifts in vegetative and animal species composition.

In addition, the toxic pollutants in the water column such as pesticides, soaps, and metals can have immediate and long-term lethal impacts. Toxic pollutants in sediments can yield similar impacts. One prime example is when the polluted sediment in urban bays causes lesions and cancers in bottom fish.

A rise in water temperature can have direct lethal effects. It reduces the maximum available dissolved oxygen and may cause algae blooms that further reduce the amount of dissolved oxygen in the water.

Figure I-1.3: Relationship Between Basin Development and Biotic Integrity in Puget Sound Lowland Streams



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Relationship Between Basin Development and Biotic Integrity in Puget Sound Lowland Streams

Revised June 2015

The Role of Land Use and Lifestyles

Land use is tied to site development standards and where development occurs. This manual is not intended to direct those land use decisions or delve deeply into those topics. Most land use decisions occur prior to the project being proposed. This manual focuses on the management of the project. This manual can provide site development strategies to reduce the pollutants generated and the hydrologic disruptions caused by development.

The engineered stormwater conveyance, treatment, and detention systems advocated by this and other stormwater manuals can reduce the impacts from development to water quality and hydrology. However, they cannot replicate the natural hydrologic functions of the natural watershed that existed before development, nor can they remove enough pollutants to replicate the water quality of pre-development conditions. Ecology understands that despite the application of appropriate practices and technologies identified in this manual, some degradation of urban and suburban receiving waters will continue, and some beneficial uses will continue to be impaired or lost due to new development. This is because land development, as practiced today, is incompatible with the achievement of sustainable ecosystems. Unless development methods are adopted that cause significantly less disruption of the hydrologic cycle, the cycle of new development followed by beneficial use impairments will continue.

In recent years, researchers (May et al., 1997) and regulators [e.g., (King County Surface Water Management, 1996)] have speculated on the amount of natural land cover and soils that should be preserved in a watershed to retain sufficient hydrologic conditions to prevent stream channel degradation, maintain base flows, and contribute to achieving properly functioning conditions for salmonids. There is some agreement that preserving a high percentage (possibly 65 to 75%) of the land cover and soils in an undisturbed state is necessary. To achieve these high percentages in urban, urbanizing, and suburban watersheds, a dramatic reduction is necessary in the amount of impervious surfaces and artificially landscaped areas to accommodate our preferred housing, play, and work environments, and most significantly, our transportation choices.

Surfaces created to provide “car habitat” comprise the greatest portion of impervious areas in land development. Therefore, to make appreciable progress in reducing impervious surfaces in a watershed, we must reduce the density of our road systems, alter our road construction standards, reduce surface parking, and rely more on transportation systems that do not require such extensive impervious surfaces (rail, bicycles, walking).

Reducing the extent of impervious surfaces and increasing natural land cover in watersheds are also necessary to solve the water quality problems of sediment, temperature, toxicants, and bacteria. Changing public attitudes toward chemical use and preferred housing are also necessary to achieve healthy water ecosystems.

Until we are successful in applying land development techniques that result in matching the natural hydrologic functions and cycles of watersheds, management of the increased surface runoff is necessary to reduce the impact of the changes. Figure I-1.3: Relationship Between Basin Development and Biotic Integrity in Puget Sound Lowland Streams illustrates that significant biological impacts in streams can occur at even low levels of development associated with rural areas where stormwater runoff has not been properly managed. Improving our stormwater detention, treatment, and source control management practices should help reduce the impacts of land development in urban and rural areas. We must also improve the operation and maintenance of our engineered systems so that they function as well as possible. This manual is Ecology's latest effort to apply updated knowledge in these areas.

The question yet to be answered is whether better management – including improved treatment and detention techniques – of the increased surface runoff from developed areas can work in combination with preservation of high percentages of natural vegetation and soils on a watershed scale to yield a minimally altered hydrologic and water quality regime that protects the water-related natural resources.

In summary, implementing improved engineering techniques and drastic changes in where and how land is developed and how people live and move across the land are necessary to achieve the goals in the federal Clean Water Act - to preserve, maintain, and restore the beneficial uses of our nation's waters.

I-1.4 Stormwater Pollutants and Their Adverse Impact

The stormwater pollutants of most concern are total suspended solids (TSS), oil and grease, nutrients, pesticides, other organics, pathogens, biochemical oxygen demand (BOD), heavy metals, and salts (chlorides) (USEPA, 1995), (Field et al., 1997), and (Strecker et al., 1997).

Total Suspended Solids

This represents particulate solids such as eroded soil, heavy metal precipitates, and biological solids (all considered as conventional pollutants), which can cause sedimentation in streams and turbidity in receiving surface waters. These sediments can destroy the desired habitat for fish and can impact drinking water supplies. The sediment may be carried to streams, lakes, or Puget Sound where they may be toxic to aquatic life and make dredging necessary.

Oil and Grease

Oil and grease can be toxic to aquatic life. Concentrations in stormwater from commercial and industrial areas often exceed Ecology guidelines of:

- 10 mg/L maximum daily average,
- 15 mg/L maximum at any time, and
- no ongoing or frequently recurring visible sheen.

Nutrients

Phosphorus and nitrogen compounds can cause excessive growth of aquatic vegetation in lakes and marine waters.

Biological Oxygen Demand (BOD)

Biological Oxygen Demand (BOD) is a measure of the oxygen demand from organic, nitrogenous, and other materials that are consumed by bacteria present in receiving waters. BOD in the water may deplete oxygen in the process, threatening higher organisms such as fish.

Toxic Organics

A study found 19 of the U.S. Environmental Protection Agency's 121 priority pollutants present in the runoff from Seattle streets. The most frequently detected pollutants were pesticides, phenols, phthalates, and polynuclear aromatic hydrocarbons (PAHs).

Heavy Metals

Stormwater can contain heavy metals such as lead, zinc, cadmium, and copper at concentrations that often exceed water quality criteria and that can be toxic to fish and other aquatic life. Research in Puget Sound has shown that metals and toxic organics concentrate in sediments and at the water surface (microlayer) where they interfere with the reproductive cycle of many biotic species as well as cause tumors and lesions in fish.

pH

A measure of the alkalinity or acidity that can be toxic to fish if it varies appreciably from neutral pH, which is 7.0.

Bacteria and Viruses

Stormwater can contain disease-causing bacteria and viruses, although not at concentrations found in sanitary sewage. Shellfish subjected to stormwater discharges near urban areas are usually unsafe for human consumption.

Research has shown that the concentrations of pollutants in stormwater from residential, commercial, and industrial areas can exceed Ecology's water quality standards and guidelines.

I-1.5 Types of Best Management Practices (BMPs) for Stormwater Management

What are BMPs?

The method by which this manual controls the adverse impacts of development and redevelopment is through the application of Best Management Practices (BMPs).

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 and other adverse impacts to waters of Washington State.

The primary *purpose* of using BMPs is to protect beneficial uses of water resources by:

- reducing pollutant loads and concentrations,
- reducing discharges (volumetric flow rates) that cause stream channel erosion, and
- reducing deviations from natural hydrology.

The *quantifiable methods* that BMPs use to prevent or reduce the release of pollutants and other adverse impacts to waters of Washington State are:

- Flow Control: Flow Control refers to reducing (or controlling) the flow and duration of stormwater runoff.
- Runoff Treatment: Runoff Treatment refers to removing pollutants from stormwater runoff.
- Source Control: Source Control refers to preventing pollutants from entering stormwater runoff.

The *types* of BMPs that this manual refers to are:

- Flow Control BMPs
- Runoff Treatment BMPs
- LID BMPs
- Source Control BMPs
- Construction BMPs

If it is found that, after the implementation of BMPs advocated in this manual, beneficial uses are still threatened or impaired, then additional controls may be required. BMPs that involve construction of engineered structures are often referred to as facilities in this manual.

Note that some individual BMPs may behave as multiple BMP types. For example, depending on the site-specific design, Bioretention may act as both a Flow Control BMP and a Runoff Treatment BMP, and depending on installation size and location, may also act as an LID BMP.

Flow Control BMPs

Flow Control BMPs refer to BMPs that are installed for the purpose of reducing stormwater surface runoff flows and durations.

Flow Control BMPs are defined as drainage facilities designed to mitigate the impacts of increased surface and stormwater runoff flow rates generated by development. Flow Control BMPs 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.

See the following sections for additional information on Flow Control BMPs:

- III-1.3 Choosing Your Flow Control BMPs
- III-2 Modeling Your BMPs
- Volume V

Runoff Treatment BMPs

Runoff Treatment BMPs refer to BMPs that are installed for the purpose of removing pollutants from stormwater runoff.

Runoff Treatment BMPs remove pollutants from stormwater runoff by simple gravity settling, centrifugal separation, filtration, biological uptake, and media or soil adsorption. The pollutants of concern include sand, silt, and other suspended solids; metals such as copper, lead, and zinc; nutrients (e.g., nitrogen and phosphorous); certain bacteria and viruses; and organics such as petroleum hydrocarbons and pesticides.

Ecology further classifies Runoff Treatment BMPs into the following categories:

- Pretreatment BMPs
- Oil Control BMPs
- Phosphorus Treatment BMPs
- Enhanced Treatment BMPs
- Basic Treatment BMPs

See the following sections for additional information on Runoff Treatment BMPs:

- III-1.2 Choosing Your Runoff Treatment BMPs
- Volume V

LID BMPs

LID (Low Impact Development) BMPs refer to BMPs that are installed for the purpose of mimicking the pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration.

LID BMPs are defined as distributed stormwater management practices, integrated into a project design, that emphasize pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration.

LID BMPs provide a combination of Runoff Treatment and/or Flow Control benefits, but are defined as their own "type" of BMP due to the additional hydrologic benefits they provide. Some of these additional benefits are difficult to model at an individual site level, but have been demonstrated to have a significant cumulative impact when distributed across large areas. The distributed nature is an important distinction of LID BMPs, and ensures that stormwater is mitigated near the location where it originates.

See Volume V for additional information on LID BMPs.

Source Control BMPs

Source Control BMPs refer to BMPs that are installed for the purpose of preventing pollution, or other adverse effects of stormwater, from occurring.

Source Control BMPs are defined as a structure or operation 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.

It is generally more cost-effective to use Source Control BMPs to prevent pollutants from entering runoff, than to use Runoff Treatment BMPs to remove pollutants. However, since Source Control BMPs cannot prevent all impacts, some combination of measures will always be needed.

Ecology further classifies Source Control BMPs as operational or structural:

- Operational Source Control BMPs are *non-structural* practices that prevent or reduce pollutants from entering stormwater. Examples include formation of a pollution prevention team, good housekeeping practices, preventive maintenance procedures, spill prevention and cleanup, street sweeping, employee training, inspections of pollutant sources, and record keeping. They can also include process changes, raw material/product changes, and recycling wastes.
- Structural Source Control BMPs are *physical, structural, or mechanical* devices or facilities intended to prevent pollutants from entering stormwater. Examples include:
    - Enclosing and/or covering the pollutant source (e.g., within a building or other enclosure, a roof over storage and working areas, temporary tarp).
    - Physically segregating the pollutant source to prevent run-on of uncontaminated stormwater.
    - Devices that direct contaminated stormwater to appropriate treatment BMPs (e.g., discharge to a sanitary sewer if allowed by the local sewer authority).

See the following sections for additional information on Source Control BMPs:

- III-1.1 Choosing Your Source Control BMPs
- Volume IV

Construction Stormwater BMPs

Construction Stormwater BMPs refer to BMPs that are installed during the construction phase of a project to protect water quality. Ecology further classifies Construction Stormwater BMPs as Construction Source Control BMPs and Construction Runoff BMPs.

Construction Stormwater BMPs include treatment systems, operating procedures, and practices associated with construction activities to control:

- Stormwater
- Ground water
- Spillage or leaks
- Sludge or waste disposal
- Drainage from raw material storage

Examples of Construction Stormwater BMPs include stabilized construction entrances, silt fences, check dams, and sediment traps.

See Volume II for additional information on Construction Stormwater BMPs.

I-1.6 Presumptive versus Demonstrative Approaches to Protecting Water Quality

Project proponents are often required to document the technical basis for their stormwater BMP designs. This includes:

- how stormwater BMPs were selected;
- the pollutant removal performance expected from the selected BMPs;
- the scientific basis, technical studies, and(or) modeling which supports the performance claims for the selected BMPs; and
- an assessment of how the selected BMP will comply with State Water Quality Standards and satisfy State AKART requirements and Federal technology-based treatment requirements.

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 the Presumptive and Demonstrative approaches are based on using best available science to protect water quality.

The Presumptive Approach

Using the Presumptive approach, project proponents may use the methods described in this manual to choose and design their stormwater BMPs. This manual is intended to provide technically sound stormwater management practices which are presumed to protect water quality and instream habitat, and meet the environmental objectives of the regulations discussed in this Volume.

The Demonstrative Approach

Using the Demonstrative approach, project proponents may choose to not follow the practices in this manual, then 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 Relationship Between the Presumptive and Demonstrative Approaches

Figure I-1.4: Relation Between Environmental Science and Standards in Stormwater Regulations graphically depicts the relation between the Presumptive approach and the Demonstrative approach for achieving the environmental objectives of the standards. Both the Presumptive and Demonstrative approaches are based on 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 known available and reasonable methods of prevention, control and treatment (AKART) of wastes prior to discharge to waters of the State.
3. Satisfy the federal technology based treatment requirements under 40 CFR part 125.3.

Under the Demonstrative approach, 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. In each case, the project proponent may be asked to document to the satisfaction of the permitting agency or other approval authority that the practices they have selected will result in compliance with the water quality protection requirements of the permit or other local, State, or Federal water-quality-based project approval condition. This approach may be more cost effective for large, complex or unusual types of projects.

Project proponents that choose to follow the stormwater management approaches contained in Ecology approved stormwater technical manuals are presumed to have satisfied this demonstration requirement and do not need to provide technical justification to support the selection of BMPs for the project. Following the stormwater management practices in this manual means adhering to the guidance provided for proper selection, design, construction, implementation, operation and maintenance of BMPs. Approved stormwater technical manuals for the Presumptive approach include this manual and other equivalent stormwater management guidance documents approved by Ecology. This approach will generally be more cost effective for typical development and redevelopment projects.

Figure I-1.4: Relation Between Environmental Science and Standards in Stormwater Regulations

Standards

Water Pollution Control Act

(Chapter 90.48 RCW)

Discharges to state waters shall not cause pollution, which is defined as an alteration of the physical, chemical or biological properties of State waters which would impair beneficial uses. Requires the use of AKART and BMPs approved by Ecology.

Federal Clean Water Act

Restore and maintain the chemical, physical, and biological integrity of the Nation's waters.

- State water quality standards (water-quality based treatment requirements)
- Federal technology-based treatment requirements
- NPDES permits
- 303(d) impaired water body list and water clean-up plans

Others

Endangered Species Act

- Properly functioning conditions

Hydraulics Code (HPA)

Safe Drinking Water Act (UIC)

Presumptive Approach

The Stormwater Management Manual for Western Washington provides a default set of stormwater practices based on current science which satisfy State and Federal stormwater requirements.

Considerations:

- More predictable, practices are approved across jurisdictions
- Costly studies, etc. are not required as they may be under the demonstrative approach

Demonstrative Approach

Project sponsor and approval agency individually review and condition proposed projects to meet federal and state stormwater standards based on current science.

Considerations:

- Lacks predictability and can be very time consuming
- For large, complex projects may reduce costs and/or improve environmental protection

Science

Hydrology

- When native vegetation is removed and replaced with impervious surfaces (roads or buildings) there is an increase in stormwater runoff and other drastic alterations to the natural hydrology.
- Increased flows lead to increased flooding and stream bank and stream bed erosion.
- Unless mitigated, adverse high flow impacts occur at even low levels of urban development: 4% to 10% total impervious area.
- Transportation infrastructure (including parking areas) represents 50% and 75% of the impervious surface area within any single watershed.

Water Quality

- More than one-third of the State's urban streams, creeks, and embayments are impaired due to stormwater runoff.
- Stormwater runoff from construction activities can contain large amounts of sediments and suspended solids which are harmful to fish and other aquatic life.
- Untreated stormwater from roads and urban areas can adversely impact water quality due to sediments, toxic metals, pesticides, herbicides, oils and greases, and possible human pathogens including fecal coliform bacteria.
- Untreated stormwater runoff from roads and urban areas can be toxic to aquatic life including fish.

DEPARTMENT OF ECOLOGY
State of Washington

Relation Between Environmental Science and Standards in Stormwater Regulations

Revised June 2016

I-2 Relationship of This Manual to Permits, Requirements, and Programs

I-2.1 The Manual's Role as Technical Guidance

The *Stormwater Management Manual for Western Washington* (the SWMMWW) is not a regulation. The SWMMWW does not have any independent regulatory authority and it does not establish new environmental regulatory requirements. Its "Requirements" and BMPs become required through:

- Ordinances and rules established by the state and local governments; and
- Permits and other authorizations issued by local, state, and federal authorities.

Current law and regulations require the design, construction, operation, and maintenance of stormwater systems that prevent pollution of State waters. The SWMMWW is a guidance document that provides local governments, State and Federal agencies, developers and project proponents with a stormwater management strategy to apply at the project level. If this strategy is implemented correctly, in most cases it should result in compliance with existing regulatory requirements for stormwater – including compliance with the Federal Clean Water Act, Federal Safe Drinking Water Act and State Water Pollution Control Act.

The SWMMWW provides generic, technical guidance on measures to:

- prevent pollutants from coming into contact with stormwater,
- control the quantity and quality of stormwater runoff from construction sites, and
- control the quantity and quality of stormwater runoff from new development and redevelopment projects.

These measures are considered to be necessary to achieve compliance with State water quality standards and to contribute to the protection of the beneficial uses of the receiving waters (both surface and ground waters). Stormwater management techniques applied in accordance with the SWMMWW are presumed to meet the technology-based treatment requirement of State law to provide all known available and reasonable methods of treatment, prevention, and control (AKART; RCW 90.52.040, and RCW 90.48.010).

This technology-based treatment requirement does not excuse any discharge from the obligation to apply additional stormwater management practices as necessary to comply with State water quality standards. The State water quality standards include: Chapter 173-200 WAC, Water Quality Standards for Ground Waters of the State of Washington; Chapter 173-201A WAC, Water Quality Standards for Surface Waters of the State of Washington; and Chapter 173-204 WAC, Sediment Management Standards.

Following the SWMMWW is not the only way to properly manage stormwater runoff. A municipality may adopt, or a project proponent may choose to implement other methods to protect water quality; but in those cases, they assume the responsibility of providing technical justification that the chosen methods will protect water quality (see I-1.6 Presumptive versus Demonstrative Approaches to Protecting Water Quality).

I-2.2 AKART

What is AKART?

RCW 90.48.010 requires the use of "all known available and reasonable methods by industries and others to prevent and control the pollution of the waters of the state of Washington." This statutory requirement is generally known by the acronym AKART.

The Underground Injection Control Program, in WAC 173-218-030, further defines AKART as the most current methodology that can be reasonably required for preventing, controlling, or abating the pollutants associated with a discharge.

How Does AKART Relate to This Manual?

Per WAC 173-218-030, this manual may be used as a guideline, to the extent appropriate, for developing best management practices (BMPs) to apply AKART for stormwater discharges to Underground Injection Control wells.

New development and redevelopment sites can use this manual to select, design, document, install, and maintain stormwater BMPs to fulfill their statutory obligation to provide “all known available and reasonable methods by industries and others to prevent and control the pollution of the waters of the State of Washington".

I-2.3 The Action Agenda for Puget Sound

What is the Action Agenda For Puget Sound?

In 2007, the Washington State Legislature passed legislation to create the Puget Sound Partnership. The legislation mandated that the Partnership coordinate the effort to protect and restore Puget Sound through a strategic, prioritized, science-based Action Agenda "that addresses all of the complex connections among the land, water, web of species, and human needs."

The Puget Sound Partnership's *Action Agenda for Puget Sound* (the Action Agenda) [e.g. (PSP, 2016)] is the Puget Sound region's shared roadmap for Puget Sound recovery. The Action Agenda outlines the strategies and actions needed to protect and restore Puget Sound. The Action Agenda is a collective effort that is informed by science and guides effective investment in Puget Sound protection and restoration.

The Action Agenda consists of a Comprehensive Plan and an Implementation Plan:

- The Comprehensive Plan outlines the long-term overarching strategies, identifies the full scope of actions and funding necessary for recovery, and introduces the approaches by which issues and activities are prioritized, progress is evaluated, and strategies and actions are adapted over time.
- The Implementation Plan is the action component of the Action Agenda for the next two years.

Based on the fundamental framework and broad strategies described in the Comprehensive Plan, the Implementation Plan defines the suite of Near Term Actions and ongoing programs that are needed in order to make progress toward achieving the 2020 recovery targets for Puget Sound.

The Action Agenda identifies three Strategic Initiatives that emphasize the priority topics and issues critical to Puget Sound recovery. The three Strategic Initiatives are:

- Stormwater Strategic Initiative: Prevent pollution from urban stormwater runoff
- Habitat Strategic Initiative: Protect and restore habitat
- Shellfish Strategic Initiative: Protect and recover shellfish beds

The Action Agenda then focuses planned efforts into Near Term Actions and numerous Ongoing Programs that support the Strategic Initiatives. Near Term Actions and Ongoing Programs can be owned by the state, local, or federal government entities as well as academic institutions and non-profit organizations.

How Does the Action Agenda For Puget Sound Relate to This Manual?

The Action Agenda and this manual mutually influence each other. First, study results from some Near Term Actions (NTAs) are anticipated to inform future updates to this manual (the NTAs influence the manual). Second, some NTAs use this manual as a guidance or reference document (the manual influences the NTAs).

The Strategic Initiative most aligned with this manual is the *Stormwater Strategic Initiative: Prevent pollution from urban stormwater runoff*. Within the Stormwater Strategic Initiative, examples of NTAs that are related to the manual are:

- *Liberty Bay Bioretention and Low-Impact Development Program:* Construct bioretention cells and other low-impact development facilities at priority commercial and residential areas to support TMDL goals and upgrades to shellfish bed classifications.
- *Determine Organics and Bacterial Reductions by Treatment Best Management Practices:* Measure how effectively best management practices remove certain organics such as polycyclic aromatic hydrocarbons (PAHs) and bacteria such as fecal coliforms and enterococci.
- *Permeable Pavement Standards Development Based on Lessons Learned:* Test new permeable mix designs and material testing procedures to further pavement durability, develop permeable pavement standards, and increase confidence in permeable pavements.
- *Improved Treatment of Phosphorus in Stormwater:* Evaluate a low-cost phosphorus treatment medium to allow its widespread use in stormwater treatment systems throughout the region.

There are also several Ongoing Programs within the Stormwater Strategic Initiative that either influence or are influenced by this manual. Examples include:

- Watershed Planning Program
- National Pollutant Discharge Elimination System Permit Program
- Stormwater Financial Assistance Program
- Stormwater Education Programs
- Water Quality Program
- Water Quality Monitoring Programs
- Spills Program

I-2.4 Phase I and Western Washington Phase II Municipal Stormwater Permits

What are the Phase I and Western Washington Phase II Municipal Stormwater Permits?

Ecology issues the Phase I and Western Washington Phase II Municipal Stormwater Permits to regulate stormwater discharges from municipal separate storm sewer systems (MS4s). These permits are used to meet both federal and state requirements:

- The federal Clean Water Act made it unlawful to discharge pollutants, including stormwater, from a point source into waters of the U.S. unless a National Pollutant Discharge Elimination System (NPDES) permit is obtained. Ecology has authority delegated under the NPDES permit program by the Environmental Protection Agency (EPA), and is therefore in charge of administering the NPDES permits within Washington State.
- State requirements are in addition to the federal requirements, and require a State Waste Discharge Permit for disposal of waste material into "waters of the state," which include rivers, lakes, streams, and all underground waters and aquifers. A State Waste Discharge Permit may be required for facilities that have stormwater runoff to surface waters.

To control discharges from MS4s, Ecology has combined the two permits described above into the General Municipal Stormwater Permits. There are two General Municipal Stormwater Permits in Western Washington:

- Phase I (for medium and large MS4s)
- Phase II (for smaller MS4s)

The Phase I and Western Washington Phase II Municipal Stormwater Permits are programmatic, and detail what is required for a Permittee to be in compliance with the federal and state requirements. Topics (in general) include:

- Public education and outreach
- Public involvement and participation
- Illicit discharge detection and elimination

- Controlling runoff from new development, redevelopment, and construction sites
- Municipal operations and maintenance

For more information, or to view the Phase I and Western Washington Phase II Municipal Stormwater Permits, refer to the following website:

https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Stormwater-general-permits/Municipal-stormwater-general-permits.

How do the Phase I and Western Washington Phase II Municipal Stormwater Permits Relate to This Manual?

The Phase I and Western Washington Phase II Municipal Stormwater Permits refer to this manual primarily for the site planning process, BMP selection, and design criteria for controlling runoff from new development, redevelopment, and construction sites. Permittees may use the methods described in this manual to meet some of their Permit requirements. Phase I Permittees also have the option of using an Ecology approved equivalent manual, and Phase II Permittees have the option to use their own, non-Ecology approved manual. If a Permittee chooses to deviate from the site planning process, BMP selection, or design criteria in this (or an Ecology approved equivalent) manual, they must demonstrate that their alternative will protect water quality, meet the federal statutory requirement to reduce pollutants to the maximum extent practicable (MEP), and satisfy the state requirement to apply all known, available, and reasonable methods of pollution control.

I-3 Minimum Requirements for New Development and Redevelopment (within this manual) provides guidance for the requirements within Appendix 1 of the Phase I and Western Washington Phase II Municipal Stormwater Permits. Text in the manual that originates from the permit is noted.

Other subjects within the Phase I and Western Washington Phase II Municipal Stormwater Permits that this manual provides additional guidance for include:

- Operation and maintenance of BMPs
- Source control
- Comprehensive stormwater planning

I-2.5 Municipalities Not Subject to the Municipal Stormwater Permits

Who Are the Municipalities Not Subject to the Municipal Stormwater Permits?

As described in I-2.4 Phase I and Western Washington Phase II Municipal Stormwater Permits, certain municipalities and other entities are required by state and federal law to be permitted under an Ecology Municipal Stormwater Permit. For a full list of Permittees under Ecology's Municipal Stormwater Permits, refer to the following website:

https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Stormwater-general-permits/Municipal-stormwater-general-permits

This section is directed at those municipalities that are NOT listed at the website above. Because they are not required to have an Ecology Municipal Stormwater Permit, they are not required by state or federal law to adopt stormwater programs. However, UIC program requirements still apply if UIC wells are used to manage stormwater, whether a municipality is covered under a municipal stormwater permit or not.

How do the Municipalities Not Subject to the Municipal Stormwater Permits Relate to This Manual?

Ecology encourages municipalities not subject to Municipal Stormwater Permits to adopt stormwater programs. This would include adoption of ordinances, minimum requirements, and BMPs equivalent to those in this manual.

Ecology recommends that municipalities not subject to the Municipal Stormwater Permits adopt and use the statements in I-3 Minimum Requirements for New Development and Redevelopment that are "boxed" and noted as originating from the Municipal Stormwater Permits. Ecology further recommends adoption and use of the text in I-3.5 Additional Protective Measures (Optional).

The text that is not "boxed" does not originate from the Municipal Stormwater Permits and is provided for background, clarification, and implementation guidance.

I-2.6 Industrial Stormwater Permits

What are Industrial Stormwater Permits?

Ecology issues Industrial Stormwater Permits to regulate stormwater discharges from industrial facilities. The permits are used to meet both federal and state requirements:

- The federal Clean Water Act made it unlawful to discharge pollutants, including stormwater, from a point source into waters of the U.S. unless a National Pollutant Discharge Elimination System (NPDES) permit is obtained. Ecology has authority delegated under the NPDES permit program by the Environmental Protection Agency (EPA), and is therefore in charge of administering the NPDES permits within Washington State.
- State requirements are in addition to the federal requirements, and require a State Waste Discharge Permit for disposal of waste material into "waters of the state," which include rivers, lakes, streams, and all underground waters and aquifers. A State Waste Discharge Permit is also required for certain industrial users that discharge industrial waste into sanitary sewer systems. A State Waste Discharge Permit may be required for facilities that have stormwater runoff to surface waters.

To control discharges from industrial facilities, Ecology has combined the two permits described above into the Industrial Stormwater Permits. Ecology issues three types of Industrial Stormwater Permits:

- *Industrial Stormwater General Permit:* The Industrial Stormwater General Permit (ISGP) is a general permit written to apply to a range of industrial facilities of various types.
- *Industrial Stormwater Individual Permit:* An individual permit is a permit that is written for and issued to a specific facility. EPA regulations require that industries not covered under a general permit must apply for an individual stormwater permit.
- *Industry-Specific General Permit:* An industry-specific permit is a permit that can apply to all industries of a similar type. Examples of industry-specific general permits that include stormwater are the Sand and Gravel General Permit and the Boatyard General Permit.

The development of an Industrial Stormwater Pollution Prevention Plan (SWPPP) by each facility is a key Industrial Stormwater Permit requirement. The Industrial SWPPP requirements include:

- Identifying the potential sources of pollutants that may contaminate stormwater.
- A description and implementation of operational and structural Source Control BMPs to reduce the stormwater pollutants and comply with the permit.

The Industrial Stormwater Permits also includes requirements for:

- Effluent limitations for certain types of industrial facilities, and certain discharges to 303(d) impaired waterbodies;
- Monitoring: All industrial facilities are required to conduct quarterly monitoring and sampling. There are additional monitoring requirements for certain, identified industry groups;
- Application of additional Source Control and Runoff Treatment BMPs to control pollutants further if certain “benchmark” levels of pollutants, as identified in the permit, are exceeded;
- Reporting and Recordkeeping;
- Operation and Maintenance

For more information, or to view the ISGP, refer to the following website:

http://www.ecy.wa.gov/programs/wq/stormwater/industrial/index.html.

How Do the Industrial Stormwater Permits Relate to This Manual?

The Industrial Stormwater Permits refer to this manual primarily for Best Management Practices (BMP) design criteria.

The ISGP requires Industrial SWPPPs to include certain mandatory BMPs, including those BMPs identified as “applicable” to specific industrial activities in Volume IV of this manual. Industrial facilities with new development or redevelopment must evaluate whether Flow Control BMPs are necessary. BMPs must be consistent with this manual, or other stormwater management guidance documents that are approved by Ecology and incorporated into the ISGP. Industrial facilities may also use alternative BMPs if their Industrial SWPPP includes documentation that the BMPs selected are demonstrably equivalent to practices contained in stormwater technical manuals approved by Ecology, including the proper selection, implementation, and maintenance of all applicable and appropriate best management practices for on-site pollution control.

ISGP facilities are required to update their Industrial SWPPPs and perform corrective actions if stormwater monitoring results exceed “benchmark” or indicator values. Facilities that trigger corrective actions under the ISGP, or otherwise need to update their SWPPP, should consider:

1. “Recommended” operational and structural Source Control BMPs listed in Volume IV.
2. Runoff Treatment BMPs listed in Volume V.
3. Erosion and sediment control BMPs listed in Volume II (e.g., if turbidity, sediment, or associated pollutants need to be addressed).
4. Manufactured Treatment Devices that have been evaluated through Ecology’s TAPE or C-TAPE program.
5. BMPs that are “demonstrably equivalent”, as defined by the ISGP.

I-2.7 Construction Stormwater General Permit

What is the Construction Stormwater General Permit?

Ecology issues the Construction Stormwater General Permit (CSWGP) to regulate stormwater discharges from construction activities. This permit is used to meet both federal and state requirements:

- The federal Clean Water Act made it unlawful to discharge pollutants, including stormwater, from a point source into waters of the U.S. unless a National Pollutant Discharge Elimination System (NPDES) permit is obtained. Ecology has authority delegated under the NPDES permit program by the Environmental Protection Agency (EPA), and is therefore in charge of administering the NPDES permits within Washington State.
- State requirements are in addition to the federal requirements, and require a State Waste Discharge Permit for disposal of waste material into "waters of the state," which include rivers, lakes, streams, and all underground waters and aquifers. A State Waste Discharge Permit may be required for facilities that have stormwater runoff to surface waters.

To control discharges from construction activities in Washington State, Ecology has combined the two permits described above into the Construction Stormwater General Permit.

The CSWGP requires application of stabilization and structural practices to reduce the potential for erosion and the discharge of sediments from the site. Coverage under the CSWGP is generally required for any clearing, grading, or excavating if the project site discharges:

- Stormwater from the site into surface water(s) State, or
- Into storm drainage systems that discharge to a surface water(s) of the State.

And

- Disturbs one or more acres of land area, or
- Disturb less than one acre of land area, if the project or activity is part of a larger common plan of development or sale.

Any construction activity discharging stormwater that Ecology determines to be a significant contributor of pollutants to waters of the State may also require permit coverage, regardless of project size, at the discretion of the agency.

For more information or to view the Construction Stormwater General Permit refer to the following website:

http://www.ecy.wa.gov/programs/wq/stormwater/construction/index.html.

How does the Construction Stormwater General Permit Relate to This Manual?

Two essential requirements within the CSWGP are the design and implementation of Construction Stormwater BMPs, and preparation and execution of Construction Stormwater Pollution Prevention Plans (SWPPPs). This manual provides guidance that may be used for both of those requirements in Volume II.

I-2.8 Endangered Species Act

What is the Endangered Species Act?

The Endangered Species Act (ESA) is a federal law that provides for the conservation of threatened and endangered plants and animals and the habitats in which they are found. The lead federal agencies for implementing ESA are the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service, National Oceanic and Atmospheric Administration (NOAA). The FWS maintains a list of domestic and foreign endangered species. Species include birds, insects, fish, reptiles, mammals, crustaceans, flowers, grasses, and trees.

The law requires federal agencies, in consultation with the FWS and/or the NOAA Fisheries Service, to ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat of such species. The law also prohibits any action that causes a "taking" of any listed species of endangered fish or wildlife. The prohibition against “taking” a listed species includes destruction of critical habitat.

For more information, or to view the Endangered Species Act in its entirety, refer to the following website:

https://www.fws.gov/endangered/laws-policies/.

How Does the Endangered Species Act Relate to This Manual?

Although the ESA does not directly refer to this manual, project proponents may find the guidance and methods advocated in this manual useful to minimize the impacts from their projects, resulting in the project not "taking" a listed species.

Potential impacts that may be minimized by using the guidance in this manual include discharges containing sediment, turbidity, or abnormal pH. Specific adverse impacts include:

- Suffocation of eggs or fry.
- Displacement and elimination of aquatic invertebrates used for food.
- Reduction in the biodiversity of aquatic invertebrates.
- Reduction of foraging abilities in turbid water.
- Irritation of gill tissue that can lead to disease or death.
- Filling of resting or feeding areas, or spawning gravels with sediment.

The stranding of listed species behind erosion and sediment control features or the impairment of their access into certain areas due to the presence of erosion and sediment control features could also be determined to be a take under ESA.

I-2.9 Section 401 Water Quality Certifications

What is a Section 401 Water Quality Certification?

Section 401 of the federal Clean Water Act (CWA) requires project proponents applying for a federal license or permit for a project that may result in discharge into navigable waters to submit a 401 Water Quality Certification to the federal licensing or permitting agency. The 401 Water Quality Certification is provided by the State, after evaluating the proposed project and determining that the project will meet state water quality standards, coastal resource protection requirements, fish and wildlife habitat standards, and other applicable regulations. Examples of federal permit applications that require a 401 Water Quality Certification are:

- a Section 404 Permit: Regulates the discharge of dredged or fill material into waters of the United States, including wetlands. Activities in waters of the United States regulated under this permit include fill for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports) and mining projects. A Section 404 Permit is required before dredged or fill material may be discharged into waters of the United States, unless the activity is exempt from Section 404 regulation (e.g., certain farming and forestry activities).
- a Federal Energy Regulatory Commission (FERC) License: Permits a dam owner to use public waters for energy generation. It specifies the conditions for construction, operation, and maintenance of the project. When final, a license is enforceable by FERC or the U.S. District Court through fines or injunction.
- a Section 402 NPDES Permit issued by the EPA in Washington State: A general NPDES permit issued by the U.S. EPA within a state, such as a municipal stormwater permit for a federal facility (e.g. military bases).

Project review is often a collaborative process between Ecology, the permitting federal agency, and the applicant.

For more information, refer to the following website:

http://www.ecy.wa.gov/programs/sea/fed-permit/index.html.

How Does a Section 401 Water Quality Certification Relate to This Manual?

For projects that require a Section 401 Water Quality Certification, Ecology must certify that the proposed project will not violate water quality standards. In order to make such a determination, Ecology may do a more specific review of the potential impacts of stormwater discharges from both the construction phase of the project and the completed project. As a result of that review, Ecology may condition the 401 Water Quality Certification to require:

- Application of the Minimum Requirements and BMPs in this manual; or
- Application of more stringent requirements.

I-2.10 Water Quality Standards

What are Water Quality Standards?

Water quality standards are provisions that describe the desired condition of a waterbody or the level of protection mandated to achieve the desired condition. These standards form a legal basis for controlling pollution entering receiving waters from a variety of sources (e.g., industrial facilities, wastewater treatment plants, and storm sewers).

Water Quality Standards consist of the following:

- Designated uses of the waterbody. The designated use specifies the goals and expectations for how each water body is used. Typical designated uses include:
    - Protection and propagation of fish, shellfish, and wildlife
    - Recreation
    - Public drinking water supply
    - Agricultural, industrial, navigational, and other purposes.
- Criteria to protect designated uses. Water quality criteria can be numeric (e.g., the maximum pollutant concentration levels permitted in a waterbody) or narrative (e.g., a criteria that describes the desired conditions of a waterbody being "free from" certain negative conditions).
- Antidegradation requirements to protect existing uses and high quality waters. One of the principal objectives of the Clean Water Act is to "maintain the chemical, physical and biological integrity of the Nation's waters." Antidegradation requirements provide a framework for maintaining and protecting water quality that has already been achieved.

  Designated uses and water quality criteria are the primary tools used to achieve the objectives and goals of the Clean Water Act, and antidegradation requirements complement these tools by providing a framework for maintaining existing uses, for protecting waters that are of a higher quality than necessary to support the Clean Water Act goals, and for protecting waters identified by states and authorized tribes as Outstanding National Resource Waters

(ONRWs).

- General policies to address implementation issues.

For more information or to view Washington State's Water Quality Standards, refer to the following WACs:

- Water Quality Standards for discharges to surface water: Chapter 173-201A WAC
- Water Quality Standards for discharges to ground water: Chapter 173-200 WAC

How Do Water Quality Standards Relate to This Manual?

Many Ecology-issued permits and programs refer to Water Quality Standards when describing how to determine if a project is in compliance with the permit or program. Project proponents often use the BMPs detailed in this manual to gain compliance.

General stormwater permittees are given a presumption of compliance with Water Quality Standards if they meet all permit conditions and fully implement all applicable and appropriate on-site pollution control BMPs as contained in, or demonstrably equivalent to practices contained in, this manual. Demonstrated site specific discharge violations remove the presumption of compliance.

I-2.11 Hydraulic Project Approvals

What Are Hydraulic Project Approvals?

Since 1943, anyone planning certain construction projects or activities in or near state waters has been required to obtain a Hydraulic Project Approval (HPA) permit. The Washington Department of Fish and Wildlife (WDFW) administers the HPA program under Chapter 77.55 RCW, which was specifically designed to protect fish life. WDFW issues thousands of HPAs each year for activities including work on bulkheads, piers, docks, culverts, bridges, and sediment dredging projects.

WDFW Habitat Biologists are available to assist with the application process and ensure projects meet state conservation standards for fish and their aquatic habitat.

For more information, refer to the following website:

http://wdfw.wa.gov/licensing/hpa/.

How Do Hydraulic Project Approvals Relate to This Manual?

An HPA may be required for stormwater discharges related to a project that may alter the natural flow or bed of state waters.

In order to minimize the impacts from stormwater discharges from these projects, WDFW may require:

- Compliance with the provisions of this manual; or
- Application of more stringent requirements that they determine are necessary to meet their statutory obligations to protect fish and wildlife.

I-2.12 Aquatic Use Authorizations

What are Aquatic Use Authorizations?

State-owned aquatic lands are managed by the Washington State Department of Natural Resources (DNR) for the benefit of the citizens Washington State. These public lands lie beneath our state's navigable waters and include tidelands and bedlands of marine waters and shorelands and bedlands of lakes and rivers. They were set aside for us at statehood and, to this day, DNR manages them to preserve their environmental integrity that is linked to our quality of life. Projects taking place on or over state-owned aquatic lands require an Aquatic Use Authorization from DNR.

Project proponents apply for an Aquatic Use Authorization from DNR by submitting the online Joint Aquatic Resources Permit Application (JARPA) and Attachment E: Aquatic Use Authorization on DNR-managed Aquatic Lands. DNR then works with applicants to determine:

- If the project will be located on state-owned aquatic lands,
- If the land is available,
- If the proposed use is appropriate, and
- How to construct the project to avoid or lessen impacts to aquatic resources.

DNR's Aquatic Resources Program is unique, acting as a landlord on behalf of the state. DNR will work with the project proponent on the details of the authorization document, which includes determining the type and terms of the use authorization. Examples of types of authorizations include licenses, leases, rights-of-entry, or easements. Examples of terms include amount of rent, survey requirements, insurance, performance security and other site-specific conditions that apply to the proposal.

For more information, refer to the following website:

https://www.dnr.wa.gov/programs-and-services/aquatics/leasing-and-land-transactions.

How Do Aquatic Use Authorizations Relate to This Manual?

A valid Aquatic Use Authorization is required for stormwater outfalls, pipes, and associated infrastructure located on state-owned aquatic lands. The terms of the Aquatic Use Authorization may require:

- Compliance with the provisions of this manual; or
- Application of more stringent requirements that DNR determines are necessary to meet their statutory obligations to protect the quality of state-owned aquatic lands and attached or embedded resources.

I-2.13 Total Maximum Daily Loads (TMDLs)

What are Total Maximum Daily Loads?

Under section 303(d) of the Clean Water Act, states, territories and authorized tribes, collectively referred to in the act as "states," are required to develop lists of impaired waters. These are waters for which technology-based regulations and other required controls are not stringent enough to meet the Water Quality Standards set by states. The law requires that states establish priority rankings for waters on the lists and develop Total Maximum Daily Loads (TMDLs) for these waters.

A TMDL is the calculation of the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet Water Quality Standards for that particular pollutant. A TMDL determines a pollutant reduction target and allocates load reductions necessary to the source(s) of the pollutant.

The objective of a TMDL is to determine the loading capacity of the waterbody, and to allocate that load among different pollutant sources so that the appropriate control actions can be taken and Water Quality Standards achieved. The TMDL process is important for improving water quality because it serves as a link in the chain between Water Quality Standards and implementation of control actions designed to attain those standards.

For more information, refer to the following website:

https://ecology.wa.gov/Water-Shorelines/Water-quality/Water-improvement/Total-Maximum-Daily-Load-process

How Do Total Maximum Daily Loads Relate to This Manual?

Requirements described in this manual can be superseded or added to through the adoption of actions and requirements identified in a TMDL. However, it is likely that at least some TMDLs will require use of BMPs in this manual.

I-2.14 Underground Injection Control (UIC) Program

What is the UIC Program?

One of the provisions of the federal Safe Drinking Water Act is to protect underground sources of drinking water (USDW). In 1984, Ecology received authority from the U.S. EPA to administer the Underground Injection Control (UIC) Program to protect USDW by regulating the discharges of fluids into the subsurface by UIC wells.

Ecology adopted Chapter 173-218 WAC to implement the program; however, the UIC program rule protects all ground water, not just USDW. The U.S. EPA organizes UIC wells into six classes. The Washington UIC program regulates Class I through Class V UIC wells, except for wells located on tribal land. UIC wells used to manage stormwater are considered Class V wells. For more information, visit Ecology's web page for the UIC program at the following address:

https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Underground-injection-control-program

The UIC program has two requirements:

1. A non-endangerment performance standard must be met, prohibiting discharges that allow movement of fluids containing contaminants to reach the ground water.
2. All UIC facility owners/operators must complete online UIC well registration with Ecology.

The UIC program defines a UIC well as a well that is used to discharge fluids from the ground surface into the subsurface and is one of the following:

1. A bored, drilled or driven shaft, or dug hole whose depth is greater than the largest surface dimension; or
2. A dug hole whose depth is greater than the largest surface dimension, or
3. An improved sinkhole; which is a natural crevice that has been modified, or
4. A subsurface fluid distribution system which includes perforated pipes, drain tiles or other similar mechanisms intended to distribute fluids below the surface of the ground.

Examples of UIC wells or subsurface infiltration systems are the following:

1. Drywells
2. Drain Fields
3. Infiltration trenches with perforated pipe
4. Storm chamber systems with the intent to infiltrate
5. French Drains
6. Bioretention systems intending to infiltrate water from a perforated pipe below the treatment soil
7. Other similar devices that discharge to ground

The following are not UIC wells:

- Buried pipe and/or tile networks that serve to collect water and discharge that water to a drainage system or to a receiving water
- Surface infiltration basins and flow dispersion stormwater facilities
- Infiltration trenches designed without perforated pipe or a similar mechanism
- Bioretention systems transporting water via a perforated pipe to a drainage system or to a receiving water

Depending upon the manner in which it is accomplished, the discharge of stormwater into the ground can be classified as a Class V injection well, and must therefore comply with Ecology's UIC Program.

The UIC rule (Chapter 173-218 WAC) applies to all Class V UIC wells that receive stormwater discharges. These wells must be sited, designed, constructed, managed, operated and maintained according to the requirements throughout I-4 UIC Program.

If all stormwater runoff from the project site discharges to a Class V UIC well, the Municipal Stormwater Permits do not pertain to the project, and the Minimum Requirements do not apply. The UIC rule (Chapter 173-218 WAC) applies in such cases. See I-4 UIC Program for details on the rules, registration requirements, regulations, non-endangerment standard, treatment requirements, and operation guidelines.

How Does the UIC Program Relate to This Manual?

This manual presents several BMPs to infiltrate stormwater (see V-5 Infiltration BMPs). If the project design includes an infiltration BMP that is classified as a UIC well by the UIC Program, the design must ensure compliance with the UIC Program as well as any other applicable regulatory requirements.

Ecology's UIC Program refers designers to this manual (or other approved Stormwater Manuals) for design guidance for infiltration BMPs and Source Control BMPs, as well as for determining the level of Runoff Treatment that is required prior to infiltrating stormwater. I-4 UIC Program provides further guidance on complying with the UIC Program.

I-2.15 Other Requirements

This section contains information on regulatory requirements not covered earlier in this chapter that may affect a project proponent's stormwater management design and/or implementation. The information contained herein is not all-encompassing of every regulatory requirement that might apply to a project, but is intended to help project proponents be aware of other requirements that may impact their project.

Local Government Requirements

Local governments have the option of applying more stringent requirements than those in this manual. They are not required to base those more stringent requirements on a watershed plan or their obligations under a TMDL. Project proponents should always check with the local government agency with jurisdiction to determine the stormwater requirements that apply to their project.

Growth Management Act

The Growth Management Act (GMA) requires local governments to ensure that planned growth and development occurs in a manner which properly manages stormwater and protects critical areas and water resources. New development and redevelopment codes based on the SWMMWW, or equivalent, may be a way for municipalities to demonstrate GMA compliance.

Requirements for Stormwater Discharges to Public Sanitary Sewers, Septic Systems, Dead-End Sumps, and Industrial Waste Treatment Systems

Stormwater Discharges to Sanitary Sewers

Discharging stormwater to a public sanitary sewer is normally prohibited, as this tends to overload the sewage treatment plant during storm events when flows are already high. Direct discharge of relatively uncontaminated or treated stormwater to the receiving water typically poses less of a threat to the environment than the pass through of solids that may occur at the sewage treatment plant during storm events, if the stormwater discharged to the sanitary sewer. Stormwater discharge to the sanitary sewer requires the approval of the local Sewer Authority if Ecology has delegated the authority to set pretreatment requirements. If the Sewer Authority has not received such authority, the business or public agency that wishes to discharge stormwater to the sanitary sewer must apply for a State Waste Discharge Permit.

In setting pretreatment requirements, the local Sewer Authority or Ecology must operate within state regulations (Chapter 173-216 WAC – State Waste Water Discharge Permit Program) which in turn must comply with federal regulations (40 CFR Part 403.5 – National Pretreatment). These regulations specifically prohibit discharge of the following:

- Any materials that pass through the municipal treatment plant untreated or interfere with its operation.
- Any materials that create a fire or explosion hazard, including, but not limited to, wastestreams with a closed cup flash point of less than 140 degrees Fahrenheit or 60 degrees Centigrade using the test methods specified in 40 CFR 261.21.
- Any materials that will cause corrosive structural damage to the Publicly Owned Treatment Works (POTW), but in no case Discharges with pH lower than 5.0, or greater than 11, unless the works is specifically designed to accommodate such Discharges; and the discharge authorized by a permit issued under Chapter 173-216 WAC. (See WAC 173-216-060 (2)(iv)).
- Solid or viscous pollutants in amounts that will cause obstruction to the flow in the POTW resulting in interference.
- Heat in amounts that will inhibit biological activity in the POTW resulting in interference, but in no case heat in such quantities that the temperature at the POTW Treatment Plant exceeds 40 degrees Centigrade (104 degrees Fahrenheit) unless the system is specifically designed to accommodate such discharge, and the discharge is authorized by a permit under Chapter 173-216 WAC. (See WAC 173-216-060 (2) (v)).
- Petroleum oil, nonbiodegradable cutting oil or products of mineral oil origin in amounts that will cause interference or pass through the treatment plant.
- Pollutants that result in the presence of toxic gases, vapors, or fumes within the POTW in a quantity that may cause acute worker health and safety problems.

- Any trucked or hauled pollutants, except at discharge points designated by the POTW.
- Any discharge which would violate the dangerous waste regulations, Chapter 173-303 WAC (see WAC 173-216-060(1)).
- Any of the following discharges, unless approved by the department under extraordinary circumstances, such as lack of direct discharge alternatives due to combined sewer service or need to augment sewage flows due to septic conditions: (WAC 173-216-060(2)(vii)):
    - Noncontact cooling water in significant volumes.
    - Stormwater, and other direct inflow sources.
    - Wastewater significantly affecting system hydraulic loading, which do not require treatment or would not be afforded a significant degree of treatment by the system.

Discharges of stormwater authorized under Chapter 173-216 WAC, typically limit flows entering the sanitary sewer based on the available hydraulic capacity of the collection system or the treatment plant by the combined flow of sanitary sewage and stormwater. The allowable concentrations of particular materials such as metals and grease vary with the particular sewer system. Discharges must comply with all local government limits. The project proponent must contact both the POTW and the regional water quality program to find out what discharge limits apply to a particular sewerage system.

Stormwater Discharges to an Industrial Waste Treatment System

The operator(s) of the industrial waste treatment system may treat the polluted stormwater, depending on the NPDES permit constraints for the particular industrial waste treatment system.

Stormwater Discharges to Dead-end Sumps

Do not discharge substances that cause a violation of water quality standards to a septic system, surface water, or ground water. If a sanitary or industrial wastewater treatment system is not available, an alternative is the use of a dead-end sump. Sumps are tanks with drains that can be periodically pumped for appropriate disposal. Depending on the composition of the waste, it may or may not be considered Dangerous Waste.

Uniform Fire Code Requirements

Storage of flammable, ignitable, and reactive chemicals and materials must comply with the stricter of local zoning codes, local fire codes, the Uniform Fire Code, Uniform Fire Code standards or the National Electric Code.

Ecology Requirements for Generators of Dangerous Wastes

The State's Dangerous Waste Regulations (Chapter 173-303 WAC) cover accumulation, storage, transportation, treatment and disposal of dangerous wastes. Of interest to this manual are those businesses or public agencies that accumulate the waste at their building until taken from the site by a contract hauler.

For more information on applicable requirements for dangerous wastes, contact Ecology's Hazardous Waste and Toxics Reduction Program.

Standards for Solid Waste Containers

Standards for solid waste containers are identified in WAC 173-350-300, On-site Storage, Collection, and Transportation Standards.

Coast Guard Requirements for Marine Transfer of Petroleum Products

Federal regulations 33 CFR Parts 153, 154 and 155 cover, respectively, general requirements on spill response, spill prevention at marine transfer facilities, and spill prevention for vessels. These regulations specify technical requirements for transfer hoses, loading arms, closure, and monitoring devices. The regulations also cover small discharge containment; they require the use of “fixed catchments, curbing, and other fixed means” at each hose handling and loading arm area and each hose connection manifold area.

The regulations also require an operations plan and specify its general contents. The plan shall describe the responsibilities of personnel, nature of the facility, hours of operation, sizes and numbers of vessels using the facility, nature of the cargo, procedures if spills occur, and petroleum transfer procedures. The plan must also include a description and location of equipment for monitoring, containment, and fire fighting.

See also *NFPA 30A: Code for Motor Fuel Dispensing Facilities and Repair Garages* (NFPA, 2012).

Washington State/Federal Emergency Spill Cleanup Requirements

Washington State Requirements

The Oil and Hazardous Substance Spills Act of 1990 and the Oil Spill Prevention and Response Act of 1991 (Chapter 90.56 RCW) authorized Ecology to develop effective oil spill response regulations.

The Facility Contingency Plan and Response Contractor Standards (Chapter 173-182 WAC)

This Ecology regulation applies to all oil handling facilities (including pipelines) that are on or near navigable waters and transfer bulk oil by tank, ship, or pipeline. It contains the following elements:

- Standards for contingency plan content
- Procedures to determine the adequacy of contingency plans
- Requirements for periodic review
- Standards for cleanup and containment contractors

The Oil Handling Training and Certification Rule (Chapter 173-180 WAC) establishes oil spill training and certification requirements for key facility personnel including applicable contractors involved in oil handling, transfer, storage, and monitoring operations.

In accordance with WAC 173-303-350 of Ecology's Dangerous Waste Regulations, generators of dangerous wastes must have a Contingency Plan that includes:

- Actions to be taken in the event of spill
- Descriptions of arrangements with local agencies
- The name of the owner's Emergency Coordinator
- A list of emergency equipment available
- An evaluation plan for business personnel

For more information on disposal requirements for solid and dangerous wastes, contact Ecology's Hazardous Waste and Toxics Reduction Program.

Federal Requirements

The Oil Pollution Act of 1990 is a comprehensive federal law that addresses marine oil spill issues including contingency plans, financial responsibility, marine safety regulations, etc.

Spill Prevention Control and Countermeasure (SPCC) Plans

Federal Regulations require that owners or operators of facilities engaged in drilling, producing, gathering, storing, processing, refining, transferring, or consuming oil and oil products have a Spill Prevention and Control Plan (SPCC) if the facility has:

- an aggregate capacity greater than 1,320 gallons, or
- a total below-ground capacity in excess of 42,000 gallons.

WSDA Pesticide Regulations

The Washington State Department of Agriculture (WSDA) administers pesticide laws, under the Washington Pesticide Control Act (Chapter 15.58 RCW), Washington Pesticide Application Act (Chapter 17.21 RCW), and regulations under Chapter 16-228 WAC. The requirements relevant to water quality protection are:

Licenses are required for persons who apply pesticides except:

- People who use general-use pesticides on their own or their employer's property;
- Grounds maintenance people using only general-use pesticides on an occasional basis not amounting to a regular occupation;
- Governmental employees who apply general-use pesticides without utilizing any kind of motorized or pressurized apparatus;
- Employees of a commercial applicator or a government agency who are under direct on-site supervision by a licensed applicator.

Licensed applicators must undergo 40 hours of continuing education to keep their license.

No person shall pollute streams, lakes, or other water supplies while loading, mixing or applying pesticides.

No person shall transport, handle, store, load, apply, or dispose of any pesticide, pesticide container, or apparatus in such a manner as to pollute water supplies or waterways, or cause damage or injury to land, including humans, desirable plants, and animals.

For more information on pesticide application and disposal requirements, the following publications may be useful:

Suspended, Canceled and Restricted Pesticides (USEPA, 1985)

Best Management Practices for Agricultural Chemicals (Ecology, 2005)

Focus on Pesticide Containment Areas - Reducing and Managing Wastes from Pesticide Containment Areas (Ecology, 2010)

Spill Reporting and Cleanup in Washington State: A Guide for Pesticide Secondary Containment (Ecology, 1994)

Focus on Dangerous Waste - Safe Handling of Empty Containers (Ecology, 2016)

Step by Step Fact Sheet for Hazardous Waste Generators (Ecology, 2003b)

Air Quality Regulations

Regulation of air pollutant emissions in Washington is controlled by seven local air pollution control agencies, three Ecology regional offices and two Ecology programs (Central Program's Industrial Section, and Nuclear and Mixed Waste Program). All of the local air pollution agencies and the regional offices enforce local, state and federal air pollution regulations. The Industrial Section of Ecology's Central Program enforces state and federal air pollution regulations at chemical pulp mills and aluminum reduction facilities. The Nuclear and Mixed Waste Program enforces state and federal air pollution regulation on the Hanford Nuclear Reservation.

Whether it is to control the generation of fugitive emissions or point source (smoke stack) emissions, new and existing sources of air pollutants must comply with the requirements contained in their air pollution permits, regulatory orders, and local, state, and federal air pollution regulations. This will minimize the effects of each facility's emissions on stormwater.

Fugitive Particulate Matter Emissions

The local and state air pollution control agencies require that all reasonable precautions be taken to prevent fugitive particulate matter (windblown dust) from becoming airborne when handling, loading, transporting, and storing particulate material. Particulate materials of concern can include grain and grain dust, saw dust, coal, gravel, crushed rock, cement, and boiler fly ash.

Some of the local authorities take the general requirement to control fugitive emissions further. For example, the Puget Sound and Benton County Air Pollution Control Agencies have defined what "reasonable precautions" means for various dust causing activities in their jurisdictions.

Some actions that have been defined as "reasonable precautions" to prevent fugitive particulate emissions include:

- paving of parking and storage areas,
- minimizing the area of land that has been cleared for a housing development,
- various housekeeping activities (such as sweeping paved areas),
- minimization of the accumulation of mud and dust,
- preventing mud and dust from being tracked onto public roads, and
- stabilization of material piles and open, cleared land areas with water sprays, chemical stabilizers or other means that minimize dust generation.

All air authorities require sand blasting and spray painting activities be performed indoors with proper air pollution controls in use or, if that is not possible, out of doors but within acceptable, temporary enclosures.

Gaseous Air Pollutant Emissions

Gaseous air pollutants are controlled at the point of origin through add-on emission controls or pollution prevention measures. Each emission point at a plant generally has emission limits that must be complied with.

Sources of gaseous air pollutants can include petroleum storage tank breather and pressure release systems, combustion units (boilers and heaters), commercial printers, can manufacturers, steel mills, pulp and paper plants, auto body repair shops, etc. Examples of gaseous air pollutants that can be emitted include acetone, methylene chloride, styrene, nitrogen oxides, benzene, carbon monoxide, alcohol, organic sulfides and petroleum, and chlorinated solvents.

Some gaseous pollutants can be washed out of the air during rainstorms and enter stormwater. Others are photochemically degraded or converted in the air to other compounds that can be removed by rainfall or by settling on the ground. Gaseous air pollutants such as sulfur dioxide react in the air to generate acidic particulate matter. These particulates are usually removed from the atmosphere by settling out or being washed out of the air. In the case of sulfur oxides, this removal usually occurs at some distance (tens to hundreds of miles) from the facility that emitted the pollutant.

Ecology Waste Reduction Program

The 1990 Hazardous Waste Reduction Act, Chapter 70.95C RCW, established a goal to reduce dangerous waste generation by 50 percent. The primary means for achieving this goal is through implementation of a pollution prevention-planning program, also established in the Act. Facilities that generate in excess of 2,640 pounds of dangerous waste per year, or who are required to report under the Toxic Release Inventory (TRI) of Title III of the Superfund Amendments and Reauthorization Act (SARA), are subject to this law. Some 650 facilities in Washington currently participate in this planning program.

Pollution prevention planning is an activity that involves:

- Inventorying substances used and dangerous waste generated;
- Identifying opportunities to prevent pollution;

- Analyzing the feasibility of these prevention opportunities; and
- Setting goals for hazardous substance use reduction and dangerous waste reduction, recycling and treatment.

Ecology promotes pollution prevention through initiatives other than planning. Several campaigns targeting specific industries have been conducted and more are being planned. These campaigns have a joint focus of pollution prevention and regulatory compliance, and help target future technical assistance. Ecology provides technical assistance through its regional offices, with emphasis on the reduction of hazardous substance use and dangerous waste generation. Site visits, phone consultations, and workshops are some of the ways assistance is provided to businesses and government entities.

Pollution prevention has emerged as a key strategy for protecting the environment. Business, industry and government alike recognize the benefits of prevention rather than end-of-pipe controls. Many factors, including regulatory compliance, cost savings, worker safety and reduced liabilities help validate pollution prevention as an approach to be incorporated into all business practices.

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I-3 Minimum Requirements for New Development and Redevelopment

I-3.1 Introduction to the Minimum Requirements

This chapter describes the Minimum Requirements for stormwater management at new development and redevelopment sites. I-3.3 Applicability of the Minimum Requirements should be consulted to determine which of the Minimum Requirements apply to any given project. Figure I-3.1: Flow Chart for Determining Requirements for New Development and Figure I-3.2: Flow Chart for Determining Requirements for Redevelopment should be consulted to determine whether the Minimum Requirements apply to new surfaces, replaced surfaces, or new and replaced surfaces. Volumes II through V of this manual present Best Management Practices (BMPs) for use in meeting the Minimum Requirements.

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Depending on the type and size of the proposed project, different combinations of the Minimum Requirements or UIC Program regulations apply. See I-4 UIC Program for information on the UIC Program regulations.

In general, small projects are required to control erosion and sedimentation from construction activities and to apply simpler approaches to runoff treatment and flow control of stormwater runoff from the developed site. Controlling flows from small projects is important because the cumulative effect of uncontrolled flows from many small projects can be as damaging as those from a single large project.

Large projects must provide erosion and sedimentation control during construction, permanent control of stormwater runoff from the developed site through selection of appropriate BMPs, and other measures to reduce and control the on-site and off-site impacts of the project.

Sites being redeveloped must generally meet the same Minimum Requirements as new development for the new hard surfaces and converted vegetation areas. Redevelopment sites must also provide erosion control, source control, and on-site stormwater management for the portion of the site being redeveloped. In addition, if the redevelopment meets certain cost or space (as applied to roads) thresholds, updated stormwater management for the redeveloped pervious and hard surfaces must be provided. There may also be situations in which additional controls are required for sites, regardless of type or size, as a result of basin plans or special water quality concerns.

I-3.2 Exemptions

Unless otherwise indicated in this section, the practices described in this section are exempt from the Minimum Requirements, even if such practices meet the definition of new development or redevelopment.

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Forest Practices

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 provisions of the Minimum Requirements.

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Commercial Agriculture

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.

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Oil and Gas Field Activities or Operations

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. Operators 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 surface water quality during storm events.

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Pavement Maintenance

The following pavement maintenance practices are exempt:

- pothole and square cut patching,
- overlaying existing asphalt or concrete pavement with asphalt or concrete without expanding the area of coverage,
- shoulder grading,
- reshaping/regrading drainage systems,
- crack sealing,
- resurfacing with in-kind material without expanding the road prism,
- pavement preservation activities that do not expand the road prism, and
- vegetation maintenance.

The following pavement maintenance practices are not categorically exempt, and are subject to the Minimum Requirements that are triggered when the thresholds identified for new or redevelopment projects are met per I-3.3 Applicability of the Minimum Requirements.

- Removing and replacing an asphalt or concrete pavement to base course or lower, or repairing the pavement base: These are considered replaced hard surfaces.
- Extending the pavement edge without increasing the size of the road prism, or paving graveled shoulders: These are considered new hard surfaces.
- Resurfacing by upgrading from dirt to gravel, a bituminous surface treatment ("chip seal"), asphalt, or concrete; upgrading from gravel to chip seal, asphalt, or concrete; or upgrading from chip seal to asphalt or concrete: These are considered new impervious surfaces.

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Underground Utility Projects

Underground utility projects that replace the ground surface with in-kind material or materials with similar runoff characteristics are only subject to I-3.4.2 MR2: Construction Stormwater Pollution Prevention Plan (SWPPP).

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I-3.3 Applicability of the Minimum Requirements

Minimum Requirement Thresholds

Follow the steps below to ensure the project complies with the applicable Minimum Requirements:

1. First, determine if all runoff is infiltrating into a UIC well (i.e. approved continuous runoff modeling methods indicate that the entire runoff file is infiltrated). If it is, refer to I-4 UIC Program. If not, continue with the steps below.
2. Determine the Minimum Requirements that apply to the entire project using the Project Thresholds for new development and redevelopment listed below.
3. Delineate the Threshold Discharge Areas (TDAs) within the Site. See the definition of TDA in the Glossary for guidance on how to delineate a TDA.
4. For each Minimum Requirement that is applicable to the project (per step 2), use the TDA Thresholds to determine which, if any, BMP(s) must be constructed within each TDA to satisfy that Minimum Requirement. The TDA Thresholds are given within the text of each Minimum Requirement.

   Minimum Requirements #1, #2, #3, #4, #5, and #9 do not have separate 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 they are applicable to the project.

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

Not all of the Minimum Requirements apply to every new development or redevelopment project. The applicability varies depending on the project type and size. This section identifies thresholds that determine the applicability of the Minimum Requirements to projects. Use the flow charts in Figure I-3.1: Flow Chart for Determining Requirements for New Development and Figure I-3.2: Flow Chart for Determining Requirements for Redevelopment to determine which of the Minimum Requirements apply. The Minimum Requirements themselves are presented in I-3.4 Minimum Requirements (MRs).

Use the thresholds in Figure I-3.1: Flow Chart for Determining Requirements for New Development and Figure I-3.2: Flow Chart for Determining Requirements for Redevelopment at the time of application for a subdivision, plat, short plat, building permit, or other construction permit. The plat or short plat approval shall identify all stormwater BMPs that are required for each lot. For projects involving only land disturbing activities, (e.g., clearing or grading), the thresholds apply at the time of application for the permit allowing or authorizing that activity. Note the exemption in I-3.2 Exemptions for forest practices other than Class IV General.

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Figure I-3.1: Flow Chart for Determining Requirements for New Development

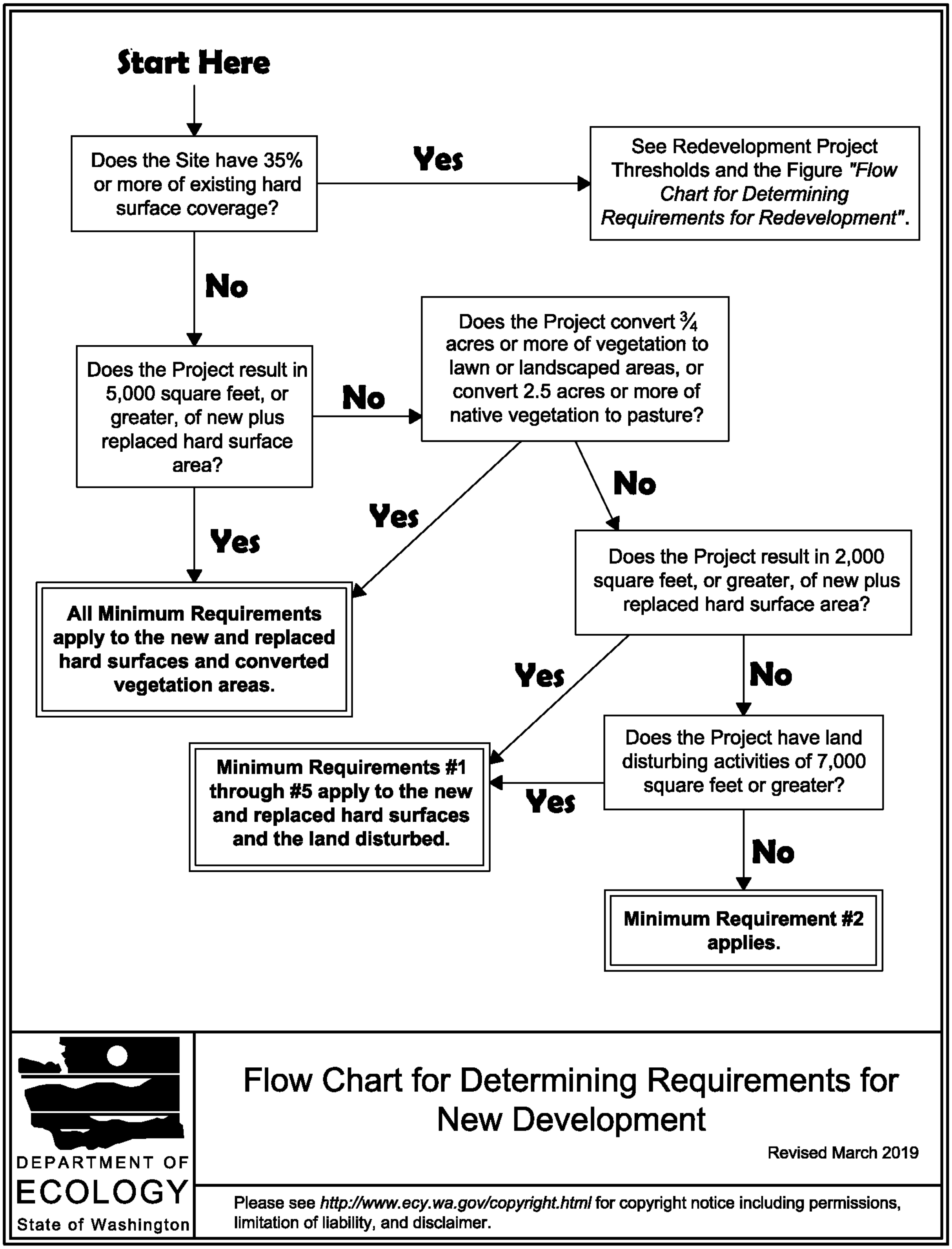
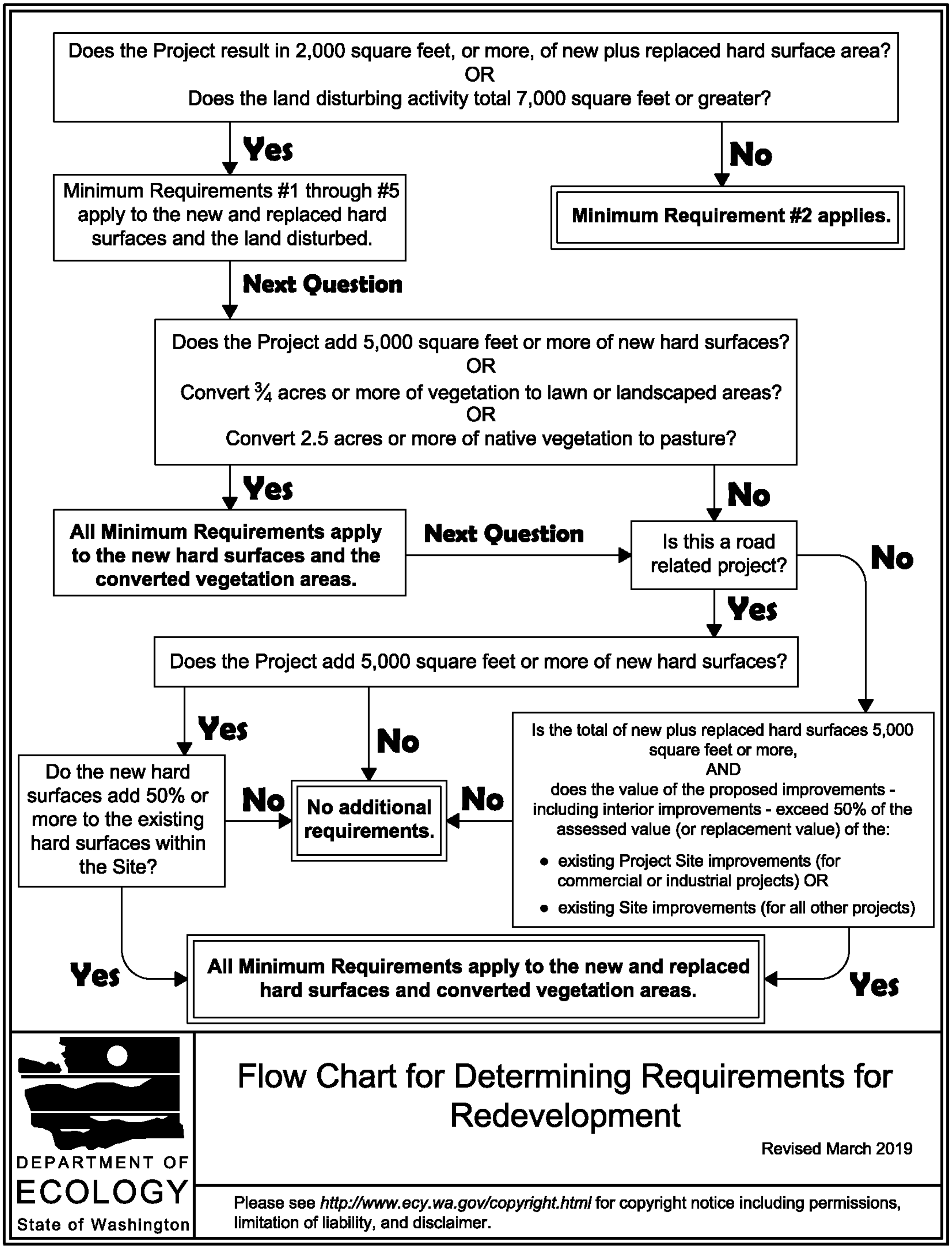


Figure I-3.2: Flow Chart for Determining Requirements for Redevelopment



New Development Project Thresholds

All new development shall be required to comply with Minimum Requirement #2.

The following new development shall comply with Minimum Requirements #1 through #5 for the new and replaced hard surfaces and the land disturbed:

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

The following new development shall comply with Minimum Requirements #1 through #9 for the new and replaced hard surfaces and the converted vegetation areas:

- Results in 5,000 square feet, or greater, 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.

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Redevelopment Project Thresholds

All redevelopment shall be required to comply with Minimum Requirement #2.

The following redevelopment shall comply with Minimum Requirements #1 through #5 for the new and replaced hard surfaces and the land disturbed:

- 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 greater.

The following redevelopment shall comply with Minimum Requirements #1 through #9 for the new hard surfaces and converted vegetation areas:

- 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.

The local government may allow the Minimum Requirements to be met for an equivalent (flow and pollution characteristics) area. The equivalent area may be within the same TDA. If the equivalent area is outside the TDA, or off-site, the equivalent area must drain to the same receiving water and the guidance for equivalent facilities using in-basin transfers must be followed (see I-D.6 Regional Facility Area Transfers). The jurisdiction is responsible for maintaining tracking records for all area transfers approved by the jurisdiction.

Additional Requirements for Redevelopment

Road-related projects shall comply with all the Minimum Requirements for the new and replaced hard surfaces (including pavement, shoulders, curbs, and sidewalks) and the converted vegetation areas if the new hard surfaces total 5,000 square feet or more and total 50% or more of the existing hard surfaces within the Site.

Other types of redevelopment projects shall comply with all the Minimum Requirements for the new and replaced hard surfaces and the converted vegetation areas if:

- the total of new plus replaced hard surfaces is 5,000 square feet or more, and
- For commercial or industrial projects: the valuation of the proposed improvements, including interior improvements, exceeds 50% of the assessed value of the existing Project Site improvements.
- For all other projects: the valuation of the proposed improvements, including interior improvements, exceeds 50% of the assessed value of the existing Site improvements.

The local government may exempt or institute a stop-loss provision for redevelopment projects from compliance with Minimum Requirement #5, #6, #7, and/or #8 as applied to the replaced hard surfaces if the local government has adopted a plan and a schedule that fulfills those requirements in regional facilities.

The local government may grant a variance/exception to the application of Minimum Requirement #7 to replaced impervious surfaces if such application imposes a severe economic hardship. See I-3.6.2 Exceptions/Variances to the MRs.

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Objective

Redevelopment projects have the same requirements as new development projects in order to minimize the impacts from new surfaces. To not discourage redevelopment projects, replaced surfaces aren't required to be brought up to new stormwater standards unless the cost or space thresholds identified above are exceeded. As long as the replaced surfaces have similar pollution-generating potential to the surfaces that they are replacing, the amount of pollutants discharged shouldn't be significantly different from the existing site conditions. However, if the redevelopment project scope is sufficiently large that the cost or space thresholds identified above are exceeded, it is reasonable to require the replaced surfaces to be brought up to current stormwater standards. This is consistent with other utility standards. When a structure or a property undergoes significant remodeling, local governments often require the site to be brought up to new building code requirements (e.g., on-site sewage disposal systems, fire systems).

Supplemental Guidelines

For purposes of applying the above thresholds to a proposed single family residential subdivision (i.e., a plat or short plat project), assume 4,000 sq. ft. of hard surface (8,000 sq. ft. on lots of 5 acres or more) for each newly created lot, unless the project proponent has otherwise formally declared other values for each lot in the corresponding complete land division application. Where local land use regulations restrict maximum hard (or impervious) surfaces to smaller amounts, those maxima may be used.

The local government may allow the Minimum Requirements to be met for an equivalent (flow and pollution characteristics) area for new development projects as well as redevelopment projects. The equivalent area may be within the same TDA. If the equivalent area is outside the TDA, or off-site, the equivalent area must drain to the same receiving water and the guidance for equivalent facilities using in-basin transfers must be followed (see I-D.6 Regional Facility Area Transfers). The jurisdiction is responsible for maintaining tracking records for all area transfers approved by the jurisdiction.

Options for Local Governments

Local governments may select from various methods for identifying projects that must comply with all the Minimum Requirements for the new and replaced hard surfaces and the converted vegetation areas on the project site (See Additional Requirements for Redevelopment, above). Examples of methods that may vary between jurisdictions include:

- Identifying the valuation of the proposed improvements by various methods such as:
  - The designer's estimate of the proposed project,
  - The anticipated future (post-project) assessed value for the improvements on the Site (not including the property value), minus the current year, pre-project assessor's data for the improvements on the Site (not including the property value),
  - The anticipated future (post-project) appraisal value for the improvements on the Site (not including the property value), minus the current (within a year or other predetermined period of time), pre-project appraisal value of the improvements on the Site (not including the property value),
- Identifying the assessed value of the existing Site improvements by various methods such as:
  - Current year, pre-project assessor's data for the improvements on the Site (not including the property value),
  - Current (within a year or other predetermined period of time), pre-project appraisal value of the improvements on the Site (not including the property value),
  - The estimated cost to replace the existing improvements on the Site, as determined by the Marshall Value System, or a similar valuation system.
- Providing an alternate method that does not rely on the direct comparison of existing and proposed Site improvements, such as:

- Exceeding a certain dollar value of improvements, as determined by a predetermined method, such as the designer's estimate of the proposed project,
- Exceeding a certain ratio of the new hard surfaces to the total of replaced plus new hard surfaces

A local government’s thresholds for the application of the Minimum Requirements to replaced hard surfaces must be at least as stringent as Ecology’s thresholds. Local governments should be prepared to demonstrate that by comparing the number and types of historical projects that would have been regulated using Ecology's thresholds versus the local government’s thresholds.

Local governments are allowed to institute a stop-loss provision on the application of the Minimum Requirements to replaced hard surfaces. A stop-loss provision is an upper limit on the extent to which a Minimum Requirement is applied. For instance, there could be a maximum percentage of the estimated total project costs that are dedicated to meeting stormwater requirements. A project would not have to incur additional stormwater costs above that maximum, even though the standard redevelopment requirements will not be fully achieved. The allowance for a stop-loss provision pertains to the extent that Minimum Requirements #6, #7, and #8 are imposed on replaced hard surfaces. It does not apply to meeting Minimum Requirements for new hard surfaces.

Local governments can also establish criteria for allowing redevelopment projects to pay a fee in lieu of constructing Runoff Treatment or Flow Control BMPs on a redeveloped site. At a minimum, the fee should be the equivalent of an engineering estimate of the cost of meeting all applicable Minimum Requirements for the project. The local government should use such funds for the implementation of stormwater control projects that would have similar benefits to the same receiving water as if the project had constructed its required improvements. Expenditure of such funds is subject to other state statutory requirements.

Ecology cautions local governments about the potential long-term consequences of allowing a fee-in-lieu of stormwater facilities. Sites that are allowed to pay a fee continue to discharge stormwater without stormwater controls. If it is determined, through future basin planning for instance, that controls on such sites are necessary to achieve water quality goals or legal requirements, the public may bear the costs for providing those controls.

Local governments are also encouraged to review all road projects for changes in elevations or drainage flowpaths that could cause flooding, upland or stream erosion, or changes to discharges to wetlands. For example, adding curbs will result in redirecting flows and possibly causing new downstream impacts. The local government should set project-specific requirements to avoid or mitigate those impacts.

Local governments may use regional facilities as an alternative method to meet Minimum Requirements #5, #6, #7, and/or #8. The local government must retain an engineering report that details how the regional facility meets the Minimum Requirements for the sites that drain to it. See Appendix I-D: Regional Facilities for details.

Local governments may use a Basin Plan to modify Minimum Requirements #5, #6, #7, and/or #8. See Appendix I-B: Basin Plans for details.

I-3.4 Minimum Requirements (MRs)

I-3.4.1 MR1: Preparation of Stormwater Site Plans

All projects meeting the thresholds in I-3.3 Applicability of the Minimum Requirements shall prepare a Stormwater Site Plan for local government review. Stormwater Site Plans shall use site-appropriate development principles, as required and encouraged by local development codes, to retain native vegetation and minimize impervious surfaces to the extent feasible. Stormwater Site Plans shall be prepared in accordance with III-3 Stormwater Site Plans.

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Objective

The 2,000 square foot threshold for hard surfaces and 7,000 square foot threshold for land disturbance, as detailed in I-3.3 Applicability of the Minimum Requirements, are chosen to capture most single family home construction and their equivalent. The scope of the stormwater site plan only covers compliance with Minimum Requirements #2 through #5 if the thresholds of 5,000 square feet of hard surface or conversion of ¾ acre of vegetation to lawn or landscape, or conversion of 2.5 acres of vegetation to pasture are not exceeded.

Supplemental Guidelines

Projects proposed by departments and agencies within the local government with jurisdiction must comply with this requirement. The local government shall determine the process for ensuring proper project review, inspection, and compliance by its own departments and agencies.

I-3.4.2 MR2: Construction Stormwater Pollution Prevention Plan (SWPPP)

Project Thresholds

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

Projects which result in 2,000 square feet or more of new plus replaced hard surface area, or which disturb 7,000 square feet or more of land must prepare a Construction Stormwater Pollution Prevention Plan (SWPPP) as part of the Stormwater Site Plan (see I-3.4.1 MR1: Preparation of Stormwater Site Plans).

Projects below those thresholds (listed above) are not required to prepare a Construction SWPPP, but must consider all of the Construction SWPPP Elements (listed below) and develop controls for all Construction SWPPP Elements that pertain to the project site.

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General Requirements

The Construction SWPPP shall include a narrative and drawings. All BMPs shall be clearly referenced in the narrative and marked on the drawings. The Construction SWPPP narrative shall include documentation to explain and justify the pollution prevention decisions made for the project. Each of the 13 Construction SWPPP Elements (listed below) must be considered and included in the Construction SWPPP unless site conditions render the Element unnecessary and the exemption from that Element is clearly justified in the narrative of the SWPPP.

Clearing and grading activities for developments shall be permitted only if conducted pursuant to an approved site development plan (e.g., subdivision approval) that establishes permitted areas of clearing, grading, cutting, and filling. These permitted clearing and grading areas and any other areas required to preserve critical or sensitive areas, buffers, native growth protection easements, or tree retention areas, shall be delineated on the site plans and the development site.

The Construction SWPPP shall be implemented beginning with initial land disturbance and until final stabilization. Sediment and Erosion control BMPs shall be consistent with the BMPs contained in II-3 Construction Stormwater BMPs.

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 local permitting authority that silt-laden runoff will be prevented from leaving the site through a combination of the following:

1. Site conditions including existing vegetative coverage, slope, soil type and proximity to receiving waters; and
2. Limitations on activities and the extent of disturbed areas; and
3. Proposed erosion and sediment control measures.

The following activities are exempt from the seasonal clearing and grading limitations:

1. Routine maintenance and necessary repair of erosion and sediment control BMPs,
2. 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, and
3. Activities where there is one hundred percent infiltration of surface water runoff within the site in approved and installed erosion and sediment control facilities.

The text in this box originates from one or more of the following Permits:
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Objective

To control erosion and prevent sediment and other pollutants from leaving the site during the construction phase of a project. To have fully functional stormwater BMPs for the developed site upon completion of construction.

Supplemental Guidelines

If a Construction SWPPP is found to be inadequate (with respect to erosion and sediment control requirements), then the Plan Approval Authority within the Local Government shall require that other Construction Stormwater BMPs be implemented, as appropriate.

The Plan Approval Authority may allow development of generic Construction SWPPP's that apply to commonly conducted public road activities, such as road surface replacement, that trigger this minimum requirement. They may also develop an abbreviated Construction SWPPP format for project sites that will disturb less than 1 acre.

Based on the information provided and/or local weather conditions, the local permitting authority may expand or restrict the seasonal limitation on site disturbance. The local permitting authority shall take enforcement action - such as a notice of violation, administrative order, penalty, or stop-work order under the following circumstances:

- If, during the course of any construction activity or soil disturbance during the seasonal limitation period, sediment leaves the construction site causing a violation of the surface water quality standard; or
- If clearing and grading limits or erosion and sediment control measures shown in the approved plan are not maintained.

The primary project proponent shall coordinate with utilities and other contractors. The primary project proponent shall evaluate, with input from utilities and other contractors, the stormwater management requirements for the entire project, including the utilities, when preparing the Construction SWPPP.

Construction SWPPP Elements

Element 1: Preserve Vegetation / Mark Clearing Limits

a. Before beginning 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.

b. Retain the duff layer, native top soil, and natural vegetation in an undisturbed state to the maximum degree practicable.

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Additional Guidance for Element 1

- Plastic, metal, fabric fence, or other physical barriers may be used to mark the clearing limits. Note the difference between the practical use and proper installation of BMP C233: Silt Fence and the proper use and installation of BMP C103: High-Visibility Fence.
- If it is not practical to retain the duff layer in place, then stockpile it on site, cover it to prevent erosion, and replace it immediately when you finish disturbing the site.

Suggested BMPs for Element 1

- BMP C101: Preserving Natural Vegetation
- BMP C102: Buffer Zones
- BMP C103: High-Visibility Fence
- BMP C233: Silt Fence

Element 2: Establish Construction Access

a. Limit construction vehicle access and exit to one route, if possible.

b. Stabilize access points with a pad of quarry spalls, crushed rock, or other equivalent BMPs, to minimize tracking of sediment onto public roads.

c. Locate wheel wash or tire baths on site, if the stabilized construction entrance is not effective in preventing tracking sediment onto roads.

d. If sediment is tracked off site, clean the affected roadway(s) thoroughly at the end of each day, or more frequently as necessary (for example, during wet weather). Remove sediment from roads by shoveling, sweeping, or picking up and transporting the sediment to a controlled sediment disposal area.

e. Conduct street washing only after sediment is removed in accordance with 2.d (above).

f. Control street wash wastewater by pumping back on site, or otherwise prevent it from discharging into systems tributary to waters of the State.

The text in this box originates from one or more of the following Permits:
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Additional Guidance for Element 2

Minimize construction site access points along linear projects, such as roadways. Street washing may require local jurisdiction approval.

Suggested BMPs for Element 2

- BMP C105: Stabilized Construction Access
- BMP C106: Wheel Wash
- BMP C107: Construction Road / Parking Area Stabilization

Element 3: Control Flow Rates

a. Protect properties and waterways downstream of development sites from erosion and the associated discharge of turbid waters due to increases in the velocity and peak volumetric flow rate of stormwater runoff from the project site.

b. Where necessary to comply with 3.a (above), construct stormwater infiltration or detention BMPs as one of the first steps in grading. Assure that detention BMPs function properly before constructing site improvements (e.g., impervious surfaces).

c. If permanent infiltration BMPs are used for temporary flow control during construction, protect these BMPs from siltation during the construction phase.

The text in this box originates from one or more of the following Permits:
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Additional Guidance for Element 3

- Conduct a downstream analysis if changes in flows could impair or alter conveyance systems, streambanks, bed sediment, or aquatic habitat. See III-3.2 Preparing a Stormwater Site Plan for off-site analysis guidelines.
- Even gently sloped areas need flow controls such as BMP C235: Wattles or other energy dissipation / filtration structures. Place dissipation facilities closer together on steeper slopes. These methods prevent water from building higher velocities as it flows downstream within the construction site.
- Control structures designed for permanent detention 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 sediment to settle. Verify that the BMP is sized appropriately for this purpose. Restore BMPs to their original design dimensions, remove sediment, and install a final control structure at completion of the project.
- Erosion has the potential to occur because of increases in the volume, velocity, and peak flow rate of stormwater runoff from the project site. The local permitting agency may require infiltration or detention BMP designs that provide additional or different stormwater flow control than the designs detailed in this manual. These requirements may be necessary to address local conditions or to protect properties and waterways downstream.
- Velocity of water leaving the site should not exceed 3 feet/second, if the discharge is to a stream or ditch. Install velocity dissipation, such as BMP C207: Check Dams or BMP C202: Riprap Channel Lining to ensure reduction of the flow velocity to a non-erosive level.
- If the discharge from a project site is to a municipal storm drainage system, the allowable discharge rate may be limited by the capacity of the public system. It may be necessary to clean the municipal storm drainage system prior to the start of the discharge to prevent scouring solids from the drainage system. Obtain permission from the owner of the collection system before discharging to it. Ensure that no downstream pipes are surcharged as a result of increased flows from the project site.

- If the discharge from a project site is directly to a flow control exempt receiving water listed in Appendix I-A: Flow Control Exempt Receiving Waters or to an infiltration system, there is no discharge flow limit.

Suggested BMPs for Element 3

- BMP C203: Water Bars
- BMP C207: Check Dams
- BMP C209: Outlet Protection
- BMP C235: Wattles
- BMP C240: Sediment Trap
- BMP C241: Sediment Pond (Temporary)
- See also V-12 Detention BMPs

Element 4: Install Sediment Controls

Design, install, and maintain effective erosion controls and sediment controls to minimize the discharge of pollutants.

a. Construct sediment control BMPs (sediment ponds, traps, filters, etc.) as one of the first steps in grading. These BMPs must be functional before other land disturbing activities take place.

b. 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 runoff, and soil characteristics, including the range of soil particle sizes expected to be present on the site.

c. Direct stormwater runoff from disturbed areas through BMP C241: Sediment Pond (Temporary) or other appropriate sediment removal BMP, before the runoff leaves a construction site or before discharge to an infiltration facility. Runoff from fully stabilized areas may be discharged without a sediment removal BMP, but must control flow rates per Element 3: Control Flow Rates.

d. Locate BMPs intended to trap sediment on site in a manner to avoid interference with the movement of juvenile salmonids attempting to enter off-channel areas or drainages.

e. Provide and maintain natural buffers around surface waters, direct stormwater to vegetated areas to increase sediment removal and maximize stormwater infiltration, unless infeasible.

f. Where feasible, design outlet structures that withdraw impounded stormwater from the surface to avoid discharging sediment that is still suspended lower in the water column.

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Additional Guidance for Element 4

- Outlet structures that withdraw impounded stormwater from the surface to avoid discharging sediment that is still suspended lower in the water column are for the construction period only. If installing a floating pump structure, include a stopper to prevent the pump basket from hitting the bottom of the pond.
- If a sediment trapping BMP utilizes a control structure that will also be used in a permanent detention BMP application, the control structure construction must be finalized for the permanent BMP application upon project completion.
- Install sediment controls in a manner that protects the sensitive areas and their buffers marked in accordance with Element 1: Preserve Vegetation / Mark Clearing Limits.
- Where feasible, direct stormwater to vegetated areas to increase sediment removal and maximize stormwater infiltration.
- Seed and mulch earthen structures such as dams, dikes, and diversions according to the timing indicated in Element 5: Stabilize Soils.
- 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.
- The Local Permitting Authority may inspect and approve areas fully stabilized by means other than pavement or quarry spalls.

Suggested BMPs for Element 4

- 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: Sediment Pond (Temporary)
- BMP C250: Construction Stormwater Chemical Treatment
- BMP C251: Construction Stormwater Filtration

Element 5: Stabilize Soils

a. Stabilize exposed and unworked soils by application of effective BMPs that prevent erosion. Applicable BMPs include, but are not limited to: temporary and permanent seeding, sodding, mulching, plastic covering, erosion control fabrics and matting, soil application of polyacrylamide (PAM), the early application of gravel base on areas to be paved, and dust control.

b. Control stormwater volume and velocity within the site to minimize soil erosion.

c. Control stormwater discharges, including both peak flow rates and total stormwater volume, to minimize erosion at outlets and to minimize downstream channel and stream bank erosion.

d. Soils must not remain exposed and unworked for more than the time periods set forth below to prevent erosion:

- During the dry season (May 1 - September 30): 7 days
- During the wet season (October 1 - April 30): 2 days

e. Stabilize soils at the end of the shift before a holiday or weekend if needed based on the weather forecast.

f. Stabilize soil stockpiles from erosion, protect with sediment trapping measures, and where possible, locate away from storm drain inlets, waterways and drainage channels.

g. Minimize the amount of soil exposed during construction activity.

h. Minimize the disturbance of steep slopes.

i. Minimize soil compaction and, unless infeasible, preserve topsoil.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Additional Guidance for Element 5

- Soil stabilization BMPs should be appropriate for the time of year, site conditions, estimated duration of use, and potential water quality impacts that stabilization agents may have on downstream waters or ground water.
- Ensure that gravel base used for stabilization is clean and does not contain fines or sediment.

Suggested BMPs for Element 5

- BMP C120: Temporary and Permanent Seeding
- BMP C121: Mulching
- BMP C122: Nets and Blankets
- BMP C123: Plastic Covering

- BMP C124: Sodding
- BMP C125: Topsoiling / Composting
- BMP C126: Polyacrylamide (PAM) for Soil Erosion Protection
- BMP C130: Surface Roughening
- BMP C131: Gradient Terraces
- BMP C140: Dust Control

Element 6: Protect Slopes

a. 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).

b. Divert off-site stormwater (run-on) or ground water away from slopes and disturbed areas with interceptor dikes, pipes and/or swales. Off-site stormwater should be managed separately from stormwater generated on site.

c. At the top of slopes, collect drainage in pipe slope drains or protected channels to prevent erosion. Temporary pipe slope drains must be sized to convey the flow rate calculated by one of the following methods:

   - Single Event Hydrograph Method: The peak volumetric flow rate calculated using a 10-minute time step from a Type 1A, 10-year, 24-hour frequency storm.

     OR

   - Continuous Simulation Method: The 10-year peak flow rate, as determined by an approved continuous runoff model with a 15-minute time step.

   The hydrologic analysis must use the existing land cover condition for predicting flow rates from tributary areas outside the project limits. For tributary areas on the project site, the analysis must use the temporary or permanent project land cover condition, whichever will produce the highest flow rates. If using the Western Washington Hydrology Model (WWHM) to predict flows, bare soil areas should be modeled as "landscaped" area.

d. Place excavated material on the uphill side of trenches, consistent with safety and space considerations.

e. Place check dams at regular intervals within constructed channels that are cut down a slope.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Additional Guidance for Element 6

- Consider soil type and its potential for erosion.
- Stabilize soils on slopes, as specified in Element 5: Stabilize Soils.
- BMP combinations are the most effective method of protecting slopes with disturbed soils. For example, use both BMP C121: Mulching and BMP C122: Nets and Blankets in combination.

Suggested BMPs for Element 6

- 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 (TSD)

Element 7: Protect Drain Inlets

a. Protect all storm drain inlets made operable during construction so that stormwater runoff does not enter the conveyance system without first being filtered or treated to remove sediment.

b. Clean or remove and replace inlet protection devices when sediment has filled one-third of the available storage (unless a different standard is specified by the product manufacturer).

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Additional Guidance for Element 7

- Protect all existing storm drain inlets so that stormwater runoff does not enter the conveyance system without first being filtered or treated to remove sediment.
- Keep all approach roads clean. Do not allow sediment and street wash water to enter storm drains without prior and adequate treatment (as defined above) unless treatment is provided before the storm drain discharges to waters of the State.
- Inlets should be inspected weekly at a minimum and daily during storm events.

Suggested BMPs for Element 7

- BMP C220: Inlet Protection

Element 8: Stabilize Channels and Outlets

a. Design, construct, and stabilize all on-site conveyance channels to prevent erosion from the flow rate calculated by one of the following methods:

   - Single Event Hydrograph Method: The peak volumetric flow rate calculated using a 10-minute time step from a Type 1A, 10-year, 24-hour frequency storm.

     OR

   - Continuous Simulation Method: The 10-year peak flow rate, as determined by an approved continuous runoff model with a 15-minute time step.

   The hydrologic analysis must use the existing land cover condition for predicting flow rates from tributary areas outside the project limits. For tributary areas on the project site, the analysis must use the temporary or permanent project land cover condition, whichever will produce the highest flow rates. If using the Western Washington Hydrology Model (WWHM) to predict flows, bare soil areas should be modeled as "landscaped" area.

b. 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.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Additional Guidance for Element 8

The best method for stabilizing channels is to completely line the channel with BMP C122: Nets and Blankets first, then add BMP C207: Check Dams as necessary to function as an anchor and to slow the flow of water.

Suggested BMPs for Element 8

- BMP C122: Nets and Blankets
- BMP C202: Riprap 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. The project proponent must:

a. 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.

b. 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 or the environment. On-site fueling tanks must include secondary containment. 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.

c. Conduct maintenance, fueling, and repair of heavy equipment and vehicles using spill prevention and control measures. Clean contaminated surfaces immediately following any spill incident.

d. Discharge wheel wash or tire bath wastewater to a separate on-site treatment system that prevents discharge to surface water, or to the sanitary sewer, with local sewer district approval.

e. Apply fertilizers and pesticides in a manner and at application rates that will not result in loss of chemical to stormwater runoff. Follow manufacturers' label requirements for application rates and procedures.

f. Use BMPs to prevent contamination of stormwater runoff by pH-modifying sources. The sources for this contamination 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, concrete pumping and mixer washout waters.

g. Adjust the pH of stormwater if necessary to prevent violations of water quality standards.

h. Assure that washout of concrete trucks is performed off site or in designated concrete washout areas only. Do not wash out concrete truck drums or concrete handling equipment onto the ground, or into storm drains, open ditches, streets, or streams. Washout of small concrete handling equipment may be disposed of in a formed area awaiting concrete where it will not contaminate surface or ground water. Do not dump excess concrete on site, except in designated concrete washout areas. Concrete spillage or concrete discharge directly to ground water or surface waters of the State is prohibited. Do not wash out to formed areas awaiting infiltration BMPs.

i. Obtain written approval from Ecology before using chemical treatment other than CO_2, dry ice, or food grade vinegar to adjust pH.

j. 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 (su).

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Additional Guidance for Element 9

- Wheel wash and/or tire bath wastewater can be combined with wastewater from concrete washout areas if the wastewaters will be properly disposed of at an offsite location or treatment facility.
- Do not use upland land applications for discharging wastewater from concrete washout areas.
- Woody debris may be chopped and spread on site.
- 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 runoff using spill prevention measures, such as drip pans.
- Clean contaminated surfaces immediately following any discharge or spill incident. Emergency repairs may be performed on-site using temporary plastic placed beneath and, if raining, over the vehicle.

Suggested BMPs for Element 9

- 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
- Also see the Source Control BMPs detailed in Volume IV

Element 10: Control Dewatering

a. Discharge foundation, vault, and trench dewatering water, which have similar characteristics to stormwater runoff at the site, into a controlled conveyance system before discharge to BMP C240: Sediment Trap or BMP C241: Sediment Pond (Temporary).

b. Discharge clean, non-turbid dewatering water, such as well-point ground water, to systems tributary to, or directly into surface waters of the State, as specified in Element 8: Stabilize Channels and Outlets, provided the dewatering flow does not cause erosion or flooding of receiving waters. Do not route clean dewatering water through stormwater sediment BMPs. Note that "surface waters of the State" may exist on a construction site as well as off site; for example, a creek running through a site.

c. Handle highly turbid or otherwise contaminated dewatering water separately from stormwater.

d. Other dewatering treatment or disposal options may include:

   i. Infiltration.

   ii. Transport off site in a vehicle, such as a vacuum flush truck, for legal disposal in a manner that does not pollute state waters.

   iii. Ecology-approved on-site chemical treatment or other suitable treatment technologies.

   iv. Sanitary or combined sewer discharge with local sewer district approval, if there is no other option.

   v. Use of a sedimentation bag that discharges to a ditch or swale for small volumes of localized dewatering.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Additional Guidance for Element 10

- Channels must be stabilized, as specified in Element 8: Stabilize Channels and Outlets.
- Construction equipment operation, clamshell digging, concrete tremie pour, or work inside a cofferdam can create highly turbid or contaminated dewatering water.
- Discharging sediment-laden (muddy) water into waters of the State likely constitutes violation of water quality standards for turbidity. The easiest way to avoid discharging muddy water is through infiltration and preserving vegetation.
- Dewatering water from contaminated sites must be handled separately from stormwater. Direct contaminated stormwater to a sanitary sewer where allowed by the local sewer authority, or to other approved treatment.

Suggested BMPs for Element 10

- BMP C203: Water Bars
- BMP C236: Vegetative Filtration

Element 11: Maintain BMPs

a. Maintain and repair all temporary and permanent erosion and sediment control BMPs as needed to assure continued performance of their intended function in accordance with BMP specifications.

b. Remove all temporary erosion and sediment control BMPs within 30 days after achieving final site stabilization or after the temporary BMPs are no longer needed.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Additional Guidance for Element 11

- Some temporary erosion and sediment control BMPs are biodegradable and designed to remain in place following construction. BMP C122: Nets and Blankets is an example of a BMP with biodegradable options.
- Provide protection to all BMPs installed for the permanent control of stormwater from sediment and compaction. All BMPs that are to remain in place following completion of construction shall be examined and placed in full operating conditions. If sediment enters the BMPs during construction, it shall be removed and the facility shall be returned to the conditions specified in the construction documents.
- Remove or stabilize trapped sediment on site. Permanently stabilize disturbed soil resulting from removal of BMPs or vegetation.

Suggested BMPs for Element 11

- BMP C150: Materials on Hand
- BMP C160: Certified Erosion and Sediment Control Lead

Element 12: Manage the Project

a. Phase development projects to the maximum degree practicable and take into account seasonal work limitations.

b. 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.

c. Maintain, update, and implement the Construction SWPPP.

d. Projects that disturb one or more acres must have site inspections conducted by a Certified Erosion and Sediment Control Lead (CESCL). Project sites disturbing less than one acre may have a CESCL or a person without CESCL certification conduct inspections. By the initiation of construction, the Construction SWPPP must identify the CESCL or inspector, who must be present on site or on-call at all times.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Additional Guidance for Element 12

The project manager must ensure that the project is built in such a way to comply with all Construction SWPPP Elements, as detailed in this section. Considerations for the project manager include, but are not limited to:

- construction phasing
- seasonal work limitations
- coordination with utilities and other contractors
- inspection
- monitoring
- maintaining an updated construction SWPPP

Phasing of Construction

Phase development projects where feasible in order to prevent soil erosion and transporting of sediment from the site during construction. Revegetate exposed areas and maintain that vegetation as an integral part of the clearing activities for any phase.

Clearing and grading activities for developments shall be permitted only if conducted using an approved site development plan (e.g., subdivision approval) that establishes permitted areas of clearing, grading, cutting, and filling. Minimize removing trees and disturbing or compacting native soils when establishing permitted clearing and grading areas. Show on the site plans and the development site permitted clearing and grading areas and any other areas required to preserve critical or sensitive areas, buffers, native growth protection easements, or tree retention areas as may be required by local jurisdictions.

Inspection

All BMPs must be inspected, maintained, and repaired as needed to assure continued performance of their intended function. Site inspections must be conducted by a person knowledgeable in the principles and practices of erosion and sediment control. The person must have the skills to 1) assess the site conditions and construction activities that could impact the quality of stormwater, and 2) assess the effectiveness of erosion and sediment control measures used to control the quality of stormwater discharges.

For construction sites one acre or larger that discharge stormwater to surface waters of the state, a CESCL must be identified in the construction SWPPP; this person must be on-site or on-call at all times. Certification must be obtained through an approved training program that meets the erosion and sediment control training standards established by Ecology. See BMP C160: Certified Erosion and Sediment Control Lead.

Appropriate BMPs or design changes shall be implemented as soon as possible whenever inspection and/or monitoring reveals that the BMPs identified in the Construction SWPPP are inadequate, due to the actual discharge of /or potential to discharge a significant amount of any pollutant.

The CESCL or inspector must examine stormwater visually for the presence of suspended sediment, turbidity, discoloration, and oil sheen. They must evaluate the effectiveness of BMPs and determine if it is necessary to install, maintain, or repair BMPs to improve the quality of stormwater discharges.

Based on the results of the inspection, construction site operators must correct the problems identified by:

- Reviewing the Construction SWPPP for compliance with the 13 elements and making appropriate revisions within 7 days of the inspection.
- Immediately beginning the process of fully implementing and maintaining appropriate source control and/or treatment BMPs as soon as possible, addressing the problems no later than within 10 days of the inspection. If installation of necessary treatment BMPs is not feasible within 10 days, the construction site operator may request an extension within the initial 10-day response period.
- Documenting BMP implementation and maintenance in the site log book (applies only to sites that have coverage under the Construction Stormwater General Permit).

The CESCL or inspector must inspect all areas disturbed by construction activities, all BMPs, and all stormwater discharge points at least once every calendar week and within 24 hours of any discharge from the site. (For purposes of this condition, individual discharge events that last more than one day do not require daily inspections. For example, if a stormwater pond discharges continuously over the course of a week, only one inspection is required that week.) The CESCL or inspector may reduce the inspection frequency for temporary stabilized, inactive sites to once every calendar month

Maintaining an Updated Construction SWPPP

Retain the Construction SWPPP on-site or within reasonable access to the site.

Modify the Construction 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.

The Construction SWPPP must be modified if, during inspections or investigations conducted by the owner/operator, or the applicable local or state regulatory authority, it is determined that the Construction SWPPP is ineffective in eliminating or significantly minimizing pollutants in stormwater discharges from the site. Modify the Construction SWPPP as necessary to include additional or modified BMPs designed to correct problems identified. Complete revisions to the Construction SWPPP within seven (7) days following the inspection.

Suggested BMPs for Element 12

- BMP C150: Materials on Hand
- BMP C160: Certified Erosion and Sediment Control Lead
- BMP C162: Scheduling

Element 13: Protect Low Impact Development BMPs

The primary purpose of On-Site Stormwater Management is to reduce the disruption of the natural site hydrology through infiltration. BMPs used to meet I-3.4.5 MR5: On-Site Stormwater Management (often called LID BMPs) are permanent facilities.

a. Protect all LID BMPs (including, but not limited to BMP T7.30: Bioretention, BMP T5.14: Rain Gardens, and BMP T5.15: Permeable Pavements) from sedimentation through installation and maintenance of erosion and sediment control BMPs on portions of the site that drain into the LID BMPs. Restore the BMPs to their fully functioning condition if they accumulate sediment during construction. Restoring the BMP must include removal of sediment and any sediment-laden Bioretention/Rain Garden soils, and replacing the removed soils with soils meeting the design specification.

b. Maintain the infiltration capabilities of LID BMPs by protecting against compaction by construction equipment and foot traffic. Protect completed lawn and landscaped areas from compaction due to construction equipment.

c. Control erosion and avoid introducing sediment from surrounding land uses onto BMP T5.15: Permeable Pavements. Do not allow muddy construction equipment on the base material or pavement. Do not allow sediment-laden runoff onto permeable pavements or base materials.

d. Permeable pavement fouled with sediments or no longer passing an initial infiltration test must be cleaned using procedures in accordance with this manual or the manufacturer's procedures.

e. Keep all heavy equipment off existing soils under LID BMPs that have been excavated to final grade to retain the infiltration rate of the soils.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Additional Guidance for Element 13

See Chapter 5: Precision Site Preparation, Construction & Inspection of LID Facilities in the *LID Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012) for more detail on protecting LID integrated management practices.

Note that the *LID Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012) is for additional informational purposes only. You must follow the guidance within this manual if there are any discrepancies between this manual and the *LID Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012).

Suggested BMPs for Element 13

- BMP C102: Buffer Zones
- 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 (TSD)
- BMP C231: Brush Barrier
- BMP C233: Silt Fence
- BMP C234: Vegetated Strip

I-3.4.3 MR3: Source Control of Pollution

All known, available and reasonable Source Control BMPs must be applied to all projects. Source Control BMPs must be selected, designed, and maintained in accordance with this manual.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

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 should be a first consideration in all projects.

Supplemental Guidelines

Source Control BMPs include Operational BMPs and Structural Source Control BMPs. See Volume IV for design details of these BMPs. For construction sites, see II-3.2 Construction Source Control BMPs.

Structural Source Control BMPs should be identified in the stormwater site plan and should be shown on all applicable plans submitted for local government review and approval.

An adopted and implemented Basin Plan (see Appendix I-B: Basin Plans) or Total Maximum Daily Load (see I-2.13 Total Maximum Daily Loads (TMDLs)) may be used to develop more stringent source control requirements that are tailored to a specific basin.

Identifying Source Control Strategies in a Basin Plan

Basin Plans can identify potential sources of pollution within the basin and develop strategies to eliminate or control these sources to protect beneficial uses.

A Basin Plan can include the following Source Control strategies:

1. Detection and correction of illicit discharges to storm sewer systems, including the use of dry weather sampling and dye-tracing techniques;
2. Identification of existing businesses, industries, utilities, and other activities that may store materials susceptible to spillage or leakage of pollutants into the storm sewer system or to the ground via wells, drains, or sumps;
3. Elimination or control of pollutant sources identified in (2);
4. Identification and control of future businesses, industries, utilities, and other activities which may store materials susceptible to spillage or leakage of pollutants into the storm sewer system; and
5. Training and public education

A Basin Plan that incorporates the standard requirements from this section as well as more stringent requirements does not require Ecology approval.

I-3.4.4 MR4: Preservation of Natural Drainage Systems and Outfalls

Natural drainage patterns shall be maintained, and discharges from the Project Site shall occur at the natural location, to the maximum extent practicable. The manner by which runoff is discharged from the Project Site must not cause a significant adverse impact to downstream receiving waters and downgradient properties. All outfalls require energy dissipation.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Objective

To preserve and utilize natural drainage systems to the fullest extent because of the multiple stormwater benefits these systems provide; and to prevent erosion at and downstream of the discharge location.

Supplemental Guidelines

Creating new drainage patterns results in more site disturbance and more potential for erosion and sedimentation during and after construction. Creating new discharge points can create significant stream channel erosion problems as the receiving water body typically must adjust to the new flows.

Diversions can cause greater impacts than would otherwise occur by discharging runoff at the natural location.

Where no conveyance system exists at the adjacent downgradient property line and the discharge was previously unconcentrated flow or significantly lower concentrated flow, then measures must be taken to prevent downgradient impacts. Drainage easements from downstream property owners may be needed and should be obtained prior to approval of engineering plans.

The following discharge requirement is recommended:

Where no conveyance system exists at the abutting downstream property line and the natural (existing) discharge is unconcentrated, any runoff concentrated by the proposed project must be discharged as follows:

a. If the 100-year peak discharge, as estimated using an approved continuous runoff model using 15-minute time steps, 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, then the concentrated runoff may be discharged onto outlet protection with riprap, such as those described in V-1.4.3 Outfall Systems, or to any other system that serves to disperse flows.

b. If the 100-year peak discharge, as estimated using an approved continuous runoff model using 15-minute time steps, 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, then the concentrated runoff may be discharged through a dispersal trench, such as those described in V-1.4.3 Outfall Systems, or other dispersal system, provided the applicant can demonstrate that there will be no significant adverse impact to downhill properties or drainage systems.

c. If the 100-year peak discharge, as estimated using an approved continuous runoff model using 15-minute time steps, is greater than 0.75 cfs for either existing or developed conditions, or if a significant adverse impact to downgradient properties or drainage systems is likely, then a conveyance system must be provided to convey the concentrated runoff across the downstream properties to an acceptable discharge point (i.e., an enclosed drainage system or open drainage feature where concentrated runoff can be discharged without significant adverse impact).

Stormwater control or treatment structures should not be located within the expected 25-year water level elevations for salmonid-bearing waters. Such areas may provide off-channel habitat for juvenile salmonids and salmonid fry. Designs for outfall systems to protect against adverse impacts from concentrated runoff are included in V-1.4.3 Outfall Systems.

I-3.4.5 MR5: On-Site Stormwater Management

> Projects shall employ Stormwater Management BMPs in accordance with the following thresholds, standards, and lists to infiltrate, disperse, and retain stormwater runoff on site to the extent feasible without causing flooding or erosion impacts.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Compliance Options by Project Type

All projects that require Minimum Requirement #5 (as detailed in I-3.3 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, the size of the parcel the project is on, and whether or not the project is Flow Control exempt.

Note that the site may contain multiple parcels. The designer may choose different compliance methods for different parcels, depending on the proposed design and the options for each parcel as detailed below.

Projects that Trigger Only Minimum Requirements #1 - #5

Projects that are not Flow Control exempt that trigger only Minimum Requirements #1 through #5 (per I-3.3 Applicability of the Minimum Requirements) shall either:

- Use the LID BMPs from List #1 for all surfaces within each type of surface in List #1;

  or

- Use any Flow Control BMP(s) desired to achieve the LID Performance Standard, and apply BMP T5.13: Post-Construction Soil Quality and Depth.

Projects that Trigger Minimum Requirements #1 - #9

Projects that are not Flow Control exempt that trigger Minimum Requirements #1 through #9 (per I-3.3 Applicability of the Minimum Requirements) have the compliance options shown in Table I-3.1: Minimum Requirement #5 Compliance Options for Projects Triggering Minimum Requirements #1 - #9.

Table I-3.1: Minimum Requirement #5 Compliance Options for Projects Triggering Minimum Requirements #1 - #9

Project Location and Parcel Size	Minimum Requirement #5 Compliance Options
Projects inside the UGA, on any size parcel	• Use the LID BMPs from List #2 for all surfaces within each type of surface in List #2; or • Use any Flow Control BMPs desired to achieve the LID Performance Standard, and apply BMP T5.13: Post-Construction Soil Quality and Depth.
Projects outside the UGA, on a parcel smaller than 5 acres	
Projects outside the UGA, on a parcel 5 acres or larger	Use any Flow Control BMPs desired to achieve the LID Performance Standard, and apply BMP T5.13: Post-Construction Soil Quality and Depth.
Note: This text refers to the Urban Growth Area (UGA) as designated under the Growth Management Act (GMA) (Chapter 36.70A RCW) of the State of Washington. If the project is located in a county that is not subject to planning under the GMA, the city limits shall be used instead.	

Flow Control Exempt Projects

Projects qualifying as Flow Control exempt in accordance with the TDA Exemption in I-3.4.7 MR7: Flow Control shall either:

- Use the LID BMPs from List #3 for all surfaces within each type of surface in List #3;

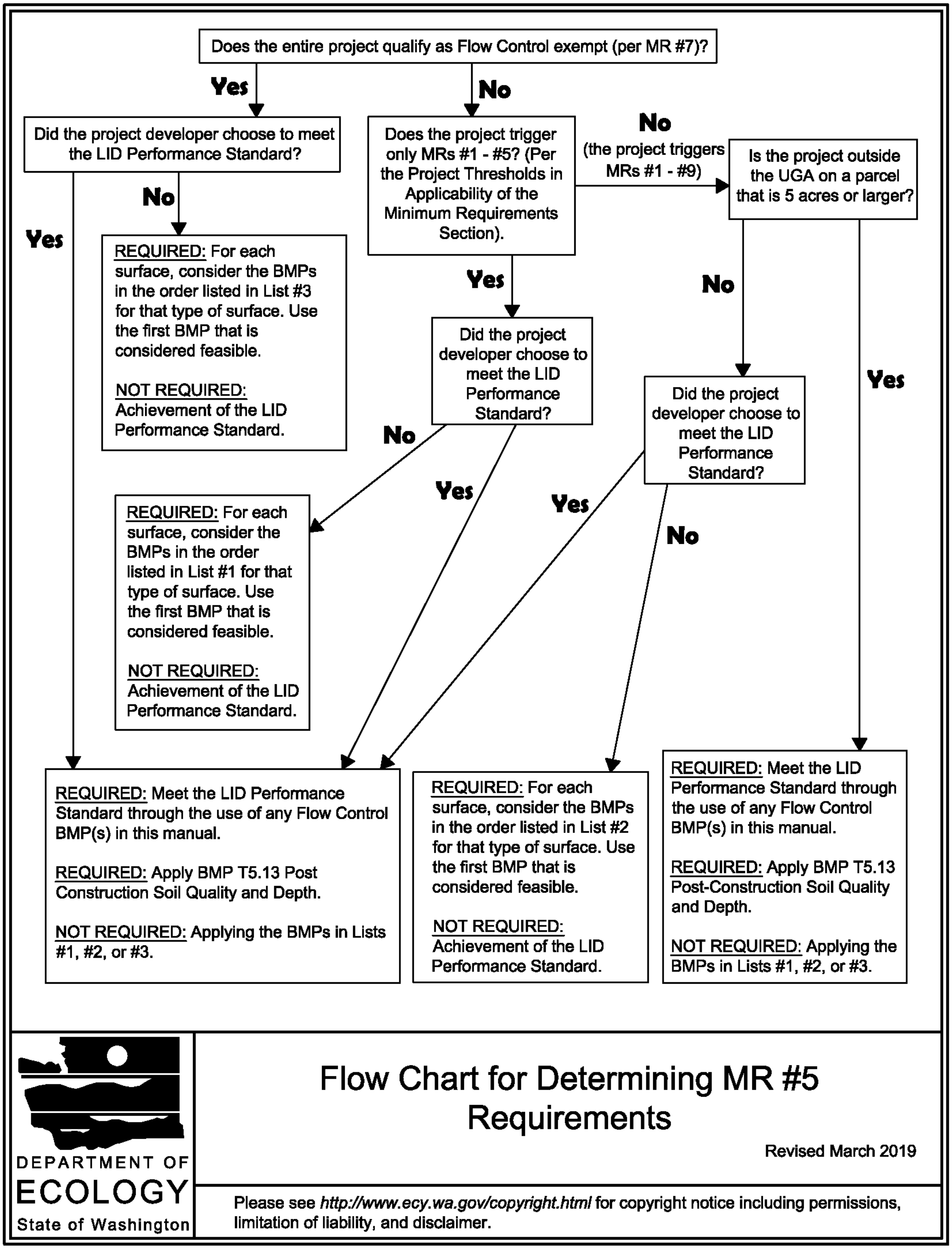
  or

- Use any Flow Control BMP(s) desired to achieve the LID Performance Standard, and apply BMP T5.13: Post-Construction Soil Quality and Depth.

If the project has multiple TDAs, all TDAs must be Flow Control exempt per the TDA Exemption in I-3.4.7 MR7: Flow Control for the project to use the options listed here.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Figure I-3.3: Flow Chart for Determining MR #5 Requirements



Compliance Methods

LID Performance Standard

The LID Performance Standard compliance method for Minimum Requirement #5 requires modeling the proposed Flow Control BMPs to demonstrate the flow reduction as described below. Note that in order to meet the LID Performance Standard, the chosen Flow Control BMPs will most likely need to include infiltration.

Stormwater discharges shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 8% of the 2-year peak flow to 50% of the 2-year peak flow. Refer to the Flow Control Performance Standard section in I-3.4.7 MR7: Flow Control for information about the assignment of the pre-developed condition. Project sites that must also meet I-3.4.7 MR7: Flow Control must match flow durations between 8% of the 2-year flow through the full 50-year flow.

Designers selecting this option cannot use BMP T5.14: Rain Gardens to achieve the LID Performance Standard. They may choose to use BMP T7.30: Bioretention to achieve the LID Performance Standard.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

The List Approach

The List Approach compliance method for Minimum Requirement #5 requires evaluating the BMPs in Table I-3.2: The List Approach for MR5 Compliance.

For each surface, evaluate the feasibility of the BMPs in the order listed, and use the first BMP that is considered feasible. The designer must document the site conditions and infeasibility criteria used to deem BMPs infeasible. Once a BMP is deemed feasible and used for a surface, no other BMP from the list is necessary for that surface.

If all BMPs in the list are infeasible, then the designer must document the site conditions and infeasibility criteria used to deem each BMP infeasible. This documentation will demonstrate compliance with Minimum Requirement #5.

Feasibility shall be determined by evaluation against:

- Design criteria, limitations, and infeasibility criteria identified for each BMP in this manual; and
- Competing Needs Criteria as listed below.

The text in this box originates from one or more of the following Permits:
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Table I-3.2: The List Approach for MR5 Compliance

List #1 (For MR #1 - #5 Projects That Are Not Flow Control Exempt)	List #2 (For MR #1 - #9 Projects That Are Not Flow Control Exempt)	List #3 (For Flow Control Exempt Projects)
Surface Type: Lawn and Landscaped Areas		
BMP T5.13: Post-Construction Soil Quality and Depth	BMP T5.13: Post-Construction Soil Quality and Depth	BMP T5.13: Post-Construction Soil Quality and Depth
Surface Type: Roofs		
1. BMP T5.30: Full Dispersion or BMP T5.10A: Downspout Full Infiltration	1. BMP T5.30: Full Dispersion or BMP T5.10A: Downspout Full Infiltration	1. BMP T5.10A: Downspout Full Infiltration
2. BMP T5.14: Rain Gardens or BMP T7.30: Bioretention	2. BMP T7.30: Bioretention	2. BMP T5.10B: Downspout Dispersion Systems
3. BMP T5.10B: Downspout Dispersion Systems	3. BMP T5.10B: Downspout Dispersion Systems	3. BMP T5.10C: Perforated Stub-out Connections
4. BMP T5.10C: Perforated Stub-out Connections	4. BMP T5.10C: Perforated Stub-out Connections	
Surface Type: Other Hard Surfaces		
1. BMP T5.30: Full Dispersion	1. BMP T5.30: Full Dispersion	BMP T5.12: Sheet Flow Dispersion or BMP T5.11: Concentrated Flow Dispersion
2. BMP T5.15: Permeable Pavements or BMP T5.14: Rain Gardens or BMP T7.30: Bioretention	2. BMP T5.15: Permeable Pavements	
3. BMP T5.12: Sheet Flow Dispersion or BMP T5.11: Concentrated Flow Dispersion	3. BMP T7.30: Bioretention	
	4. BMP T5.12: Sheet Flow Dispersion or BMP T5.11: Concentrated Flow Dispersion	

Notes for using the List Approach:

1. Size BMP T5.14: Rain Gardens and BMP T7.30: Bioretention used in the List Approach to have a minimum horizontal projected surface area below the overflow which is at least 5% of the area drain-

Table I-3.2: The List Approach for MR5 Compliance (continued)

List #1 (For MR #1 - #5 Projects That Are Not Flow Control Exempt)	List #2 (For MR #1 - #9 Projects That Are Not Flow Control Exempt)	List #3 (For Flow Control Exempt Projects)
ing to it. 2. When the designer encounters BMP T5.15: Permeable Pavements in the List Approach, it is not a requirement to pave these surfaces. Where pavement is proposed, it must be permeable to the extent feasible unless BMP T5.30: Full Dispersion is employed.		

Objective

The objective of On-Site Stormwater Management is to use practices distributed across a development that reduce the amount of disruption of the natural hydrologic characteristics of the site.

Competing Needs Criteria

LID BMPs can be superseded or restricted where they are in conflict with:

- 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,
  - Americans with Disabilities Act.
- When an LID requirement has been found to be in conflict with special zoning district design criteria adopted and being implemented pursuant to a community planning process. The existing local codes may supersede or reduce the LID requirement.
- Public health and safety standards (e.g. 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.
- A local Critical Area Ordinance that provides protection of tree species.
- A local code or rule adopted as part of a Wellhead Protection Program established under the Federal Safe Drinking Water Act; or adopted to protect a Critical Aquifer Recharge Area established under the State Growth Management Act.

Supplemental Guidelines

In order to meet the LID Performance Standard, designers may use any Flow Control BMP in the SWMMWW. There are no specific Flow Control BMPs that must be used to meet the LID Performance Standard.

“Flooding or erosion impacts” include flooding of septic systems, crawl spaces, living areas, outbuildings, etc.; increased ice or algal growth on sidewalks/roadways; earth movement/settlement; erosion and other potential damage.

Recent research indicates that traditional development techniques in residential, commercial, and industrial land development cause gross disruption of the natural hydrologic cycle with severe impacts to water and water-related natural resources. Based upon gross level applications of continuous runoff modeling and assumptions concerning minimum flows needed to maintain beneficial uses, watersheds must retain the majority of their natural vegetation cover and soils, and developments must minimize their disruption of the natural hydrologic cycle in order to avoid significant natural resource degradation in lowland streams.

The BMPs listed in this section are likely insufficient by themselves to prevent significant hydrologic disruptions and impacts to streams and their natural resources. Therefore, local governments should look for opportunities to change their local development codes to minimize impervious surfaces and retain native vegetation in all development situations. Most importantly, to maintain the beneficial uses of our lowland freshwater systems will require land use planning that targets retention of a majority of a creek’s watershed in its natural condition, and retains most of the benefits of headwater areas, connected wetlands, riparian, and floodplain areas.

I-3.4.6 MR6: Runoff Treatment

Projects shall employ Runoff Treatment BMPs in accordance with the following thresholds, standards, and requirements to remove pollutants from stormwater runoff.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

TDA Thresholds

Each TDA within a project that requires Minimum Requirement #6 (as detailed in I-3.3 Applicability of the Minimum Requirements) must be reviewed to determine if Runoff Treatment BMPs are required for the TDA to be in compliance with Minimum Requirement #6.

Note that it is possible for a project that requires Minimum Requirement #6 with multiple TDAs to not need Runoff Treatment BMP(s) in one or more individual TDAs. If a TDA does not trigger the TDA threshold for Runoff Treatment BMPs, then the designer must document the areas within the TDA used to determine that the TDA threshold was not met. This documentation will demonstrate compliance with Minimum Requirement #6 for the TDA.

When assessing a TDA against the following thresholds, only consider the types of surfaces (e.g. new hard surfaces, replaced hard surfaces, converted vegetation areas) that are subject to Minimum Requirement #6, per the Project Thresholds in I-3.3 Applicability of the Minimum Requirements.

The following TDAs require construction of Runoff Treatment BMPs. If a TDA meets any of the following thresholds, Runoff Treatment BMPs are required. The project proponent must demonstrate that the TDA does not meet either of the following thresholds for Runoff Treatment BMPs to not be required for that TDA.

- TDAs that have a total of 5,000 square feet or more of pollution-generating hard surface (PGHS), or
- TDAs that have a total of 3/4 of an acre or more of pollution-generating pervious surfaces (PGPS) – not including permeable pavements, and from which there will be a surface discharge in a natural or man-made conveyance system from the site.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Runoff Treatment BMP Sizing

Size Runoff Treatment BMPs to treat the Water Quality Design Flow Rate or Water Quality Design Storm Volume, as detailed in III-2.6 Sizing Your Runoff Treatment BMPs.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Runoff Treatment BMP Selection, Design, and Maintenance

Runoff Treatment BMPs shall be:

- Selected in accordance with the process identified in III-1.2 Choosing Your Runoff Treatment BMPs,
- Designed in accordance with the design criteria in Volume V, and
- Maintained in accordance with the maintenance criteria in Volume V.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Additional Requirements

The (direct or indirect) discharge of untreated stormwater from pollution-generating hard surfaces to ground water must not be authorized by the local government, except for infiltration or dispersion of runoff through LID BMPs per The List Approach in I-3.4.5 MR5: On-Site Stormwater Management.

> ***The text in this box originates from one or more of the following Permits:***
> *Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits*
> *Construction Stormwater General Permit*

The direct discharge of untreated stormwater from pollution-generating hard surfaces to ground water is prohibited, except for infiltration or dispersion of runoff through LID BMPs per The List Approach in I-3.4.5 MR5: On-Site Stormwater Management.

Objective

The purpose of Runoff Treatment is to reduce pollutant loads and concentrations in stormwater runoff using physical, biological, and chemical removal mechanisms so that beneficial uses of receiving waters are maintained and, where applicable, restored. When site conditions are appropriate, infiltration can potentially be the most effective BMP for Runoff Treatment.

Supplemental Guidelines

See III-1.2 Choosing Your Runoff Treatment BMPs for determining the appropriate Runoff Treatment Performance Goal for the site, and a list of BMPs that may be used to meet that performance goal using the presumptive approach.

See Volume V for detailed guidance on design and maintenance of Runoff Treatment BMPs.

An adopted and implemented basin plan, or a Total Maximum Daily Load (TMDL - also known as a Water Clean-up Plan) may be used to develop Runoff Treatment requirements that are tailored to a specific basin. However, Runoff Treatment requirements shall meet, at a minimum, the Basic Treatment Performance Goal (as detailed in III-1.2 Choosing Your Runoff Treatment BMPs).

Runoff from surfaces that are not pollution-generating do not need to be treated and may bypass the Runoff Treatment BMP(s), if it is not mingled with runoff from pollution-generating surfaces.

Drainage from areas in native vegetation should not be mixed with untreated runoff from streets and driveways, if possible. It is best to infiltrate or disperse this relatively clean runoff to maximize recharge to shallow ground water, wetlands, and streams.

Revising MR6 through a Basin Plan

Basin Plans (see Appendix I-B: Basin Plans) can develop different requirements and performance standards than those detailed above to reduce pollutant concentrations or loads based on an evaluation of the beneficial uses to be protected within or downstream of the basin. Consideration must be given to the antidegradation provisions of the Clean Water Act and implementing state water quality standards. The evaluation should include an analysis of existing and future conditions. Basin specific requirements and performance standards can be developed based on an evaluation of pollutant loads and modeling of receiving water conditions.

Basic Treatment (as described in III-1.2 Choosing Your Runoff Treatment BMPs) is a minimum standard that must be applied regardless of the quality of the receiving water(s). Additional levels of Runoff Treatment beyond Basic Treatment may be justified in order to control the impacts of future development.

Runoff Treatment requirements and performance standards developed from a Basin Plan should apply to individual development sites within the basin. Regional Runoff Treatment BMPs can be considered an acceptable substitute for on-site Runoff Treatment BMPs if they can meet the Runoff Treatment requirements and performance standards identified in the Basin Plan. A limitation to the use of regional Runoff Treatment BMPs is that the conveyances used to transport the stormwater to the Regional BMP must not include waters of the state that have existing or attainable beneficial uses other than drainage.

The above text describes how Basin Plans can influence Runoff Treatment requirements and performance standards for new and redevelopment. Basin Plans can also be used to identify structural retrofit Runoff Treatment requirements for reducing the effects of existing development on the aquatic resources.

I-3.4.7 MR7: Flow Control

Projects shall employ Flow Control BMPs in accordance with the following thresholds, standards, and requirements to reduce the impacts of stormwater runoff from hard surfaces and land cover conversions.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

TDA Exemption

Flow Control is not required for TDAs that discharge directly to, or indirectly through an MS4 to a water listed in Appendix I-A: Flow Control Exempt Receiving Waters, subject to all of the following restrictions:

- Direct discharge to the exempt receiving water 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 or conveyance elements that deliver flow 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.

- The TDA must be drained by a conveyance system that is comprised entirely of manmade conveyance elements (e.g., pipes, ditches, outfall protection) and extends to the ordinary high water line of the exempt receiving water.
- 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 condition from contributing off-site areas.
- Any erodible elements of the manmade conveyance system must be adequately stabilized to prevent erosion under the conditions noted above.

Local governments may petition Ecology to exempt projects in additional areas. A petition must justify the proposed exemption based upon a hydrologic analysis that demonstrates that the potential stormwater runoff from the exempted area will not significantly increase the erosion forces on the stream channel nor have near field impacts. See Appendix I-A: Flow Control Exempt Receiving Waters for details

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

TDA Thresholds

Each TDA within a project that requires Minimum Requirement #7 (as detailed in I-3.3 Applicability of the Minimum Requirements) must be reviewed to determine if Flow Control BMPs are required for the TDA to be in compliance with Minimum Requirement #7.

Note that it is possible for a project that requires Minimum Requirement #7 with multiple TDAs to not need Flow Control BMP(s) in one or more individual TDAs. If a TDA does not trigger the TDA thresholds for Flow Control BMPs, then the designer must document the areas within the TDA used to determine that the TDA thresholds were not met. This documentation will demonstrate compliance with Minimum Requirement #7 for the TDA.

When assessing a TDA against the following thresholds, only consider the types of surfaces (e.g. new hard surfaces, replaced hard surfaces, converted vegetation areas) that are subject to Minimum Requirement #7, per the Project Thresholds in I-3.3 Applicability of the Minimum Requirements.

The following TDAs require construction of Flow Control BMPs to achieve the Flow Control Performance Standard. If a TDA meets any of the following thresholds, Flow Control BMPs are required. The project proponent must demonstrate that the TDA does not meet any of the following thresholds for Flow Control BMPs to not be required for that TDA.

- TDAs that have a total of 10,000 square feet or more of effective impervious surfaces, or
- TDAs that convert ¾ acres or more of native vegetation, pasture, scrub/shrub, or unmaintained non-native vegetation to lawn or landscape, or convert 2.5 acres or more of native

vegetation to pasture, and from which there is a surface discharge in a natural or man-made conveyance system from the TDA, or

- TDAs that through a combination of effective hard surfaces and converted vegetation areas cause a 0.15 cubic feet per second (cfs) or greater increase in the 100-year flow frequency as estimated using an approved continuous simulation model and 15-minute time steps.

The 0.15 cfs increase should be a comparison of the post project runoff to the existing condition runoff. For the purpose of applying this threshold, the existing condition is either the pre-project land cover, or the land cover that existed at the site as of a date when the local jurisdiction first adopted Flow Control requirements into code or rules.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Flow Control Performance Standard

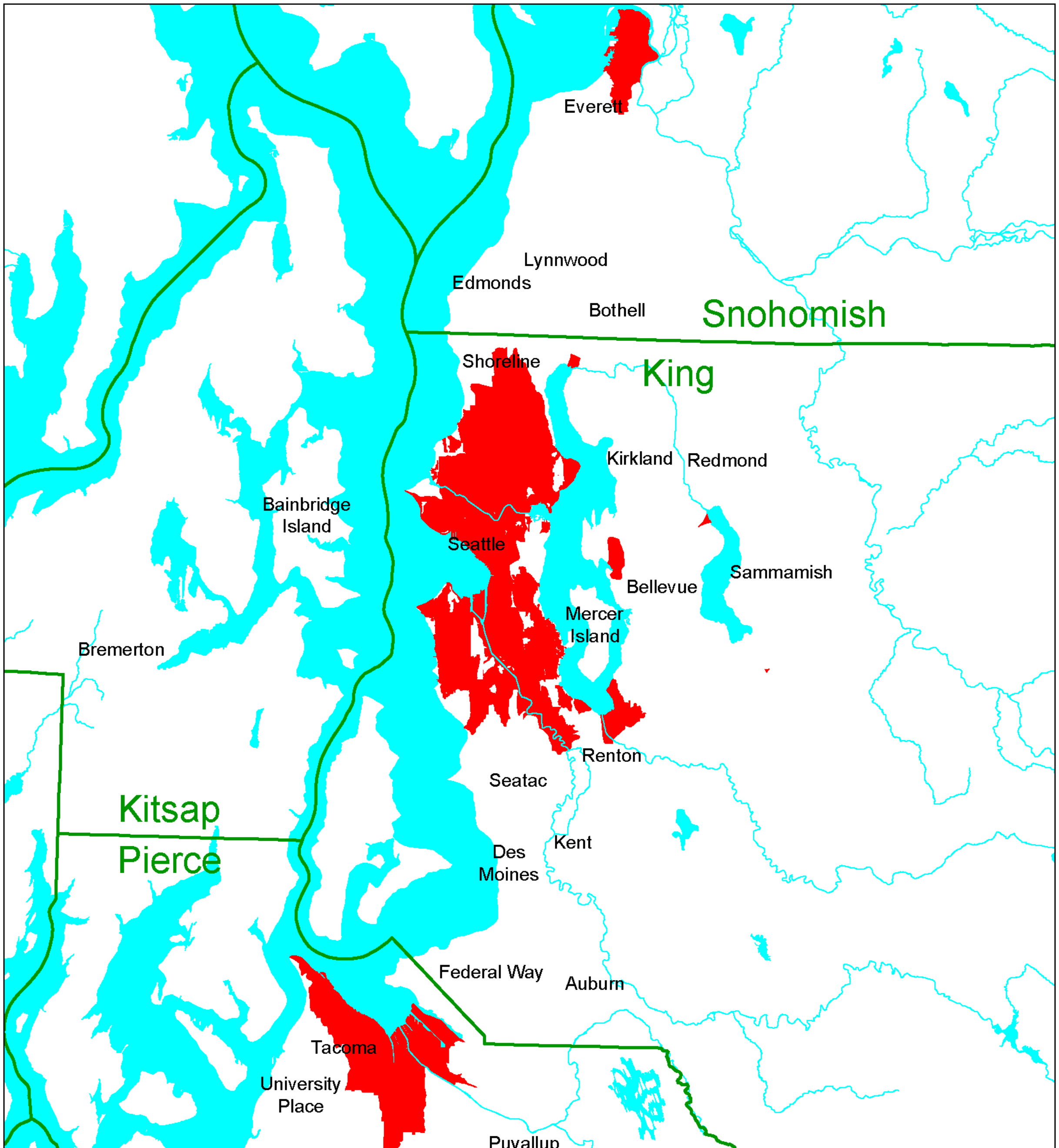
Stormwater discharges shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow. The pre-developed condition to be matched shall be a forested land cover unless:

- Reasonable, historic information is provided that indicates the site was prairie prior to settlement (modeled as pasture in the approved continuous simulation model); or,

- The drainage area of the immediate stream and all subsequent downstream basins have had at least 40% total impervious area (TIA) since 1985. In this case, the pre-developed condition to be matched shall be the existing land cover condition. Figure I-3.4: Basins with 40% Total Impervious Area as of 1985 depicts those areas which meet this criterion. Where basin-specific studies determine a stream channel to be unstable, even though the above criterion is met, the pre-developed condition assumption shall be the “historic” land cover condition, or a land cover condition commensurate with achieving a target flow regime identified by an approved basin study.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Figure I-3.4: Basins with 40% Total Impervious Area as of 1985



DEPARTMENT OF ECOLOGY State of Washington

Basins with 40% Total Impervious Area as of 1985

Revised June 2016

Alternative Flow Control Performance Standard

An alternative Flow Control Performance Standard may be established through application of watershed-scale hydrologic modeling and supporting field observations. Possible reasons for an alternative Flow Control Performance Standard include:

- Establishment of a stream–specific threshold of significant bedload movement other than the assumed 50% of the 2-year peak flow;
- Zoning and Land Clearing Ordinance restrictions that, in combination with an alternative Flow Control Performance Standard, maintain or reduce the naturally occurring erosive forces on the stream channel; or
- A duration control standard is not necessary for protection, maintenance, or restoration of designated and existing beneficial uses or Clean Water Act compliance.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Additional Requirement

Flow Control BMPs shall be selected, designed, and maintained in accordance with this manual.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Objective

The objective of this Minimum Requirement is to prevent increases in the stream channel erosion rates that are characteristic of natural conditions (i.e., prior to disturbance by European settlement). The Flow Control Performance 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 peak flow. Maintaining the naturally occurring erosion rates within streams is vital, though by itself insufficient, to protect fish habitat and production.

Supplemental Guidelines

The 1992 Ecology manual (Ecology, 1992) focused primarily on controlling the peak flow release rates for recurrence intervals of concern – the 2, 10, and 100-year rates. This level of control did not adequately address the increased duration at which those high flows occur because of the increased volume of water from the developed condition as compared to the pre-developed conditions.

To protect stream channels from increased erosion, it is necessary to control the durations over which a stream channel experiences geomorphically significant flows such that the energy imparted to the stream channel does not increase significantly. Geomorphically significant flows are those that are capable of moving sediments. This target will translate into lower release rates and significantly larger Flow Control BMPs than the standard from the 1992 Ecology manual. The size of Flow Control BMPs can be reduced by changing the extent to which the site is disturbed.

Reduction of flows through infiltration decreases stream channel erosion and helps to maintain base flow throughout the summer months. Infiltration should follow the guidance in this manual to reduce the chance of threatening ground water quality.

Using LID BMPs reduces the predicted runoff rates and volumes, and thus also reduces the size of required Flow Control BMPs.

Application of certain LID and/or infiltration BMPs can result in reducing the effective impervious area and the converted vegetation areas such that the TDA Thresholds are not triggered, and a Flow Control BMP is not required. See the definition of Effective Impervious Surface in the Glossary for details. Application of BMP T5.30: Full Dispersion also results in eliminating the requirement for a Flow Control BMP for those areas that are “fully dispersed.”

Diversion of flow from perennial streams and from wetlands can be considered if significant existing (i.e., pre-project) flooding, stream stability, water quality, or aquatic habitat problems would be solved or significantly mitigated by bypassing stormwater runoff rather than providing stormwater detention and discharge to natural drainage features. Bypassing should not be considered as an alternative to applicable Flow Control or Runoff Treatment if the flooding, stream stability, water quality or habitat problem to be solved would be caused by the project. In addition, the proposal should not exacerbate other water quality/quantity problems such as inadequate low flows or inadequate wetland water elevations. The existing problems and their solution or mitigation as a result of the direct discharge should be documented by a stormwater engineer or scientist after review of any available drainage reports, basin plans, or other relevant literature. The restrictions in this Minimum Requirement on conveyance systems that transfer water to an exempt receiving water are also applicable in these situations. Approvals by all regulatory authorities with relevant permits applicable to the project are necessary.

How to Determine an Alternative Flow Control Performance Standard

A Basin Plan (see Appendix I-B: Basin Plans) may be used to identify an Alternative Flow Control Performance Standard. The Basin Plan must contain an analyses to determine the measures necessary to protect a stream channel from accelerated erosion.

Ecology’s default Flow Control Performance Standard is based upon a generalization that the threshold of significant bedload movement in Western Washington streams occurs at 50% of the 2-year return stream flow. Through field observations and measurements, a local government may estimate a more appropriate threshold – higher or lower- for a specific stream. The alternative threshold can become the lower limit for the range of flows over which the duration standard applies. For instance, if the threshold is established at 70% of a 2-year return flow, the Alternative Flow Control Performance Standard would be to match the discharge durations of flows from the developed site to the range of pre-developed discharge rates from 70% of the 2-year peak flow up to the full 50-year peak flow.

An Alternative Flow Control Performance Standard must be compatible with maintaining and restoring the designated beneficial uses for that stream. If the existing stream condition is not compatible with the beneficial uses, it should not be used to determine an Alternative Flow Control Performance Standard.

Basin Plans that intend to identify an Alternative Flow Control Performance Standard will require the use of computer models and field work to verify and support the models. Permit holders considering the use of Basin Plans to identify an Alternative Flow Control Performance Standard are encouraged to contact their regional permit specialist during the planning stage.

Ecology cautions local governments seeking to determine a threshold of bed load movement for a stream whose channel has been significantly altered from its historic condition by stormwater flows. An Alternative Flow Control Performance Standard must be compatible with the restoration and maintenance of the designated beneficial uses of the stream. If the current threshold of bed load movement is not compatible with creating and sustaining channel conditions for the beneficial uses, it is not an acceptable regulatory target.

How did Ecology Determine Which Areas Meet the 40% TIA Since 1985 Criterion?

Figure I-3.4: Basins with 40% Total Impervious Area as of 1985 shows those basins that qualify for use of a Flow Control Performance Standard that would require matching high flow durations of a project to the durations produced by the existing land cover condition. To qualify, a basin must have been at or above 40 percent total impervious area (TIA) since 1985. Figure I-3.4: Basins with 40% Total Impervious Area as of 1985 depicts basins that exceeded 40 percent total impervious area as of 1986. The Department of Ecology has used 1986 land covers as estimated from satellite images as the best available information upon which to make these designations.

Ecology contracted with Sanborn, Inc. to provide land cover data for Western Washington for 1991, and an analysis of change in land cover, impervious surface, and forest canopy for all of Western Washington between 1991 and 2001. The project built upon land cover data classified under the NOAA Coastal Change Analysis Program (C-CAP) for 1996 and 2001.

The resulting report is titled *Western Washington Land Cover Change Analysis: Final Report* (Fiorella, 2005).

Ecology used one of the report's outputs, total impervious area by basin in 1991, to create and publish a map of areas that potentially qualified for use of the existing land cover condition as the flow control target for new and re-development projects. Now that 1986 land cover data using similar estimating techniques has been made available by NOAA, Ecology has produced Figure I-3.4: Basins with 40% Total Impervious Area as of 1985 that supersedes the previous map.

The analysis involved the following steps:

- Determine the basin scale upon which to do the analysis. Some streams have only one basin designated for their drainage area. Other streams have multiple sub-basins for which the TIA and area data are available. The analysis begins just above those points at which a Flow Control standard does not apply. Usually that is a stream's discharge to Puget Sound or a large lake system that is exempt from flow control, e.g., Lake Washington/Lake Union/Ship Canal area.
- Using the 1986 data, compute an area-weighted TIA using data for all sub-basins within the

larger basin.

- If the basin does not exceed the 40% TIA criterion, none of the sub-basins potentially qualify unless a sub-basin discharges very near to the bottom of the basin drainage. If the basin exceeds 40% TIA at least some area within the basin potentially qualifies. To determine that area, proceed upstream and compute areal weighted %TIA for smaller drainages within the subject basin. A drainage area of an identifiable side-stream or an upper area draining to the main stream channel does not qualify if the respective areal-weighted %TIA of its sub-basins does not exceed the 40% criterion.
- Remove designation of basins which met the 40% criterion, but for which:
    - a basin-specific study suggests the stream channel to be unstable;
    - an approved basin study identified a target flow regime intended to achieve acceptable natural resource objectives (e.g. Des Moines Creek).

Ecology's *Discussion Paper: Proposed Flow Control Standard for Highly Urbanized Drainage Basins* (Ecology, 2004c) explains the basis for the less stringent Flow Control standard for basins meeting the criteria. The implementation section at the end of the paper no longer applies to the updated (2010) map, but the background and rationale for the exemption does.

The map in GIS format and all associated metadata are available to local governments from Ecology's GIS web site at the following address:

https://ecology.wa.gov/Research-Data/Data-resources/Geographic-Information-Systems-GIS/GIS-data#l

Permit holders interested in using alternative data or methods to demonstrate that a basin meets this criterion for a highly urbanized basin prior to 1985 should contact their Regional Permit Specialist prior to beginning such a study.

Revising MR7 through a Basin Plan

Basin Plans (see Appendix I-B: Basin Plans) are well-suited to control stream channel erosion for both existing and future conditions. Flow Control standards developed from a Basin Plan may be used to alter the default standards described above, and can include a combination of on-site, regional, and stream protection and rehabilitation measures, and retrofitting opportunities.

- On-site standards are usually the primary mechanism to protect streams from the impacts of increased high flows in future conditions.
- Regional Flow Control facilities are used primarily to correct existing stream erosion problems.
- In-stream protection and rehabilitation measures may be applied where stream channel erosion problems exist that will not be corrected by on-site or regional facilities. However, caution is urged in the application of such measures. If the causes of the stream channel erosion problems still exist, repairs to the physical expression of those problems may be short-lived. In some instances, it may be prudent to apply in-stream measures to reduce impacts until the basin hydrology is improved. This does not alleviate the jurisdiction from needing to ensure that existing and beneficial uses are restored to the receiving water. In stream work cannot be

used to satisfy the Minimum Requirements under the permit.

- Retrofitting opportunities may include modified outlets for, and expansion of existing Detention BMPs.

Basin Plans may be used to:

- develop an Alternative Flow Control Performance Standard, as described above.
- identify additional receiving waters as Flow Control Exempt, as described in Appendix I-A: Flow Control Exempt Receiving Waters.
- identify basins that have had at least 40% total impervious area since 1985, as described above.

I-3.4.8 MR8: Wetlands Protection

Projects shall employ Stormwater Management BMPs in accordance with the following thresholds, standards, and requirements to reduce the impacts of stormwater runoff to wetlands.

The text in this box originates from one or more of the following Permits:
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TDA Thresholds

This Minimum Requirement applies only to TDAs whose stormwater discharges into a wetland, either directly or indirectly through a conveyance system.

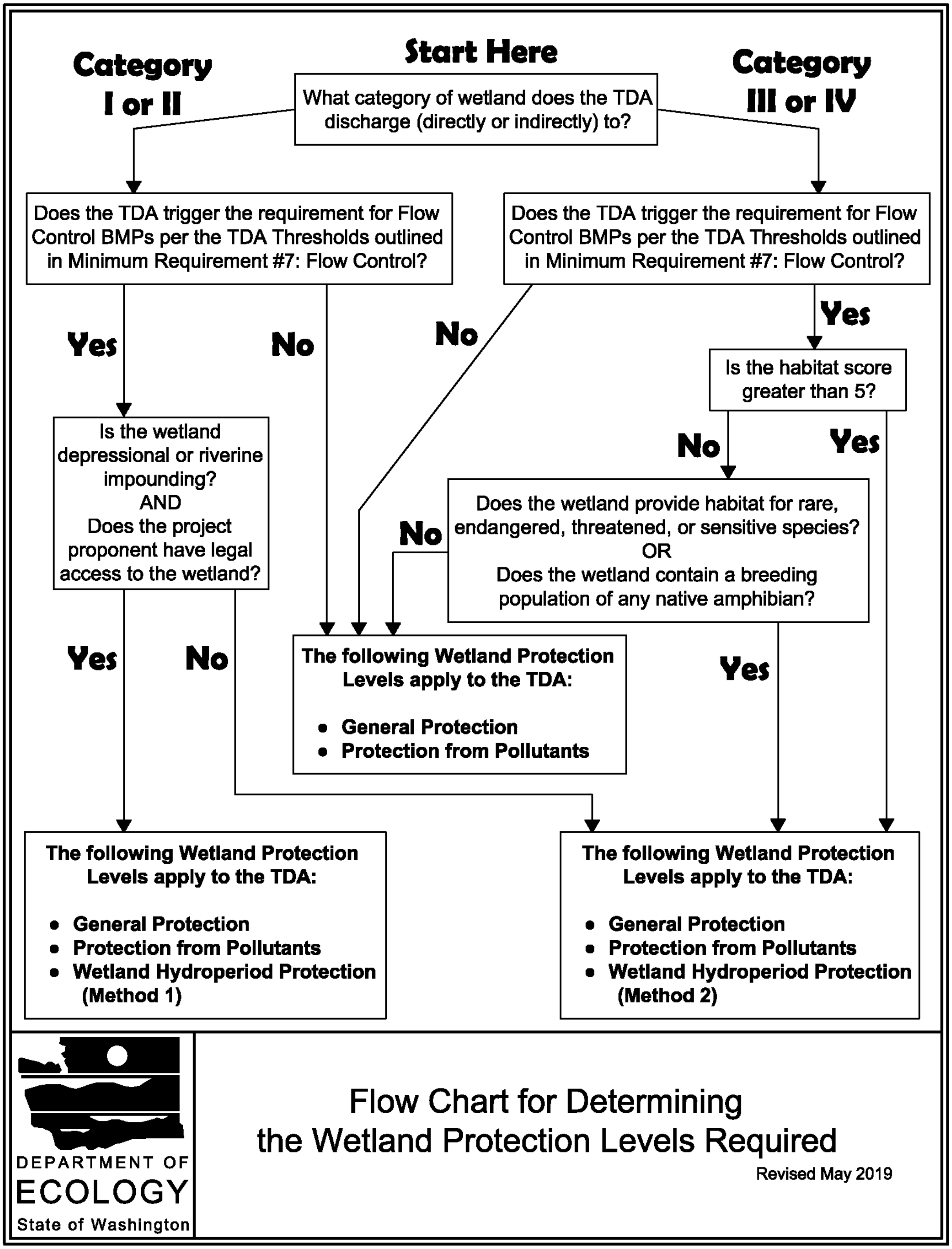
Each TDA within a project that requires Minimum Requirement #8 (as detailed in I-3.3 Applicability of the Minimum Requirements) must be reviewed to determine what Level(s) of Wetland Protection must be applied to the TDA to comply with Minimum Requirement #8. The Level(s) of Wetland Protection that must be applied are dependent upon:

- The category of wetland that the TDA is discharging to,
- Whether or not the TDA triggers the requirement for Flow Control BMPs per the TDA Thresholds in I-3.4.7 MR7: 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
- Presence of a breeding population of native amphibians.

Refer to Figure I-3.5: Flow Chart for Determining Wetland Protection Level Requirements to determine what Level(s) of Wetland Protection must be applied to comply with Minimum Requirement #8.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Figure I-3.5: Flow Chart for Determining Wetland Protection Level Requirements



Levels of Wetland Protection

The following Levels of Wetland Protection are further explained in Appendix I-C: Wetland Protection Guidelines.

General Protection

General Protection includes general practices that benefit wetlands of all types. See I-C.2 General Protection for details.

Protection from Pollutants

Protection from Pollutants includes measures to protect the wetland from pollutants in stormwater runoff. Measures of protection include Construction Stormwater BMPs, Source Control BMPs, LID practices and principles, and Runoff Treatment BMPs. See I-C.3 Protection from Pollutants for details.

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 Modeling

  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 pre-development condition.

See I-C.4 Wetland Hydroperiod Protection for details on both methods.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Additional Requirements

Stormwater Management BMPs shall not be built within a wetland or its buffer, except for:

- Necessary conveyance systems as approved by the local government; or
- As allowed in I-C.6 Compensatory Mitigation of Wetlands.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Objective

The objective of this Minimum Requirement is to ensure that wetlands receive the same level of protection as any other water of the state. Wetlands are extremely important natural resources that provide multiple functions and values, including ground water 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 the natural hydrologic pattern of the wetland.

Supplemental Guidelines

Appendix I-C: Wetland Protection Guidelines shall be used for discharges to natural wetlands and mitigated wetlands.

How Do I Reconcile the Flow Control Performance Standard from MR7 with MR8?

In most cases, if Wetland Hydroperiod Protection is required per I-3.4.8 MR8: Wetlands Protection, then the Flow Control Performance Standard is also required per I-3.4.7 MR7: Flow Control. In these cases, the designer must attempt to meet the requirements for both MRs. This may prove to be feasible in many situations because I-3.4.7 MR7: Flow Control will seek to adjust the flow in small time intervals and I-3.4.8 MR8: Wetlands Protection looks to maintain daily flow volumes.

If the designer is unable to meet both requirements, then the requirement to maintain the hydroperiod of the wetland becomes the overriding concern and the designer must show compliance with I-3.4.8 MR8: Wetlands Protection. If this is the case, the designer must also provide documentation detailing why they are unable to meet both requirements.

Revising MR8 through a Basin Plan

Basin Plans (see Appendix I-B: Basin Plans) can be used to develop alternative protection standards for wetlands and other sensitive areas, such as landslide hazard areas, wellhead protection areas, and ground water quality management areas. These standards can include Source Control, Runoff Treatment, Flow Control, stage levels, and frequency and duration of inundations.

I-3.4.9 MR9: Operation and Maintenance

An operation and maintenance manual that is consistent with the provisions in Volume V shall be provided for proposed Runoff Treatment and Flow Control BMPs. The party (or parties) responsible for maintenance and operation shall be identified in the operation and maintenance manual. At private facilities, a copy of the operation and maintenance manual shall be retained on site or within reasonable access to the site, and shall be transferred with the property to the new owner. For public facilities, a copy of the operation and maintenance manual shall be retained in the appropriate department. A log of maintenance activity that indicates what actions were taken shall be kept and be available for inspection by the local government.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Objective

The objective of this Minimum Requirement is to ensure that Stormwater Management BMPs are properly maintained and operated.

Supplemental Guidelines

Inadequate maintenance is a common cause of failure for Stormwater Management BMPs. See the maintenance section within each BMP, as well as the tables in Appendix V-A: BMP Maintenance Tables. Local governments should consider more detailed requirements for maintenance logs, such as a record of where wastes were disposed.

I-3.5 Additional Protective Measures (Optional)

I-3.5.1 What Are Additional Protective Measures (APMs)?

Additional Protective Measures (APMs) are measures above and beyond the Minimum Requirements (MRs) that Ecology recommends for local governments to consider in their stormwater program. Ecology considers their use to be in the best interest of the general public and the environment, but will not make their implementation a requirement for manual equivalency or permit compliance.

I-3.5.2 APM1: Financial Liability

Ecology recommends that local governments require performance bonding or other appropriate financial guarantees for all projects to ensure construction of Stormwater Management BMPs in compliance with these standards. In addition, Ecology recommends that local governments require a project applicant post a minimum two-year financial guarantee of the satisfactory performance and maintenance of any Stormwater Management BMPs that are scheduled to be assumed by the local government for operation and maintenance.

Local governments may choose to require longer performance bonds for certain project types, such as those that use the demonstrative approach (see I-1.6 Presumptive versus Demonstrative Approaches to Protecting Water Quality).

Objective

The objective of this APM is to ensure that development projects have adequate financial resources to fully implement their stormwater management requirements and that liability is not unduly incurred by local governments.

Supplemental Guidelines

The type of financial instrument required is less important than ensuring that there are adequate funds available in the event that non-compliance occurs.

I-3.5.3 APM2: Off-Site Analysis Report

Ecology recommends that local governments require development projects that discharge stormwater off-site to submit an off-site analysis report that assesses the potential off-site water quality, erosion, slope stability, and drainage impacts associated with the project, and proposes appropriate mitigation for those impacts. The report should also assess the amount of off-site run-on from upstream off-site areas that may affect the site design.

The initial qualitative analysis shall extend along the flow path from the project site to the receiving water, for a distance up to one mile. If the receiving water is within one-quarter mile from the project site, the analysis shall extend within the receiving water to one-quarter mile from the project site. The analysis shall extend one-quarter mile beyond any improvements proposed as mitigation. The analysis must extend upstream from the project site to a point where there are no backwater effects created by the project, and the designer can determine all areas contributing run-on to the project.

The existing or potential impacts to be evaluated and mitigated should include:

- Conveyance system capacity problems;
- Localized flooding;
- Erosion, including landslide hazards and erosion along streambanks and at the outfall location;
- Violations of surface water quality standards as identified in a Basin Plan or a TMDL; or violations of ground water quality standards in a wellhead protection area.

Objective

The objective of the off-site analysis report is to identify, evaluate, and determine measures to prevent off-site water quality, erosion, slope stability, and drainage impacts that may be caused or aggravated by a proposed project. "Aggravated" shall mean increasing the frequency of occurrence and/or severity of a problem.

Supplemental Guidelines

Some of the most common and potentially destructive impacts of land development are erosion of downgradient properties, localized flooding, and slope failures. These are caused by increased surface water volumes and changed runoff patterns. Because these problems frequently do not have a related water quality impact, Ecology is not listing off-site analysis as a Minimum Requirement. However, taking the precautions of off-site analysis could prevent substantial property damage and public safety risks.

Projects should be required to initially submit, with the permit application, a qualitative off-site analysis report of each downstream system leaving a site. Upon review of the qualitative analysis, the local project reviewer may require that a quantitative analysis be performed. A quantitative off-site analysis report should contain the following:

1. **Define and map the study area**

   The off-site analysis report should include a map of the study area to show:

   - the study area's boundaries;
   - the study area's topography (at a minimum a USGS 1:24000 Quadrangle Topographic map);
   - the site's property lines;
   - the boundaries of proposed land disturbance;
   - the downstream flow path(s);
   - the tributary drainage areas to the downstream flow path(s); and
   - existing and/or potential problems.

2. **Review all available information on the study area**

   The designer should review, and the off-site analysis report should summarize all available basin plans, ground water management area plans, drainage studies, floodplain/floodway FEMA maps, wetlands inventory maps, Critical Areas maps, stream habitat reports, salmon distribution reports, etc. within the study area.

3. **Field inspect the study area**

   The designer should physically inspect the existing on- and off-site drainage systems within the study area for existing or potential problems and drainage features. An initial inspection and investigation should include:

   - Investigate problems reported or observed during the resource review;
   - Locate existing/potential constrictions or capacity deficiencies in the drainage system;
   - Identify existing/potential flooding problems;
   - Identify existing/potential overtopping, scouring, bank sloughing, or sedimentation;
   - Identify significant destruction of aquatic habitat (e.g., siltation, stream incision);
   - Collect qualitative data on features such as land use, impervious surface, topography, soils, presence of streams and/or wetlands;

- Collect information on pipe sizes, channel characteristics, drainage structures;
- Verify tributary drainage areas identified in the mapped study area;
- Contact the local government office with drainage review authority, neighboring property owners, and residents about drainage problems;
- Note date and weather at time of inspection.

The results of this inspection should be detailed in the off-site analysis report.

4. **Describe the drainage system, and its existing and predicted problems**

   For each drainage system component (e.g., pipe, culvert, bridges, outfalls, ponds, vaults) the following should be covered in the off-site analysis report: location, physical description, problems, and field observations.

   All existing or potential problems (e.g., ponding water, erosion) identified from the field inspection and information review should be described. The descriptions should be used to determine whether adequate mitigation can be identified, or whether a more detailed analysis is necessary. The following information should be provided for each existing or potential problem:

   - Magnitude of or damage caused by the problem
   - General frequency and duration
   - Return frequency of storm or flow when the problem occurs
   - Water elevation when the problem occurs
   - Names and concerns of parties involved
   - Current mitigation of the problem
   - Possible cause of the problem
   - Whether the project is likely to aggravate the problem or create a new one.

Upon review of the off-site analysis report, the local government may require mitigation measures deemed adequate for the problems depending upon the presence of existing or predicted flooding, erosion, or water quality problems, and on the proposed design of the Stormwater Management BMPs.

I-3.6 Adjustments and Exceptions/Variances to the MRs

I-3.6.1 Adjustments to the MRs

Adjustments to the Minimum Requirements may be granted prior to permit approval and construction. The jurisdiction may grant an adjustment provided that written findings of fact are prepared that address the following:

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

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

I-3.6.2 Exceptions/Variances to the MRs

Exceptions/variances (exceptions) to the Minimum Requirements may be granted prior to permit approval and construction. The jurisdiction may grant an exception following legal public notice of an application for an exception or variance, legal public notice of the jurisdiction's decision on the application, and written findings of fact that document the jurisdiction's determination to grant an exception.

The jurisdiction may grant an exception to the Minimum Requirements if such application imposes a severe and unexpected economic hardship. To determine whether the application imposes a severe and unexpected economic hardship on the project applicant, the jurisdiction must consider and document, with written findings of fact, the following:

- The current (pre-project) use of the Site, and
- How the 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.

In addition, any exception must meet the following criteria:

- 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.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Supplemental Guidelines

The adjustment (see I-3.6.1 Adjustments to the MRs) and exception provisions are an important element of the plan review and enforcement programs. They are intended to maintain a necessary flexible working relationship between local officials and applicants. Plan Approval Authorities should consider these requests judiciously, keeping in mind both the need of the applicant to maximize cost-effectiveness and the need to protect off-site properties and resources from damage.

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I-4 UIC Program

I-4.1 Introduction to UIC Wells

I-4 UIC Program defines site suitability, treatment requirements, and design criteria for discharges of stormwater to Underground Injection Control (UIC) wells. The requirements of this chapter may be superseded by the Industrial Stormwater General Permit for those permitted sites. See the Glossary and I-2.14 Underground Injection Control (UIC) Program for the UIC well definition and a list of examples.

All UIC wells receiving stormwater, except those located on tribal lands and UIC wells at single-family homes receiving only residential roof runoff or used to control basement flooding, must be registered with the state of Washington. The majority of UIC wells receiving stormwater runoff can be authorized by the UIC program without requiring individual permits, provided the non-endangerment standard is met by fulfilling the requirements detailed throughout I-4 UIC Program. Subsurface infiltration (UIC wells) may be used to provide flow control for stormwater runoff under any of the following conditions:

- Pollutant concentrations expected to reach ground water will meet Washington State ground water quality standards.
- Stormwater is treated according to the requirements of this section prior to reaching the aquifer.
- Flows are greater than the water quality design flow rate (see III-2.6 Sizing Your Runoff Treatment BMPs).

The unsaturated geologic material between the bottom of the UIC well and the top of an unconfined aquifer, herein called the vadose zone, usually provides some level of treatment by removing contaminants by filtration, adsorption, and/or degradation. In some cases, the treatment provided by the vadose zone is suitable for protecting ground water quality from contamination by stormwater runoff. In other cases, additional treatment may be required to protect ground water quality. I-4.16 Determining Treatment Requirements and I-4.17 Classification of Vadose Zone Treatment Capacity describe these assessments and their application.

I-4 UIC Program does not address the following:

- UIC wells that receive fluids other than stormwater (precluding accidental spills and illicit discharges, which are addressed in Volume IV)
- The infiltration capacity of the vadose zone below the UIC well
- The ability of the UIC well to meet local operational requirements to infiltrate a certain volume of water in a given amount of time (see I-3.4.7 MR7: Flow Control for more detail on flow control)

The UIC rule, WAC 173 218, requires a well assessment (see I-4.5 Well Assessment) for UIC wells that were constructed prior to February 3, 2006. The rule refers to these UIC wells as “existing” UIC wells.

The UIC program considers an infiltration trench where the design includes perforated pipe to be classified as a UIC well. Registration requirements do not apply to infiltration trenches without perforated pipes. Infiltration trenches designed, constructed, operated, and maintained according to the specifications in BMP T7.20: Infiltration Trenches and a UIC registration with Ecology can be rule-authorized by the presumptive approach (see I-4.8 The Presumptive Approach).

I-4.2 Rule-Authorization or Permit

UIC wells must either be rule-authorized or covered by a state waste discharge permit to operate. If a UIC well is rule-authorized, an individual permit is not required. Rule-authorization can be rescinded if a UIC well no longer meets the non-endangerment standard, i.e., the discharge does not meet ground water quality standards.

A UIC well may be rule-authorized when both of the following required actions are completed:

- Submit a registration form to Ecology (unless the UIC well is on tribal land, then registration is through U.S. Environmental Protection Agency (U.S. EPA), Region 10).
- Protect ground water quality. The discharge from the UIC well must meet the non-endangerment standard.

I-4.3 Registration

Register UIC wells using Ecology's online registration process. See the following website for details:

https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Underground-injection-control-program/Register-UIC-wells-online

All UIC wells must be registered except: UIC wells at single-family homes (or duplexes) receiving only residential roof runoff used to collect stormwater runoff from roof surfaces on an individual home (or duplex) or for basement flooding control.

New UIC Wells

Ecology considers UIC wells constructed on or after February 3, 2006, to be new wells. The registration provides Ecology with information to determine if the new UIC well meets the conditions to be rule-authorized:

- Applicants must submit the registration form 60 days prior to construction to allow for a full review of the application by Ecology and other interested stakeholders.
- The UIC well must meet the non-endangerment standard, i.e., it complies with all of the siting, design, and treatment requirements through either the presumptive approach (I-4.8 The Presumptive Approach) or the demonstrative approach (I-4.9 The Demonstrative Approach).

Existing UIC Wells

The UIC rule considers UIC wells constructed prior to February 3, 2006, as "existing." Existing wells used to manage stormwater runoff do not have to meet the new UIC well treatment requirements; however, registration is required if the UIC well is not already registered, and the owner must also complete a well assessment (I-4.5 Well Assessment) to determine if an existing UIC well is a high threat to ground water. See WAC 173 218 090(2) and Ecology's UIC web page at the following address:

https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Underground-injection-control-program/Register-UIC-wells-online

I-4.4 Meeting the Non-Endangerment Standard

According to WAC 173-218-080(3), UIC wells must be constructed, operated, and maintained in a manner that protects water quality.

New UIC Wells

Ecology 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 non-endangerment standard.

Designers may use either the presumptive or the demonstrative approach described in I-4.8 The Presumptive Approach and I-4.9 The Demonstrative Approach to meet the non-endangerment standard. UIC wells installed according to the specifications throughout I-4 UIC Program are not considered a high threat to ground water.

Existing UIC Wells

To determine compliance with the UIC rule, owners of existing UIC wells must complete a well assessment to determine if an existing UIC well is a high threat to ground water (I-4.5 Well Assessment). The owner of a UIC well that is a high threat to ground water must retrofit the well to protect ground water quality.

Requirements for Municipal UIC Wells

The UIC program rule is the regulatory authority for UIC wells in Washington. The UIC program rule applies to Class V wells that receive stormwater regardless of whether a UIC well is located in a municipality permitted under the Phase I or Phase II Municipal Stormwater National Pollutant Discharge Elimination System (NPDES) Permit for Western Washington (MS4 Permit).

The MS4 Permit does not authorize stormwater discharges to/from UIC wells unless the overflow or discharge from a UIC well drains to a NPDES municipal separate storm sewer system (MS4). In those cases, the MS4 Permit does authorize the discharge and the conditions of the MS4 Permit directly apply. For example, if a UIC well is designed to infiltrate the 10-year storm and route larger storms to the MS4, then the requirements of the MS4 Permit apply to the well.

To prevent redundancy between the NPDES and the UIC programs, the UIC program rule allows permitted MS4s that also own or operate Class V UIC wells to satisfy the UIC rule by the presumptive approach (I-4.8 The Presumptive Approach). MS4 permittees have the option of applying the Stormwater Management Programs (SWMPs) that comply with the MS4 Permit to the areas served by their municipal UIC wells pursuant to WAC 173-218-090 (1)(c)(C) in the manner described below. Municipalities not covered by the MS4 Permit may follow a similar approach. Note that the MS4 Permit does not require jurisdictions to fulfill all the requirements of the UIC program.

Municipalities may fulfill the source control and operation and maintenance requirements for new and existing municipal UIC wells under the following conditions:

- All areas served by municipally owned and operated UIC wells must be included in a Stormwater Management Program (SWMP) that ensures appropriate siting, treatment, design, operation, and maintenance of new municipal UIC wells as well as source control activities (including targeted education and outreach) that are well-suited for the land uses in these areas.
    - MS4 permittees may have a combined SWMP that addresses UIC and NPDES permit requirements together, or they may have two separate SWMPs for the areas served respectively by their municipal UIC wells and by their MS4.
    - In areas not covered by the MS4 permit, municipalities may create a SWMP specifically for the areas served by municipal UIC wells.
- To comply with the UIC rule, jurisdictions must implement all of the following activities and include them in their SWMP:
    - Register all UIC wells, including existing and new wells.
    - Design, construct, operate, and maintain new UIC wells according to the specifications throughout I-4 UIC Program.
    - Operate and maintain existing wells according to the specifications throughout I-4 UIC Program.

Municipalities choosing not to develop and implement a SWMP in areas served by existing Class V UIC wells must:

- Conduct a well assessment (I-4.5 Well Assessment) for each existing UIC well, and
- Create a Stormwater Site Plan (SSP) for the area served by each existing municipal UIC well. The SSP will include source control best management practices applicable to the activities present in the area and describe operation and maintenance procedures to keep the UIC well functioning properly to provide necessary treatment to protect groundwater.

All new municipal UIC wells must be sited, designed, constructed, managed, operated, and maintained according to the requirements throughout I-4 UIC Program.

I-4.5 Well Assessment

The assessment of an existing UIC well evaluates the potential risks to ground water from the use of the well and includes information such as:

- The land use and activities around the well (which affect the quality of the discharge),
- The local geology,
- Depth of the ground water table in relation to the UIC well, and
- Whether the UIC well is located in a ground water protection area.

Use this information to assess whether the well is a high threat to ground water quality, by applying the information in I-4.16 Determining Treatment Requirements and I-4.17 Classification of Vadose Zone Treatment Capacity. If an existing UIC well is located in a ground water protection area and the assessment determines that sufficient best management practices are not provided under the current conditions, retrofitting is required to protect ground water quality. Existing UIC wells in ground water protection areas that receive prohibited discharges (I-4.12 Prohibitions) must either be decommissioned or the activities must be moved and separated from the areas served by the existing UIC well.

A UIC well that was in use prior to the project is considered an existing well only if it remains in place. The well may be retrofitted or reconstructed in place without being considered a new well. Otherwise, if an existing well is moved, it is considered a new well, and the UIC requirements pertaining to new UIC wells apply.

Evaluating High Threat to Ground Water

For existing UIC wells, Ecology considers any of the following a high threat to ground water for which the UIC well must be retrofitted.

- Existing UIC wells receiving prohibited discharges (I-4.12 Prohibitions); these wells also require a separate groundwater discharge permit.
- Existing UIC wells receiving a high pollutant load where the vadose zone between the bottom of the UIC well and the top of the ground water has no treatment capacity or the vadose zone conditions are unknown; retrofits must provide treatment prior to the discharge to the well.
- Existing UIC well structures completed below the ground water table; retrofits must provide separation and, if needed (I-4.16 Determining Treatment Requirements and I-4.17 Classification of Vadose Zone Treatment Capacity), treatment. (If a UIC well has standing water when it has not received recent stormwater inflows, it is likely completed below the ground water table. See WAC 173-218-090(1)(b) for separation requirements between the bottom of the UIC well and the top of the ground water table.)
- Site-specific information indicates that a ground water quality problem exists in the vicinity of the existing UIC well.

A UIC well retrofit means to reduce the pollutant load from a UIC well to meet the nonendangerment standard by applying source control activity and/or structural controls such as a treatment BMP or create separation between the base of the well and the top of the groundwater table, WAC 173-218-030.

I-4.6 Preservation and Maintenance Projects

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 UIC well. Maintenance projects do not increase the traffic capacity of a roadway or parking area.

A UIC well that was in use prior to a preservation or maintenance project is considered an existing well only if it remains in place. The well may be retrofitted or reconstructed in place without being considered a new well. Otherwise, if an existing UIC well is moved, it is considered a new well and the UIC requirements apply pertaining to new UIC wells apply.

I-4.7 Emergency Situations

In emergency situations, such as roadway flooding, a jurisdiction may install a UIC well that does not meet the requirements in this manual on a temporary basis. When weather permits, and within a year of the event, the jurisdiction must either fully decommission the well or ensure that the UIC well meets the requirements of the rule.

For example, excessive winter rainfall overwhelms the capacity of the existing drainage system along a road. The water drains onto the road and turns to ice. The jurisdiction installs a new UIC well to fix the immediate problem and, once the weather permits, implements the required runoff treatment BMPs.

I-4.8 The Presumptive Approach

New UIC wells that meet all of the requirements detailed throughout I-4 UIC Program meet the presumptive approach to comply with the non-endangerment standard. Otherwise, the demonstrative approach (I-4.9 The Demonstrative Approach) is required.

The presumptive approach requires the implementation of BMPs in Volume V, and/or Volume IV of this manual or an equivalent manual, adopted at the time of construction. The manual addresses the following issues:

- The potential pollutant loading expected in the stormwater runoff for the planned land use(s) (see I-4.17 Classification of Vadose Zone Treatment Capacity)
- Source control of pollutants, especially those that are difficult to remove from stormwater by filtration, settlement, or other treatment technologies (see Volume IV)
- Known treatment methods (see other sections of Volume V)
- The potential treatment capacity of the vadose zone (see I-4.16 Determining Treatment Requirements)
- Siting (see the Site Suitability Criteria [SSC] in V-5.6 Site Suitability Criteria (SSC))
- Design (see I-4.10 Siting and Design of New UIC Wells or V-5 Infiltration BMPs)
- Operation and maintenance (O&M) (see Appendix V-A: BMP Maintenance Tables)

I-4.10 Siting and Design of New UIC Wells details the siting and design criteria to meet the presumptive approach for drywells designed to meet runoff treatment. V-5 Infiltration BMPs details the design requirements for infiltration trenches and drywells.

The presumptive approach may not be used when none of the source control or treatment BMPs in the manual are expected to eliminate or reduce concentrations of the pollutant(s) of concern (WAC 173-218-090(1)(i)(D)) to meet the nonendangerment standard.

I-4.9 The Demonstrative Approach

New UIC wells must meet the demonstrative approach to meet the non-endangerment 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 ground water 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
- 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 ground water quality standards and satisfy state all known, available, and reasonable methods of prevention, control, and treatment (AKART) requirements

I-4.10 Siting and Design of New UIC Wells

The requirements in this section apply to UIC wells built on or after February 3, 2006.

Minimum Siting Requirements for Rule-Authorization of New UIC Wells

The following Site Suitability Criteria (SSC) from V-5.6 Site Suitability Criteria (SSC) apply to all UIC wells:

- SSC-1 Setback Criteria
- SSC-2 Ground Water Protection Areas
- SSC-3 High Vehicle Traffic Areas
- SSC-5 Depth to Bedrock, Water Table, or Impermeable Layer
- SSC-7 Seepage Analysis and Control
- SSC-8 Cold Climate and Impact of Roadway Deicers

UIC wells may be used to provide flow control for stormwater runoff where pollutant concentrations that reach ground water will meet the Washington State ground water quality standards in the following situations:

- For flows greater than the water quality design flow rate (see III-2.6 Sizing Your Runoff Treatment BMPs); or
- Where stormwater is treated prior to discharge into the UIC well according to the requirements in I-4.16 Determining Treatment Requirements.

Furthermore, If SSC-4 Soil Infiltration Rate/Drawdown Time and SSC-6 Soil Physical and Chemical Suitability for Treatment are met, the site is considered to have a high treatment capacity, and the existing site soils may be used to provide runoff treatment for flows through the UIC well (see I-4.13 Source Control and Runoff Treatment Requirements).

Restrictions on Siting UIC Wells

- Prohibited areas: A UIC well may not be sited in prohibited areas; see I-4.12 Prohibitions for the list of areas where stormwater discharges to UIC wells are prohibited.
- Soil contamination: UIC wells may not be sited where there are soil contaminants that could be transported to ground water unless the site is remediated prior to construction.

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 ground water flow, and the vulnerability of the drinking water supply well to potential contamination, which is influenced by the following 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.

Ground Water 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 I-4.3: Pollutant Loading Classifications for Solids, Metals, and Oil in Stormwater Runoff Directed to UIC Wells).

Local jurisdictions may have ordinances that apply to development within ground water protection areas, such as sole source aquifers, ground water management areas, wellhead protection areas, and areas designated as Critical Aquifer Recharge Areas. To locate the wellhead 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/

Consult with the local jurisdiction for information on ground water protection areas.

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.

Prevention of Clogging During Construction

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

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 runoff treatment requirement, the long-term infiltration rate (see V-5.4 Determining the Design Infiltration Rate of the Native Soils) must be sufficient to accommodate the water quality design flow rate (see III-2.6 Sizing Your Runoff Treatment BMPs).

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 ground water. A 5-foot separation between the bottom of the well and the top of the ground water is required, unless a demonstrative approach confirms that a separation of 3 feet will meet the non-endangerment standard.

The required depth to ground water/vertical separation between the base of the UIC well and the top of the ground water table for rule-authorization using the presumptive approach depends on the treatment capacity of the unsaturated zone. I-4.16 Determining Treatment Requirements and I-4.17 Classification of Vadose Zone Treatment Capacity 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 ground water 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 I-4.9 The Demonstrative Approach), 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 I-4.16 Determining Treatment Requirements and I-4.17 Classification of Vadose Zone Treatment Capacity), and:
  - The ground water mounding analysis, the volumetric water holding capacity of the zone receiving the water, and the design of the overflow and/or bypass structures are judged by the design professional as adequate to prevent overtopping and meet the SSC specified in this section.

I-4.11 Operation and Maintenance of UIC Wells

The UIC rule requires that wells are operated and maintained to protect ground water 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 Appendix V-A: BMP Maintenance Tables for recommended maintenance criteria and inspection frequencies.

I-4.12 Prohibitions

UIC wells may not receive stormwater from the activities and conditions listed below:

- 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
- 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 IV 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, ground water, surface water, if the ground water 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 ground water, 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 runoff treatment to be protective of ground water in these situations. Stormwater from areas subject to the activities listed above must be handled onsite with a closed-loop system or discharged to the sanitary sewer, if allowed by the local jurisdiction.

However, careful design of these project sites may allow UIC wells to handle some of the stormwater runoff that will be generated. Stormwater from any portions of the site or facility that do not come in contact with these activities (or the areas of the facility associated with these activities) are allowed to be discharged to a UIC well following the presumptive approach.

See WAC 173-218-040(5)(b) for a list of examples of other prohibited UIC wells.

I-4.13 Source Control and Runoff Treatment Requirements

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

The rule presumes a UIC well meets the non-endangerment 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 runoff 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 I-4.16 Determining Treatment Requirements and I-4.17 Classification of Vadose Zone Treatment Capacity)

Source Control

Source control is necessary to protect ground water 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 non-endangerment standard for various land uses are described in Volume IV or other equivalent manuals. 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 II or in an equivalent manual. Where there are no existing runoff 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 non-endangerment standard. Otherwise, the discharge to the UIC well is prohibited (WAC 173-218-090(1)(c)(i)(D)). See I-4.12 Prohibitions 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 runoff
- 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

Contact the local jurisdiction to determine whether specific source control requirements apply to your project in addition to those methods described in this manual for the proposed land use.

Runoff Treatment

The BMPs chosen for the site must remove or reduce the target pollutants to levels that will comply with State ground water quality standards when the discharge reaches the ground water 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 V for specific runoff 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 (basic treatment, see the Glossary for definition) must be designed, constructed, operated and maintained in accordance with this manual or an equivalent manual.

Designers may alternatively use the demonstrative approach (I-4.9 The Demonstrative Approach) 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 V. 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.

Runoff 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, biofiltration, or bioinfiltration BMP after the nutrient budget is addressed; or
- Diverted through stormwater treatment wetlands (BMP T10.30: 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 budgets, 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 ground water 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 I-4.9 The Demonstrative Approach. Nonbiological treatment systems are ineffective at removing these pollutants from runoff. Instead, runoff from these types of landscaped areas should be directed to bioretention, biofiltration, or bioinfiltration systems or constructed wetlands 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 budgets, 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. Runoff from sites where nitrate, nitrite, ammonia, or phosphorus come into contact with stormwater must be directed to one of the following:

- Bioretention, biofiltration, or bioinfiltration systems
- Constructed wetlands prior to discharge
- Sanitary sewer, if allowed by the local jurisdiction

- Municipal drainage system that discharges to surface water, if allowed by the local jurisdiction and following treatment for removal of solids

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 I-4.17 Classification of Vadose Zone Treatment Capacity 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 Table I-4.3: Pollutant Loading Classifications for Solids, Metals, and Oil in Stormwater Runoff Directed to UIC Wells), 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)).

I-4.14 Spills and Illicit Discharges

Appropriate spill control, prevention and response measures for various land uses are described in Volume IV and in equivalent manuals. The spill control requirements in Volume IV 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.

I-4.15 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. Local jurisdictions may impose additional limits on the total depth of these UIC wells based on specific hydrologic conditions and other considerations.

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 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 ground water flow.
    - Evaluation of the treatment capacity of the vadose zone (see I-4.16 Determining Treatment Requirements and I-4.17 Classification of Vadose Zone Treatment Capacity).
    - Determination as to whether the proposed deep UIC well is located within a ground water 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 ground water 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.
- 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 runoff 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 ground water 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 should also be included in the 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.

In the design phase of a deep UIC drywell proposal, the project proponent should notify the drinking water supply purveyor when the proposed UIC well will be located in a wellhead protection area, Critical Aquifer Recharge Area or a Sole Source Aquifer.

Submittal of a State Waste Discharge Permit application may be required and will be determined on a site-by-site basis following the evaluation of the UIC permit application. Ecology will notify the project proponent if this is the case.

I-4.16 Determining Treatment Requirements

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.

Designers intending to use the presumptive approach can use the tables in I-4.17 Classification of Vadose Zone Treatment Capacity to identify the necessary level of Runoff Treatment prior to discharge to the UIC well.

Designers for industrial sites with no outdoor processing, storage, or handling of raw or finished products may use the Tables in I-4.17 Classification of Vadose Zone Treatment Capacity. Designers may not use the tables in I-4.17 Classification of Vadose Zone Treatment Capacity for stormwater runoff 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.

Where on-site or nearby geologic and ground water depth information is available, designers can use the tables in I-4.17 Classification of Vadose Zone Treatment Capacity to evaluate whether the presumption that a stormwater discharge from a road, commercial site, or residential site to a UIC well meets the non-endangerment standard for solids, metals, oil, grease, and polycyclic aromatic hydrocarbons (PAHs).

Used together, the tables in I-4.17 Classification of Vadose Zone Treatment Capacity 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 ground water 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 I-4.4: Treatment Required for Solids, Oil, and Metals for treatment requirements as a function of pollutant loading classification and vadose zone treatment capacity.

Exceptions Based on Site-Specific or Local Studies

Exceptions to the tables in I-4.17 Classification of Vadose Zone Treatment Capacity may be made under any of the following circumstances:

- Local planning efforts have generated an alternative method that meets the non-endangerment standard based on local conditions. For example, local jurisdictions may choose to allow changes in the pollutant loading categories in Table I-4.3: Pollutant Loading Classifications for Solids, Metals, and Oil in Stormwater Runoff Directed to UIC Wells based on source control BMPs implemented at a site.
- More detailed site-specific data are gathered by the project proponent and local permission is granted under a locally developed stormwater management program.
- The required thicknesses of the vadose zone treatment layer listed in Table I-4.2: 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 I-4.4 Meeting the Non-Endangerment Standard, and local jurisdiction 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 water level data justifies the minimal separation from the ground water 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 ground water table.
  - Potential mounding of infiltrating stormwater above the ground water table is likely. Additional separation or treatment may be required.

Vadose Zone Treatment Capacity

In general, the vadose zone may provide adequate filtration, adsorption, and other pollutant reduction capacity to meet the non-endangerment standard for solids, metals, oil, grease, and PAHs. Designers may use the tables in I-4.17 Classification of Vadose Zone Treatment Capacity 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 ground water 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.

I-4.17 Classification of Vadose Zone Treatment Capacity

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, as defined in Table I-4.1: Examples of Geologic Material Descriptions.

Table I-4.1: Examples of Geologic Material Descriptions

Geologic 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. These may be mixtures of materials where silt and clay fill the void spaces in the matrix of the coarser materials. More compaction results in better filtration. High-capacity treatment layers must total a minimum of 5 feet between the bottom of the

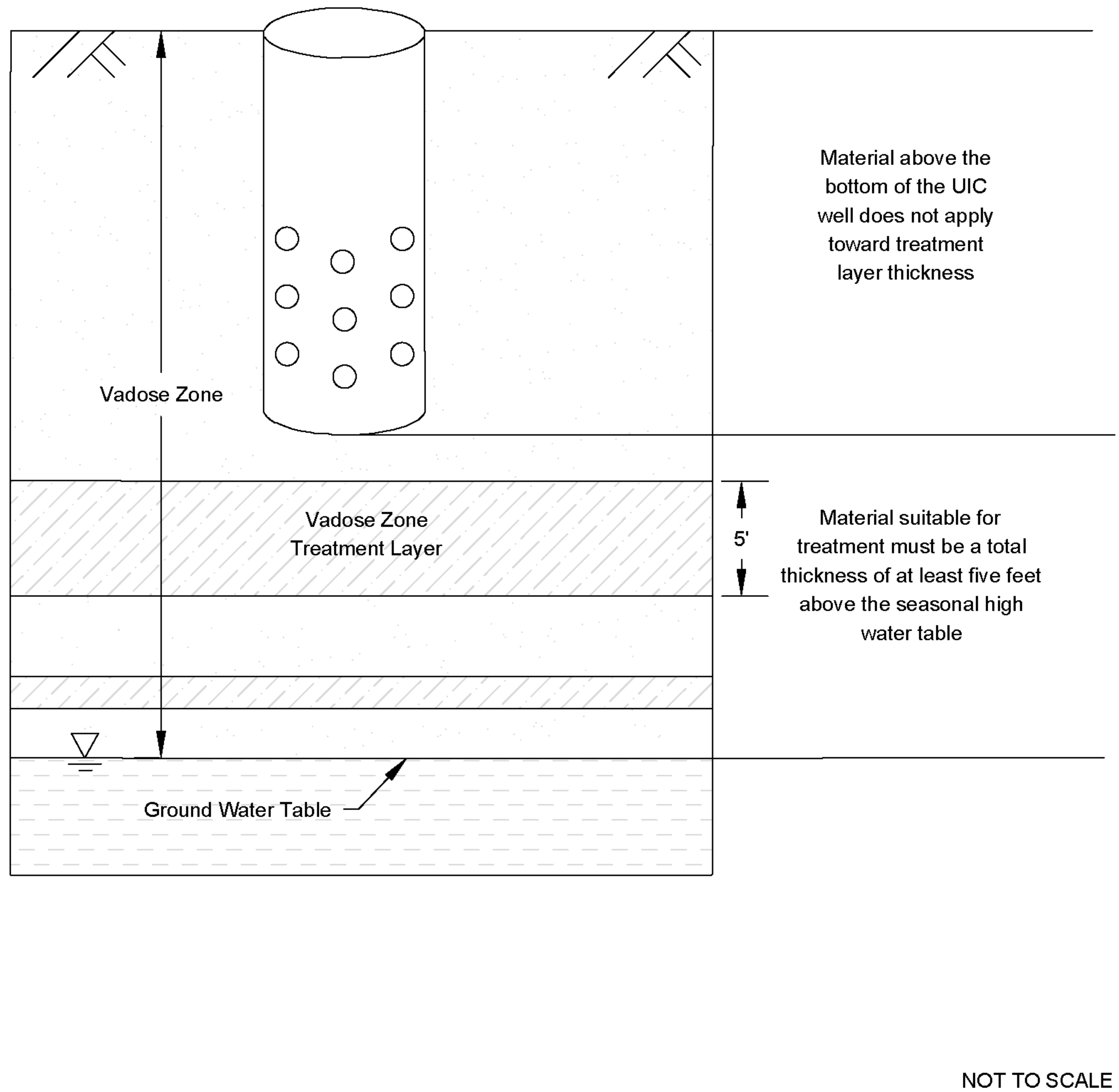
UIC well and the seasonal high ground water table to provide an adequate level of treatment (see Figure I-4.1: Schematic Vadose Zone Treatment Layer Example).

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 ground water 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 I-4.3: Pollutant Loading Classifications for Solids, Metals, and Oil in Stormwater Runoff Directed to UIC Wells.

Figure I-4.1: Schematic Vadose Zone Treatment Layer Example



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Schematic Vadose Zone Treatment Layer Example

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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 I-4.2: Vadose Zone Treatment Capacity.

In some cases, geologic information may be available from regional geology maps in publications from the Washington State Department of Natural Resources or the U.S. Geological Survey, from a well borehole log(s) in the same quarter-section on Ecology's well log web page (https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Well-report-gateway), or from local jurisdictions.

The following should be kept in mind when using these sources.

- Surface soil maps generally do not provide adequate information although the parent material information provided may be helpful in some locations.
- Verify well borehole log locations because electronic databases contain many errors of this type.
- When using borehole logs, a "nearby" site is generally defined as being within a quarter of a mile, but preferably within 50 to 500 feet of the project site, depending on the heterogeneity of the region.
- Subsurface geology can vary considerably in a very short horizontal distance in many areas of the state. Use professional judgment to determine whether the available data are adequate or site exploration is necessary.
- Alternatively, for small projects where site exploration is not cost-effective, a design professional may apply a conservative design approach, subject to the approval of the local jurisdiction.

The treatment capacity classifications in Table I-4.2: Vadose Zone Treatment Capacity apply to the vadose zone between the bottom of the UIC well and the top of the highest known seasonal ground water table. Designers should use Table I-4.2: Vadose Zone Treatment Capacity to assist in the determination of treatment requirements when using Table I-4.4: Treatment Required for Solids, Oil, and Metals. 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 I-4.9 The Demonstrative Approach). Separation between the bottom of the UIC well and the top of the ground water table is still required, see WAC 173-218-090(1)(b).

Depth to Ground Water

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

Knowledge of the seasonal high ground water table is especially important for siting UIC wells in areas with seasonal high ground water table < 15 feet below the bottom of the UIC well.

Significant mounding of infiltrating stormwater can occur above the ground water table (Appleyard, 1993) and UIC wells must not discharge stormwater directly into ground water at any time. This applies even if the ground water 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 ground water table. This is especially true if drilling was conducted outside of the period of seasonal high ground water levels or following a period of lower than normal precipitation. Seasonal high ground water tables generally occur during late winter through mid-spring in most of Washington State. In heavily irrigated areas, the seasonal high ground water table elevation may occur in late summer. The elevation of the seasonal high ground water table is best determined through installation and periodic monitoring of one or more ground water monitoring wells at the infiltration BMP location.

In portions of eastern Washington, ground water table elevations can fluctuate by tens of feet seasonally. At sites where the fluctuation of the seasonal ground water table is large (several feet) or unknown, designers should err on the side of caution. As described above and reinforced here, UIC wells must not discharge stormwater directly into ground water.

Table I-4.2: Vadose Zone Treatment Capacity

Treatment Capacity Classification and Required Minimum Thickness	Description of Vadose Zone Layer[c,d]
HIGH A minimum thickness of 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% • Field-tested saturated hydraulic conductivity below 2.4 in/hr at the bottom elevation of the proposed BMP • 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.*
MEDIUM	Meets all of the following characteristics:

Table I-4.2: Vadose Zone Treatment Capacity (continued)

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

A minimum thickness of 10 feet	• 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.

LOW
A minimum thickness of 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.

NONE
Minimum thickness not applicable
	Meets any 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 (sand and mud) < 5%
	    ○ Field-tested saturated hydraulic conductivity > 12

Table I-4.2: Vadose Zone Treatment Capacity (continued)

Treatment Capacity Classification and Required Minimum Thickness	Description of Vadose Zone Layer[c,d]
	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 ▪ Fractured 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.*

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 runoff 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 ground water table is required, see WAC 173-218-090(1)(b).

Table I-4.3: Pollutant Loading Classifications for Solids, Metals, and Oil in Stormwater Runoff Directed to UIC Wells

Classification	Areas Contributing Runoff to the UIC Well
Insignificant	• 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)

Table I-4.3: Pollutant Loading Classifications for Solids, Metals, and Oil in Stormwater Runoff Directed to UIC Wells (continued)

Classification	Areas Contributing Runoff to the UIC Well

	• **Inside Urban Growth Management Areas**
	  ◦ Fully controlled and partially controlled limited access highways with ADT < 15,000
	  ◦ Other roads with ADT < 7,500 vehicles
	• **Outside Urban Growth Management Areas**
	  ◦ All roads with ADT < 15,000 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
	• **Inside Urban Growth Management Areas**
	  ◦ 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
	• **Outside Urban Growth Management Areas**
	  ◦ All roads with ADT between 15,000 and 30,000 vehicles

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 runoff 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 I-4.2: Vadose Zone Treatment Capacity and the pollutant loading classification from Table I-4.3: 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 I-4.4: Treatment Required for Solids, Oil, and Metals.

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

Table I-4.4: Treatment Required for Solids, Oil, and Metals

Pollutant Loading	Treatment 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 pre-treatment 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 or bioinfiltration 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.

Table I-4.4: Treatment Required for Solids, Oil, and Metals (continued)

Pollutant Loading	Treatment Capacity			
	High	Medium	Low	None
• The requirement to apply a basic treatment BMP with adsorptive characteristics also applies to commercial parking and to streets with ADT > 7,500.				

Appendix I-A: Flow Control Exempt Receiving Waters

See I-3.4.7 MR7: Flow Control for the criteria required for a TDA to be exempt from the Flow Control requirement.

Table I-A.1: Flow Control Exempt Receiving Waters

Water Body	Upstream Point/Reach for Exemption (if applicable)
All Salt Waterbodies	
Alder Lake	
Baker Lake	
Baker River	Baker River/Baker Lake downstream of the confluence with Noisy Creek
Bogachiel River	0.4 miles downstream of Dowans Creek
Calawah River	Downstream of confluence with South Fork Calawah River
Capital Lake / Deschutes River	Downstream of Tumwater Falls
Carbon River	Downstream of confluence with South Prairie Creek
Cascade River	Downstream of Found Creek
Cedar River	Downstream of confluence with Taylor Creek
Chehalis River	1,500 feet downstream of confluence with Stowe Creek
Chehalis River, South Fork	1,000 feet upstream of confluence with Lake Creek
Cispus River	Downstream of confluence with Cat Creek
Clearwater River	Downstream of confluence with Christmas Creek
Coal Creek Slough	Boundary of Consolidated Diking and Irrigation District #1 to confluence with the Columbia River.
Columbia River	Downstream of Canadian border
Consolidated Diking and Improvement District #1 (Cowlitz County)	Waters that lie within the area bounded by the Columbia River on the south, the Cowlitz River on the east, Ditch No. 10 to the west, and Ditch No. 6 to the north.
Consolidated Diking and Improvement District #3 (Cowlitz County)	Ditches served by these pump stations: Tam O'Shanter #1 and #2, Coweeman, Baker Way, Elk's
Coweman River	Downstream of confluence with Gobble Creek
Cowlitz River	Downstream of confluence of Ohanapecosh River and Clear Fork Cowlitz

Table I-A.1: Flow Control Exempt Receiving Waters (continued)

Water Body	Upstream Point/Reach for Exemption (if applicable)
	River
Crescent Lake	
Dickey River	Downstream of confluence with Coal Creek
Dosewallips River	Downstream of confluence with Rocky Brook
Dungeness River	Downstream of confluence with Gray Wolf River
Duwamish / Green River	Downstream River Mile 6 (S. Boeing Access Road)
Elwha River	Downstream of confluence with Goldie River
Erdahl Ditch in Fife	Downstream of pump station
First Creek in Tacoma	
Grays River	Downstream of confluence with Hull Creek
Green River (WRIA 26 - Cowlitz)	3.5 miles upstream of Devils Creek
Hoh River	1.2 miles downstream of Jackson Creek
Humptulips River	Downstream of confluence with West and East Forks
Johns Creek	Downstream of Interstate-405 East Right-of-way
Kalama River	2.0 miles downstream of Jacks Creek
Lacamas Lake	
Lake Cushman	
Lake Quinault	
Lake River (Clark County)	
Lake Shannon	
Lake Sammamish	
Lake Union & Union Bay	King County
Lake Washington, Montlake Cut, Ship Canal, & Salmon Bay	
Lake Whatcom	
Lewis River	Downstream of confluence with Quartz Creek
Lewis River, East Fork	Downstream of confluence with Big Tree Creek
Lightning Creek	Downstream of confluence with Three Fools Creek
Little White Salmon River	Downstream of confluence with Lava Creek
Mayfield Lake	

Table I-A.1: Flow Control Exempt Receiving Waters (continued)

Water Body	Upstream Point/Reach for Exemption (if applicable)
Mercer Slough	
Muddy River	Downstream of confluence with Clear Creek
Naselle River	Downstream of confluence with Johnson Creek
Newaukum River	Downstream of confluence with South Fork Newaukum River
Nisqually River	Downstream of confluence with Big Creek
Nooksack River	Downstream of confluence of North Fork and Middle Forks
Nooksack River, North Fork	Downstream of confluence with Glacier Creek, at USGS gauge 12205000
Nooksack River, South Fork	0.1 miles upstream of confluence with Skookum Creek
North River	Downstream of confluence with Vesta Creek
Ohanapecosh River	Downstream of confluence with Summit Creek
Puyallup River	Half-mile downstream of confluence with Kellog Creek
Queets River	Downstream of confluence with Tshletshy Creek
Quillayute River	Downstream of Bogachiel River
Quinault River	Downstream of confluence with North Fork Quinault River
Riffe Lake	
Round Lake	
Ruby Creek	Ruby Creek at SR-20 crossing downstream of Granite and Canyon Creeks
Sammamish River	Downstream of Lake Sammamish
Satsop River	Downstream of confluence of Middle and East Forks
Satsop River, East Fork	Downstream of confluence with Decker Creek
Sauk River	Downstream of confluence of South Fork and North Fork
Sauk River, North Fork	North Fork Sauk River at Bedal Campground
Silver Lake	Cowlitz County
Skagit River	Downstream of Canadian Border
Skokomish River	Downstream of confluence of North and South Fork
Skokomish River, South Fork	Downstream of confluence with Vance Creek
Skokomish River, North Fork	Downstream of confluence with McTaggert Creek
Skookumchuck River	1 mile upstream of Bucoda at SR 507 mile post 11.0
Skykomish River	Downstream of South Fork
Skykomish River, South Fork	Downstream of confluence of Tye and Foss Rivers

Table I-A.1: Flow Control Exempt Receiving Waters (continued)

Water Body	Upstream Point/Reach for Exemption (if applicable)
Snohomish River	Downstream of confluence of Snoqualmie and Skykomish Rivers
Snohomish River Estuary	
Snoqualmie River	Downstream of confluence of the Middle Fork
Snoqualmie River, Middle Fork	Downstream of confluence with Rainy Creek
Sol Duc River	Downstream of confluence of North and South Fork Sol Duc River
Stillaguamish River	Downstream of confluence of North and South Fork
Stillaguamish River, North Fork	7.7 highway miles west of Darrington on SR 530, downstream of confluence with French Creek
Stillaguamish River, South Fork	Downstream of confluence of Cranberry Creek and South Fork
Suiattle River	Downstream of confluence with Milk Creek
Sultan River	0.4 miles upstream of SR 2
Swift Creek Reservoir	
Thunder Creek	Downstream of the confluence with Neve Creek
Tilton River	Downstream of confluence with North Fork Tilton River
Toutle River	North and South Fork confluence
Toutle River, North Fork	Downstream of confluence with Hoffstadt Creek
Toutle River, South Fork	Downstream of confluence with Thirteen Creek
Union Bay	
Vancouver Lake	
White River	Downstream of confluence with Huckleberry Creek
Willapa River	Downstream of confluence with Mill Creek
Wind River	Downstream of confluence with Cold Creek
Wynochee Lake	
Wynochee River	Downstream of confluence with Schafer Creek

How Did Ecology Determine Which Receiving Waters Are Flow Control Exempt?

Ecology based its decisions for which receiving waters are Flow Control exempt on the analysis presented in *Discharge of Stormwater to High Order Streams – Determining Exempt Reaches* (WSDOT, 2004). The stream reaches that qualify for this exemption must be sufficiently large watercourses to accept a limited amount of un-detained stormwater discharge without sustaining significant environmental damage. The one-time analysis will not be repeated in the near future.

The analysis referenced above considered the following factors:

- Water bodies with at least 100-square miles of drainage area. The study found that most, but not all, river segments that drain more than 100 square miles qualify as exempt reaches.
- Modeling of flows at maximum build-out scenarios for impervious area and forest conversions based on local Comprehensive Plans, zoning, upstream land uses and ownership.
- Land cover criterion equations developed to predict stream stability.
- Presence of unconfined receiving channels.

In addition to stream size and future land cover conditions, the study identified methods for determining proximity requirements to limit the exemption area in order to protect small streams from excessive diversion. The two methods identified included:

1. within a specified distance from the ordinary high water of a stream or other water body, and
2. a more complex analysis to determine potential impacts on adjacent land uses and smaller water bodies in the floodplain.

How Can Local Governments Add Receiving Waters to This List?

Local Governments may request additional receiving waters, including streams with a low gradient and stream reaches with tidal or backwater conditions, as further detailed below, be added to Table I-A.1: Flow Control Exempt Receiving Waters. Local governments seeking exemptions for additional receiving waters may refer to (WSDOT, 2004) for methodologies to use. A study to satisfy the criteria for the Flow Control exempt reaches require the services of a qualified hydrogeologist or hydrologic engineer. The local study must demonstrate how the proposed water body meets the study objectives using the factors above, and how the stormwater discharge meets the proximity requirements outlined in the study. Proponents are encouraged to contact their regional permit specialist to explore this option before undertaking such an analysis.

Ecology will review all exemption analyses and approve any qualifying receiving waters for addition to Table I-A.1: Flow Control Exempt Receiving Waters. Table I-A.1: Flow Control Exempt Receiving Waters will then be updated as the SWMMWW is revised.

Flow Control Exemptions for Streams with a Low Gradient

Local governments may designate waters as Flow Control Exempt based upon a very flat stream gradient. Because prevention of stream erosion is part of the intent of the Flow Control standard, to obtain an exemption the local government must demonstrate that a stream with a very flat gradient will not be destabilized by flows produced when the drainage area is fully developed.

A professional hydrogeologist must estimate the maximum possible velocity in the channel (based upon build-out conditions in the drainage area) versus the likely velocity necessary to initiate significant bed load movement. Streams that have qualified as Flow Control Exempt have typically been located in a broad, lowland floodplain of a large river and have rather cemented banks that do not show signs of recent destabilization (e.g., downed trees). (WSDOT, 2004) provides an example of such an analysis.

Exemptions should not extend to discharges into the upper reaches of such creeks that may have higher gradients and different bed and bank material.

Flow Control Exemptions for Stream Reaches with Tidal or Backwater Conditions

Discharges to stream reaches heavily influenced by tides or backwater conditions can also be candidates for a Flow Control exemption. In some tidally influenced reaches with low gradients, increases in discharge may not have a significant effect on the processes that control channel morphology. The combination of a low gradient and the possible effects of tidal backwater may dominate the channel forming processes to a far greater extent than potential stormwater discharges.

A local government can establish the Flow Control exemption by conducting hydrogeologic studies using hydrologic data and stream geometry to numerically model the discharge thresholds to demonstrate that the effects would be negligible. However, stream channels periodically exposed to higher velocities under some hydrologic conditions (e.g. low tide), probably do not warrant an exemption. Also, discharges are still subject to I-3.4.4 MR4: Preservation of Natural Drainage Systems and Outfalls, which requires energy dissipation at the outfall site. An example of an analysis for a tidal prism is included in (WSDOT, 2004). Local governments interested in exploring this approach should contact their regional permit specialist prior to beginning such a study.

Appendix I-B: Basin Plans

Ecology promotes Basin Plans as a means to develop and implement comprehensive water quality protection measures. Primary objectives of Basin Plans are to reduce pollutant loads and hydrologic impacts to surface and ground waters in order to protect beneficial uses within a basin.

Although the Minimum Requirements (see I-3 Minimum Requirements for New Development and Redevelopment) establish general standards for individual sites, a Basin Plan is needed to evaluate the overall pollution impacts and protection opportunities that could exist at the watershed level.

Basin Plans provide a mechanism by which the Minimum Requirements and implementing BMPs can be evaluated and refined based on an analysis of an entire basin. Basin Plans are especially well suited to develop control strategies to address impacts from future development, and to correct specific problems whose sources are known or suspected. Basin Plans can be effective at addressing both long-term cumulative impacts of pollutant loads and short-term acute impacts of pollutant concentrations, as well as hydrologic impacts to streams, wetlands, and ground water resources.

Ecology has not published definitive guidance regarding the scope of work for Basin Plans. Ecology hopes to have such guidance available for urbanized basins in the future after assessing the procedures and experiences of some test cases. We encourage you to contact your regional permit specialist if you interested in conducting a Basin Plan.

What Are Basin Plans?

A Basin Plan is a plan that assesses, evaluates, and proposes solutions to existing and potential future impacts to the beneficial uses of, and the physical, chemical, and biological properties of waters of the state within a basin. Basins typically range in size from 1 to 50 square miles. A plan should include but not be limited to recommendations for:

- Stormwater requirements for new development and redevelopment;
- Capital improvement projects;
- Land Use management through identification and protection of critical areas, comprehensive land use and transportation plans, zoning regulations, site development standards, and conservation areas;
- Source control activities including public education and involvement, and business programs;
- Other targeted stormwater programs and activities, such as maintenance, inspections and enforcement;
- Monitoring; and
- An implementation schedule and funding strategy.

A plan that is “adopted and implemented” must have the following characteristics:

- It must be adopted by legislative or regulatory action of jurisdictions with responsibilities under the plan;

- Ordinances, regulations, programs, and procedures recommended by the plan should be in effect or on schedule to be in effect; and,
- An implementation schedule and funding strategy that are in progress.

Revising Minimum Requirement Default Standards through Basin Plans

Basin Plans provide a mechanism by which the Minimum Requirements and implementing BMPs can be evaluated and refined based on an analysis of a basin or watershed. Basin Plans may be used to develop control strategies to address impacts from future development and to correct specific problems whose sources are known or suspected. Basin Plans can be effective at addressing both long-term cumulative impacts of pollutant loads and short-term acute impacts of pollutant concentrations, as well as hydrologic impacts to streams, wetlands, and ground water resources.

Basin Plans may be used by the local jurisdiction to revise the default standards of the following Minimum Requirements:

- I-3.4.5 MR5: On-Site Stormwater Management,
- I-3.4.6 MR6: Runoff Treatment,
- I-3.4.7 MR7: Flow Control, and/or
- I-3.4.8 MR8: Wetlands Protection.

In order for a Basin Plan to serve as a means of revising the standards of one or more of the Minimum Requirements listed above, the following conditions must be met:

- The Basin Plan must be formally adopted by all jurisdictions with responsibilities under the plan; and
- All ordinances or regulations called for by the Basin Plan must be in effect; and
- The Basin Plan must be reviewed and approved by Ecology.

Further guidance, if available, specific to revising the default standards of individual Minimum Requirements through a Basin Plan is provided in the supplemental guidelines of the Minimum Requirement.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

Basin Plans That Have Been Approved by Ecology

The following Basin Plans have been approved by Ecology for incorporation into local codes:

- Alternative Flow Control Requirement in Central Sub-Area, Issaquah, WA
- Mill Creek Alternative Flow Control, Clark County, WA

- Des Moines Creek Regional Detention Facility, King County, WA

This list will be updated with each manual release and may not reflect all approved plans at the time of reading.

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Appendix I-C: Wetland Protection Guidelines

I-C.1 Scope and Principles for Wetland Protection

Purpose

These guidelines are intended to prevent diminishment of the functions and values of wetlands by avoiding alterations to the structural, hydrologic, and water quality characteristics of existing wetlands to the extent feasible during new development, redevelopment, and stormwater management projects.

New development, redevelopment, and stormwater management projects may decrease the function and value of a wetland by:

- Increasing the amount of water flow discharged to a wetland.
- Decreasing the amount of water flow discharged to a wetland.
- Increasing the amount of pollutants discharged to a wetland.

This can happen even if the wetland is not physically altered for development or stormwater management purposes.

Wetland Rating System

A wetland identified as a receiving water of a project needs to be rated using the *Washington State Wetland Rating System for Western Washington: 2014 Update* (Hruby, 2014) to determine its category and habitat score.

Wetlands in Washington State differ widely in their functions and values. The Washington State Wetland Rating System categorizes wetlands into four categories (I, II, III and IV) based on their sensitivity to disturbance, their rarity, our ability to replace them, and the functions they provide. Category I is the highest rated wetland and the most sensitive to disturbance and Category IV wetlands are the lowest rated, based on relatively low functions and values.

This Appendix uses categories and habitat scores for wetlands to determine the level of protection necessary to reduce the risk of loss of wetland functions and values.

The rating system does not replace a full assessment of wetland functions that may be necessary if wetlands are impacted and mitigation permits are required.

For more information on the wetlands rating system refer to the following webpage:

https://ecology.wa.gov/Water-Shorelines/Wetlands/Tools-resources/Rating-systems

Regulatory Authority

Wetlands are Waters of the State as defined under Chapter 90.48 RCW, Surface Waters of the State under Chapter 173-201A WAC, and may be Waters of the U.S. according to the 2015 Clean

Water Rule and regulated under the Clean Water Act. This Appendix does not include guidance for wetland delineation, assessment, permitting, or restoration.

Every development project should follow the requirements of the State Environmental Policy Act. Proponents should contact the local permitting authority and any other agency that deals with wetland protection. Other state and federal agencies may also have jurisdiction over projects affecting wetlands such as the Washington State Departments of Ecology, Natural Resources, and Fish & Wildlife; the U.S. Environmental Protection Agency; and the U.S. Army Corps of Engineers.

Wetland Guidelines from Previous SWMMWWs

This guidance replaces prior Ecology SWMMWW guidelines to protect wetlands.

Wetland Protection Levels

The level of protection required for existing wetlands is based on the wetland category, habitat score, and the wetland characteristics.

The levels of wetland protection outlined in this Appendix include:

- I-C.2 General Protection
- I-C.3 Protection from Pollutants
- I-C.4 Wetland Hydroperiod Protection

Information needs

The following information is needed to assess the impacts and risks to wetlands, and to determine the necessary protection level.

1. Size, boundary, and characteristics of the proposed project site, wetland contributing drainage area, and the wetland and its buffer.
2. Following Ecology's *Wetland Rating System for Western Washington: 2014 Update* (Hruby, 2014) determine:
    a. Wetland type.
    b. Wetland category.
    c. Wetland habitat score.
3. Presence of rare, endangered, threatened, or sensitive species.
4. Presence of breeding populations of native amphibian species.
5. Use of an Ecology approved continuous simulation model.
6. If the TDA Thresholds for I-3.4.7 MR7: Flow Control are triggered, the project proponent may also need:

a. Legal access to the wetland,

b. Wetland field monitoring data (See I-C.5 Wetland Hydroperiod Data Collection and Evaluation Procedures).

I-C.2 General Protection

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

1. Consult regulations issued under federal and state laws that regulate the discharge of pollutants to surface waters, including the Construction Stormwater General NPDES Permit.

2. Maintain the wetland buffer required by local and/or state regulations.

3. Retain areas of native vegetation connecting the wetland and its buffer with nearby wetlands and other contiguous areas of native vegetation.

4. Avoid compaction of soil and introduction of invasive plant or animal species in the wetland and its buffer.

5. Take measures to avoid general physical impacts (e.g., littering and vegetation destruction). Examples are protecting existing buffer zones; discouraging access, especially by vehicles, by planting outside the wetland, and encouragement of stewardship and signage by landowners.

6. Any stormwater management practices, such as Runoff Treatment or Flow Control BMP implementation, must be done outside of the wetland buffer boundary, except limited circumstances where the wetland and/or buffer may be used for additional Runoff Treatment and/or Flow Control of stormwater (See I-C.6 Compensatory Mitigation of Wetlands)

7. Discharge from a BMP or project site should be dispersed using a method to diffuse the flow before entering the wetland buffer.

8. Consider fences to restrict human access, but make sure it doesn't interfere with wildlife movement. They 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.

I-C.3 Protection from Pollutants

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

1. Provide Construction Stormwater BMPs as directed in I-3.4.2 MR2: Construction Stormwater Pollution Prevention Plan (SWPPP) to prevent sediment and other pollutants from entering the wetland.

2. Provide Source Control BMPs as directed in I-3.4.3 MR3: Source Control of Pollution. Refer to Volume IV and local jurisdiction requirements.

3. Provide On-Site Stormwater Management and use LID principles as much as practicable for the site, as directed in I-3.4.5 MR5: On-Site Stormwater Management. LID principles and

practices will help meet other wetland hydroperiod protection criteria and provide additional habitat.

4. Provide Runoff Treatment BMPs as directed in I-3.4.6 MR6: Runoff Treatment to treat runoff prior to entering the wetland and its buffer.

   Note: If the thresholds for I-3.4.6 MR6: Runoff Treatment are not met for a TDA, then it is not required to provide Runoff Treatment BMPs for that TDA to comply with I-3.4.8 MR8: 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 Runoff Treatment BMPs with the most advanced ability to control nutrient loads. Consider using Runoff Treatment BMPs with infiltration and active biological filtration.

I-C.4 Wetland Hydroperiod Protection

Protection of many wetland functions and values depends on maintaining the existing wetland's hydroperiod. This means maintaining the annual fluctuations in water depth and its timing as closely as possible. If a project triggers the requirements for Flow Control BMPs per the TDA Thresholds in I-3.4.7 MR7: Flow Control, the project must apply the following Wetland Hydroperiod Protection.

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.

The first method requires a minimum one year of monitoring followed by continuous simulation modeling of the wetland stage (called Method 1). 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 shall 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 are off-site or 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.

Method 1: 1-yr 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 < 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 ≥ 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 ≥ 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 < 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 ≥ 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 ≥ 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 I-C.5 Wetland Hydroperiod Data Collection and Evaluation Procedures.

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 15% higher or lower than the pre-project volumes.

- 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. No month can exceed 15% change in volume.

The guidance for implementing Method 2 and assessing the criteria above in the respective model is provided in section I-C.5 Wetland Hydroperiod Data Collection and Evaluation Procedures.

Limitations

Method 2 may not result in complete protection of wetland functions and values as these criteria are based on risk to the resource rather than an actual understanding of the impacts. When applicable, Ecology recommends application of the Wetland Hydroperiod Protection with wetland-specific monitoring as described in Method 1.

I-C.5 Wetland Hydroperiod Data Collection and Evaluation Procedures

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 I-C.4 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

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

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 should provide the details of how this estimated in its hydrologic assessment report, so that it can be reviewed by the local jurisdiction.

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 I-C.4 Wetland Hydroperiod Protection.

Steps to Verify Compliance with the Method 1 Hydroperiod Protection Criteria

Ecology has provided an excel template to assist with the calculations in the steps below. The excel template may be downloaded form the interactive online version of the manual.

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 < 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 ≥ 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.

Method 2

Model Construction and Simulation

When modeling, include the wetland buffer as the final element in both pre- and post-project scenarios, downstream of the project area including any Flow Control BMPs. The point of compliance (POC) should be assigned to capture the total (surface, interflow, and ground water) volume leaving the wetland buffer for both the pre-project and the post-project scenarios.

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.
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 ground water) 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 ground water.

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 ground water) 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 ground water.
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 ground water.

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

Strategies to meet the Wetland Hydroperiod Protection Criteria

Consider the following strategies to minimize impacts on the wetland hydroperiod and to meet the 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 on-site LID techniques.
- Increasing or maintaining larger wetland buffer zones.
- Increasing infiltration and/or storage capacity of Flow Control BMPs.

I-C.6 Compensatory Mitigation of Wetlands

It is always necessary to treat stormwater prior to discharge to a wetland and its buffer. Any required Runoff Treatment BMPs including the outlet structure must be provided outside of the wetland and its buffer boundaries. If outflow from a BMP or project site is concentrated, flow should be diffused prior to discharge into the buffer.

Compensatory Mitigation Required

When project proponents alter a wetland(s) as part of a Runoff Treatment and/or Flow Control BMP system, they must demonstrate that they have done everything possible to avoid and minimize impacts. Remaining impacts to wetland area and/or functions must be compensated according to local, state, and federal regulations and guidelines. Check with the agencies responsible for issuing permits.

Compensatory Mitigation Not Required

Treated stormwater may be beneficial to wetlands that have been heavily disturbed by human activities and can improve wetland hydrologic functions. In these limited cases when all of the solid bullets below are met, hydrologic alteration of the wetland to meet the requirements of a Flow Control BMP/facility is allowed without compensatory mitigation. This alteration will be considered a hydrologic functional restoration activity.

- The wetland is rated Category III or IV.
- The wetland has a habitat score of 5 or less.
- The wetland does not provide habitat for rare, threatened or endangered species.
- The wetland does not contain a breeding population of any native amphibians.
- The hydrologic functions of the wetland can be improved by modification. Generally, this

means that constraints exist within the wetland (or surrounding area) that have altered natural hydrologic processes. The constraints are described in Charts 4 & 5 in *Selecting Wetland Mitigation Sites Using a Watershed Approach* (Hruby et al., 2009).

Proponents must identify and address at least one of the following common constraints to document improvement of hydrologic functions:

- ◦ Surface water flows have been diverted away from the wetland by prior development. Surface/subsurface water flows could be directed to the site to augment hydrologic inputs.
- ◦ Ditches that artificially drain water from the wetland could be filled or plugged to retain water.
- ◦ Drain tiles that artificially drain water from the wetland could be broken or removed to retain water.
- ◦ Artificially placed fill that decreases surface water storage capacity could be removed to increase surface water storage capacity.
- ◦ Dikes or berms that prevent overbank flooding could be breached or removed.
- ◦ Outlet culvert that is lower than the surrounding topographic depression could have its invert elevation raised to increase surface water storage

  OR

- ◦ The wetland is part of a priority restoration plan that achieves restoration goals identified in a Shoreline Master Program or other local or regional watershed plan.

- The wetland lies in the natural route of water and the discharge follows the natural routing.
- Successful demonstration that no net loss of wetland function and value occurs as a result of the structural or hydrologic modifications.
    - ◦ This includes the impacts from the machinery used for the construction. Heavy equipment can damage the soil structure of a wetland.
    - ◦ When the functions and values of a degraded wetland are improved by project alterations, the project proponent must specify which project activities would thus be self-mitigating.
    - ◦ Check with the agency(ies) issuing the permits for the modification(s) to determine which method(s) and/or analyses to use to determine no net loss of wetland functions and values.
    - ◦ Functions and values that are not replaced on site will have to be compensated for elsewhere.

I-C.7 Jurisdictional Planning for Wetland Protection from Stormwater

Ecology recommends that local jurisdictions plan and manage their resources to protect overall wetland functions and values, including their role in stormwater management.

Wetlands protection planning can help local jurisdictions to take advantage of the most options for managing stormwater from development projects. Policies for the protection of wetlands should aim to prevent or minimize impacts at their point of origin and be self-perpetuating, that is they do not require periodic infusions of capital or labor.

The Department of Ecology, Puget Sound Partnership, and other agencies are actively developing new tools for watershed planning that will address many of the steps outlined below. We suggest you review information that has already been developed for your region or jurisdiction. This may significantly reduce your efforts. A good place to start is:

https://ecology.wa.gov/Water-Shorelines/Puget-Sound/Watershed-characterization-project/Watershed-characterization

Information for Wetlands Protection Planning

1. A map of the contributing watershed to the wetlands, or other appropriate landscape unit (see I-C.8 Wetland Protection Definitions), and an estimate of its area.
2. Approximate or precise wetland boundaries. Wetland boundaries may have been previously delineated by the jurisdiction or by a project proponents working in the vicinity. Boundaries should be delineated using the latest approved Federal Manuals. Refer to https://ecology.wa.gov/Water-Shorelines/Wetlands/Tools-resources/Delineation-resources for details. Use the best information available.
3. A definition of environmental and development goals for the landscape unit subject to planning and management.
4. Existing management and monitoring plans.
5. Existing and projected land uses in the landscape unit in the following categories, expressed as percentages of the total watershed area:
    - commercial,
    - industrial,
    - multi-family residential,
    - single-family residential,
    - agricultural,
    - various categories of undeveloped, and
    - areas subject to active logging or construction.

6. Hydrologic network throughout the landscape unit.

7. Soil conditions, including soil types, infiltration rates, and elevation of water table as it changes seasonally, and the presence of any restrictive layers.

8. Ground water recharge and discharge points.

Typical Steps in Wetlands Protection Planning

1. Define the landscape unit you will be using for your planning effort. See the definition of landscape unit in I-C.8 Wetland Protection Definitions.

2. Begin the plan for the landscape unit with attention to the following general principles:

    a. Formulate the plan based on clearly articulated community goals. Carefully identify conflicts and choices between retaining and protecting desired resources and community growth.

    b. Map and assess the suitability of different areas for urban uses.

    There are several tools available for identifying such areas. For more information visit the following website:

    https://ecology.wa.gov/Water-Shorelines/Puget-Sound/Watershed-characterization-project/Watershed-characterization

    When appropriate, the assessment can also highlight outstanding local or regional resources that the community determines should be protected. Examples include a fish spawning and rearing, scenic areas, recreational areas, threatened or endangered species habitat, and farmland.

3. Maximize natural water storage and infiltration opportunities within the landscape unit and outside of existing wetlands, especially:

    a. Promote the conservation of forest cover. Develop on deforested land. This affects the water flows in a basin less than building on land that requires removing forest cover. Loss of forest cover increases peak runoff requiring expensive structural solutions.

    b. Maintain natural storage reservoirs and drainage corridors, including depressions, areas of permeable soils, swales, and intermittent streams. Implement policies and regulations to discourage the clearing, filling, and channelization of these features. Use existing drainage networks in preference to pipes, culverts, and engineered ditches as long as the flows and volumes of water in them are not increased.

4. Establish and maintain buffers surrounding wetlands and in riparian zones as required by the Critical Area Ordinance for the local jurisdiction. Also, maintain interconnections among wetlands and other natural habitats to allow for wildlife movements (see *Update on Wetland Buffers: The State of the Science*, (Ecology 2013)).

5. Implement measures to avoid general impacts on wetlands and other water bodies (e.g., littering, vegetation destruction, and human and pet intrusion harmful to wildlife).

6. In wetlands that are relatively unaffected by human activities, plan so the quantity of

stormwater flows match the pre-project hydroperiod and hydrodynamics. In wetlands where water flows have been disturbed, consider ways of reducing the existing changes to flows. This involves not only management of high volumes and rates of flow during the wet season, but also preventing water supply depletion during the dry season. The latter may require augmenting flows if urbanization reduces existing surface or ground water inflows. Refer to I-C.5 Wetland Hydroperiod Data Collection and Evaluation Procedures for details on implementing these guidelines.

7. Assess alternatives for controlling the quantities of runoff as follows:

   a. Analyze proposed development actions in terms of changes to quantity of runoff.

   b. For existing development or redevelopment, assess possible alternative solutions to adding flow controls by:

      - Protecting health, safety, and property from flooding by removing buildings from floodplains.

      - Preventing stream channel erosion by stabilizing the eroding bed and/or bank area with bioengineering techniques, preferably, by using structural reinforcements that are consistent with the protection of aquatic habitats and beneficial uses of the stream (refer to Chapter 173-201A WAC for the definition of beneficial uses).

   c. For new development or redevelopment, assess different regulatory alternatives or incentives for changing common practices in land use including: density controls, clearing limits, impervious surface limits, transfer of development rights, purchase of conservation areas, etc.

   d. If the alternatives considered in Steps (a-c) above cannot solve an existing or potential problem, perform an analysis of the contributing drainage catchment to assess possible alternative solutions that can be applied on-site or on a regional scale. The most appropriate solution or combination of alternatives should be selected with regard to the specific opportunities and constraints existing in the drainage catchment.

      For new development or redevelopment, on-site scale solutions that should be assessed include, in approximate order of preference:

      - LID BMPs and LID principles.
      - Infiltration basins or trenches.
      - Detention ponds.
      - Below-ground vault or tank storage.
      - Parking lot detention.

      Regional scale solutions that should be assessed for solving problems associated with new development, redevelopment or existing development include:

      - LID BMPs and LID principles
      - Infiltration basins or trenches.

- Detention ponds.
- Constructed wetlands.

e. Consider altering an existing wetland for controlling water quantities only if upland alternatives are inadequate to solve the existing or potential problem. Refer to the criteria in I-C.6 Compensatory Mitigation of Wetlands to evaluate if wetlands can be altered.

8. Place strong emphasis on water resource protection during construction of new development. Establish effective erosion control programs to reduce the sediment loading to receiving waters. No existing wetland or other water body should ever be used for the sedimentation of solids in construction-phase runoff.

9. Stimulate public awareness of and interest in wetlands and other water resources in order to encourage protective attitudes in the community. This program should include:

   a. Education regarding the use of fertilizers and pesticides, automobile maintenance, the care of animals and the importance of retaining buffers to prevent water pollution. Refer to *Homeowners' Guide to Wetlands and Buffers* (Ecology, 2014).

   b. Descriptive signboards adjacent to wetlands informing residents of the wetland type, its functions, the protective measures taken, etc.

   c. If beavers are present in a wetland, educate residents about their ecological role and value and take steps to avoid human interference with beavers.

10. If long term water quality impacts are a concern, the monitoring program should include the following tasks:

   a. Perform pre-project baseline sampling by collecting water quality grab samples in an open water pool of the wetland for at least one year, allocated through the year as follows:

      - November 1 - March 31: 4 samples
      - April 1 - May 31: 1 sample
      - June 1 - August 31: 2 samples
      - September 1 - October 31: 1 sample

      If the wetland is dry during any period, reallocate the sample(s) scheduled then to another time when the wetland is no longer dry.

      The monitoring program should use the analytical methods approved by the U.S. Environmental Protection Agency and listed at 40 CFR part 136 or approved by Department of Ecology with similar reporting limits.

   b. Considering the baseline results, set water quality goals to be maintained in the post-project period. Example goals are:

      - No increase in violations of the Water Quality Standards for Surface Waters of the State of Washington (Chapter 173-201A WAC). Repeat the sampling on the same schedule for at least once year after all development is complete. Compare the results to the set goals.

I-C.8 Wetland Protection Definitions

The following terms are applicable only to this Appendix.

Buffer

The area (either upland, open water, or another wetland) that surrounds a wetland or watercourse and that reduces adverse impacts to the ecosystem functions and values from adjacent development.

Compensatory mitigation

The stage of the mitigation sequence where impacts to wetland functions are offset (i.e., compensated for) through creation (establishment), restoration (re-establishment, rehabilitation), or enhancement of other wetlands. Because regulatory requirements and policies tend to focus on compensatory mitigation, the term “mitigation” is often used to refer to compensation, which is just one part of the overall mitigation sequence.

Constructed wetland

A wetland intentionally created from a non-wetland site for the purpose of water treatment.

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

Depressional wetlands occur in topographic depressions where the elevation of the surface within the wetland is lower than in the surrounding landscape. These wetlands often pond water at the surface but they can also be saturated without surface ponding.

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.

Estuarine wetland

Wetlands where salt tolerant plant species are dominant 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.

Hydrodynamics

The science involving the energy and forces acting on water or other liquids and the resulting impact on the motion of the liquid.

Hydroperiod

The seasonal occurrence of flooding and/or soil saturation; it encompasses the depth, frequency, duration, and seasonal pattern of inundation.

Invasive species

Nonnative organisms whose introduction causes or is likely to cause economic or environmental harm or harm to human, animal or plant health.

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.

Lake Fringe Wetlands

Lake Fringe wetlands 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 (8 ha), and more than 6.6 ft deep (2 m) over 30% of the open water areas.

Modification, 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.

Peat Wetland

Unique, irreplaceable bogs and fens that can exhibit water pH in a wide range from highly acidic to alkaline, including fens typified by *Sphagnum* species, *Rhododendron 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.

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.

Polishing

Additional treatment of a waste stream that has already received one or more stages of treatment by other means.

Rare, threatened, endangered, or sensitive species

Plant or animal species that are relatively uncommon regionally, are nearing endangered status, or whose existence is in jeopardy and is usually restricted to highly specific habitats. Threatened, endangered or sensitive species are listed by federal or state authorities, whereas rare species are unofficial species of concern that fit the above definitions.

Regional

An action (here, for stormwater management purposes) that involves more than one discrete property.

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.

Riverine impounding wetland

Riverine impounded wetlands 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 stream or river channels. They lie in the active floodplain 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.

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.

Slope Wetlands

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.

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.

Water Level Fluctuation (WLF)

This is a defining characteristic of a wetland. Water level fluctuation (WLF) during a monitoring interval is as follows:

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

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, ground water 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 Wetland 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 ground water 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 drainage ditches, grass-lined swales, canals, detention BMPs, 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.)

Appendix I-D: Regional Facilities

I-D.1 Introduction to Regional Facilities

What Are Regional Facilities?

A regional facility is a stormwater BMP that provides Runoff Treatment and/or Flow Control to more than one property, resulting in the requirement for onsite controls to be either eliminated or reduced. The individual properties that are served by a regional facility may fulfill stormwater requirements by using a percentage of the regional facility to provide Runoff Treatment and/or Flow Control rather than providing individual Runoff Treatment and/or Flow Control BMPs on site.

Regional facilities are an entirely optional method of managing stormwater runoff, can be constructed to serve a variety of different purposes, and may be used to meet a variety of goals. There are distinct advantages and some disadvantages to building and operating regional facilities:

- **Advantages of Regional Facilities:**
    - **Reduced construction costs.** Design and construction of a single regional facility can be far more cost-effective than numerous individual onsite structural controls.
    - **Reduced operation and maintenance costs.** Rather than multiple owners and associations being responsible for the maintenance of several stormwater BMPs on their developments, it is simpler and more cost-effective to establish scheduled maintenance of a single regional facility.
    - **Higher assurance of maintenance.** Regional facilities are far more likely to be adequately maintained as they are large and have a higher visibility, and are often (but not always) the responsibility of the municipality.
    - **Maximum utilization of developable land.** Developers are able to maximize the utilization of the proposed development for the purpose intended by minimizing the land normally set aside for the construction of stormwater BMPs.
    - **Retrofit potential.** Regional facilities can be used by a community to mitigate existing developed areas that have insufficient or no Runoff Treatment and/or Flow Control BMPs, as well as provide stormwater controls for future development.
    - **Other benefits.** Well-sited regional facilities can serve as an educational, recreational, wildlife, and aesthetic amenity for a community.
- **Disadvantages of Regional Facilities:**
    - **Location and siting.** Regional facilities may be difficult to site, particularly for large facilities or in areas with existing development.
    - **Capital costs.** The municipality must typically provide capital construction funds for a regional facility, including the costs of land acquisition. However, if a downstream developer is the first to build, that person could be required to construct the facility and later be compensated by upstream developers for the capital construction costs and

annual maintenance expenditures. Conversely, an upstream developer may have to establish temporary control structures if the regional facility is not in place before construction.

- **Need for planning.** The implementation of regional facilities requires substantial planning, financing, and permitting. Land acquisition must be in place ahead of future projected growth.

Ecology's guidance is limited to regional facilities planned to provide Runoff Treatment and/or Flow Control for projects in the following locations:

a. a project within the contributing area to the regional facility.

b. a project that is not within the contributing area to the regional facility, but has equivalent flow and/or pollution characteristics to an area that does contribute to the regional facility. This situation requires in-basin-area or out-of-basin-area transfer tracking. Only I-3.4.7 MR7: Flow Control requirements may be transferred out-of-basin. See I-D.6 Regional Facility Area Transfers for details.

c. a combination of (a) and (b) above.

Regional Facilities as Part of a Larger Plan

Regional facilities that are planned, designed, and constructed to provide Runoff Treatment and/or Flow Control to help meet Minimum Requirements for projects located within the drainage area contributing to the regional facility are typically not part of a larger plan and are allowed under the Phase I and Western Washington Phase II Municipal Stormwater Permits without prior approval by Ecology.

Other regional facilities may be part of a larger plan, and may not be able to proceed without the jurisdiction soliciting and receiving Ecology's approval of the plan. The jurisdiction must refer to the guidance related to the specific type of larger plan to ensure they can gain Ecology's approval.

Several types of larger plans may use regional facilities to meet their objectives. Some examples include:

- Basin Plans (see Appendix I-B: Basin Plans) that could:
  - Tailor the Minimum Requirements to that basin.
  - Demonstrate an equivalent level of protection through a regional facility.
- A Stormwater Control Transfer Program (see Appendix I-E: Stormwater Control Transfer Program) that requires the Minimum Requirements be met, but allows I-3.4.7 MR7: Flow Control to be met through an "equivalent" site in a different basin (an out-of-basin-area transfer).
- Stormwater Planning guidance (see Ecology Publication Number 19-10-010).
- A jurisdiction's Structural Stormwater Controls plan.
- TMDL implementation plans (see I-2.13 Total Maximum Daily Loads (TMDLs)).
- To voluntarily improve water quality through some other plan.

I-D.2 Design Considerations for Regional Facilities

Regional facilities are significantly larger than typical stormwater BMPs provided for individual projects. Ecology does not have any specific additional requirements for these facilities, but recommends that the jurisdictions implementing regional facilities consider their larger scale during design.

Some design aspects that may require special consideration due to a regional facility's larger size include:

- Addition of a Runoff Treatment BMP prior to the regional facility to reduce the maintenance needs and costs for the regional facility.
- Protective conveyance design. The jurisdiction should have a good understanding of the flow regime at and upstream of the regional facility. Ecology cautions that continuous simulation software was not designed to provide conveyance peak flows. Other tools may be more suitable. If the jurisdiction is uncertain of the importance of interflow or groundwater, Ecology recommends a strategically designed monitoring program to determine the expected flows.
- Installation of adjustable components to allow for optimization of the regional facility once it is in operation.
- Periodic performance evaluations of the regional facility and adjustments to improve the effectiveness of operation. A well placed time lapse camera can provide important information that can be downloaded and evaluated to investigate the causes of concerns.
- Consideration of Dam Safety regulations if the height of an embankment or volume of water exceed thresholds. See Dam Safety for Detention BMPs in BMP D.1: Detention Ponds.

I-D.3 Regional Facility Timing

Regional facilities can be implemented at different times and locations, depending on the types of development they serve. The following lists timing considerations that must be made when using regional facilities for different types of development.

New Development and New Surfaces in Redevelopment

Regional facilities must be operational prior to and must have capacity for new development and new surfaces in redevelopment projects.

Replaced Hard Surfaces in Redevelopment Projects

A local government may exempt redevelopment projects from constructing Runoff Treatment and/or Flow Control BMPs to comply with all or part of I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.6 MR6: Runoff Treatment, I-3.4.7 MR7: Flow Control, and/or I-3.4.8 MR8: Wetlands Protection as applied to the replaced hard surfaces if the local government has adopted a plan and a schedule that fulfills those requirements in regional facilities.

Future Project Site(s) Served by an Existing Regional Facility

Regional facilities can be designed for future development. However, the timing of the future development may effect whether or not the regional facility is adequately sized for current (at the time of the future development) standards. If requirements for Runoff Treatment and/or Flow Control (as used to comply with I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.6 MR6: Runoff Treatment, I-3.4.7 MR7: Flow Control, and/or I-3.4.8 MR8: Wetlands Protection) have changed between the time that the regional facility was designed and the time that the development (that discharges to the regional facility) occurs, Ecology has the following guidance:

- If the regional facility is publicly owned, then the delta between the amount of Runoff Treatment and/or Flow Control provided by the existing facility designed to the outdated standards and the amount of Runoff Treatment and/or Flow Control that needs to be provided per the current (at time of development) standards needs to be made up. The project proponent can make up this difference by either retrofitting the existing regional facility, or by providing Runoff Treatment and/or Flow Control BMPs on the individual lot that is being developed.
- If the regional facility is privately owned and specifies the ultimate construction of all of the areas it was designed to serve, it is all considered one project. That project is protected by the timing requirements of the jurisdiction.

I-D.4 Using Regional Facilities to Meet Minimum Requirements

A regional facility may be used as an alternate method to meet (or help to meet) one or more of the following Minimum Requirements. The regional facility design must include an engineering report detailing how the proposed regional facility meets the requirements for the site.

- I-3.4.5 MR5: On-Site Stormwater Management
- I-3.4.6 MR6: Runoff Treatment
- I-3.4.7 MR7: Flow Control
- I-3.4.8 MR8: Wetlands Protection

The site using the regional facility to meet (or help meet) one or more of the above Minimum Requirements does not have to be within the area contributing to the regional facility. If the site is not within the area contributing to the regional facility, the jurisdiction must document in-basin or out-of-basin transfer tracking. See I-D.6 Regional Facility Area Transfers for details.

Using Regional Facilities to Help Meet Minimum Requirement #5

I-3.4.5 MR5: On-Site Stormwater Management cannot be entirely satisfied by a regional facility. A regional facility may be used to meet the LID Performance Standard, but a regional facility cannot substitute for use of BMP T5.13: Post-Construction Soil Quality and Depth on site, where feasible.

Since the regional facility benefit for I-3.4.5 MR5: On-Site Stormwater Management is limited to the LID Performance Standard, which is a flow standard, it follows all of the guidance provided for using regional facilities to meet I-3.4.7 MR7: Flow Control, such as limitations, concerns, conditions, capacity, and tracking.

Using Regional Facilities to Meet Minimum Requirement #6

Regional facilities may be used to meet I-3.4.6 MR6: Runoff Treatment as long as the regional facility provides the level of treatment necessary for the individual site.

If the project is using an in-basin or out-of-basin transfer, as described in I-D.6 Regional Facility Area Transfers, then the areas transferred must have similar pollution characteristics. “Similar pollution characteristics” is not limited to the types of treatment (Basic, Enhanced, Phosphorus or Oil Treatment).

For example, two areas that may require the same level of treatment, but do not have similar pollution-generating characteristics, are:

- a commercial area that includes restaurants and high traffic roads
- a business park with lower traffic volumes.

Both of these areas would require enhanced treatment, but their pollution characteristics may be quite different.

The most certain way to ensure that a regional facility designed to meet I-3.4.6 MR6: Runoff Treatment treats areas with similar pollution characteristics as the projects it is meant to give credit for is to limit the projects getting credit to projects that are within the contributing area of the regional facility. This eliminates the option to use an in-basin or out-of-basin transfer program for regional facilities designed to meet I-3.4.6 MR6: Runoff Treatment.

Due to these area specific concerns, Ecology has not provided a generalized method for in-basin or out-of-basin transfers for regional facilities designed to meet I-3.4.6 MR6: Runoff Treatment. Jurisdictions seeking to make in-basin or out-of-basin transfers for regional facilities designed to meet I-3.4.6 MR6: Runoff Treatment must develop area specific trading criteria that ensures equivalent or improved Runoff Treatment when compared to the on-site option. Ecology will review and consider approving this plan when it is part of a Stormwater Control Transfer Program.

Using Regional Facilities to Meet Minimum Requirement #7

Regional facilities may be used to meet I-3.4.7 MR7: Flow Control for individual project sites that contribute to the regional facility.

If the project is using an in-basin or out-of-basin transfer, as described in I-D.6 Regional Facility Area Transfers, then the trading of surfaces translates directly to the hydrology modeled. Guidance for how a jurisdiction can track the trading of surfaces is presented in I-D.6 Regional Facility Area Transfers.

It is not acceptable to use flow splitters upstream of regional facilities that are being used to meet I-3.4.7 MR7: Flow Control if the regional facility, or combination of facilities, cannot fully meet the Flow Control standard for the contributing area. Flow splitting cannot replicate the distribution of flows that would be produced by a subset of the contributing area.

Using Regional Facilities to Meet Minimum Requirement #8

Regional facilities may be used to meet I-3.4.8 MR8: Wetlands Protection for individual project sites that contribute to the regional facility.

I-3.4.8 MR8: Wetlands Protection is a complex criteria that has wetland specific goals. Ecology acknowledges that a regional facility is possible under I-3.4.8 MR8: Wetlands Protection, but it does not lend itself to a generic capacity and tracking system such as the in-basin and out-of-basin transfers as described in I-D.6 Regional Facility Area Transfers.

I-D.5 Sizing Regional Facilities

Regional facilities are sized using the same principles as would be used for the same BMP on a single-project scale.

How to Size a New Regional Facility to Serve the Entire Contributing Area

To size a new regional facility that is meant to serve the entire area contributing to it, the designer must first determine the contributing area to the regional facility.

Next, size the regional facility for the contributing area. The developed conditions used in the sizing will depend on if the purpose of the regional facility is to provide Runoff Treatment and/or Flow Control to the existing development (as a retrofit) or for future new development. Refer to the design guidance for the type of BMP that is being used as the regional facility for specific design guidance.

- If the regional facility was sized for future development: As projects within the contributing area of the regional facility are developed, they may refer to the regional facility for compliance with the Minimum Requirements (or other stormwater requirements) that the regional facility was designed and constructed to meet. See I-D.3 Regional Facility Timing for additional guidance about a new project using an existing regional facility.
- If a new regional facility will serve a contributing area that has already been partially developed with separate stormwater BMPs on individual sites, refer to the methodology in How to Expand an Existing Regional Facility to Serve Additional Development (below).

How to Expand an Existing Regional Facility to Serve Additional Development

If development is proposed within the contributing area of an existing regional facility, but the regional facility was not originally sized to serve this proposed development, the following guidance may be used to expand the regional facility to serve the additional development.

Ecology provides guidance for one method for expanding an existing regional facility providing Flow Control; local jurisdictions may choose to use an alternate method, and they are responsible to document how minimum requirements are met. In all cases the regional facility must provide equivalent or better environmental benefit as compared with the traditional approach.

Although allowed, Ecology does not provide guidance on how to expand an existing regional facility providing Runoff Treatment to serve additional development; local jurisdictions would develop methodology and document how Runoff Treatment requirements are met.

The existing regional facility may be designed to comply with an outdated flow frequency matching standard (e.g. single event methodology), but it is critical to know how much and how to expand the regional facility to mitigate the additional runoff associated with additional new or redevelopment projects.

Below is an example of how to use continuous runoff modeling software to design the expansion of an existing regional facility to serve additional development. The example shows a pond, but a similar approach can be used for other regional facilities. The designer must consult with the reviewing jurisdiction to make sure that they approve the design assumptions and modeling approach. WWHM screenshots are included for clarity.

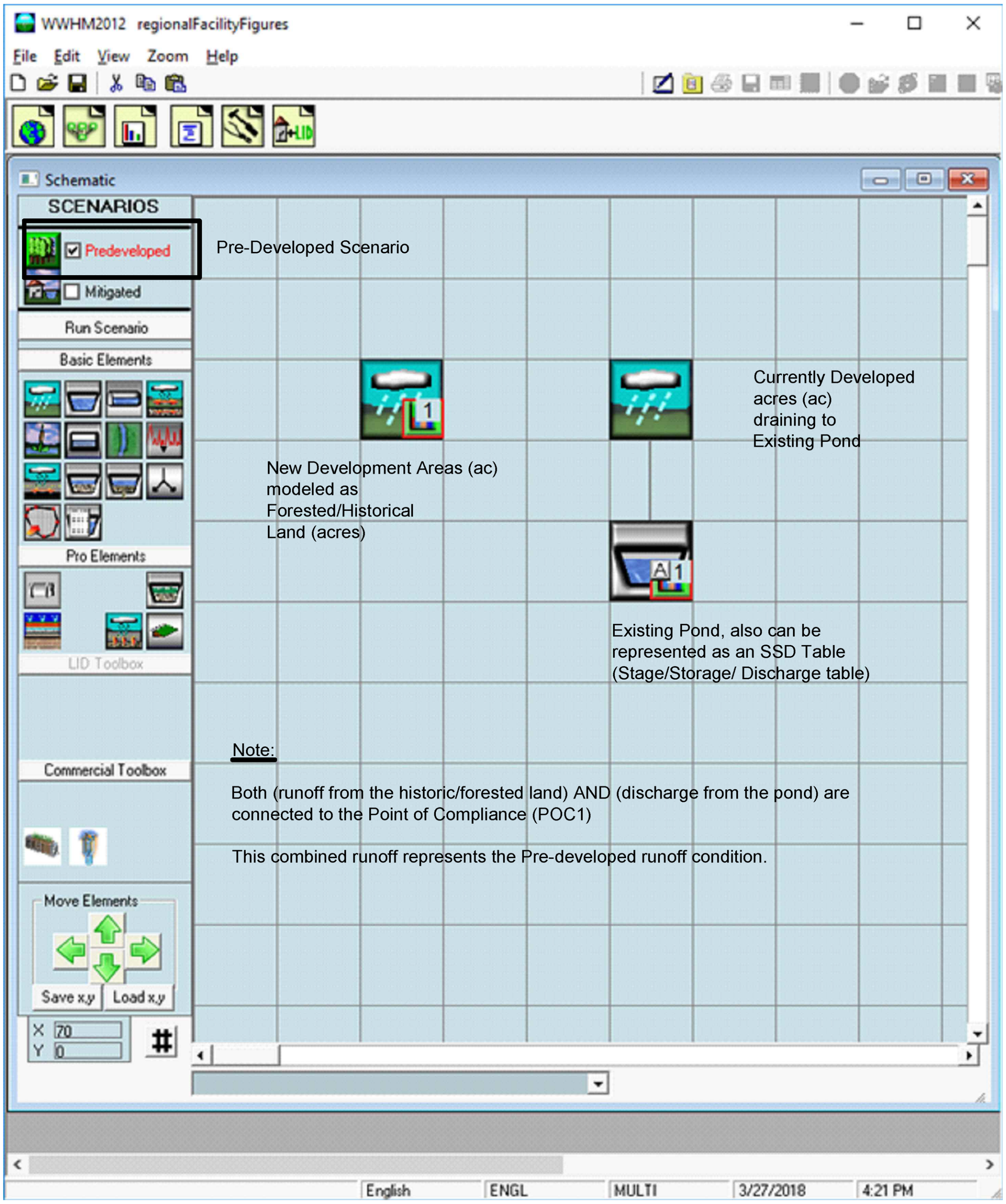
Pre-Developed Scenario

The predeveloped scenario will have 2 distinct components:

1. First, a basin element modeled as Historic/Forested land. This is the area associated with the new or redevelopment. Refer to I-3.4.7 MR7: Flow Control to determine if the predeveloped scenario may be modeled as anything other than historic/forested.
2. Second, a basin element modeled as the currently developed conditions, linked to a pond element modeled as the existing pond (regional facility).

Runoff from both of these components will connect to the Point of Compliance (POC1). Their combined flow represents the pre-developed runoff condition. See Figure I-D.1: Pre-Developed Scenario for an Existing Regional Facility.

Figure I-D.1: Pre-Developed Scenario for an Existing Regional Facility



DEPARTMENT OF ECOLOGY State of Washington

Pre-Developed Scenario for an Existing Regional Facility

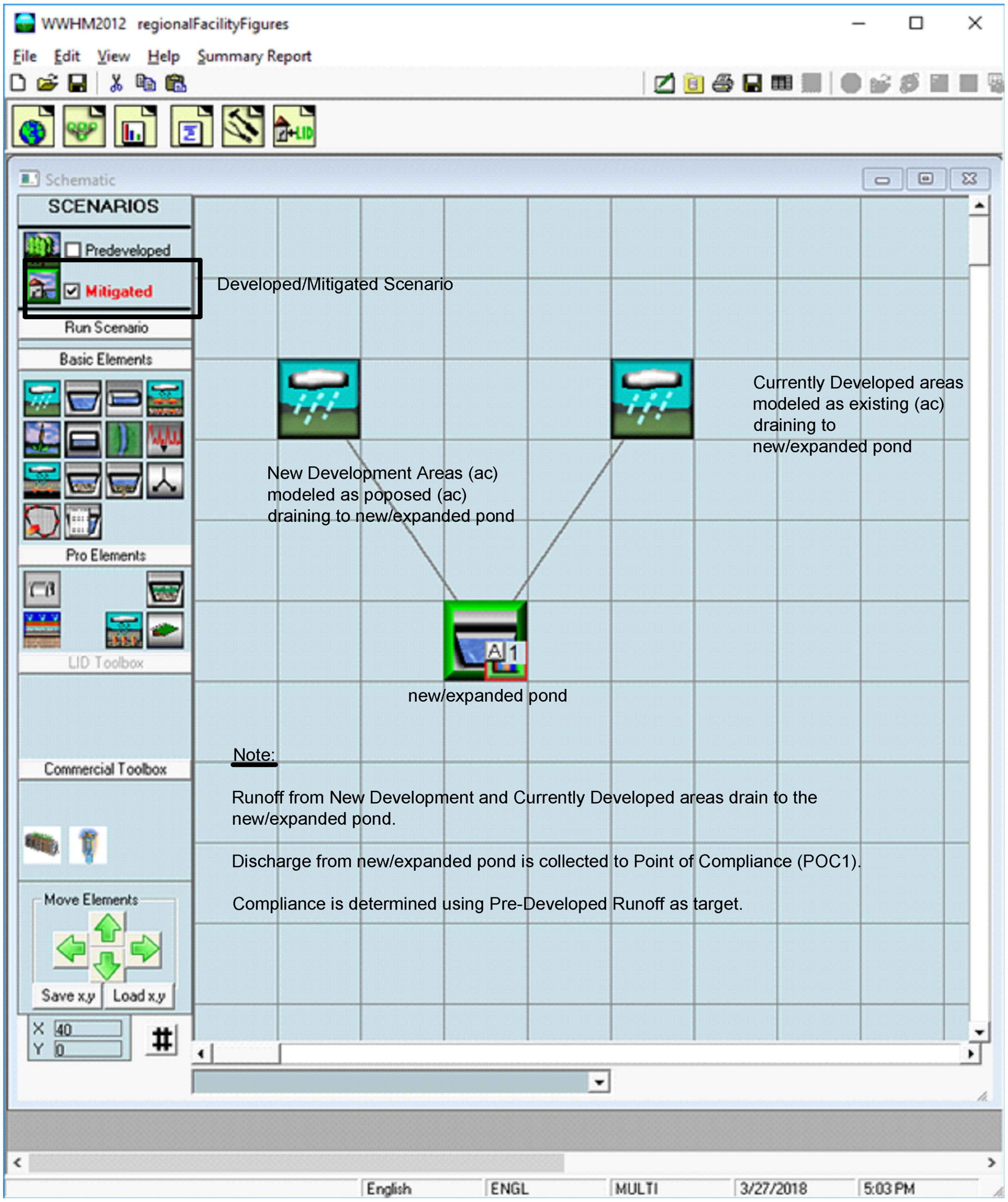
Revised March 2018

Post-Development / Mitigated Scenario

The mitigated scenario will consist of the new development areas and the currently developed areas. Runoff from both the new development and the currently developed areas drain to a new/-expanded pond. The expanded pond is connected to the Point of Compliance (POC1) and the compliance is determined using the pre-developed scenario flows as the target. The expanded pond can then be sized using the Auto-Pond algorithm in the continuous simulation software. See Figure I-D.2: Developed / Mitigated Scenario for a Regional Facility.

The storage volume and control structure of the existing pond must be modified by construction to match the modeling results of the new/expanded pond.

Figure I-D.2: Developed / Mitigated Scenario for a Regional Facility



DEPARTMENT OF ECOLOGY
State of Washington

Developed / Mitigated Scenario for a Regional Facility

Revised March 2018

I-D.6 Regional Facility Area Transfers

What Are Regional Facility Area Transfers?

With proper planning and documentation, municipalities may allow projects that must comply with Minimum Requirements #5, #6, #7, and/or #8 to transfer the on-site benefit of those requirements to another area that is served by a regional facility. The area transfer can be from an in-basin project or an out-of-basin project, as further described below.

Jurisdictions choosing to use in-basin or out-of-basin area transfers to regional facilities must provide a plan that dictates how the capacity of the regional facility and the tracking of the in-basin and out-of-basin area transfers will be calculated and documented. See Appendix I-E: Stormwater Control Transfer Program for further guidance on the documentation necessary to implement the area transfers described here.

In all cases, the jurisdiction is responsible for ensuring that all new and redevelopment projects have met their applicable Minimum Requirements. Whenever a regional facility is used to meet Minimum Requirements, the jurisdiction must demonstrate that the regional facility will meet or exceed those requirements and provide at least equivalent environmental benefit as a traditional Runoff Treatment or Flow Control BMP.

Below, Ecology provides guidance for one method of determining capacity and tracking in-basin and out-of-basin area transfers to regional facilities, relative to the Minimum Requirements. Local jurisdictions may choose to select an alternate way of measuring the benefits of their regional facilities, but they are responsible to document and report how they are meeting the Minimum Requirements.

Current guidance for area transfers is limited to the flow based Minimum Requirements, such as I-3.4.7 MR7: Flow Control and the LID Performance Standard portion of I-3.4.5 MR5: On-Site Stormwater Management.

Local jurisdictions may develop methods for determining capacity and tracking in-basin and out-of-basin area transfers to regional facilities, relative to requirements other than the Minimum Requirements (such as requirements set by a TMDL or other planning document). Ecology does not have any additional guidance for those situations at this time.

In-Basin Area Transfers

Municipalities may allow projects that must comply with Minimum Requirements #5, #6, #7, and/or #8 to transfer the on-site benefit of those requirements to another area that is served by a regional facility within the same basin. This is an in-basin area transfer. In-basin area transfers are restricted to the extent described herein. An in-basin transfer program, and in-basin transfers for individual projects, do not require prior approval from Ecology.

For an in-basin area transfer, the regional facility must discharge to the same point (or upstream) in the receiving water as the project that transferred the on-site benefit to it. To discharge downstream of the project site, Municipal Stormwater General Permit Permittees must submit a Basin Plan to Ecology for review and approval, and demonstrate how discharging downstream of the project site provides an equal or greater benefit. See Appendix I-B: Basin Plans.

Municipalities may allow in-basin area transfers that comply with the guidance in this section. Though this guidance is not expressly incorporated into the Phase I and Western Washington Phase II Municipal Stormwater Permits, Permittees may infer Ecology's acceptance of programs that follow the guidance. Alternatives may also be appropriate.

Although in-basin area transfers are acceptable, they are not the intent of an area transfer program, as described in Appendix I-E: Stormwater Control Transfer Program, because the transfer is not from a lower priority watershed.

Note that for in-basin area transfers, the entire on-site benefit (e.g. Flow Control from impervious to forested) may be transferred. This differs from an out-of-basin transfer, where only a portion of the on-site benefit may be transferred. See guidance for out-of-basin transfers, below, for details.

Out-Of-Basin Area Transfers

Municipalities may allow projects that must comply with Minimum Requirements #5, #6, and/or #7, to transfer the on-site benefit of those requirements to another area that is served by a regional facility in a different, higher priority, watershed. This is an out-of-basin area transfer. See Appendix I-E: Stormwater Control Transfer Program for guidance on how to determine basin priorities, and the documentation necessary to implement out-of-basin area transfers.

Equivalent Facilities

The concepts, including tracking guidance, provided in this section can also be applied to an area transfer to an equivalent facility, instead of to a regional facility.

A municipality may permit a project applicant to provide an in-basin or out-of-basin area transfer by constructing an equivalent facility in the same or higher priority watershed, rather than using capacity in a regional facility. The equivalent facility must be sized to provide stormwater controls for an area equivalent to the area requiring the stormwater controls on their project site. It is allowable that the equivalent facility only serves an area that matches the transferred project's stormwater control obligation.

Types of Regional and Equivalent Facilities for Area Transfers

There are several types of facilities that can serve either as equivalent facilities or as regional facilities with capacity available for area transfers from projects outside of the contributing area. The Flow Control facility types include but are not limited to:

- BMP D.1: Detention Ponds
- BMP T7.10: Infiltration Basins
- Combination Infiltration Basins / Detention Ponds
- BMP T5.30: Full Dispersion
- BMP T5.15: Permeable Pavements
- BMP T7.30: Bioretention
- Existing Flow Control facility retrofits

- Reforestation of impervious area, pasture, and/or lawn landscaping on land protected by covenant or easement.

Determining Regional Facility Capacity for Area Transfers

Use the following guidance to determine the net capacity available in a regional facility that is included in an area transfer program. For tracking purposes, the capacity of a regional facility may be calculated and documented in terms of area of impervious surfaces, other hard surfaces, lawn/-landscape, pasture, etc. Local jurisdictions may develop an alternative tracking methodology, however the credits between facilities must be able to discern that requirements are being met. Ecology's guidance focuses on the option to use areas for tracking purposes.

Preferably, a new regional facility should be designed and constructed specifically for the area transfer program described in Appendix I-E: Stormwater Control Transfer Program. If a new regional facility is designed and constructed to fully mitigate the entire contributing area, then the entire contributing area is the regional facility's net capacity available for area transfers.

If a municipality is unable to design and construct a new regional facility, they may expand an existing regional facility to provide Flow Control for areas that were not mitigated prior to the expansion. The amount of newly mitigated area determines the regional facility's net capacity available for area transfers. The expansion may include expanding the volume/capacity of the regional facility, expanding the contributing area to the regional facility through added conveyance measures, or both.

For Flow Control area transfers, jurisdictions may use the following guidance to determine the net capacity available in a regional facility that is included in a Flow Control area transfer program. Ecology provides guidance for one method to determine the net capacity available in a regional facility; local jurisdictions may choose to use an alternate method, but they are responsible to document how minimum requirements are met. Although allowed, Ecology does not provide guidance on how to determine the net capacity available in a regional facility that is included in a Runoff Treatment area transfer program; local jurisdictions would develop methodology and how requirements are met.

Determining Net Capacity Available for Area Transfers in a Regional Infiltration Basin / Detention Pond Type Facility

The procedure detailed below describes one example of how to calculate the available capacity of a regional infiltration basin / detention pond type facility (a type of Flow Control BMP) for area transfers. The procedure assumes the most simple scenario of identical soil types, slopes and precipitation regimes. The procedure uses a continuous simulation runoff software to iteratively test the amount of impervious area, lawn, or pasture that is fully mitigated to historic conditions by the proposed regional facility. Recognizing that a new regional facility may not fully mitigate the entire contributing area, the procedure below describes how to design and determine available capacity for both new ponds and expanded ponds.

Provided the proposed regional facility does not have a flow splitter, the following steps are an Ecology accepted method to determine the Flow Control net capacity available for a regional facility. This calculation must be prepared as part of the planning and documentation required to use the regional facility for area transfers. See Appendix I-E: Stormwater Control Transfer Program for further guidance on the documentation necessary to implement the area transfers described here.

Table I-D.1: Detention / Retention Facility Net Capacity Determination is provided as a template to be used for each regional facility.

1. **Step 1:** Determine the contributing area to the regional facility prior to enlisting the regional facility in the area transfer program.

   Is this a new regional facility that will be constructed specifically for the area transfer program?

   - If Yes:

     The "Pre-AreaTransfer Program Contributing Area to Facility" and "Capacity Used Pre-Area Transfer Program" are both zero. Enter 0 in all boxes in Rows 1 and 2 of Table I-D.1: Detention / Retention Facility Net Capacity Determination.

     Skip to Step 3.

   - If No, this is an existing regional facility that will be expanded to implement the area transfer program.

     In Table I-D.1: Detention / Retention Facility Net Capacity Determination, Row 1, enter the land uses (Impervious areas, Other Hard Surfaces, Lawn / Landscape, Pasture areas) of the existing contributing area to the existing regional facility prior to the proposed expansion and implementation of the area transfer program.

2. **Step 2**: Determine the capacity used by the existing regional facility, prior to any proposed expansion or implementation of the area transfer program ("Capacity Used Pre-Area Transfer Program"). This represents the area that is already being mitigated, and cannot be used for the area transfers in the area transfer program.

   Using a continuous simulation software, determine the smallest (hypothetical) regional facility that can meet the Flow Control standard that the regional facility is proposed to mitigate for (e.g. the Flow Control Performance Standard from I-3.4.7 MR7: Flow Control or the LID Performance Standard from I-3.4.5 MR5: On-Site Stormwater Management), for the entire contributing area to the existing regional facility.

   Is the (hypothetical) regional facility the same size or smaller than the existing (actual) regional facility?

   - If Yes:

     The existing regional facility is sized to mitigate the entire existing contributing area, and has no more capacity for area transfers without expanding the contributing area.

     The "Capacity Used Pre-Area Transfer Program" is the same as the "Pre-Area Transfer Program Contributing Area to Facility" determined in Step 1. Enter this information in Table I-D.1: Detention / Retention Facility Net Capacity Determination in Row 2.

     Continue to Step 3.

   - If No:

     The existing regional facility is undersized for the existing contributing area. The existing regional facility may be expanded to mitigate for the entire contributing area, and the amount of additional area that is mitigated by the expansion will be the available capacity for area transfers (this will be done in Steps 3 and 4).

To determine the capacity used by the existing regional facility, begin reducing the contributing area that was entered into the continuous simulation software (creating a hypothetical contributing area). It is preferable to make this area reduction by first eliminating the lawn area, and then by reducing the impervious area. Adjust the control structure as necessary, and maintain the same pond dimensions. This will be an iterative process to determine how much contributing area the existing regional facility can mitigate for.

Using this iterative process, determine the (hypothetical) area that the existing regional facility can mitigate, and is therefore already using as capacity.

Ensure that the existing regional facility can pass up to the 100-year peak flow from the actual contributing area through the control structure (typically through the standpipe), prior to engaging the emergency overflow spillway. Iterate to ensure that any overflow structure adjustments for the actual contributing area do not impact the hypothetical contributing area that is being mitigated.

Enter the modeled areas of the hypothetical contributing area found after the iterative process described above into Row 2 in Table I-D.1: Detention / Retention Facility Net Capacity Determination. This is the "Capacity Used Pre-Area Transfer Program".

3. **Step 3:** Determine the proposed contributing area to the regional facility, after design and implementation in the area transfer program.

    - If this is an existing regional facility, and you are not proposing to expand the contributing area, this area is the same as the area determined in Step 1.
    - If this is a new regional facility designed specifically for the area transfer program, enter the land uses (Impervious areas, Other Hard Surfaces, Lawn / Landscape, Pasture areas) of the proposed contributing area to the proposed regional facility.
    - If this is an existing regional facility, and you are proposing to expand the contributing area to the regional facility to create additional capacity for use in the area transfer program, enter the land uses (Impervious areas, Other Hard Surfaces, Lawn / Landscape, Pasture areas) of the entire proposed contributing area to the regional facility.

    Enter the characteristics in Table I-D.1: Detention / Retention Facility Net Capacity Determination, Row 3.

4. **Step 4:** Determine the gross capacity of the proposed (either new or expanded) regional facility. This represents the total area that the regional facility can mitigate, including both the area that was mitigated prior to implementation in the area transfer program, as well as the area that will be available as capacity for area transfers using the area transfer program.

    Using a continuous simulation software, determine the smallest (hypothetical) regional facility that can meet the Flow Control standard that the regional facility is proposed to mitigate for (e.g. the Flow Control Performance Standard from I-3.4.7 MR7: Flow Control or the LID Performance Standard from I-3.4.5 MR5: On-Site Stormwater Management), for the entire proposed contributing area to the proposed regional facility.

Is the (hypothetical) regional facility the same size or smaller than the proposed (either new or expanded) regional facility?

- If Yes:

  The proposed regional facility is sized to mitigate the entire proposed contributing area.

  The "Area Transfer Program Contributing Area to Facility" is the same as the "Gross Capacity in Regional Facility". Enter the area into Row 4 in Table I-D.1: Detention / Retention Facility Net Capacity Determination.

  Continue to Step 5.

- If No:

  The proposed regional facility is undersized for the proposed contributing area.

  To determine the gross capacity of the proposed regional facility, begin reducing the contributing area that was entered into the continuous simulation software (creating a hypothetical contributing area). It is preferable to make this area reduction by first eliminating the lawn area, and then by reducing the impervious area. Adjust the control structure as necessary, and maintain the same pond dimensions. This will be an iterative process to determine how much contributing area the proposed regional facility can mitigate for.

  Using this iterative process, determine the (hypothetical) area that the proposed regional facility can mitigate, and is therefore has available for gross capacity.

  Ensure that the proposed regional facility can pass up to the 100-year peak flow from the actual proposed contributing area through the control structure (typically through the standpipe), prior to engaging the emergency overflow spillway. Iterate to ensure that any overflow structure adjustments for the actual proposed contributing area do not impact the hypothetical contributing area that is being mitigated.

  Enter the modeled areas of the hypothetical contributing area found after the iterative process described above into Row 4 in Table I-D.1: Detention / Retention Facility Net Capacity Determination. This is the "Gross Capacity in Regional Facility".

5. **Step 5:** Determine the "Net Capacity Available for Area Transfers".

   Subtract the "Capacity Used Pre-Area Transfer Program" determined in Step 2 (Table I-D.1: Detention / Retention Facility Net Capacity Determination, Row 2) from the "Gross Capacity in Regional Facility" determined in Step 4 (Table I-D.1: Detention / Retention Facility Net Capacity Determination, Row 4). Enter this information in Table I-D.1: Detention / Retention Facility Net Capacity Determination, Row 5. This is the "Net Capacity Available for Area Transfers".

Table I-D.1: Detention / Retention Facility Net Capacity Determination

Facility Name:	Impervious (acres)	Other Hard Surfaces (acres)	Lawn / Landscape (acres)	Pasture (acres)
Row 1: Pre-Area Transfer Program Contributing Area to Facility				
Row 2: Capacity Used Pre-Area Transfer Program				
Row 3: Area Transfer Program Contributing Area to Facility				
Row 4: Gross Capacity in Regional Facility				
Row 5: Net Capacity Available for Area Transfers				

Determining Net Capacity Available for Area Transfers in a Regional Bioretention or Permeable Pavement Type Facility

BMP T5.15: Permeable Pavements and BMP T7.30: Bioretention may be used as an equivalent or regional facility with capacity to transfer areas. If these facilities fully infiltrate the runoff file as demonstrated by using a continuous simulation software, the entire area draining to the facility is considered the available capacity for Flow Control.

Determining Net Capacity Available for Area Transfers in a Regional Reforestation Type Facility

A regional reforestation facility is an area that has directly converted effective impervious area, landscaped area or maintained pasture to native vegetation that will develop into a fully evergreen forested condition. The native vegetation area must be protected with a conservation covenant, or with a conservation easement granted to the Permittee in cases where the Permittee does not own the land.

In this case, the available capacity for area transfers is the totals of effective impervious area, lawn/-landscaping, and pasture that are converted to native vegetation.

The area undergoing reforestation must meet the following criteria:

- Existing impervious, lawn/landscaped, and pasture areas that are intended for conversion back to native pre-developed conditions must meet the soil quality and depth requirements of BMP T5.13: Post-Construction Soil Quality and Depth.
- The reforestation area must be planted with native vegetation, including evergreen trees. For

further guidelines, see the Washington State Department of Transportation's *Roadside Manual* (WSDOT, 2017). Refer to Sections 800 and 810 in regard to design, procedures, and other recommendations pertinent to Accelerated Climax Community Development.

- The reforestation area must be permanently protected from development through a conservation easement or some other legal covenant that requires it to remain in native vegetation. The legal covenant may allow logging as long as the area is re-planted in accordance with Department of Natural Resources requirements and remains in long-term forestry.

Reforested areas are considered stormwater facilities and should be mapped and maintained. Existing native vegetation areas that have the potential to be developed cannot be used for this reforestation credit.

Tracking Regional Facility Area Transfers

The municipality must prepare and maintain a tracking table as described below for any regional facility that serves areas outside of its contributing area using in-basin or out-of-basin area transfers.

Regional Flow Control Facility Tracking Example

Some examples of the type of information that the municipality must prepare and maintain for each regional facility providing Flow Control benefits include:

- The regional facility ID
- The regional facility name
- The name of the watershed that the regional facility is located in. For in-basin area transfers, this will be the same watershed that the project using the transfer is in. For out-of-basin area transfers, this must be a higher priority watershed than the watershed that the project using the transfer is in. See Appendix I-E: Stormwater Control Transfer Program for more information on watershed prioritization for out-of-basin area transfers to regional facilities.
- The Flow Control standard used to determine the regional facility's capacity.
- The Net Capacity Available for Area Transfers, in terms of acres as described in Determining Regional Facility Capacity for Area Transfers (above).
- The Used Capacity, in terms of acres of the same land covers as documented for Net Capacity Available.
- The Remaining Capacity Available for Area Transfers, in terms of acres of the same land covers as documented for Net Capacity Available.

An example of a regional facility tracking table is included as Table I-D.2: Example Regional Facility Tracking Table. The municipality shall update the table each time a development project uses the regional facility. Projects that may use the regional facility and must be tracked include:

- Projects within the contributing area of the regional facility.
- Projects outside the contributing area of the regional facility, but within the same basin (in-basin area transfer).

- Projects outside the contributing area of the regional facility, and in a lower priority watershed (out-of-basin area transfer).

In addition, for each regional facility, the municipality shall maintain a summary sheet that identifies each project that has used capacity within the regional facility. The summary sheet will document the location and the capacity used in the regional facility. For regional facilities providing Flow Control, this may be the acreage amount of each land cover type that was used by each project. See Table I-D.3: Example Summary Sheet for Projects Using a Regional Facility for an example with the total for each type of land cover in Table I-D.3: Example Summary Sheet for Projects Using a Regional Facility matching the Used Capacity column in Table I-D.2: Example Regional Facility Tracking Table.

Permittees under the Phase I and Western Washington Phase II Municipal Stormwater Permits shall submit, as an attachment to their annual reports, the regional facility tracking tables that are updated to at least the calendar year covered by the annual report. These tracking tables will be made publicly available through Ecology's PARIS database.

Table I-D.2: Example Regional Facility Tracking Table

Facility ID: F001			
Facility Name: Sample Regional Facility			
Name of Watershed: Sample Watershed			
Flow Control Standard Used to Determine Capacity: Flow Control Performance Standard (MR #7)			
	Net Capacity (acres)	**Used Capacity (acres)**	**Remaining Capacity (acres)**
Impervious	5.00	3.05	1.95
Other Hard Surfaces	4.00	2.00	2.00
Lawn / Landscape	3.00	1.10	1.90
Pasture	2.00	0.50	1.50

Table I-D.3: Example Summary Sheet for Projects Using a Regional Facility

Project Name and ID No.	Impervious (acres)	Other Hard Surfaces (acres)	Lawn/Landscape (acres)	Pasture (acres)
Elysian Fields; ID No. P123	2.00	1.00	0.60	0.30
Scab Lands Estates ID No. P456	1.05	1.00	0.50	0.20
TOTAL	**3.05**	**2.00**	**1.10**	**0.50**

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Appendix I-E: Stormwater Control Transfer Program

I-E.1 Introduction to the Stormwater Control Transfer Program

What is a Stormwater Control Transfer Program?

A Stormwater Control Transfer Program is an alternative program that a Phase I or Western Washington Phase II Municipal Stormwater Permittee may use to meet Permit requirements. The goal of this innovative stormwater management approach is to direct stormwater management efforts to watersheds where reducing high stream flows is more likely to contribute to maintaining or restoring designated and existing beneficial uses.

A Stormwater Control Transfer Program directs stormwater control efforts (e.g., Flow Control BMP upgrades or installation) from a project to other, higher priority watersheds within a jurisdiction. How to determine the priority of a watershed for a Stormwater Control Transfer Program is discussed in I-E.3 Establishing a Watershed Prioritization for Stormwater Control Transfer Programs. High priority watersheds are more likely to contribute to maintaining or restoring designated and existing beneficial uses of receiving waters.

Current guidance for Stormwater Control Transfer Programs is limited to methods to meet the Flow Control Performance Standard in I-3.4.7 MR7: Flow Control.

Why Use a Stormwater Control Transfer Program?

In the Puget Sound region, the predicted annual rate of new and redevelopment is 1.6 percent (King County, 2014). At this pace, it will take 60+ years to install or upgrade stormwater BMPs to a level comparable to the current NPDES municipal stormwater new and redevelopment standards across the Puget Sound region. Elsewhere in western Washington, new and redevelopment rates are lower, meaning that it may take significantly longer. Regardless, patterns of redevelopment are based on market forces and not on the stormwater management needs, nor the environmental value or priority those watersheds represent.

A Stormwater Control Transfer Program allows a Permittee to transfer some stormwater improvements from individual sites, as is done in the traditional site-by-site approach, to stormwater facilities in high priority watersheds. This allows investments to focus in areas where stormwater control facility upgrades and/or installations will provide a more immediate benefit to waterbodies showing environmental stress associated with stormwater impacts.

How Can Municipal Stormwater Permittees Use a Stormwater Control Transfer Program?

Phase I and Western Washington Phase II Municipal Stormwater Permittees (Permittees) can implement a Stormwater Control Transfer Program to satisfy permit requirements associated with the Flow Control Performance Standard from I-3.4.7 MR7: Flow Control as it is triggered at new and redevelopment project sites.

A Stormwater Control Transfer Program may serve to meet the Long-Term Municipal Stormwater Planning requirement in the Permits; however, this program cannot serve to meet Phase I Permittees' obligation to implement a Structural Stormwater Control Program as currently required by Special Condition S5.C.6. That said, a Permittee may use a priority ranking system similar to the one described for a Stormwater Control Transfer Program (see I-E.3 Establishing a Watershed Prioritization for Stormwater Control Transfer Programs) to direct its Structural Stormwater Control Program. Furthermore, this guidance does not restrict a Permittee from also using its Structural Stormwater Control Program to accelerate improvements in high priority watersheds.

Permittees establishing a Stormwater Control Transfer Program that includes out-of-basin transfers must obtain written approval from Ecology as required by Special Conditions S5.C.5.a.i. of the Phase I Permit or S5.C.4.a.i. of the Phase II Permit. A submitted plan to Ecology must include the following elements, as described in this guidance:

- Key Features,
- Watershed Prioritization,
- Effectiveness Monitoring, and
- Tracking.

Permittees must seek input on the proposed plan prior to submission to Ecology from:

- Local tribes
- State and federal natural resource agencies
- Public

How to Use this Guidance

This appendix contains information that will be useful for Permittees to establish a Stormwater Control Transfer Program that is approvable by Ecology.

This appendix does not provide exhaustive or detailed instructions on how to set up and implement a Stormwater Control Transfer Program. It likewise does not provide direction on siting individual facilities within a high priority watershed. Rather, this guidance is intended to inform Permittees considering this approach and to provide general guidance and principles when developing a Stormwater Control Transfer Program focused on Flow Control. This guidance is based on Ecology's experience in reviewing and approving alternative programs on a case-by-case basis, and may evolve as issues or nuances are raised and better understood. Permittees exploring this alternative approach to meet permit requirements are encouraged to contact Ecology early in the planning stage.

I-E.2 Stormwater Control Transfer Program Principles, Elements, and Guidelines

General Stormwater Control Transfer Program Principles

1. The environmental goal is to reduce the duration and frequency of high stream flows that are incompatible with protection/restoration of designated and existing uses.

   "Designated uses" shall be as defined in Chapters 173-200 and 173-201A WAC. "Existing uses" are defined in 40CFR 131.3 as "those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards."

2. A Stormwater Control Transfer Program must accelerate hydrologic improvements in high priority watersheds.

3. Transferring stormwater Flow Control away from a project site cannot result in increasing the pre-project flow duration within the Flow Control Performance Standard range to any receiving water.

4. Projects triggering I-3.4.7 MR7: Flow Control and located within a high priority watershed cannot transfer Flow Control improvements to another watershed.

5. A municipality must evaluate its watersheds and establish a science-based prioritization scheme and assign relative priority rankings prior to implementing a Stormwater Control Transfer Program.

6. Ecology approval of a Stormwater Control Transfer Program does not shield the Permittee from additional or more stringent requirements associated with TMDLs, S4.F.3 adaptive management plans, future stormwater requirements, or other enforceable mechanisms.

7. Flow Control improvements for replaced impervious surfaces, and in some cases, Flow Control improvements for new impervious surfaces, can be transferred to a high priority watershed either within the same municipality or among municipalities with an agreement to do so. The watershed receiving the improvements ("receiving watershed") must have a higher priority than the watershed from which the improvements are transferred ("sending watershed").

8. Stormwater Control Transfer Program proposals with draft documents and proposed Ecology conditions will have a public review and appeal process.

Key Stormwater Control Transfer Program Elements

1. For replaced and new surfaces, Flow Control improvements may be transferred to a high priority watershed. Flow Control "improvement transfers" to high priority watersheds are allowed in the following manner:

   a. I-3.4.7 MR7: Flow Control requires that qualifying projects provide Flow Control to control post-developed flow durations to match those conditions produced by the pre-developed land cover condition (generally, forested) rather than by the immediate pre-project land cover condition.

b. In the Flow Control "improvement transfer" scenario, a qualifying project provides Flow Control on site to control post-developed flow durations to match the immediate pre-project land cover condition at the project site.

c. The project then transfers the Flow Control improvement requirement to a higher priority watershed. The Flow Control improvement requirement matches the immediate pre-project land cover flow durations to the pre-developed land cover condition (generally, forested).

2. In accordance with S5.C.10 of the Phase I Municipal Stormwater Permit, and S5.C.7.c. of the Phase II Municipal Stormwater Permit, Permittees must verify the long-term operation and maintenance of off-site stormwater Flow Control facilities constructed as part of an out-of-basin transfer under a Stormwater Control Transfer Program.

3. Any Flow Control facilities in high priority watersheds built to provide Flow Control improvements in lieu of making those improvements at an out-of basin project site must be fully functional before or concurrent with any project that shall use that facility to help meet its stormwater requirements.

4. In no case can a Permittee allow less stormwater improvement than what would have been realized (i.e., equivalent acreage) by following the jurisdiction's adopted stormwater runoff controls program. That program could include:

   a. The default Appendix 1 permit requirements, or

   b. Requirements approved through S5.C.5 of the Phase I Municipal Stormwater Permit, or

   c. Requirements allowed through S5.C.4 of the Phase II Municipal Stormwater Permit, or

   d. Alternative requirements established through an Ecology-approved Basin Plan per Appendix I-B: Basin Plans.

5. The Permittee must track Flow Control improvement transfers for each project as explained in I-E.5 Stormwater Facility Transfer Capacity Credits and Tracking.

6. The Permittee shall provide annual reports to Ecology documenting Flow Control capacity used and available in off-site facilities associated with this program.

7. Any Permittee implementing a "fee-in-lieu" option must establish a dedicated account to manage any "fee-in-lieu" payments (public and private) that it collects. These funds will not be used for any capital investment outside of this program.

Specific Technical Guidelines for Flow Control Improvement Transfers

1. Any project in a lower priority watershed transferring Flow Control improvements to a high priority watershed must match or improve the immediate pre-project durations within the Flow

Control Performance Standard range. See Table I-E.1: How Minimum Requirement #7 Flow Control Standards Are Met in a Stormwater Control Transfer Program for examples.

2. Flow Control improvement transfers will be based on land cover on an area basis for each type of land cover (i.e., impervious surfaces, other hard surfaces, lawn/landscape, and pasture). See Table I-E.2: Flow Control Requirement Targets for Land Cover Changes in a Stormwater Control Transfer Program for examples.

3. For replaced hard surfaces, Permittees may transfer required Flow Control improvements for the immediate pre-project surfaces to priority watersheds.

4. All new surfaces at development sites must have Flow Control facilities to match flow durations from the post-developed land cover conditions to the pre-project land cover conditions at the project site. The incremental obligation to provide Flow Control to match the pre-project condition to the pre-developed land cover condition may then be approved as a Flow Control improvement transfer to the high priority watershed. If a Permittee does not approve the transfer, the project must provide Flow Control to the pre-developed condition at the project site.

5. Only effective impervious surfaces, hard surfaces, and converted vegetation areas that are subject to I-3.4.7 MR7: Flow Control have to be considered when determining the areas proposed for Flow Control improvement transfers, and when determining which areas to use for matching existing conditions.

6. When a regional facility in a high priority watershed will serve to provide capacity credits for purchase, it should be designed for future build-out of the contributing area whenever possible so that it can fully meet the needs of the contributing area.

7. When a regional facility that has been designed for future build-out of the full contributing area in a high priority watershed has exhausted its capacity credits, projects within its contributing area that must comply with I-3.4.7 MR7: Flow Control have the following options:

    - Transfer the Flow Control improvements to another Flow Control facility site within the high priority watershed, but outside of the contributing area to the regional facility. This could be to another regional facility or to an equivalent facility.

    or

    - Transfer the Flow Control improvements to another high priority watershed.

    Once the capacity of the regional facility has been exhausted, projects within the contributing basin for that regional facility do not have the options of using the regional facility or of providing Flow Control on-site. The runoff from the project has been factored into the sizing of the regional facility, and has already been accounted for by the capacity credits that have been purchased by other projects outside of the high priority watershed.

8. When a regional facility that has NOT been designed for future build-out of the full contributing area in a high priority watershed has exhausted its capacity credits, projects within its contributing area that must comply with I-3.4.7 MR7: Flow Control have the following options:

    - Meet the Flow Control requirements with BMPs on-site. The jurisdiction must track the projects choosing this option, and reduce the calculated contributing area to the regional facility by the area that will be treated on the project site. Over time, the tracking will show that the regional facility capacity matches the contributing area. Once this happens, new projects developing within the contributing area to the regional facility will have to follow the guidance above for projects developing within contributing areas to regional facilities that have been designed for future build-out of the full contributing area.

- Transfer the Flow Control improvements to another Flow Control facility site within the high priority watershed, but outside of the contributing area to the regional facility. This could be to another regional facility or to an equivalent facility.

or

- Transfer the Flow Control improvements to another high priority watershed.

Table I-E.1: How Minimum Requirement #7 Flow Control Standards Are Met in a Stormwater Control Transfer Program

Surface Subject to Minimum Requirement #7	Flow Control Improvement Required at a Location in a High Priority Watershed	Flow Control Required at Project Site
New or replaced impervious surface, or converted vegetation areas	Match flow durations within the Flow Control Performance Standard range produced by the pre-project land covers to the pre-developed land cover. Use an equivalent amount and type of pre-project land covers within the High Priority Watershed.	Match flow durations within the Flow Control Performance Standard range produced by the developed land covers to the pre-project land covers.

Table I-E.2: Flow Control Requirement Targets for Land Cover Changes in a Stormwater Control Transfer Program

Pre-Project (existing) Land Cover	Post-Developed Land Cover	Flow Control Requirement(s) to be added/used as part of the Development Project
Forested	New Impervious	Project Site: Impervious to Forested - provide onsite Flow Control BMPs to match forested condition. Transfer Site: No Additional Improvements - no transfer of Flow Control to a priority watershed.
Pasture	New Impervious	Project Site: Impervious to Pasture - provide onsite Flow Control BMPs to match pasture conditions. Transfer Site: Pasture to Forested - transfer Flow Control improvements to meet forested condition in the priority watershed.
Impervious	Replaced Impervious	Project Site: No Additional improvements Transfer Site: Impervious to Forested - transfer Flow Control improvements to meet forested condition in the priority watershed.

Table I-E.2: Flow Control Requirement Targets for Land Cover Changes in a Stormwater Control Transfer Program (continued)

Pre-Project (existing) Land Cover	Post-Developed Land Cover	Flow Control Requirement(s) to be added/used as part of the Development Project
Lawn / Land-scape	New Imper-vious	Project Site: Impervious to Lawn / Landscape - provide onsite Flow Control BMPs to match lawn/landscape condition. Transfer Site: Lawn / Landscape to forested - transfer the Flow Control improvements from lawn/landscape to meet forested condition in the priority watershed.

I-E.3 Establishing a Watershed Prioritization for Stormwater Control Transfer Programs

The goal of the Stormwater Control Transfer Program is to direct Flow Control improvements to high priority watersheds. High priority watersheds are those where reducing high stream flows is more likely to contribute to maintaining or restoring designated and existing beneficial uses. At the same time, the approach prevents increasing the flow durations within the Flow Control Performance Standard range to any receiving water. As individual high priority watersheds are rehabilitated, remaining watersheds are prioritized for improvement until flow duration-related water quality issues in all of the municipality's watersheds are addressed.

As a first step in establishing the Stormwater Control Transfer Program, a Permittee must document a clear prioritization goal/focus (e.g., restore beneficial uses). Next, a Permittee must evaluate its watersheds to identify high priority watersheds (or, "receiving watersheds"), lower priority watersheds (or, "sending watersheds"), and any watersheds excluded from the program.

Permittees must clearly document in their Stormwater Control Transfer Program submittal to Ecology all data sources used to prioritize watersheds.

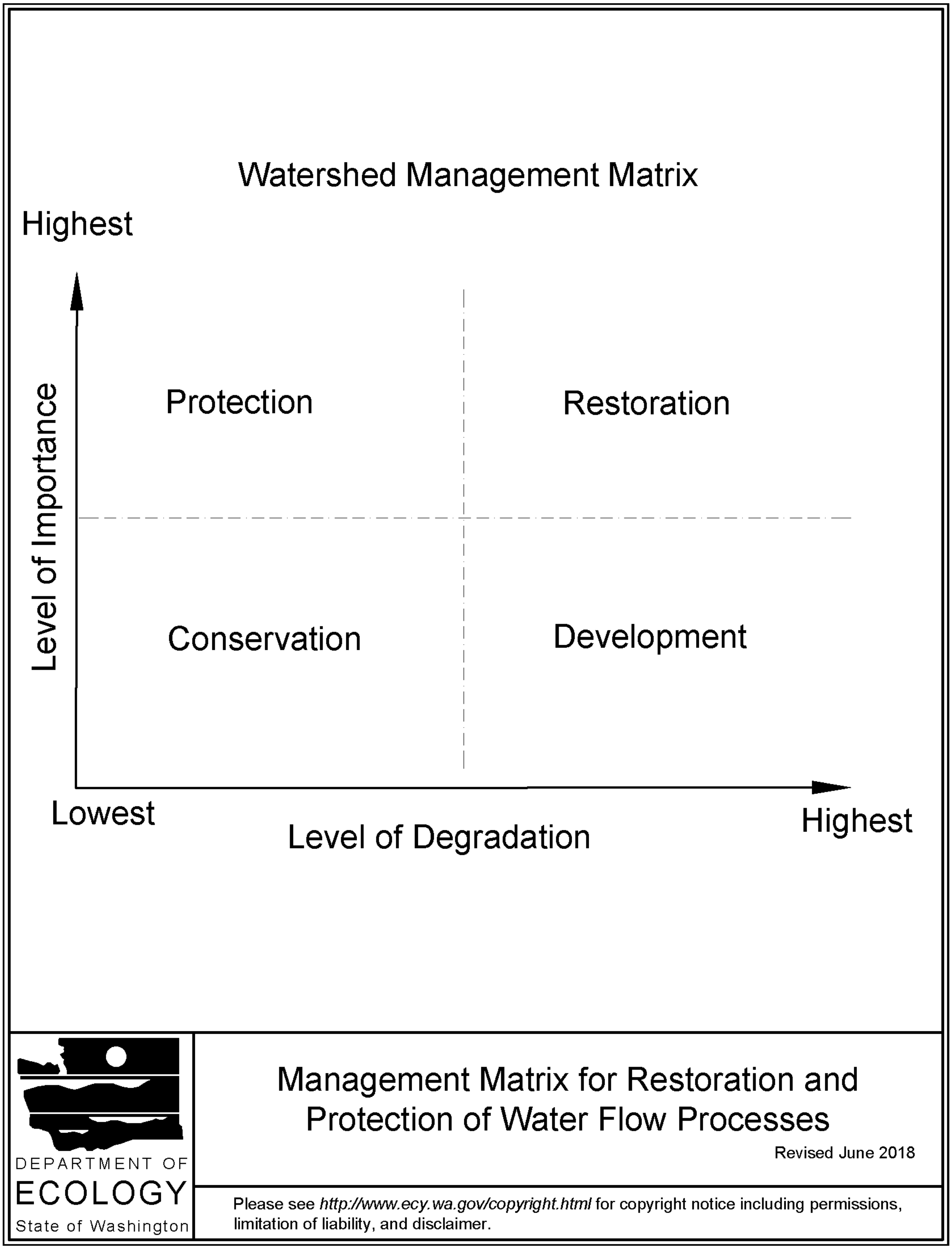
Prioritization Analysis Support

The process described in the *Puget Sound Watershed Characterization Project* published by Ecology is one analysis that can be used to set preliminary priorities. For more information, refer to the following website:

https://ecology.wa.gov/Water-Shorelines/Puget-Sound/Watershed-characterization-project

Generally, watersheds that fall into the "Protection" and "Restoration" categories described in *Puget Sound Characterization – Volume 1: The Water Resource Assessments (Water Flow and Water Quality)* (Ecology, 2016d) are expected to rank as higher priority than watersheds in the "Conservation" or "Development" categories (see Figure I-E.1: Management Matrix for Restoration and Protection of Water Flow Processes).

Figure I-E.1: Management Matrix for Restoration and Protection of Water Flow Processes



The output from the process described in the *Puget Sound Watershed Characterization Project* should not be relied upon as the only line of information to designate priorities. Local jurisdictions must verify drainage/watershed area delineations, include finer scale information and may need to perform in-stream assessments to better refine the analysis.

Ultimately, implementing a program to transfer stormwater controls to a site in a different, higher priority watershed requires more detailed, finer scale information about all of a municipality's watersheds. To establish a more detailed, locally informed prioritization, Permittees are encouraged to consult *Building Cities in the Rain - Watershed Prioritization for Stormwater Retrofits* (Ballash et al., 2016). The four step process and Table I-E.3: Recommended Data Sources for Use in Watershed Prioritization Steps provided below were adapted from (Ballash et al., 2016)

Watershed Prioritization Step 1: Fish Use and Aquatic Habitat

Review the receiving waterbodies or receiving waters for actual or potential fish use with a focus on the biological conditions and potential for environmental improvement. Give higher priority to receiving waterbodies or receiving waters with low to moderate levels of impairment.

Watershed Prioritization Step 2: Flow Control opportunities

Assess the watersheds for opportunities to address Flow Control issues. Give higher priority to watersheds within which hydrologic improvements are expected to accelerate improvements in designated and existing beneficial uses.

Watershed Prioritization Step 3: Environmental Justice Considerations

A Permittee may determine that there are environmental justice issues that need to be addressed in a given watershed. If two or more watersheds are determined of equal priority using the other data sources listed above, Permittees are encouraged to consider environmental justice opportunities and needs.

Watershed Prioritization Step 4: Feedback from Federal, Tribal, and State Agencies

In all cases, actively seek input from federal (US Fish and Wildlife, NOAA Fisheries, US Environmental Protection Agency), tribal, and state (Departments of Fish and Wildlife and Natural Resources) resource agencies to gain buy-in on proposed watershed prioritization. Those agencies may have data or local knowledge pertinent to establishing priorities, and informed opinions about the relative importance of watersheds. As part of the submittal to Ecology, provide documentation of all outreach efforts, issues raised, and resolution provided.

If the Permittee is unable to resolve any issues raised by state, tribal, or federal natural resource agencies, Ecology will confer with that agency prior to making its approval decision.

Table I-E.3: Recommended Data Sources for Use in Watershed Prioritization Steps

Data Sources	Comments / Notes
Step 1: Fish Use and Aquatic Conditions	
Actual or Potential Fish Use and Existing Aquatic Conditions: Current Chinook, Coho and other salmonid use and potential use data	
Data Sources	***Comments / Notes***
Water Resource Inventory Area (WRIA) Plans provide fish distribution information. E.g., WRIA 9 Fish Distribution Maps.	• A local government needs to know that fish are present if they are prioritizing for habitat restoration. • Potential fish use data is highly useful for salmon recovery.
WDFW's SalmonScape web site provides a computer mapping system for salmon recovery planners. It provides lifestage and barriers information for mainstems and named tributaries. It will need to be verified and refined by local data and knowledge, especially for smaller or un-named tributaries.	
WDFW's Salmonid Stock Inventory (SaSI) web site has reports describing and categorizing the status of 435 salmon and steelhead stocks.	
Location of physical and natural barriers: • WDFW maintains a centralized database of fish passage, diversion screening, fish use, and habitat information from inventory efforts on its Fish Passage and Diversion Screening Inventory (FPDSI) database web site. • WSDOT maintains a culvert database on its web site at Working with Fish Passage Partners.	
Subareas (acres) of streams that drain to downstream hatcheries as well as to salmon bearing streams. • WDFW maintains a list of hatcheries are listed by county. • Northwest Indian Fisheries Commission maintains a map of Tribal salmon hatcheries.	
County and city-specific fish data, such as the location of physical and natural barriers.	
All available physical stream assessment data related to salmonid habitat conditions, including, but not limited to: pool/riffle ratio; type of substrate; embeddedness; and naturally occurring large woody debris/100 linear feet - weighted average of large woody debris density over walked channel length. This data can be collected by local government staff walking each creek.	Large woody debris is defined as wood at least four inches in diameter and six feet long (WAC 220-660-220), in or over bankfull channel counted by field crews. "Bankfull width" is defined by the Washington State Department of Natural Resources for streams as "the measurement of the lateral extent of the water surface elevation perpendicular to the channel at bank-

Table I-E.3: Recommended Data Sources for Use in Watershed Prioritization Steps (continued)

Data Sources	Comments / Notes
All available physical nearshore marine assessment data related to salmonid habitat conditions (refuge, feeding, and migratory) including, but not limited to: elevation; slope; type of substrate (fish mix gravels); embeddedness; armoring – manmade or natural; and naturally occurring large woody debris/100 linear feet - weighted average of large woody debris density over walked shore length. This data can be collected by local government staff walking the shoreline. The Washington State Department of Natural Resources provides an interactive map of annual eelgrass data at its Puget Sound Eelgrass Monitoring Data Viewer. See also: *Estuarine Habitat Assessment Protocol* (Simenstad et al., 1991)	full depth (WAC 222-16-010). In cases where multiple channels exist, bankfull width is the sum of the individual channel widths along the cross-section.
All available physical river assessment data related to salmonid habitat conditions (refuge, feeding, and migratory), including, but not limited to: pool/riffle ratio; type of substrate (fish mix gravels); embeddedness; and naturally occurring large woody debris/100 linear feet - weighted average of large woody debris density over walked channel length. This data can be collected by local government staff walking each river.	
A study assessing streams in WRIA 8 provides recommendations for salmon habitat parameters and procedures (King County, 2015):	
Tree Canopy/Condition of Buffer for Habitat	
Data Sources	***Comments / Notes***
Tree canopy percentage cover in local government regulatory stream buffers using aerial photography.	• Tree canopy includes trees with a minimum 10-foot diameter canopy within regulatory buffers for open channel stream reaches within the jurisdictional limits. • Tree canopy can be used as a tiebreaker between two otherwise equally ranked receiving waterbodies or receiving waters.
Percentage of intact 300-foot vegetated stream buffer using aerial photography.	

Table I-E.3: Recommended Data Sources for Use in Watershed Prioritization Steps (continued)

Data Sources	Comments / Notes
Percentage of intact 100-foot vegetated stream buffer using aerial photography.	The extent of intact buffers throughout a stream system correlates well with fish recovery/potential. Higher values equate to more vegetation. All vegetation including landscaped and mowed or plowed land is included – trees, shrubs, and unmowed grasses.
Benthic Index of Biotic Integrity (B-IBI) or Fish Index of Biotic Integrity (F-IBI), where appropriate, to measure aquatic health	
Data Sources	***Comments / Notes***
Local F-IBI data	F-IBI is good data where it is available, but it can be hard to interpret as it is stream size dependent.
Using passive fallout traps to characterize the insect community simulates insects that could fall on the surface of the water and be available as fish prey. Insect communities may vary depending on the amount of riparian vegetation, shoreline armoring, and other habitat features.	• BIBI scores provide a quantitative method for determining and comparing the biological condition of streams using the diversity and abundance of macro-invertebrates as indicators. Scores can be shown as the median value of all samples taken from the applicable stream. • BIBI data is highly useful for fresh water, but is not available for salt water. As it cannot be collected in all streams, other measures of aquatic health may be needed. It is a good metric on a yearly scale for the general health of a stream and shows a good correlation with impervious surface and flow metrics. • Terrestrial insects are a good indicator of shoreline conditions and an important prey component for juvenile salmon. • Local government can collect this data relatively inexpensively.
Puget Sound Stream Benthos: Restoration Priorities – King County worked with regional partners to develop a framework for identifying sites and strategies to protect watersheds with "excellent" B-IBI scores or restore watersheds with "fair" B-IBI scores (King County, 2015b). B-IBI Restoration Decision Framework and Site Identification - This report explains the criteria used for selecting and prioritizing "Fair" B-IBI sites for restoration actions and lists the selected sites (King County, 2014b).	
Known Water Quality Impairment	
Data Sources	***Comments / Notes***

Table I-E.3: Recommended Data Sources for Use in Watershed Prioritization Steps (continued)

Data Sources	Comments / Notes
Ecology listed water quality impairments - State Water Quality Assessment (cat 4a, 4b, 4c, or 5) at Ecology's Water Quality Assessment and 303(d) List.	Waterbodies identified on Ecology's 303 (d) list as category 5 or 5B due to impairment from the indicated water quality parameter.
Known water quality concerns based on locally-collected data: High temperature, low dissolved oxygen, and high fecal coliform bacteria.	These data may be collected by local governments, volunteers, Ecology, and others.
Shellfish bed health - shellfish bed closure(s)- Washington State Department of Health Beach Closures	Shellfish bed closures by the Washington Department of Health are an indicator of water quality issues.
Step 2: Flow Control Opportunity Assessment	
Existing/Current Land Cover - Percentage of land in the watershed in each category: forest, pasture, landscaping and impervious surface.	
Data Sources	***Comments / Notes***
Forest – percentage of land per aerial photography or satellite imagery.	• Disturbed land is the area in watersheds that is developed and not impervious, forested, or pasture. • Total impervious area will generally provide enough information for this purpose. For areas with highly porous soils, total impervious surface should be considered. • Effective impervious surface is the area in developed watersheds that is impervious and directly connected to the drainage system. But if effective impervious area information is available, it can be more useful. • If comparing two identical watersheds and one has a much higher effective impervious area, it should be considered for high priority retrofit designation. • A local government should use the best available data to determine these surfaces. See the Western Washington Land Cover Change Analysis discussed under Data

Table I-E.3: Recommended Data Sources for Use in Watershed Prioritization Steps (continued)

Data Sources	Comments / Notes
	Sources.
Pasture - percentage of land per aerial photography or satellite imagery. The pasture in this instance refers to areas that were pasture in the historic condition, i.e. prior to the influence of Euro-American settlement.	
Disturbed Land and Impervious surfaces - percentage of land in developed areas (all areas not pasture or forest) are identified as disturbed or impervious. This can be done at the parcel level, combining zoning or land use designations into commercial, industrial, low/medium/high density residential, and roads using aerial photography, satellite imagery or literature values.	
The Western Washington Land Cover Change Analysis project provides a look at land cover change over time and provides estimates of percent forest cover and impervious surface for designated catchment areas. It is based on specific aerial photographic analysis. WDFW is currently working on a high resolution land cover change product, available at: http://www.pshrcd.com/#/intro Square miles of road density as a percentage of the watershed – as a metric of aquatic health. Local governments will need to derive this data from GIS layers.	
Existing/Current Land Use Data – Percentage of land in use for commercial, industrial, roads (include the right-of-way parcel, private, and public roads), single-family and multi-family residential, and parks and undeveloped land.	Land use and land cover data are often available in the same data set.
Data Sources	***Comments / Notes***
Land uses are parcel based and calculated by summing different land use types into the categories presented from a maintained city or county Land Use GIS database.	
Buildable Lands Analysis per RCW 36.70A.215 information can also be used. Under the Buildable Lands Program, five Puget Sound counties (King, Snohomish, Pierce, Kitsap and Thurston) monitor the intensity and density of development to determine whether a county and the cities within its boundaries are achieving urban densities sufficient to meet state growth projections. The 2014 reports can be viewed on county web sites.	• Land use designations/zoning are not always indicative of existing uses. • This exercise should be simple once the jurisdiction decides what to use for categories of existing land use.
City or county mapped number of culvert crossings (street,	• Doesn't include trail bridges, long

Table I-E.3: Recommended Data Sources for Use in Watershed Prioritization Steps (continued)

Data Sources	Comments / Notes
driveway or utility)/1,000 linear feet on mapped stream channels in each watershed within the jurisdiction. Local governments should use DNR or their own stream typing for mapping.	storm pipes, pipe outfalls, or piped sections of stream headwaters (even if mapped in culvert layer). • Multiple parallel culverts are counted as one crossing.
SalmonScape web site maintained by WDFW provides a computer mapping system for salmon recovery planners. It has lifestage and barriers information for mainstems and named tributaries. It will need to be verified and refined by local data and knowledge, especially for smaller or un-named tributaries.	
Age and condition of stormwater management Flow Control infrastructure	
Data Sources	***Comments / Notes***
Local government inventory of outdated Flow Control infrastructure needing retrofit based on flow duration. Infrastructure built to earlier stormwater design standards (or prior to adoption of standards) is likely to be more appropriate for retrofit.	• Local government infrastructure inspection and maintenance records may offer insight into the age and condition of stormwater controls. • This data indicates the environmental lift potential from installing stormwater retrofits. While a good indicator, not all jurisdictions will have this information.
Local government mapped number and distribution of stormwater piped and ditch outfalls.	• Mapped stormwater outfalls draining pollution generating surfaces for 1,000 linear feet on all stream classes within the jurisdiction. • All permitted MS4 cities and counties are required to map all known MS4 outfalls and discharge points.
Readiness to proceed	
Data Sources	***Comments / Notes***
Local knowledge of alignment with other programs such as tree planting, capital improvement plan, asset management plans, etc.	This criterion recognizes opportunities for leveraging other programs.
Watershed Area Data	
Data Sources	***Comments / Notes***

Table I-E.3: Recommended Data Sources for Use in Watershed Prioritization Steps (continued)

Data Sources	Comments / Notes
Watershed area data –inside and outside jurisdictional boundaries. Local governments could be very accurate with this exercise or simply use topography to delineate areas that drain to each receiving water body/receiving waters. If nothing else, local governments could use catchments delineated in the Puget Sound Watershed Characterization Project. See https://-fortress.wa.gov/ecy/coastalatlas/wc/landingpage.html	Includes stormwater conveyance and topographic based watershed.
Each stream length—total stream miles and percentage of total stream miles within jurisdictional boundaries. Local governments should create their own stream data, which likely occurred as part of developing the critical areas ordinance.	• Even with inaccuracies local critical area maps should be sufficient. • Newer LiDAR data to map water bodies is by far the most accurate. • If a stream flows into the jurisdiction from a less developed area outside the jurisdiction, then the jurisdiction may want to prioritize that stream. Context will be important to understand the habitat well.
Class II (Department of Natural Resources Type F plus S) stream length inside jurisdictional boundaries. Local critical area mapping may provide this data.	The Washington State Forest Practices Board has adopted an interim water typing system in WAC 222-16-031. Type F streams have fish use as defined in WAC 222-16-031(2) and (3). Type S streams are inventoried shorelines of the state as referenced in WAC 222-16-031(1).
Coordination with State, Regional and Local Plans	
Data Sources	***Comments / Notes***
The Puget Sound Salmon Recovery Plan includes strategies and actions associated with marine and freshwater habitat protection and restoration, hatchery management, and harvest management. The Watershed Recovery Plan Chapters of the Salmon Recovery Plan include three-year work plans that identify priority projects and programs that can be started within the next three years. This includes capital and non-capital activities/projects for habitat protection and restoration.	
Total Maximum Daily Load plans, active and planned: A total maximum daily load (TMDL) is a numerical value representing the highest amount of pollutant a surface water body can	

Table I-E.3: Recommended Data Sources for Use in Watershed Prioritization Steps (continued)

Data Sources	Comments / Notes
receive and still meet water quality standards. Washington State's TMDL process identifies pollution sources within a watershed and determining what needs to change so that pollution is reduced or eliminated. A TMDL plan is developed with public input, and implemented through water quality improvement projects.	
Puget Sound Initiative Site Cleanups - Through the Puget Sound Initiative, Washington State has committed the resources and funding for a healthier Puget Sound and surrounding communities. Ecology's Toxics Cleanup Program has identified contaminated sites within one-half mile of the Sound. Ecology is taking a baywide approach, rather than site-specific, approach to cleaning up numerous sites within a geographic area.	
Puget Sound Action Agenda Ecosystem Recovery Targets – Setting targets is a critical part of the Action Agenda. The Partnership adopted ecosystem recovery targets as policy statements that reflect the region's commitments to and expectations for recovery, or a measurable path to recovery, by 2020. Targets are based on scientific understandings of the ecosystem. For example, a freshwater water quality target of B-IBI scores in small streams.	
Endangered Species Act listings and critical habitat designations – The federal services (NOAA Fisheries, US Fish and Wildlife, etc.) have authority under the federal Endangered Species Act to list plant or animal species as endangered (in danger of extinction) or threatened (likely to become endangered), and to designate critical habitat that must be protected for the species. For example, Chinook Salmon are listed as threatened with critical habitat in Puget Sound.	
Existing prioritization efforts if available, especially those with tribal co-manager involvement.	
Step 3: Environmental Justice and Social Equity (Tie Breaker)	
Coordination with State, Regional and Local Plans	
Data Sources	***Comments / Notes***

Table I-E.3: Recommended Data Sources for Use in Watershed Prioritization Steps (continued)

Data Sources	Comments / Notes
The U.S. Environmental Protection Agency (EPA) provides an Environmental Justice Screening and Mapping Tool that may help a city or county identify areas with minority and/or low-income populations, potential environmental quality issues, or the potential for disproportionate impacts due to a combination of environmental and demographic indicators. The Washington State Department of Health's *Washington State's Health Disparity Map* provides Washington State health information overlayed with EPA EJ screen data.	A city or county may determine that there are equity and social justice or environmental justice issues that need to be addressed in a watershed. If two or more watersheds are determined of equal priority using the other data sources listed above, cities and counties are encouraged to prioritize a watershed for stormwater retrofits using the factors in the EPA's ESJ Screening and Mapping Tool that are appropriate to their jurisdiction.

Prioritization Principles to Consider

As part of the prioritization analysis, Permittees must consider the following principles for establishing priority watersheds:

1. Give higher priority to watersheds with waterbodies that show low to moderate levels of impairment (e.g., as assessed via water quality data, BIBI scores, habitat surveys). These watersheds are expected to benefit more quickly as a result of stormwater control improvements.
2. Give higher priority to watersheds where the municipality can exert greater influence. For example, assign higher priority to watersheds that have most of their associated drainage area within the municipality, or where an inter-local agreement is in place with one or more neighboring municipalities to implement the transfer approach. In other words, if the municipality coordinates a priority watershed identification and rehabilitation strategy approach with a neighboring municipality, a shared watershed may score higher.
3. Give higher priority to watersheds where regional rehabilitation efforts are also focused. Certain watersheds may be identified as important under other planning processes such as WRIA plans, Salmon Recovery Plans, MTCA/Superfund cleanups, Endangered Species Act listings and critical habitat designations. Watersheds listed in the 303(d) Watershed Assessment as Category 5 based on B-IBI scores may warrant higher priority if low B-IBI scores are likely due at least in part to hydrologic conditions.

I-E.4 Effectiveness Monitoring for Stormwater Control Transfer Programs

Background

The Washington State Pollution Control Hearings Board ruled (PCHB No. 10-013) that a monitoring program is necessary to confirm the equivalency of a Stormwater Control Transfer Program's approach concerning compliance with the default stormwater management requirements in the

Phase I Municipal Stormwater Permit. Ecology supports the concept of establishing a monitoring program to document the effectiveness of a Stormwater Control Transfer Program in improving water quality and/or quantity conditions in a targeted, priority watershed and offers the following guidance for establishing such a program.

General Guidelines for Monitoring Programs

The purpose of the monitoring program is to measure the effectiveness of improvements in the high priority watershed(s) where stormwater facilities have been constructed under a Stormwater Control Transfer Program. The monitoring program shall track stream hydrologic changes. Monitoring in high priority watersheds in advance of facilities' construction is necessary to establish a baseline condition. Repeat the monitoring at some infrequent interval (i.e., annually is probably too frequent) to track cumulative improvements over a number of years, and after significant increments of program implementation.

An approach that would provide the most definitive data involves installing continuous recording stream flow gages to record flow data over a period of at least one year to establish a baseline. Two or more years of continuous streamflow data prior to initiating construction of Flow Control BMPs in the priority watershed is preferred. The more data available to establish the baseline, the more likely changes in stream flows as a result of BMP implementation will be discernible through computation of various hydrologic metrics. (If the watershed under study includes upgradient areas with uncontrolled inputs, then gages upstream and immediately downstream of the transfer area in the priority watershed will be needed.) Repeat the monitoring after the Stormwater Control Transfer Program is well under way, and a significant portion of the priority watershed has been retrofitted with Flow Control BMPs.

The continuous streamflow monitoring described above is the preferred option. However, municipalities can also consider reducing the monitoring to focus on capturing stream flows during storm events. Rainfall and corresponding flow gage-based monitoring should target a number of storms, covering all seasons and a range of storm sizes to define a baseline of stream responses to a variety of events. Repeat the monitoring after the Stormwater Control Transfer Program is well under way to provide data for comparing the pre- and post- project stream responses. The more pre- and post-data collected, the easier it will be to discern changes in stream flows.

I-E.5 Stormwater Facility Transfer Capacity Credits and Tracking

Purpose

This section describes a recommended method by which a municipality implementing a Stormwater Control Transfer Program can track the Flow Control “improvement transfer” obligation for each development project that proposes to either construct its Flow Control obligation in another location (equivalent facility), or purchase capacity in a regional stormwater facility in a high priority watershed.

Guidance for how to determine the capacity available in a regional stormwater facility constructed to provide Flow Control capacity in a priority watershed is provided in I-D.6 Regional Facility Area Transfers.

Determining a Project's Flow Control Improvement Transfer Obligation

The transfer obligation of a development/redevelopment project participating in a Stormwater Control Transfer Program is to provide Flow Control facilities fully meeting the requirements in I-3.4.7 MR7: Flow Control for areas equivalent to the pre-project land cover of the development/redevelopment project site. The transfer obligation shall be represented and tracked as acres of pre-project land cover for each of the following land cover categories:

- Impervious Area
- Other hard surfaces
- Lawn/landscape
- Pasture

NOTE: Projects that convert a forested (or historic prairie) land cover to any other post-developed land cover cannot make use of the Stormwater Control Transfer Program because the flow durations required to be matched at the project site are those of the forested (or historic prairie) condition.

Transfer obligation areas will be tracked by the Permittee to the nearest one-hundredth acre. Table I-E.4: Example Project to Demonstrate How and Where Flow Control Requirements Are Met in a Stormwater Control Transfer Program provides an example of a proponent proposing a 5 acre redevelopment project that will convert an existing mixed land use to 100% impervious (5 acres).

Table I-E.4: Example Project to Demonstrate How and Where Flow Control Requirements Are Met in a Stormwater Control Transfer Program

Pre-Project Land Cover	Post-Developed Land Cover	Flow Control Requirement(s) to be added as part of the Development Project
0.50 acres Forested	0.50 acres New Impervious	Project Site: 0.50 acres Impervious to Forested Transfer Site: No additional Improvements (transfer not allowed)
3.30 acres Pasture	3.30 acres New Impervious	Project Site: 3.30 acres Impervious to Pasture Transfer Site: 3.30 acres Pasture to Forest
1.00 acre Lawn/Landscape	1.00 acre New Impervious	Project Site: 1.00 acre Impervious to Lawn/Landscape Transfer Site: 1.00 acre Lawn/Landscape to Forested
0.20 acres Impervious	0.20 Replaced Impervious	Project Site: No additional improvements Transfer Site: 0.20 acres Impervious to Forested

The Stormwater Control Transfer Program allows the proponent to construct Flow Control facilities or purchase available capacity in an existing facility in a high priority watershed that serves a contributing area with at least:

- 3.30 acres of Pasture
- 1.00 acre of lawn/Landscape
- 0.20 acres of Effective Impervious Area

Tracking / Storing Stormwater Obligation Transfers

The project applicant will submit, and the municipality shall retain, tables for each development/redevelopment project proposing a stormwater transfer. The table will identify whether and to what extent surfaces are being managed on-site, and what surfaces are proposed for transfer. A useable tracking table is included as Table I-E.5: Project Transfer Obligation Table. All of the information in Table I-E.5: Project Transfer Obligation Table shall also be tracked by the municipality. Note that Project ID is a unique ID attached to the project site by the municipality. Similarly, Facility ID is a unique ID attached to the regional facility by the municipality.

A copy of the tracking table shall be retained with the project file. A second copy shall be placed within the file for the facility (regional or equivalent) in which capacity was purchased by that project.

Table I-E.5: Project Transfer Obligation Table

Project ID: **Project Name:** **Date:** **Address:** **Parcel #:** **Watershed:** **Date of Complete Application:**	**Acres (to the hundredth)**
1. Flow Control Improvement Transfer to Facility in Priority Watershed	
a. Impervious to Forest Debit	
b. Other Hard Surface to Forest Debit	
c. Lawn/Landscape to Forest Debit	
d. Pasture to Forest Debit	
2. Flow Control Provided at Project Site	
a. Impervious to Existing Forest	
b. Impervious to Existing Pasture	
c. Impervious to Existing Lawn/Landscape	
d. Other Hard Surface to Existing Forest	

Table I-E.5: Project Transfer Obligation Table (continued)

Project ID: **Project Name:** **Date:** **Address:** **Parcel #:** **Watershed:** **Date of Complete Application:**	**Acres (to the hundredth)**
e. Other Hard Surface to Existing Pasture	
f. Other Hard Surface to Existing Lawn/Landscape	
g. Lawn/Landscape to Existing Forest	
h. Lawn/Landscape to Existing Pasture	
i. Pasture to Existing Forest	
3. Stormwater Control Provided Only at Facility in Priority Watershed **Facility ID:** **Facility Name:**	
a. Impervious redeveloped as Impervious at the project site	
b. Other Hard Surface redeveloped as Other Hard Surface at the project site	
Notes: 1a = 3a 1b = 3b 1c = 2c + 2f 1d = 2b + 2e + 2h	

Volume II

Construction Stormwater Pollution Prevention

Stormwater Management Manual for Western Washington

Prepared by:

Washington State Department of Ecology
Water Quality Program

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Executive Summary of Volume II

Welcome to Volume II of Ecology's 2019 Stormwater Management Manual for Western Washington. Volume II addresses the planning, design, and implementation of BMPs before and during construction projects. In this Volume you will find the following:

II-1 Soil Erosion and Sedimentation from Construction Sites details the impacts that can occur from soil erosion and sedimentation at construction sites, if no construction stormwater BMPs are implemented.

II-2 Construction Stormwater Pollution Prevention Plans (Construction SWPPPs) outlines what a Construction SWPPP is, who is responsible for it, and the steps necessary to prepare and maintain it.

II-3 Construction Stormwater BMPs contains a library of construction stormwater BMPs, including both construction source control BMPs and construction runoff BMPs.

Appendix II-A: Recommended Standard Notes for Construction SWPPP Drawings provides standard notes that may be used in construction SWPPP drawings.

Refer to Volumes I, III, IV, and V for information on the following:

Volume I introduces the measures necessary to control the quantity and quality of stormwater produced by new development and redevelopment. It includes an introduction to stormwater management, guidance on regulatory requirements for stormwater management, and details the minimum requirements for new development and redevelopment sites.

Volume III provides guidance on how to choose, hydrologically model, and document stormwater BMPs in a stormwater site plan.

Volume IV contains a library of source control BMPs, categorized by types of activities.

Volume V contains a library of design criteria for BMPs that project proponents can use to meet I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.6 MR6: Runoff Treatment, and/or I-3.4.7 MR7: Flow Control.

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II-1 Soil Erosion and Sedimentation from Construction Sites

II-1.1 Soil Erosion

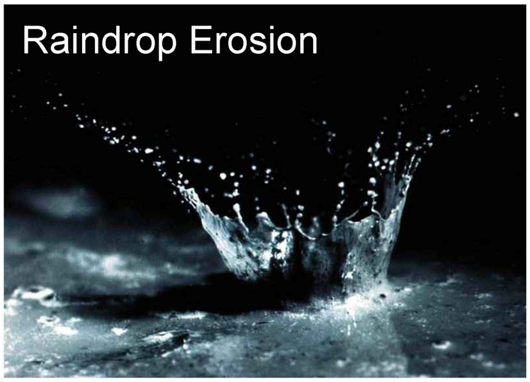
What is Soil Erosion?

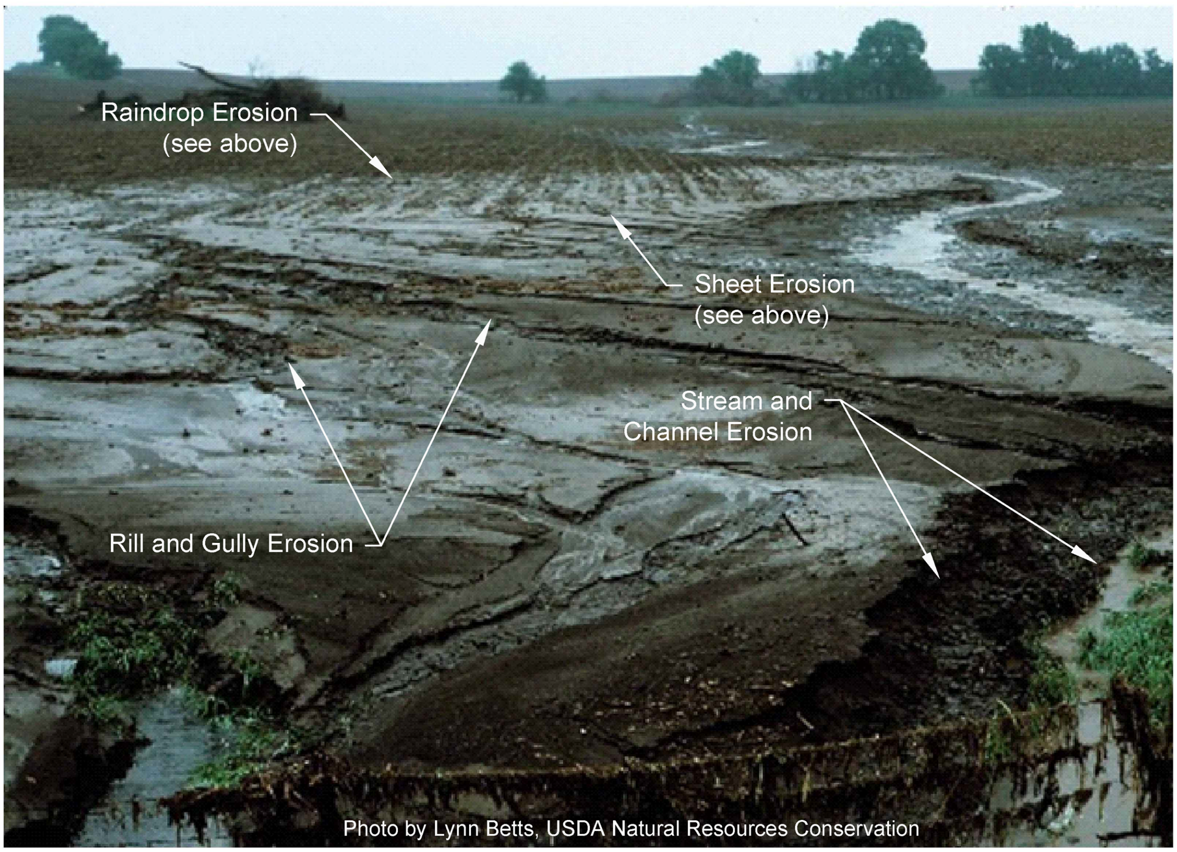
Soil erosion is defined as the removal of soil from its original location by the action of water, ice, gravity, or wind. In construction activities, soil erosion is largely caused by the force of falling and flowing water. Erosion by water includes the following processes:

- Raindrop Erosion: The direct impact of falling drops of rain on soil dislodges soil particles so that they can then be easily transported by runoff.
- Sheet Erosion: The removal of a layer of exposed soil by the action of raindrop splash and runoff, as water moves in broad sheets over the land (not confined in small depressions).
- Rill and Gully Erosion: As runoff concentrates in rivulets, it cuts grooves called rills into the soil surface. If the flow of water is sufficient, rills may develop into larger gullies.
- Stream and Channel Erosion: Increased volume and velocity of runoff in an unprotected, confined channel may cause stream meander instability and scouring of significant portions of the stream or channel banks and bottom.

Soil erosion by wind creates a water quality problem when dust is blown into water. Dust control on paved streets using washdown waters, if not conducted properly, can also create water quality problems.

Figure II-1.1: Types of Erosion





DEPARTMENT OF
ECOLOGY
State of Washington

Types of Erosion

Revised May 2017

Factors Influencing Erosion Potential

The erosion potential of soils can be readily determined using various models such as the Flaxman Method or the Revised Universal Soil Loss Equation (RUSLE).

The soil erosion potential of an area, including a construction site, is determined by four interrelated factors:

- Soil characteristics
- Vegetative cover
- Topography
- Climate

Collect, analyze, and use detailed information specific to the construction site for each of these four factors when selecting Construction Stormwater BMPs to prevent erosion.

The first three factors (soil characteristics, vegetative cover, and topography) are constant with respect to time until altered by construction. The designer, the project proponent, and the construction contractor should have a working knowledge of, and control over, these factors to provide high quality stormwater results.

The fourth factor, climate, is predictable by season, historical record, and probability of occurrence. While predicting a specific rainfall event is not possible, plan appropriate seasonal construction activity and use properly designed BMPs to minimize or avoid many of the impacts of construction stormwater runoff.

How Soil Characteristics Affect Erosion Potential

The vulnerability of soil to erode is determined by the following soil characteristics:

Particle Size: Soils that contain high proportions of silt and very fine sand are the most erodible and are easily detached and carried away. The erosion potential of soil decreases as the percentage of clay or organic matter increases; clay acts as a binder and tends to limit erosion potential. Most soils with high clay content are relatively resistant to detachment by rainfall and runoff. Once eroded, however, clays are easily suspended and settle out very slowly.

Organic Content: Organic matter creates a favorable soil structure, improving its stability and permeability. This increases infiltration capacity, delays the start of erosion, and reduces the amount of runoff.

The addition of organic matter increases infiltration rates (and, therefore, reduces surface flows and erosion potential), water retention, pollution control, and pore space for oxygen.

Soil Structure: Organic matter, particle size, and gradation affect soil structure, which is the arrangement, orientation, and organization of particles. When the soil system is protected from compaction, the natural decomposition of plant debris on the surface maintains a healthy soil food web. The soil food web in turn maintains the porosity both on and below the surface.

Soil Permeability: Soil permeability refers to the ease with which water passes through a given soil. Well-drained and well-graded gravel and gravel mixtures with little or no silt are the least erodible soils. Their high permeability and infiltration capacity helps prevent or delay runoff.

How Vegetative Cover Affects Erosion Potential

Vegetative cover plays an extremely important role in controlling erosion by:

- Shielding the soil surface from the impact of falling rain.
- Slowing the velocity of runoff, thereby permitting greater infiltration.
- Maintaining the soil's capacity to absorb water through root zone uptake and evapotranspiration.
- Holding soil particles in place.

Limiting the removal of existing vegetation and decreasing duration of soil exposure to rainfall events can reduce erosion. Give special consideration to preserving existing vegetation on areas with a high potential for erosion such as erodible soils, steep slopes, drainage ways, and the banks of streams. When it is necessary to remove vegetation, such as removing noxious weeds, revegetate these areas immediately.

How Topography Affects Erosion Potential

The size, shape, and slope of a construction site influence the amount and rate of stormwater runoff. Each site’s unique dimensions and characteristics provide both opportunities for and limitations on the use of specific control measures to protect vulnerable areas from high runoff amounts and rates. Slope length, steepness, and surface texture are key elements in determining the volume and velocity of runoff. As slope length and/or steepness increase, the rate of runoff and the potential for erosion increases. Slope orientation is also a factor in determining erosion potential. For example, a slope that faces south and contains dry soils may provide such poor growing conditions that vegetation will be difficult to re-establish.

How Climate Affects Erosion Potential

Seasonal temperatures and the frequency, intensity, and duration of rainfall are fundamental in determining amounts of runoff. As the volume and the velocity of runoff increase, the likelihood of erosion increases. Where storms are frequent, intense, or long, erosion risks are high. Seasonal changes in temperature, as well as variations in rainfall, help to define the period of the year when there is a high erosion risk. When precipitation falls as snow, erosion may not occur until the spring, when melting snow adds to the runoff, and erosion potential will be higher. Partially frozen ground reduces infiltration capacity. Rain-on-snow events are common in western Washington between 1,500- and 3,000-foot elevations.

Western Washington is characterized in fall, winter, and spring by storms that are mild and long lasting. The fall and early winter events saturate the soil profile and fill stormwater detention ponds, increasing the amount of runoff leaving the construction site. Shorter-term, more intense storms occur in the summer. These storms can cause problems if adequate BMPs have not been installed on site.

II-1.2 Sedimentation

Sedimentation is defined as the gravity-induced settling of soil particles transported by water. The process is accelerated in slower-moving, quiescent stretches of natural waterbodies or in treatment facilities such as sediment ponds and wetponds.

Sedimentation occurs when the velocity of water in which soil particles are suspended is slowed for a sufficient time to allow the soil particles to settle. The settling rate depends on the soil particle size. Heavier particles, such as sand and gravel, settle more rapidly than fine particles such as clay and silt. Sedimentation of clay soil particles is reduced due to clay's relative low density and electro-charged surfaces, which discourage aggregation. The presence of clay particles in stormwater run-off can result in highly turbid water, which is not amenable to treatment by settling.

Turbidity, an indirect measure of soil particles in water, is one of the primary water quality standards in Washington State law (WAC 173-201A-200). Turbidity is increased when erosion carries soil particles into receiving waters. Treating stormwater to reduce turbidity can be an expensive, difficult process with limited effectiveness. Any actions or prevention measures that reduce the volume of water needing treatment for turbidity are beneficial.

II-1.3 Soil Erosion and Sedimentation Impacts

Soil erosion and sedimentation caused by land development impact the environment, damaging aquatic and recreational resources, as well as affecting aesthetic qualities. Erosion and sedimentation ultimately affect everyone.

Common examples of soil erosion and sedimentation impacts are:

- Natural, nutrient-rich topsoils erode. Re-establishing vegetation is difficult without applying soil amendments and fertilizers.
- Silt fills culverts and storm drains, decreasing capacities and increasing flooding and maintenance frequency.
- Detention facilities fill rapidly with sediment, decreasing storage capacity and increasing flooding.
- Sediment clogs infiltration devices, causing failure.
- Sediment causes obstructions in streams and harbors, requiring dredging to restore navigability.
- Shallow areas in lakes form rapidly, resulting in growth of aquatic plants and reduced usability.
- Nutrient loading from phosphorus and nitrogen attached to soil particles and transported to lakes and streams cause a change in the water pH, algal blooms, and oxygen depletion, leading to eutrophication and fish kills.
- Water treatment for domestic uses becomes more difficult and costly.
- Turbid water replaces aesthetically pleasing, clear, clean water in streams and lakes.
- Eroded soil particles decrease the viability of macro-invertebrates and food-chain organisms,

impair the feeding ability of aquatic animals, clog gill passages of fish, and reduce photosynthesis.

- Sediment-clogged gravel diminishes fish spawning and can smother eggs or young fry.

Costs associated with these impacts may be obvious or subtle. Some are difficult to quantify, such as the loss of aesthetic values or recreational opportunities. Restoration and management of a single lake can cost millions of dollars. Reductions in spawning habitat, and subsequent reduction in salmon and trout production, cause economic losses to sport fisheries, traditional Native American fisheries, and the fishing industry. The maintenance costs of man-made structures and harbors are readily quantifiable. Citizens pay repeatedly for these avoidable costs in their tax dollars.

Effective erosion and sediment control practices on construction sites can greatly reduce undesirable environmental impacts and costs. Being aware of the erosion and sedimentation process is helpful in understanding the role of Construction Stormwater BMPs in controlling stormwater runoff.

II-2 Construction Stormwater Pollution Prevention Plans (Construction SWPPPs)

II-2.1 What is a Construction SWPPP?

A Construction Stormwater Pollution Prevention Plan (SWPPP) is a written document (text and drawings) to implement measures to identify, prevent, and control the contamination of stormwater from construction sites. The Construction SWPPP explains and illustrates the measures, usually in the form of best management practices (BMPs), to implement on a construction site to control potential pollution problems.

While it is a good idea to include standards and specifications from the Construction SWPPP in the contract documents, the Construction SWPPP should be a separate document that can stand alone.

As site work progresses, the Construction SWPPP must be reviewed and modified routinely in prescribed time periods to reflect changing site conditions, subject to the rules for plan modification in the Construction Stormwater General Permit and/or the local permitting authority.

II-2.2 When is a Construction SWPPP Required?

A Construction Stormwater Pollution Prevention Plan (SWPPP) is required if one of the following applies:

- The construction project must have coverage under the Construction Stormwater General Permit (CSWGP). See I-2.7 Construction Stormwater General Permit.
- The construction project is located in a municipality covered under one of the following Municipal Stormwater Permits and meets the thresholds for requiring a Construction SWPPP in the permit:
    - Phase 1
    - Western Washington Phase II
- The local permitting authority requires a Construction SWPPP. Check with your jurisdiction about local requirements related to construction stormwater.
- Ecology and/or the local permitting authority determined the project, site, or facility to be a significant contributor of pollutants to waters of the state.

II-2.3 Who is Responsible for the Construction SWPPP?

The owner or lessee of the land being developed is responsible for preparing the Construction SWPPP and submitting it to local authorities. The owner or lessee may designate someone (that is, an engineer, architect, contractor, etc.) to prepare the Construction SWPPP, but the owner retains the ultimate responsibility for environmental protection at the site.

An engineer is required when proposed BMPs require design calculations such as, temporary detention ponds or ditch sizing.

The Construction SWPPP narrative must be located on the construction site or within reasonable access to the site for construction and inspection personnel. A copy of the Construction SWPPP drawings must be kept on the construction site at all times.

II-2.4 Preparing Construction SWPPPs

This section presents what you should consider when preparing a Construction SWPPP, as well as what you should include in the Construction SWPPP document. Local permitting authorities may allow small construction projects to prepare a simpler Construction SWPPP, consisting of a checklist and drawings. Designers should check with the local permitting authority about local requirements for Construction SWPPPs.

On construction sites that discharge to surface water, the primary concern in the preparation of the Construction SWPPP is compliance with Washington State Water Quality Standards. On construction sites that infiltrate all stormwater runoff, the primary concern in the preparation of the Construction SWPPP is the protection of the infiltration facilities from fine sediments during the construction phase and protection of ground water from other pollutants. Several of the other elements are very important at these sites as well, such as marking the clearing limits, establishing the construction access, and managing the project.

Each of the thirteen elements identified in I-3.4.2 MR2: Construction Stormwater Pollution Prevention Plan (SWPPP) must be considered and included in the SWPPP unless site conditions render the element unnecessary and the exemption from that element is clearly justified in the narrative of the SWPPP.

Ecology has prepared the following tools for your use as you prepare your Construction SWPPP:

- Construction SWPPP Template (available at the following web address):

  https://ecology.wa.gov/Asset-Collections/Doc-Assets/Water-quality/Water-Quality-Permits/Stormwater-General-Permits/Construction-Stormwater-General-Permit/NEW-SWPPP

  This customizable template presents the recommended structure and content for the Construction SWPPP.

- Construction SWPPP Checklist, available for download within the interactive online 2019 SWMMWW. The interactive online 2019 SWMMWW is available at the following web address:

  https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Stormwater-manuals

  This checklist is a quick reference to help determine if all the major items are included in the Construction SWPPP.

Step 1: Research Site Conditions

Consider and research the following site specific factors to understand the site specific construction stormwater pollution prevention needs.

Topography

Consider the topography of the site. The primary topographic considerations are slope steepness and length. Steeper and longer slopes have greater erosion potential than do flat and short slopes. A licensed engineer in the state of Washington, soil professional, or certified erosion control specialist should determine erosion potential.

Drainage

Identify existing drainage patterns including swales, ditches, storm drain pipe systems, etc.

Plan to convey runoff through natural drainage patterns that consist of overland flow, swales, and depressions to avoid constructing an artificial drainage system. Properly stabilize man-made ditches and waterways so they do not create erosion problems. Ensure that increased runoff from the site will not erode or flood the existing natural drainage system. Consider possible sites for temporary stormwater retention and detention.

Direct construction away from areas with saturated soil where you may encounter ground water and away from critical areas where drainage may concentrate. Preserve natural drainage patterns on the site.

Soils

Identify soil type(s) and erodibility (low, medium, high or an index value) on the site. Evaluate soil properties such as surface and subsurface runoff characteristics, depth to impermeable layer, depth to seasonal ground water table, permeability, shrink-swell potential, texture, settleability, potential contamination, and erodibility.

Express these qualities in averaged or nominal terms for the site. This information is often available in published literature by qualified soil professionals or engineers. For example, the *1983 Soil Survey of Snohomish County* lists the following information for each soil mapping unit or designation (e.g., a Sultan silt loam):

- A sieve analysis of the soils
- Permeability (in/hr)
- Available water-holding capacity (in/in)
- The percent of organic matter

Soils information can be obtained from a Natural Resource Conservation Service (NRCS) manual (if one has been published for the county containing the site) or the NRCS' Web Soil Survey website at http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm. If a soil survey is not available, make a request to a District NRCS.

Additionally, soil data can be obtained through site soil analysis as a part of preparation of a Stormwater Site Plan (See III-3 Stormwater Site Plans).

Ground Cover

Identify features such as tree clusters, grassy areas, and unique or sensitive vegetation. Unique vegetation may include existing trees above a given diameter. Investigate local requirements regarding tree preservation. Note any existing denuded or exposed soil areas.

Ground cover is the most important factor in terms of preventing erosion. Saving existing vegetation will prevent erosion better than constructing BMPs. Trees and other vegetation protect the soil structure. If you cannot save the existing vegetation, consider such practices as phasing construction, temporary seeding, and mulching. Phasing construction involves stabilizing one part of the site before disturbing another. In this way, the entire site is not disturbed at once.

Critical Areas

Identify critical areas adjacent to or within the site. Critical areas may include flood hazard areas, mine hazard areas, slide hazard areas, sole source aquifers, wetlands, streambanks, fish-bearing streams, and other water bodies. Any critical areas within or adjacent to the site should exert a strong influence on land development decisions. Delineate critical areas and their buffers on the Construction SWPPP drawings and clearly flag critical areas in the field. Chain link fencing may be more useful than flagging to assure that equipment operators stay out of critical areas.

Only unavoidable work should take place within critical areas and their buffers. Such unavoidable work will require special BMPs, permit restrictions, and mitigation plans – documented routinely in the Construction SWPPP.

Adjacent Areas

Identify existing buildings, roads, and facilities adjacent to or within the site. Prepare to identify existing and proposed utility locations, construction clearing limits and erosion and sediment control BMPs on the drawings.

The analysis of adjacent properties should focus on areas both upslope and downslope from the construction project. Water bodies that will receive direct runoff from the site are a major concern. Evaluate the types, values, sensitivities of, and risks to downstream resources such as private property, stormwater facilities, public infrastructure, or aquatic systems.

Existing Encumbrances

Identify wells, existing and abandoned septic drainfields, utilities, easements, setbacks, and site constraints.

Precipitation Records

Determine the average monthly rainfall and rainfall intensity for the required design storm events. These records may be available from the local permitting agency. You may also refer to Appendix III-

B: Isopluvial Maps for Design Storms and Appendix III-C: Rainfall Amounts and Statistics to help determine rainfall patterns at your site.

Timing of the Project

Consider the timing and duration of the project when selecting BMPs. Projects that will proceed during the wet season and projects that will last through several seasons must take all necessary precautions to remain in compliance with the water quality standards.

Step 2: Prepare the SWPPP

After collecting and analyzing the data described above to determine the site limitations, designers can then develop a Construction SWPPP. Designers must consider the 13 elements described in I-3.4.2 MR2: Construction Stormwater Pollution Prevention Plan (SWPPP) and include them in the Construction SWPPP; unless site conditions render the element unnecessary and the exemption from that element is clearly justified in the narrative of the SWPPP.

A Construction SWPPP includes a narrative and drawings. The narrative is a written statement to explain and justify the pollution prevention decisions made for a particular project. The narrative contains concise, site specific information about existing conditions, construction schedules, and other pertinent items that are not contained on the drawings. The drawings show, on a site map, the specific BMPs that will be installed. Provide text notes on the drawings to describe the performance standards the BMPs should achieve, and actions to take if the performance goals are not achieved. See the sections below for further information on what to include in the Construction SWPPP narrative and drawings.

Prepare and retain reports summarizing the scope of inspections, the personnel conducting the inspection, the date(s) of the inspection, major observations relating to implementing the Construction SWPPP, and actions taken as a result of these inspections as part of the Construction SWPPP.

Construction SWPPPs can also contain BMPs from other guidance documents or manuals which Ecology has approved as providing an equivalent level of pollution prevention. If a Construction SWPPP uses an experimental, modified, or approved equivalent BMP, then the SWPPP must contain the following:

1. The technical basis for the selection of the experimental, modified, or approved equivalent BMP (scientific, technical studies, and/or modeling) that support the performance claims for the BMP.

2. An assessment of how the experimental, modified, or approved equivalent BMP will satisfy all known, available, and reasonable methods of prevention, control and treatment (AKART) requirements and the applicable federal technology-based treatment requirements under 40 Code of Federal Regulations (CFR) part 125.3.

Ecology has a list of manufactured BMPs that we consider Functionally Equivalent to BMPs listed in this manual. Designers can access this list of Functionally Equivalent BMPs at:

https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies

Construction SWPPP Narrative

The author of the Construction SWPPP should evaluate the following subject areas for inclusion in the Construction SWPPP narrative. The subject areas below are not an outline for the Construction SWPPP narrative. Not all items listed below are applicable to all construction projects. The author of the Construction SWPPP should ensure that the applicable sections are addressed.

- General Information on the Existing Site and Project
  - Project description: Describe the nature and purpose of the construction project. Include the total size of the area, any increase in existing impervious area; the total area expected to be disturbed by clearing, grading, excavation or other construction activities, including off-site borrow and fill areas; and the volumes of grading cut and fill that are proposed.
  - Existing site conditions: Describe the existing topography, vegetation, and drainage. Include a description of any structures or development on the parcel including the area of existing impervious surfaces.
  - Adjacent areas: Describe adjacent areas, including streams, lakes, wetlands, residential areas, and roads that the construction project might affect. Describe how upstream drainage areas may affect the site. Provide a description of the upstream drainage leading to the site and the downstream drainage leading from the site to the receiving body of water.
  - Critical areas: Describe areas on or adjacent to the site that are classified as critical areas. Critical areas that receive runoff from the site shall be described up to ¼ mile away. The local permitting authority may increase the distance. Describe special requirements for working near or within these areas.
  - Soil: Describe the soil on the site, giving such information as soil names, mapping unit, erodibility, settleability, permeability, depth, depth to ground water, texture, and soil structure.
  - Potential erosion problem areas: Describe areas on the site that have potential erosion problems.
- 13 Elements: Describe how the Construction SWPPP addresses each of the 13 required elements (see I-3.4.2 MR2: Construction Stormwater Pollution Prevention Plan (SWPPP)). Include the type and location of BMPs used to satisfy the required element. Often using a combination of BMPs is the best way to satisfy required elements. If an element is not applicable to a project, provide a written justification for why it is not applicable.
  - If you propose to use a permanent BMP as temporary storage, provide the plan to return the BMP to the designed condition prior to leaving the site.
- Construction Schedule and Phasing: Describe the construction schedule. If the schedule extends into the wet season, describe what activities will continue during the wet season and how the transport of sediment from the construction site to receiving waters will be prevented. Describe the intended sequence and timing of construction activities and any proposed construction phasing.

- Financial/Ownership Responsibilities: Describe ownership and obligations for the project. Include bond forms and other evidence of financial responsibility for environmental liabilities associated with construction.
- Engineering calculations: Attach any calculations made for the design of such items as sediment ponds, diversions, and waterways, as well as calculations for runoff and stormwater detention design (if applicable). Engineering calculations must bear the signature and stamp of an engineer licensed in the state of Washington.
- Certified Erosion and Sediment Control Lead (CESCL): Identify CESCL(s) along with their contact information and expiration of their CESCL certification.

Construction SWPPP Drawings

The author of the Construction SWPPP should include the following items in the Construction SWPPP drawings. Not all items listed below are applicable to all construction projects. The author of the Construction SWPPP should ensure that the applicable sections are addressed.

- Vicinity map: Provide a vicinity map with enough detail to identify the location of the construction site, adjacent roads, and receiving waters.
- Site map: Provide a site map(s) showing the features listed below. The site map requirements may be met using multiple plan sheets for ease of legibility.
    - A legal description of the property boundaries or an illustration of property lines (including distances) in the drawings.
    - The direction of north in relation to the site.
    - Existing structures and roads, if present.
    - The boundaries of and labels indicating different soil types.
    - Areas of potential erosion problems.
    - Any on-site and adjacent surface waters, critical areas, their buffers, FEMA base flood boundaries, and Shoreline Management boundaries.
    - Existing contours and drainage basins and the direction of flow for the different drainage areas.
    - Final and interim grade contours as appropriate, drainage basins, and the direction of stormwater flow during and upon completion of construction.
    - Construction clearing limits.
    - Areas of soil disturbance, including all areas affected by clearing, grading and excavation.
    - Locations where stormwater discharges to surface waters during and upon completion of construction.
    - Existing unique or valuable vegetation and the vegetation that is to be preserved.

- Cut and fill slopes indicating top and bottom of slope catch lines.
- Stockpile, waste storage, and vehicle storage/maintenance areas.
- Total cut and fill quantities and the method of disposal for excess material.

- Conveyance systems: Show on the site map the following temporary and permanent conveyance features:
  - Locations for temporary and permanent swales, interceptor trenches, or ditches.
  - Drainage pipes, ditches, or cut-off trenches associated with erosion and sediment control and stormwater management.
  - Temporary and permanent pipe inverts and minimum slopes and cover.
  - Grades, dimensions, and direction of flow in all ditches and swales, culverts, and pipes.
  - Details for bypassing off-site runoff around disturbed areas.
  - Locations and outlets of any dewatering systems.
- Location of detention BMPs: Show on the site map the locations of stormwater detention BMPs.
- Erosion and Sediment Control (ESC) BMPs: Show on the site map all major structural and nonstructural ESC BMPs including:
  - The location of sediment pond(s), pipes and structures.
  - Dimension of pond berm widths and inside and outside pond slopes.
  - The trap/pond storage required and the depth, length, and width dimensions.
  - Typical section views through pond and outlet structure.
  - Typical details of gravel cone and standpipe, and/or other filtering devices.
  - Stabilization technique details for inlets and outlets.
  - Control/restrictor device location and details.
  - Stabilization practices for berms, slopes, and disturbed areas.
  - Rock specifications and detail for rock check dam, if used.
  - Spacing for rock check dams as required.
  - Front and side sections of typical rock check dams.
  - The location, detail, and specification for silt fence.
  - The construction entrance location and a detail.
- Detailed drawings: Any structural source control practices used that are not referenced in this manual or other local manuals must be explained and illustrated with detailed drawings.

- Other pollutant BMPs: Indicate on the site map the location of BMPs to be used for the control of pollutants other than sediment such as high or low pH and hydrocarbons.
- Monitoring locations: Indicate on the site map the water quality sampling locations, if required by the local permitting authority or the Department of Ecology. Sampling stations must be located in accordance with applicable permit requirements.
- Standard notes are suggested in Appendix II-A: Recommended Standard Notes for Construction SWPPP Drawings. Notes addressing construction phasing and scheduling must be included on the drawings.

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II-3 Construction Stormwater BMPs

II-3.1 A Summary of Construction Stormwater BMPs

This chapter contains standards and specifications for temporary BMPs, used as appropriate during the construction phase of a project. Often using BMPs in combination is the best method to meet Construction Stormwater Pollution Prevention Plan (Construction SWPPP) requirements.

The standards and specifications in this chapter are not intended to limit innovative efforts to effectively control erosion and sedimentation. Construction SWPPPs can contain experimental BMPs or make minor modifications to standard BMPs. However, the permitting authority (state, local, or both) must approve such practices before use. Experimental and modified BMPs must achieve the same or better performance than the BMPs listed below.

None of the BMPs listed below will work successfully throughout the construction project without inspection and maintenance. Regular inspections to identify problems with the operation of each BMP, and the timely repair of any problems are essential to the continued operation of the BMPs. As site conditions change, BMPs must change to remain in compliance.

Construction stormwater BMPs are divided into two categories: Construction Source Control BMPs and Construction Runoff BMPs.

Table II-3.1: Construction Stormwater BMPs by SWPPP Element shows the relationship of the Construction Stormwater BMPs to the Construction SWPPP Elements described in I-3.4.2 MR2: Construction Stormwater Pollution Prevention Plan (SWPPP).

Table II-3.1: Construction Stormwater BMPs by SWPPP Element

Construction Stormwater BMP	Construction SWPPP Element #												
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13
Construction Source Control BMPs													
BMP C101: Preserving Natural Vegetation	✓												
BMP C102: Buffer Zones	✓												✓
BMP C103: High-Visibility Fence	✓												✓
BMP C105: Stabilized Construction Access		✓											
BMP C106: Wheel Wash		✓											

Table II-3.1: Construction Stormwater BMPs by SWPPP Element (continued)

Construction Stormwater BMP	Construction SWPPP Element #												
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13
BMP C107: Construction Road / Parking Area Stabilization		✓											
BMP C120: Temporary and Permanent Seeding					✓	✓							
BMP C121: Mulching					✓	✓							
BMP C122: Nets and Blankets					✓	✓		✓					
BMP C123: Plastic Covering					✓	✓							
BMP C124: Sodding					✓	✓							
BMP C125: Topsoiling / Composting					✓								
BMP C126: Polyacrylamide (PAM) for Soil Erosion Protection					✓								
BMP C130: Surface Roughening					✓	✓							
BMP C131: Gradient Terraces					✓	✓							
BMP C140: Dust Control					✓								
BMP C150: Materials on Hand											✓	✓	
BMP C151: Concrete Handling									✓				
BMP C152: Sawcutting and Surfacing Pollution Prevention									✓				
BMP C153: Material Delivery, Storage, and Containment									✓				

Table II-3.1: Construction Stormwater BMPs by SWPPP Element (continued)

Construction Stormwater BMP	Construction SWPPP Element #												
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13
BMP C154: Concrete Washout Area									✓				
BMP C160: Certified Erosion and Sediment Control Lead											✓	✓	
BMP C162: Scheduling												✓	
Construction Runoff BMPs													
BMP C200: Interceptor Dike and Swale						✓							✓
BMP C201: Grass-Lined Channels						✓							✓
BMP C202: Riprap Channel Lining								✓					
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 (TSD)						✓							✓
BMP C209: Outlet Protection			✓					✓					
BMP C220: Inlet Protection							✓						
BMP C231: Brush Barrier				✓									✓
BMP C232: Gravel Filter Berm				✓									

Table II-3.1: Construction Stormwater BMPs by SWPPP Element (continued)

Construction Stormwater BMP	Construction SWPPP Element #												
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13
BMP C233: Silt Fence				✓									✓
BMP C234: Vegetated Strip				✓									✓
BMP C235: Wattles			✓	✓									
BMP C236: Vegetative Filtration										✓			
BMP C240: Sediment Trap			✓	✓									
BMP C241: Sediment Pond (Temporary)			✓	✓									
BMP C250: Construction Stormwater Chemical Treatment				✓					✓				
BMP C251: Construction Stormwater Filtration				✓					✓				
BMP C252: Treating and Disposing of High pH Water									✓				

Construction SWPPP Elements:

Element 1: Preserve Vegetation / 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 Drain 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 Low Impact Development BMPs

II-3.2 Construction Source Control BMPs

BMP C101: Preserving Natural Vegetation

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.

Conditions of Use

Natural vegetation should be preserved on steep slopes, near perennial and intermittent watercourses or swales, and on building sites in wooded areas.

- As required by local governments.
- Phase construction to preserve natural vegetation on the project site for as long as possible during the construction period.

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. Local governments may also have ordinances to save natural vegetation and trees.
- Fence or clearly mark areas around trees that are to be saved. It is preferable to keep ground disturbance away from the trees at least as far out as the dripline.

Plants need protection from three kinds of injuries:

- *Construction Equipment* - This injury can be above or below the ground level. Damage results from scarring, cutting of roots, and compaction of the soil. Placing a fenced buffer zone around plants to be saved prior to construction can prevent construction equipment injuries.
- *Grade Changes* - Changing the natural ground level will alter grades, which affects the plant's ability to obtain the necessary air, water, and minerals. Minor fills usually do not cause problems although sensitivity between species does vary and should be checked. Trees can typically tolerate fill of 6 inches or less. For shrubs and other plants, the fill should be less.

  When there are major changes in grade, it may become necessary to supply air to the roots of plants. This can be done by placing a layer of gravel and a tile system over the roots before the fill is made. The tile system should be laid out on the original grade leading from a dry well around the tree trunk. The system should then be covered with small stones to allow air to circulate over the root area.

Lowering the natural ground level can seriously damage trees and shrubs. The highest percentage of the plant roots are in the upper 12 inches of the soil and cuts of only 2-3 inches can cause serious injury. To protect the roots it may be necessary to terrace the immediate area around the plants to be saved. If roots are exposed, construction of retaining walls may be needed to keep the soil in place. Plants can also be preserved by leaving them on an undisturbed, gently sloping mound. To increase the chances for survival, it is best to limit grade changes and other soil disturbances to areas outside the dripline of the plant.

- *Excavations* - Protect trees and other plants when excavating for drainfields, power, water, and sewer lines. Where possible, the trenches should be routed around trees and large shrubs. When this is not possible, it is best to tunnel under them. This can be done with hand tools or with power augers. If it is not possible to route the trench around plants to be saved, then the following should be observed:
    - Cut as few roots as possible. When you have to cut, cut clean. Paint cut root ends with a wood dressing like asphalt base paint if roots will be exposed for more than 24-hours.
    - Backfill the trench as soon as possible.
    - Tunnel beneath root systems as close to the center of the main trunk to preserve most of the important feeder roots.

Some problems that can be encountered with a few specific trees are:

- Maple, Dogwood, Red alder, Western hemlock, Western red cedar, and Douglas fir do not readily adjust to changes in environment and special care should be taken to protect these trees.
- The windthrow hazard of Pacific silver fir and madrona is high, while that of Western hemlock is moderate. The danger of windthrow increases where dense stands have been thinned. Other species (unless they are on shallow, wet soils less than 20 inches deep) have a low windthrow hazard.
- Cottonwoods, maples, and willows have water-seeking roots. These can cause trouble in sewer lines and infiltration fields. On the other hand, they thrive in high moisture conditions that other trees would not.
- Thinning operations in pure or mixed stands of Grand fir, Pacific silver fir, Noble fir, Sitka spruce, Western red cedar, Western hemlock, Pacific dogwood, and Red alder can cause serious disease problems. Disease can become established through damaged limbs, trunks, roots, and freshly cut stumps. Diseased and weakened trees are also susceptible to insect attack.

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. Treatment of sap flowing trees (fir, hemlock, pine, soft maples) is not advised as sap forms a natural healing barrier.

BMP C102: Buffer Zones

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 runoff velocities.

Conditions of Use

Buffer zones are used along streams, wetlands and other bodies of water that need protection from erosion and sedimentation. Contractors can use vegetative buffer zone BMPs to protect natural swales and they can incorporate them into the natural landscaping of an area.

Do not use critical-areas buffer zones as sediment treatment areas. These areas shall remain completely undisturbed. The local permitting authority may expand the buffer widths temporarily to allow the use of the expanded area for removal of sediment.

The types of buffer zones can change the level of protection required as shown below:

Designated Critical Area Buffers - buffers that protect Critical Areas, as defined by the Washington State Growth Management Act, and are established and managed by the local permitting authority. These should not be disturbed and must protected with sediment control BMPs to prevent impacts. The local permitting authority may expand the buffer widths temporarily to allow the use of the expanded area for removal of sediment.

Vegetative Buffer Zones - areas that may be identified in undisturbed vegetation areas or managed vegetation areas that are outside any Designated Critical Area Buffer. They may be utilized to provide an additional sediment control area and/or reduce runoff velocities. If being used for preservation of natural vegetation, they should be arranged in clumps or strips. They can be used to protect natural swales and incorporated into the natural landscaping area.

Design and Installation Specifications

- Preserving natural vegetation or plantings in clumps, blocks, or strips is generally the easiest and most successful method.
- Leave all unstable steep slopes in natural vegetation.
- Mark clearing limits and keep all equipment and construction debris out of the natural areas and buffer zones. Steel construction fencing is the most effective method to protect sensitive areas and buffers. Alternatively, wire-backed silt fence on steel posts is marginally effective. Flagging alone is typically not effective.
- Keep all excavations outside the dripline of trees and shrubs.
- Do not push debris or extra soil into the buffer zone area because it will cause damage by

burying and smothering vegetation.

- Vegetative buffer zones for streams, lakes or other waterways shall be established by the local permitting authority or other state or federal permits or approvals.

Maintenance Standards

Inspect the area frequently to make sure flagging remains in place and the area remains undisturbed. Replace all damaged flagging immediately. Remove all materials located in the buffer area that may impede the ability of the vegetation to act as a filter.

BMP C103: High-Visibility Fence

Purpose

High-visibility 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, exits, or internal roads.
- Protect areas where marking with survey tape may not provide adequate protection.

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.

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 requirements of this BMP.

Metal fences shall be designed and installed according to the manufacturer's specifications.

Metal fences shall be at least 3 feet high and must be highly visible.

Fences shall not be wired or stapled to trees.

Maintenance Standards

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

BMP C105: Stabilized Construction Access

Purpose

Stabilized construction accesses are established to reduce the amount of sediment transported onto paved roads outside the project site by vehicles or equipment. This is done by constructing a stabilized pad of quarry spalls at entrances and exits for project sites.

Conditions of Use

Construction accesses shall be stabilized wherever traffic will be entering or leaving a construction site if paved roads or other paved areas are within 1,000 feet of the site.

For residential subdivision construction sites, provide a stabilized construction access for each residence, rather than only at the main subdivision entrance. Stabilized surfaces shall be of sufficient length/width to provide vehicle access/parking, based on lot size and configuration.

On large commercial, highway, and road projects, the designer should include enough extra materials in the contract to allow for additional stabilized accesses not shown in the initial Construction SWPPP. It is difficult to determine exactly where access to these projects will take place; additional materials will enable the contractor to install them where needed.

Design and Installation Specifications

See Figure II-3.1: Stabilized Construction Access for details. Note: the 100' minimum length of the access shall be reduced to the maximum practicable size when the size or configuration of the site does not allow the full length (100').

Construct stabilized construction accesses with a 12-inch thick pad of 4-inch to 8-inch quarry spalls, a 4-inch course of asphalt treated base (ATB), or use existing pavement. Do not use crushed concrete, cement, or calcium chloride for construction access stabilization because these products raise pH levels in stormwater and concrete discharge to waters of the State is prohibited.

A separation geotextile shall be placed under the spalls to prevent fine sediment from pumping up into the rock pad. The geotextile shall meet the standards listed in Table II-3.2: Stabilized Construction Access Geotextile Standards.

Table II-3.2: Stabilized Construction Access Geotextile Standards

Geotextile Property	Required Value
Grab Tensile Strength (ASTM D4751)	200 psi min.

Table II-3.2: Stabilized Construction Access Geotextile Standards (continued)

Geotextile Property	Required Value
Grab Tensile Elongation (ASTM D4632)	30% max.
Mullen Burst Strength (ASTM D3786-80a)	400 psi min.
AOS (ASTM D4751)	20-45 (U.S. standard sieve size)

- Consider early installation of the first lift of asphalt in areas that will be paved; this can be used as a stabilized access. Also consider the installation of excess concrete as a stabilized access. During large concrete pours, excess concrete is often available for this purpose.
- Fencing (see BMP C103: High-Visibility Fence) shall be installed as necessary to restrict traffic to the construction access.
- Whenever possible, the access shall be constructed on a firm, compacted subgrade. This can substantially increase the effectiveness of the pad and reduce the need for maintenance.
- Construction accesses should avoid crossing existing sidewalks and back of walk drains if at all possible. If a construction access must cross a sidewalk or back of walk drain, the full length of the sidewalk and back of walk drain must be covered and protected from sediment leaving the site.

Alternative Material Specification

WSDOT has raised safety concerns about the Quarry Spall rock specified above. WSDOT observes that the 4-inch to 8-inch rock sizes can become trapped between Dually truck tires, and then released off-site at highway speeds. WSDOT has chosen to use a modified specification for the rock while continuously verifying that the Stabilized Construction Access remains effective. To remain effective, the BMP must prevent sediment from migrating off site. To date, there has been no performance testing to verify operation of this new specification. Jurisdictions may use the alternative specification, but must perform increased off-site inspection if they use, or allow others to use, it.

Stabilized Construction Accesses may use material that meets the requirements of WSDOT's *Standard Specifications for Road, Bridge, and Municipal Construction* Section 9-03.9(1) (WSDOT, 2016) for ballast except for the following special requirements.

The grading and quality requirements are listed in Table II-3.3: Stabilized Construction Access Alternative Material Requirements.

Table II-3.3: Stabilized Construction Access Alternative Material Requirements

Sieve Size	Percent Passing
2½″	99-100

Table II-3.3: Stabilized Construction Access Alternative Material Requirements (continued)

Sieve Size	Percent Passing
2″	65-100
¾″	40-80
No. 4	5 max.
No. 100	0-2
% Fracture	75 min.

- All percentages are by weight.
- The sand equivalent value and dust ratio requirements do not apply.
- The fracture requirement shall be at least one fractured face and will apply the combined aggregate retained on the No. 4 sieve in accordance with FOP for AASHTO T 335.

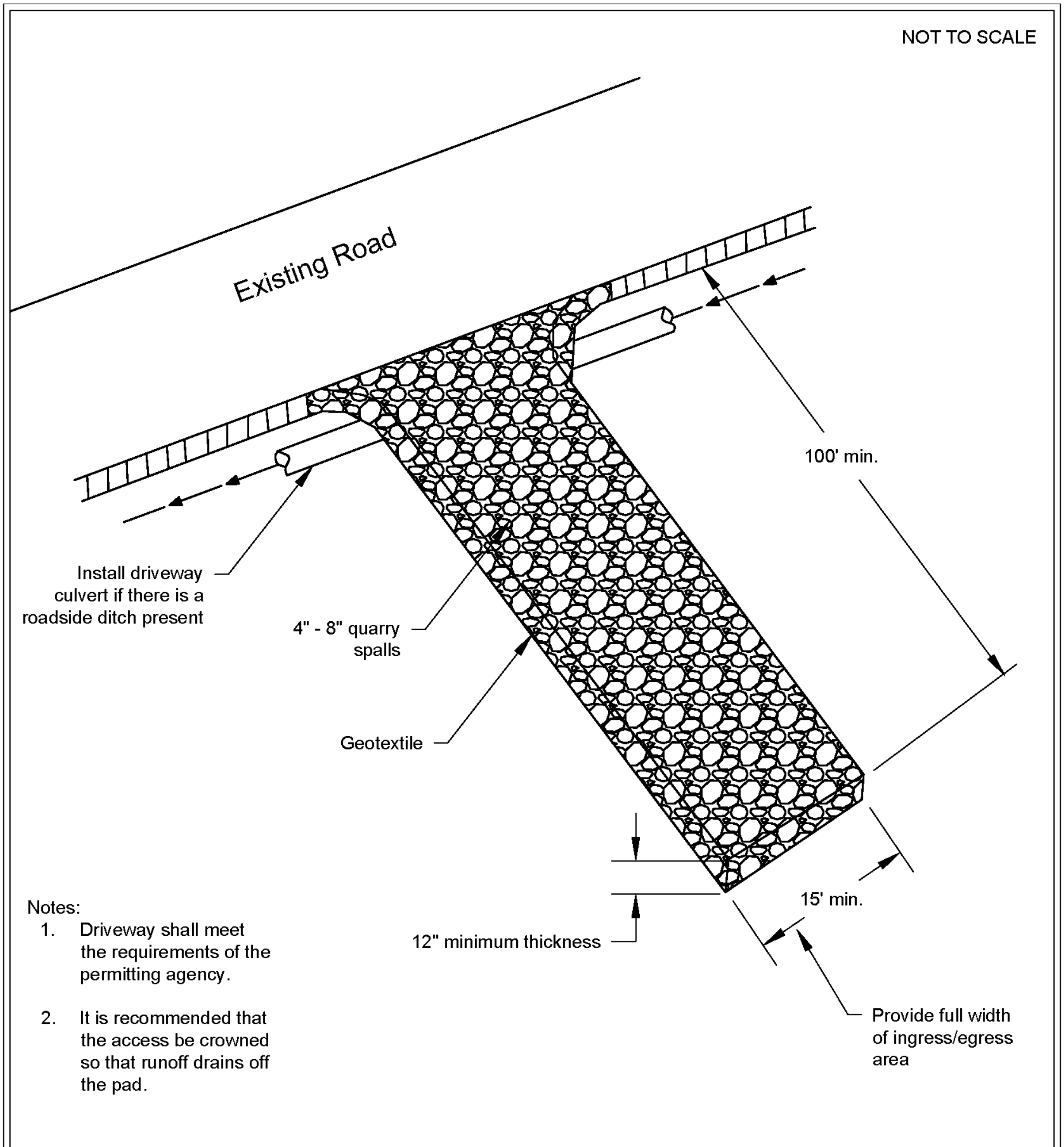
Maintenance Standards

Quarry spalls shall be added if the pad is no longer in accordance with the specifications.

- If the access is not preventing sediment from being tracked onto pavement, then alternative measures to keep the streets free of sediment shall be used. This may include replacement/cleaning of the existing quarry spalls, street sweeping, an increase in the dimensions of the access, or the installation of BMP C106: Wheel Wash.
- Any sediment that is tracked onto pavement shall be removed by shoveling or street sweeping. The sediment collected by sweeping shall be removed or stabilized on site. The pavement shall not be cleaned by washing down the street, except when high efficiency sweeping is ineffective and there is a threat to public safety. If it is necessary to wash the streets, the construction of a small sump to contain the wash water shall be considered. The sediment would then be washed into the sump where it can be controlled.
- 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.
- Any quarry spalls that are loosened from the pad, which end up on the roadway shall be removed immediately.
- If vehicles are entering or exiting the site at points other than the construction access(es), BMP C103: High-Visibility Fence shall be installed to control traffic.

- Upon project completion and site stabilization, all construction accesses intended as permanent access for maintenance shall be permanently stabilized.

Figure II-3.1: Stabilized Construction Access



DEPARTMENT OF ECOLOGY
State of Washington

Stabilized Construction Access

Revised June 2018

Approved as Functionally Equivalent

Ecology has approved products as able to meet the requirements of this BMP. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept these products, or may require additional testing prior to consideration for local use. Products that Ecology has approved as functionally equivalent are available for review on Ecology's website at:

https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies

BMP C106: Wheel Wash

Purpose

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

Conditions of Use

- Use a wheel wash when BMP C105: Stabilized Construction Access is not preventing sediment from being tracked off site.
- 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 drainage to a large 10-foot x 10-foot sump can be very effective.
- Wheel wash wastewater is not stormwater. It is commonly called process water, and must be discharged to a separate on-site treatment system that prevents discharge to waters of the State, or to the sanitary sewer with local sewer district approval.
- Wheel washes may use closed-loop recirculation systems to conserve water use.
- Wheel wash wastewater shall not include wastewater from concrete washout areas.
- When practical, the wheel wash should be placed in sequence with BMP C105: Stabilized Construction Access. Locate the wheel wash such that vehicles exiting the wheel wash will enter directly onto BMP C105: Stabilized Construction Access. In order to achieve this, BMP C105: Stabilized Construction Access may need to be extended beyond the standard installation to meet the exit of the wheel wash.

Design and Installation Specifications

Suggested details are shown in Figure II-3.2: Wheel Wash. The Local Permitting Authority may allow other designs. 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.

Midpoint spray nozzles are only needed in extremely muddy conditions.

Wheel wash systems should be designed with a small grade change, 6- to 12-inches for a 10-foot-wide pond, to allow sediment to flow to the low side of pond to help prevent re-suspension of sediment. A drainpipe with a 2- to 3-foot riser should be installed on the low side of the pond to allow for easy cleaning and refilling. 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.

Maintenance Standards

The wheel wash should start out each day with fresh water.

The wheel wash water should be changed a minimum of once per day. On large earthwork jobs where more than 10-20 trucks per hour are expected, the wheel wash water will need to be changed more often.

Approved as Functionally Equivalent

Ecology has approved products as able to meet the requirements of this BMP. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept these products, or may require additional testing prior to consideration for local use. Products that Ecology has approved as functionally equivalent are available for review on Ecology's website at:

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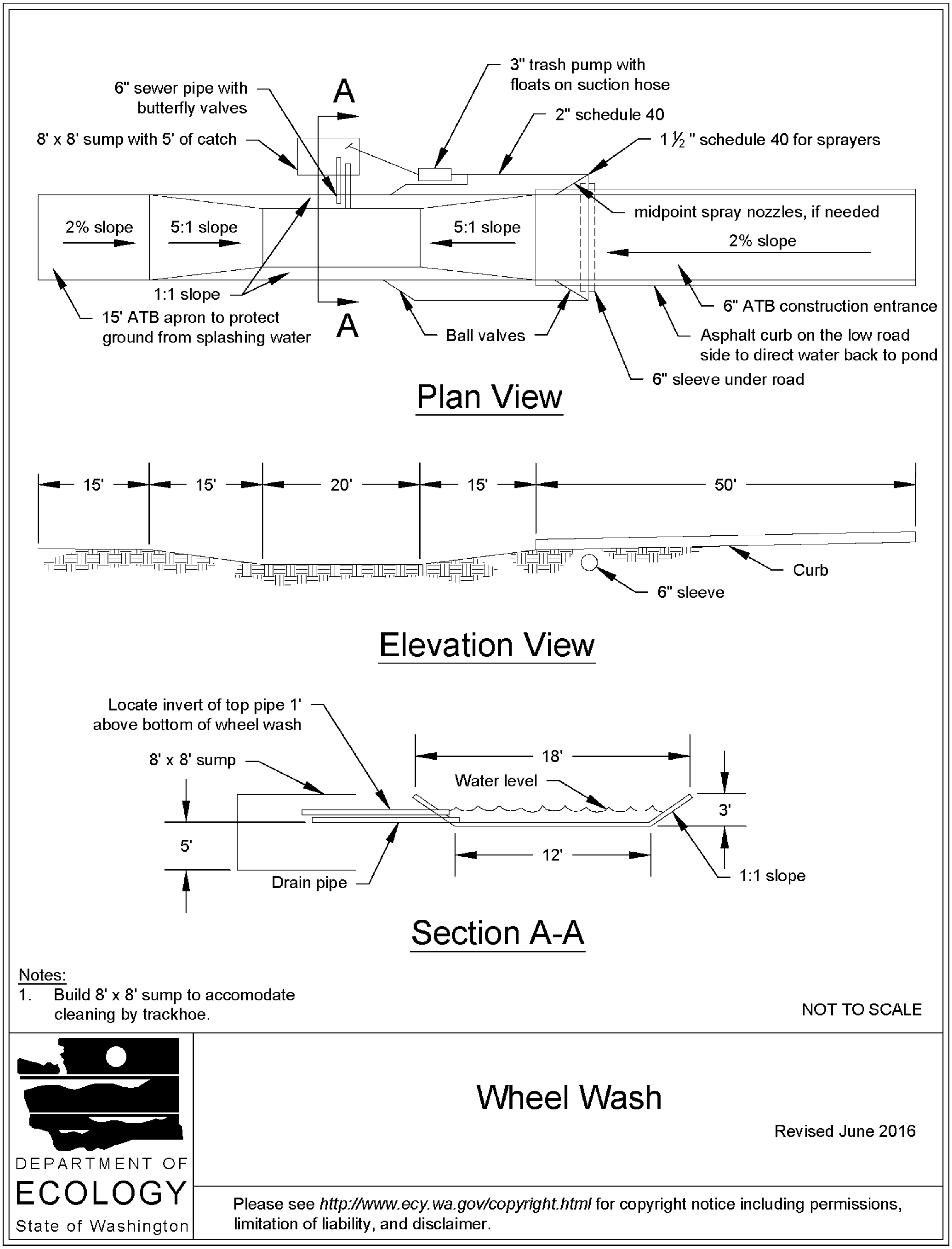
Figure II-3.2: Wheel Wash



BMP C107: Construction Road / Parking Area Stabilization

Purpose

Stabilizing roads, parking areas, and other on-site vehicle transportation routes immediately after grading reduces erosion caused by construction traffic or stormwater runoff.

Conditions of Use

Roads and parking areas shall be stabilized wherever they are constructed, whether permanent or temporary, for use by construction traffic.

BMP C103: High-Visibility Fence shall be installed, if necessary, to limit the access of vehicles to only those roads and parking areas that are stabilized.

Design and Installation Specifications

- On areas that will receive asphalt as part of the project, install the first lift as soon as possible.
- A 6-inch depth of 2- to 4-inch crushed rock, gravel base, or crushed surfacing base course shall be applied immediately after grading or utility installation. A 4-inch course of asphalt treated base (ATB) may also be used, or the road/parking area may be paved. It may also be possible to use cement or calcium chloride for soil stabilization. If cement or cement kiln dust is used for roadbase stabilization, pH monitoring and BMP C252: Treating and Disposing of High pH Water is necessary to evaluate and minimize the effects on stormwater. If the area will not be used for permanent roads, parking areas, or structures, a 6-inch depth of hog fuel may also be used, but this is likely to require more maintenance. Whenever possible, construction roads and parking areas shall be placed on a firm, compacted subgrade.
- Temporary road gradients shall not exceed 15 percent. Roadways shall be carefully graded to drain. Drainage ditches shall be provided 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. Drainage ditches shall be directed to a sediment control BMP.
- Rather than relying on ditches, it may also be possible to grade the road so that runoff sheetflows 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 that water can flow through, 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 or their buffers. 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.
- Storm drain inlets shall be protected to prevent sediment-laden water entering the drainage system (see BMP C220: Inlet Protection).

Maintenance Standards

Inspect stabilized areas regularly, especially after large storm events.

Crushed rock, gravel base, etc., shall be added as required to maintain a stable driving surface and to stabilize any areas that have eroded.

Following construction, these areas shall be restored to pre-construction condition or better to prevent future erosion.

Perform street cleaning at the end of each day or more often if necessary.

BMP C120: Temporary and Permanent Seeding

Purpose

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

Conditions of Use

Use seeding throughout the project on disturbed areas that have reached final grade or that will remain unworked for more than 30 days.

The optimum seeding windows for western Washington are April 1 through June 30 and September 1 through October 1.

Between July 1 and August 30 seeding requires irrigation until 75 percent grass cover is established.

Between October 1 and March 30 seeding requires a cover of mulch or an erosion control blanket until 75 percent grass cover is established.

Review all disturbed areas in late August to early September and complete all seeding by the end of September. Otherwise, vegetation will not establish itself enough to provide more than average protection.

Mulch is required at all times for seeding 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.

Seed and mulch all disturbed areas not otherwise vegetated at final site stabilization. Final stabilization means the completion of all soil disturbing activities at the site and the establishment of a permanent vegetative cover, or equivalent permanent stabilization measures (such as pavement, riprap, gabions, or geotextiles) which will prevent erosion. See BMP T5.13: Post-Construction Soil Quality and Depth.

Design and Installation Specifications

General

- Install channels intended for vegetation before starting major earthwork and hydroseed with a Bonded Fiber Matrix. For vegetated channels that will have high flows, install erosion control blankets over the top of hydroseed. Before allowing water to flow in vegetated channels, establish 75 percent vegetation cover. If vegetated channels cannot be established by seed before water flow; install sod in the channel bottom — over top of hydromulch and erosion control blankets.

- Confirm the installation of all required surface water control measures to prevent seed from washing away.
- Hydroseed applications shall include a minimum of 1,500 pounds per acre of mulch with 3 percent tackifier. See BMP C121: Mulching for specifications.
- Areas that will have seeding only and not landscaping may need compost or meal-based mulch included in the hydroseed in order to establish vegetation. Re-install native topsoil on the disturbed soil surface before application. See BMP T5.13: Post-Construction Soil Quality and Depth.
- 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. To overcome this, consider increasing seed quantities by up to 50 percent.
- Enhance vegetation establishment 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.

  Or, enhance vegetation by:

    - Installing the mulch, seed, fertilizer, and tackifier in one lift.
    - Spread or blow straw over the top of the hydromulch at a rate of 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 Bonded Fiber Matrix/ Mechanically Bonded Fiber Matrix (BFM/MBFMs) (3,000 pounds per acre minimum).

- Seed may be installed by hand if:
    - Temporary and covered by straw, mulch, or topsoil.
    - Permanent in small areas (usually less than 1 acre) and covered with mulch, topsoil, or erosion blankets.
- The seed mixes listed in Table II-3.4: Temporary and Permanent Seed Mixes include

recommended mixes for both temporary and permanent seeding.

- Apply these mixes, with the exception of the wet area seed mix, at a rate of 120 pounds per acre. This rate can be reduced if soil amendments or slow-release fertilizers are used. Apply the wet area seed mix at a rate of 60 pounds per acre.
- Consult the local suppliers or the local conservation district for their recommendations. The appropriate mix depends on a variety of factors, including location, exposure, soil type, slope, and expected foot traffic. Alternative seed mixes approved by the local authority may be used, depending on the soil type and hydrology of the area.

Table II-3.4: Temporary and Permanent Seed Mixes

Common Name	Latin Name	% Weight	% Purity	% Germination
Temporary Erosion Control Seed Mix A standard mix for areas requiring a temporary vegetative cover.				
Chewings or annual blue grass	*Festuca rubra var. commutata* or *Poa anna*	40	98	90
Perennial rye	*Lolium perenne*	50	98	90
Redtop or colonial bentgrass	*Agrostis alba* or *Agrostis tenuis*	5	92	85
White dutch clover	*Trifolium repens*	5	98	90
Landscaping Seed Mix A recommended mix for landscaping seed.				
Perennial rye blend	*Lolium perenne*	70	98	90
Chewings and red fescue blend	*Festuca rubra var. commutata* or *Festuca rubra*	30	98	90
Low-Growing Turf Seed Mix A turf seed mix for dry situations where there is no need for watering. This mix requires very little maintenance.				
Dwarf tall fescue (several varieties)	*Festuca arundinacea var.*	45	98	90
Dwarf perennial rye (Barclay)	*Lolium perenne var. barclay*	30	98	90
Red fescue	*Festuca rubra*	20	98	90
Colonial bentgrass	*Agrostis tenuis*	5	98	90
Bioswale Seed Mix A seed mix for bioswales and other intermittently wet areas.				
Tall or meadow fes-	*Festuca arundin-*	75-80	98	90

Table II-3.4: Temporary and Permanent Seed Mixes (continued)

Common Name	Latin Name	% Weight	% Purity	% Germination
cue	*acea* or *Festuca elatior*			
Seaside/Creeping bentgrass	*Agrostis palustris*	10-15	92	85
Redtop bentgrass	*Agrostis alba* or *Agrostis gigantea*	5-10	90	80
Wet Area Seed Mix A low-growing, relatively non-invasive seed mix appropriate for very wet areas that are not regulated wetlands. Consult Hydraulic Permit Authority (HPA) for seed mixes if applicable.				
Tall or meadow fescue	*Festuca arundinacea* or *Festuca elatior*	60-70	98	90
Seaside/Creeping bentgrass	*Agrostis palustris*	10-15	98	85
Meadow foxtail	*Alepocurus pratensis*	10-15	90	80
Alsike clover	*Trifolium hybridum*	1-6	98	90
Redtop bentgrass	*Agrostis alba*	1-6	92	85
Meadow Seed Mix A recommended meadow seed mix for infrequently maintained areas or non-maintained areas where colonization by native plants is desirable. Likely applications include rural road and utility right-of-way. Seeding should take place in September or very early October in order to obtain adequate establishment prior to the winter months. Consider the appropriateness of clover, a fairly invasive species, in the mix. Amending the soil can reduce the need for clover.				
Redtop or Oregon bentgrass	*Agrostis alba* or *Agrostis oregonensis*	20	92	85
Red fescue	*Festuca rubra*	70	98	90
White dutch clover	*Trifolium repens*	10	98	90

Roughening and Rototilling

- The seedbed should be firm and rough. Roughen all soil no matter what the slope. Track walk slopes before seeding if engineering purposes require compaction. Backblading or smoothing of slopes greater than 4H:1V is not allowed if they are to be seeded.
- Restoration-based landscape practices require deeper incorporation than that provided by a simple single-pass rototilling treatment. Wherever practical, initially rip the subgrade to improve long-term permeability, infiltration, and water inflow qualities. At a minimum,

permanent areas shall 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 engineered soil system per specifications and place to achieve the specified depth.

Fertilizers

- Conducting soil tests to determine the exact type and quantity of fertilizer is recommended. This will prevent the over-application of fertilizer.
- Organic matter is the most appropriate form of fertilizer because it provides nutrients (including nitrogen, phosphorus, and potassium) in the least water-soluble form.
- In general, use 10-4-6 N-P-K (nitrogen-phosphorus-potassium) fertilizer at a rate of 90 pounds per acre. Always use slow-release fertilizers because they are more efficient and have fewer environmental impacts. Do not add fertilizer to the hydromulch machine, or agitate, more than 20 minutes before use. Too much agitation destroys the slow-release coating.
- There are numerous products available that take the place of chemical fertilizers. These include several with seaweed extracts that are beneficial to soil microbes and organisms. If 100 percent cottonseed meal is used as the mulch in hydroseed, chemical fertilizer may not be necessary. Cottonseed meal provides a good source of long-term, slow-release, available nitrogen.

Bonded Fiber Matrix and Mechanically Bonded Fiber Matrix

- On steep slopes use Bonded Fiber Matrix (BFM) or Mechanically Bonded Fiber Matrix (MBFM) products. Apply BFM/MBFM products at a minimum rate of 3,000 pounds per acre with approximately 10 percent tackifier. Achieve a minimum of 95 percent soil coverage during application. Numerous products are available commercially. Most products require 24-36 hours to cure before rainfall and cannot be installed on wet or saturated soils. Generally, products come in 40-50 pound bags and include all necessary ingredients except for seed and fertilizer.
- Install products per manufacturer's instructions.
- BFMs and MBFMs provide good alternatives to blankets in most areas requiring vegetation establishment. Advantages over blankets include:
    - BFM and MBFMs do not require surface preparation.
    - Helicopters can assist in installing BFM and MBFMs in remote areas.
    - On slopes steeper than 2.5H:1V, blanket installers may require ropes and harnesses for safety.
    - Installing BFM and MBFMs can save at least $1,000 per acre compared to blankets.

Maintenance Standards

Reseed any seeded areas that fail to establish at least 75 percent cover (100 percent cover for areas that receive sheet or concentrated flows). If reseeding is ineffective, use an alternate method such as sodding, mulching, nets, or blankets.

- Reseed and protect by mulch any areas that experience erosion after achieving adequate cover. Reseed and protect by mulch any eroded area.
- Supply seeded areas with adequate moisture, but do not water to the extent that it causes run-off.

Approved as Functionally Equivalent

Ecology has approved products as able to meet the requirements of this BMP. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept these products, or may require additional testing prior to consideration for local use. Products that Ecology has approved as functionally equivalent are available for review on Ecology's website at:

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BMP C121: Mulching

Purpose

Mulching soils provides immediate temporary protection from erosion. Mulch also enhances plant establishment by conserving moisture, holding fertilizer, seed, and topsoil in place, and moderating soil temperatures. There are a variety of mulches that can be used. This section discusses only the most common types of mulch.

Conditions of Use

As a temporary cover measure, mulch should be used:

- For less than 30 days on disturbed areas that require cover.
- At all times for seeded areas, especially during the wet season and during the hot summer months.
- 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.

For seeded areas, mulch may be made up of 100 percent:

- cottonseed meal;
- fibers made of wood, recycled cellulose, hemp, or kenaf;

- compost;
- or blends of these.

Tackifier shall be plant-based, such as guar or alpha plantago, or chemical-based such as polyacrylamide or polymers.

Generally, mulches come in 40-50 pound bags. Seed and fertilizer are added at time of application.

Recycled cellulose may contain polychlorinated biphenyl (PCBs). Ecology recommends that products should be evaluated for PCBs prior to use.

Refer to BMP C126: Polyacrylamide (PAM) for Soil Erosion Protection for conditions of use. PAM shall not be directly applied to water or allowed to enter a water body.

Any mulch or tackifier product used shall be installed per the manufacturer’s instructions.

Design and Installation Specifications

For mulch materials, application rates, and specifications, see Table II-3.6: Mulch Standards and Guidelines. Consult with the local supplier or the local conservation district for their recommendations. Increase the application rate until the ground is 95% covered (i.e. not visible under the mulch layer). Note: Thickness may be increased for disturbed areas in or near sensitive areas or other areas highly susceptible to erosion.

Where the option of “Compost” is selected, it should be a coarse compost that meets the size gradations listed in Table II-3.5: Size Gradations of Compost as Mulch Material when tested in accordance with Test Method 02.02-B found in *Test Methods for the Examination of Composting and Compost* (Thompson, 2001).

Table II-3.5: Size Gradations of Compost as Mulch Material

Sieve Size	Percent Passing
3"	100%
1"	90% - 100%
3/4"	70% - 100%
1/4"	40% - 100%

Mulch used within the ordinary high-water mark of surface waters should be selected to minimize potential flotation of organic matter. Composted organic materials have higher specific gravities (densities) than straw, wood, or chipped material. Consult the Hydraulic Permit Authority (HPA) for mulch mixes if applicable.

Maintenance Standards

The thickness of the mulch cover must be maintained.

Any areas that experience erosion shall be remulched and/or protected with a net or blanket. If the erosion problem is drainage related, then the problem shall be fixed and the eroded area remulched.

Table II-3.6: Mulch Standards and Guidelines

Mulch Material	Guideline	Description
Straw	Quality Standards	Air-dried; free from undesirable seed and coarse material.
	Application Rates	2"-3" thick; 5 bales per 1,000 sf or 2-3 tons per acre
	Remarks	Cost-effective protection when applied with adequate thickness. Hand-application generally requires greater thickness than blown straw. The thickness of straw may be reduced by half when used in conjunction with seeding. In windy areas straw must be held in place by crimping, using a tackifier, or covering with netting. Blown straw always has to be held in place with a tackifier as even light winds will blow it away. Straw, however, has several deficiencies that should be considered when selecting mulch materials. It often introduces and/or encourages the propagation of weed species and it has no significant long-term benefits It should also not be used within the ordinary high-water elevation of surface waters (due to flotation).
Hydromulch	Quality Standards	No growth inhibiting factors.
	Application Rates	Approx. 35-45 lbs per 1,000 sf or 1,500 - 2,000 lbs per acre
	Remarks	Shall be applied with hydromulcher. Shall not be used without seed and tackifier unless the application rate is at least doubled. Fibers longer than about 3/4 - 1 inch clog hydromulch equipment. Fibers should be kept to less than 3/4 inch.
Compost	Quality Standards	No visible water or dust during handling. Must be produced per WAC 173-350, Solid Waste Handling Standards, but may have up to 35% biosolids.
	Application Rates	2" thick min.; approx. 100 tons per acre (approx. 750 lbs per cubic yard)
	Remarks	More effective control can be obtained by increasing thickness to 3". Excellent mulch for protecting final grades until landscaping because it can be directly seeded or tilled into soil as an amendment. Compost used for mulch has a coarser size gradation than compost used for BMP C125: Topsoiling / Composting or BMP T5.13: Post-Construction Soil Quality and Depth. It is more stable and practical to use in wet areas and during rainy weather conditions. Do not use near wetlands or near phosphorous impaired water bodies.
Chipped Site Vegetation	Quality Standards	Gradations from fines to 6 inches in length for texture, variation, and interlocking properties. Include a mix of various sizes so that the average size is between 2- and 4- inches.
	Application Rates	2" thick min.;

Table II-3.6: Mulch Standards and Guidelines (continued)

Mulch Material	Guideline	Description
	Remarks	This is a cost-effective way to dispose of debris from clearing and grubbing, and it eliminates the problems associated with burning. Generally, it should not be used on slopes above approx. 10% because of its tendency to be transported by runoff. It is not recommended within 200 feet of surface waters. If permanent seeding or planting is expected shortly after mulch, the decomposition of the chipped vegetation may tie up nutrients important to grass establishment. Note: thick application of this material over existing grass, herbaceous species, and some groundcovers could smother and kill vegetation.
Wood-Based Mulch	Quality Standards	No visible water or dust during handling. Must be purchased from a supplier with a Solid Waste Handling Permit or one exempt from solid waste regulations.
	Application Rates	2" thick min.; approx. 100 tons per acre (approx. 750 lbs. per cubic yard)
	Remarks	This material is often called "wood straw" or "hog fuel". The use of mulch ultimately improves the organic matter in the soil. Special caution is advised regarding the source and composition of wood-based mulches. Its preparation typically does not provide any weed seed control, so evidence of residual vegetation in its composition or known inclusion of weed plants or seeds should be monitored and prevented (or minimized).
Wood Strand Mulch	Quality Standards	A blend of loose, long, thin wood pieces derived from native conifer or deciduous trees with high length-to-width ratio.
	Application Rates	2" thick min.
	Remarks	Cost-effective protection when applied with adequate thickness. A minimum of 95-percent of the wood strand shall have lengths between 2 and 10-inches, with a width and thickness between 1/16 and 1/2-inches. The mulch shall not contain resin, tannin, or other compounds in quantities that would be detrimental to plant life. Sawdust or wood shavings shall not be used as mulch. [Specification 9-14.4(4) from the *Standard Specifications for Road, Bridge, and Municipal Construction* (WSDOT, 2016)

BMP C122: Nets and Blankets

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 drainage ways 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.

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 drainage ditches and swales (highly recommended). The application of appropriate netting or blanket to drainage 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. Nets and blankets can be used to permanently stabilize channels and may provide a cost-effective, environmentally preferable alternative to riprap.

Disadvantages of nets and blankets include:

- Surface preparation is required.
- On slopes steeper than 2.5H:1V, net and blanket installers may need to be roped and harnessed for safety.
- They cost at least $4,000-6,000 per acre installed.

Advantages of nets and blankets include:

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

An alternative to nets and blankets in some limited conditions is BMP C202: Riprap Channel Lining. Ensure that BMP C202: Riprap Channel Lining is appropriate before using it as a substitute for nets and blankets.

Design and Installation Specifications

- See Figure II-3.3: Channel Installation (Clackamas County et al., 2008) and Figure II-3.4: Slope Installation for typical orientation and installation of nets and blankets used in channels and as slope protection. Note: these are typical only; all nets and 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 nets and blankets on slopes:
    1. Complete final grade and track walk up and down the slope.
    2. Install hydromulch with seed and fertilizer.
    3. Dig a small trench, approximately 12 inches wide by 6 inches deep along the top of the slope.
    4. Install the leading edge of the net/blanket into the small trench and staple approximately every 18 inches. NOTE: Staples are metal, "U"-shaped, and a minimum of 6 inches long. Longer staples are used in sandy soils. Biodegradable stakes are also available.
    5. Roll the net/blanket slowly down the slope as the installer walks backward. NOTE: The net/blanket rests against the installer's legs. Staples are installed as the net/blanket is unrolled. It is critical that the proper staple pattern is used for the net/blanket being installed. The net/blanket is not to be allowed to roll down the slope on its own as this stretches the net/blanket, making it impossible to maintain soil contact. In addition, no one is allowed to walk on the net/blanket after it is in place.
    6. If the net/blanket is not long enough to cover the entire slope length, the trailing edge of the upper net/blanket should overlap the leading edge of the lower net/blanket and be stapled. On steeper slopes, this overlap should be installed in a small trench, stapled, and covered with soil.
- 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 designer consult the manufacturer's information and that a site visit takes place in order to ensure that the product specified is appropriate. Information is also available in WSDOT's *Standard Specifications for Road, Bridge, and Municipal Construction* Division 8-01 and Division 9-14 (WSDOT, 2016).
- Use jute matting 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

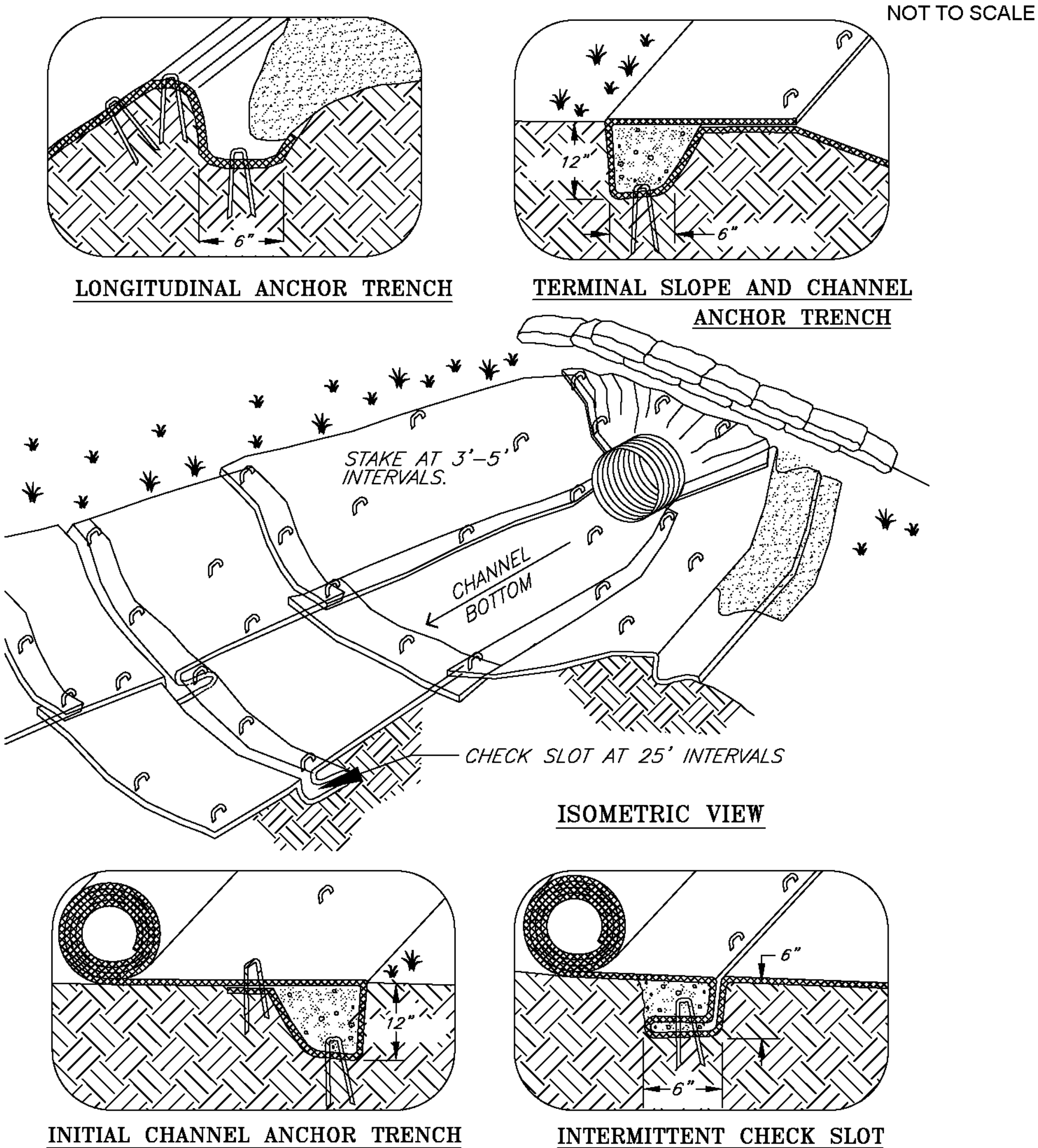
synthetic blankets are used, the soil should be hydromulched first.

- 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 breaks 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.

Maintenance Standards

- Maintain good contact with the ground. Erosion must not occur beneath the net or blanket.
- Repair and staple any areas of the net or blanket that are damaged or not in close contact with the ground.
- Fix and protect eroded areas if erosion occurs due to poorly controlled drainage.

Figure II-3.3: Channel Installation



Notes:

1. Check slots to be constructed per manufacturers specifications.
2. Staking or stapling layout per manufacturers specifications.

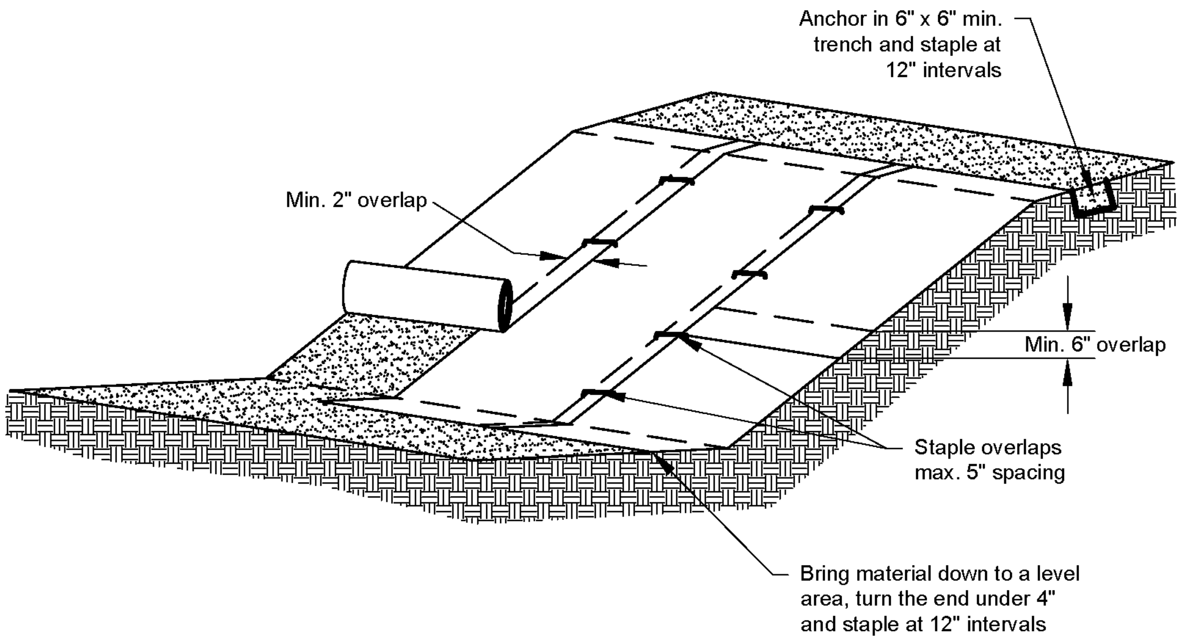
(Clackamas County et al., 2008)

DEPARTMENT OF ECOLOGY State of Washington

Channel Installation

Revised July 2016

Figure II-3.4: Slope Installation



Notes:

1. Slope surface shall be smooth before placement for proper soil contact.
2. Stapling pattern as per manufacturer's recommendations.
3. Do not stretch blankets/mattings tight - allow the rolls to mold to any irregularities.
4. For slopes less than 3H:1V, rolls may be placed in horizontal strips.
5. If there is a berm at the top of the slope, anchor upslope of the berm.
6. Lime, fertilize, and seed before installation. Planting of shrubs, trees, etc. should occur after installation.

NOT TO SCALE

DEPARTMENT OF ECOLOGY
State of Washington

Slope Installation

Revised June 2016

BMP C123: Plastic Covering

Purpose

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

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. However, the relatively rapid breakdown of most polyethylene sheeting makes it unsuitable for applications greater than six months.
- Due to rapid runoff caused by plastic covering, do not use this method upslope of areas that might be adversely impacted by concentrated runoff. Such areas include steep and/or unstable slopes.
- Plastic sheeting may result in increased runoff volumes and velocities, requiring additional on-site measures to counteract the increases. Creating a trough with wattles or other material can convey clean water away from these areas.
- To prevent undercutting, trench and backfill rolled plastic covering products.
- Although the plastic material is inexpensive to purchase, the cost of installation, maintenance, removal, and disposal add to the total costs of this BMP.
- Whenever plastic is used to protect slopes, install water collection measures 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. Do not mix clean runoff from a plastic covered slope 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.
    - Temporary drainpipe (“elephant trunk”) used to direct water.

Design and Installation Specifications

- Plastic slope cover must be installed as follows:
    1. Run plastic up and down the slope, not across the slope.
    2. Plastic may be installed perpendicular to a slope if the slope length is less than 10 feet.

3. Provide a minimum of 8-inch overlap at the seams.
4. On long or wide slopes, or slopes subject to wind, tape all seams.
5. 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.
6. Place sand filled burlap or geotextile bags every 3 to 6 feet along seams and tie them together with twine to hold them in place.
7. 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.
8. Sandbags may be lowered into place tied to ropes. However, all sandbags must be staked in place.

- Plastic sheeting shall have a minimum thickness of 0.06 millimeters.
- 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.

Maintenance Standards

- Torn sheets must be replaced and open seams repaired.
- Completely remove and replace the plastic if it begins to deteriorate due to ultraviolet radiation.
- Completely remove plastic when no longer needed.
- Dispose of old tires used to weight down plastic sheeting appropriately.

Approved as Functionally Equivalent

Ecology has approved products as able to meet the requirements of this BMP. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept these products, or may require additional testing prior to consideration for local use. Products that Ecology has approved as functionally equivalent are available for review on Ecology's website at:

https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies

BMP C124: Sodding

Purpose

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

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.

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:

1. Shape and smooth the surface to final grade in accordance with the approved grading plan. Consider any areas (such as swales) that need to be overexcavated below design elevation to allow room for placing soil amendment and sod.
2. 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 permeability is less than 0.6 inches per hour. See https://ecology.wa.gov/Waste-Toxics/Reducing-recycling-waste/Organic-materials/Managing-organics-compost for further information.
3. Fertilize according to the sod supplier's recommendations.
4. Work lime and fertilizer 1 to 2 inches into the soil, and smooth the surface.
5. 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.
6. Roll the sodded area and irrigate.
7. When sodding is carried out in alternating strips or other patterns, seed the areas between the sod immediately after sodding.

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.

BMP C125: Topsoiling / Composting

Purpose

Topsoiling and composting provide a suitable growth medium for final site stabilization with vegetation. While not a permanent cover practice in itself, topsoiling and composting are an integral component of providing permanent cover in those areas where there is an unsuitable soil surface for plant growth. Use this BMP in conjunction with other BMPs such as BMP C120: Temporary and Permanent Seeding, BMP C121: Mulching, or BMP C124: Sodding. Implementation of this BMP may meet the post-construction requirements of BMP T5.13: Post-Construction Soil Quality and Depth.

Native soils and disturbed soils that have been organically amended not only retain much more stormwater, but also serve as effective biofilters for urban pollutants and, by supporting more vigorous plant growth, reduce the water, fertilizer and pesticides needed to support installed landscapes. Topsoil does not include any subsoils but only the material from the top several inches including organic debris.

Conditions of Use

- Permanent landscaped areas shall contain healthy topsoil that reduces the need for fertilizers, improves overall topsoil quality, provides for better vegetative 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. Stripping of existing, properly functioning soil system and vegetation for the purpose of topsoiling during construction is not acceptable. Preserve existing soil systems in undisturbed and uncompacted conditions if functioning properly.
- Areas that already have good topsoil, such as undisturbed areas, do not require soil amendments.
- Restore, to the maximum extent practical, native soils disturbed during clearing and grading to a condition equal to or better than the original site condition's moisture-holding capacity. Use on-site native topsoil, incorporate amendments into on-site 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.
- Beware of where the topsoil comes from, and what vegetation was on site 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 mycorrhiza are acclimated to the site and will provide optimum conditions for establishing grasses. Use commercially available mycorrhiza products when using off-site topsoil.

Design and Installation Specifications

Meet the following requirements for disturbed areas that will be developed as lawn or landscaped areas at the completed project site:

- Maximize the depth of the topsoil wherever possible to provide the maximum possible infiltration capacity and beneficial growth medium. 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 re-structuring 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 depth 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.
  - If blended topsoil is imported, then fines should be limited to 25 percent passing through a 200 sieve.
- Mulch planting beds with 2 inches of organic material
- Accomplish the required organic content, depth, and pH by returning native topsoil to the site, importing topsoil of sufficient organic content, and/or incorporating organic amendments. When using the option of incorporating amendments to meet the organic content requirement, use compost that meets the compost specification for Bioretention (See BMP T7.30: Bioretention), with the exception that the compost may have up to 35% biosolids or manure.
- Sections 3 through 7 of *Building Soil: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13 in WDOE Stormwater Management Manual for Western Washington* (Stenn et al., 2016), provides useful guidance for implementing whichever option is chosen. It includes guidance for pre-approved default strategies and guidance for custom strategies. Check with your local jurisdiction concerning its acceptance of this guidance.
- 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, incorporation of topsoil may favor grasses, while layering with mildly acidic, high-carbon amendments may favor more woody vegetation.
- Allow sufficient time in scheduling for topsoil spreading prior to seeding, sodding, or planting.
- Take care when applying top soil to subsoils with 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 promote bonding is to actually 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, and clay loam). Avoid areas of natural ground water recharge.

- Stripping shall be confined to the immediate construction area. A 4-inch to 6-inch stripping depth is common, but depth may vary depending on the particular soil. All surface runoff control structures shall be in place prior to stripping.
- 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.
- In any areas requiring grading, remove and stockpile the duff layer and topsoil on site in a designated, controlled area, not adjacent to public resources and critical areas. Reapply stockpiled topsoil to other portions of the site where feasible.
- Locate the topsoil stockpile so that 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.
- Stockpiling of topsoil shall occur in the following manner:
    - Side slopes of the stockpile shall not exceed 2H:1V.
    - Between October 1 and April 30:
        - An interceptor dike with gravel outlet and silt fence shall surround all topsoil.
        - Within 2 days complete erosion control seeding, or covering stockpiles with clear plastic, or other mulching materials.
    - Between May 1 and September 30:
        - An interceptor dike with gravel outlet and silt fence shall surround all topsoil if the stockpile will remain in place for a longer period of time than active construction grading.
        - Within 7 days complete erosion control seeding, or covering stockpiles with clear plastic, or other mulching materials.
- 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:
    - Re-install topsoil within 4 to 6 weeks.
    - Do not allow the saturation of topsoil with water.
    - Do not use plastic covering.

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 construction and once established, protect from compaction, such as from large machinery use, and from 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.

BMP C126: Polyacrylamide (PAM) for Soil Erosion Protection

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. First, PAM increases the soil's available pore volume, thus increasing infiltration and reducing the quantity of stormwater runoff. Second, it increases flocculation of suspended particles and aids in their deposition, thus reducing stormwater runoff turbidity and improving water quality.

Conditions of Use

PAM shall not be directly applied to water or allowed to enter a water body. Stormwater runoff shall pass through a sediment pond prior to discharging to surface waters.

PAM can be applied to bare soil under the following conditions:

- During rough grading operations.
- In Staging areas.
- Balanced cut and fill earthwork.
- Haul roads prior to placement of crushed rock surfacing.
- Compacted soil roadbase.
- Stockpiles.
- After final grade and before paving or final seeding and planting.
- Pit sites.
- 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.

Design and Installation Specifications

- Do not use PAM on a slope that flows directly into a stream or wetland.
- Do not add PAM to water discharging from the site.

- When the total drainage area is greater than or equal to 5 acres, PAM treated areas shall drain to a sediment pond.
- Areas less than 5 acres shall drain to sediment control BMPs, such as sediment trap. The total number of sediment traps used shall be maximized to achieve the greatest amount of settlement of sediment prior to discharging from the site. Check dams may be used in a drainage channel to form the sediment trap.
- Maximize the use of silt fence to limit the discharge of sediment from the site.
- All areas not being actively worked shall be covered and protected 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.

The Preferred Application Method

PAM may be applied with water in dissolved 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. See Table II-3.7: PAM and Water Application Rates to determine the PAM and water application rate for a disturbed soil area. Higher concentrations of PAM **do not** provide any additional effectiveness.

Table II-3.7: PAM and Water Application Rates

Disturbed Area (ac)	PAM (lbs)	Water (gal)
0.50	0.33	500
1.00	0.66	1,000
1.50	1.00	1,500
2.00	1.32	2,000
2.50	1.65	2,500
3.00	2.00	3,000
3.50	2.33	3,500
4.00	2.65	4,000
4.50	3.00	4,500
5.00	3.33	5,000

Follow the steps below to apply PAM using the preferred method:

1. 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/1000 gallons/acre).
2. PAM has infinite solubility in water, 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.
3. 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.
4. Add the PAM/Water mixture to the truck.
5. Completely fill the water truck to the specified volume.
6. Spray the PAM/Water mixture onto dry soil, until the soil surface is uniformly and completely wetted.

An Alternate Application Method

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

The following shall be used for application of powdered PAM:

- Powdered PAM shall be used in conjunction with other BMPs and not in place of other BMPs.
- 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.

Safety and Toxicity

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 to avoid the pavement becoming slippery. If PAM powder gets on skin or clothing, wipe it off with a rough towel rather than washing with water. Washing with water will make 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.** Use only the highest drinking water grade PAM, certified for compliance with NSF International (NSF)/American National Standards Institute (ANSI) Standard 60 for drinking water treatment, for soil applications. Recent media attention and high interest in PAM has resulted in some entrepreneurial exploitation of the term "polymer." All PAM are polymers, but not all polymers are PAM, and not all PAM products comply with ANSI/NSF Standard 60. PAM use shall be reviewed and approved by the local permitting authority.

- PAM designated for these uses should be "water soluble" or "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 2-30 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 mixing rate of no more than 0.5-1 lb. per 1000 gallons of water in a hydromulch machine. Some tackifier product instructions say to use at an application rate of 3 – 5 lbs per acre, which can be too much. In addition, pump problems can occur at higher application rates due to increased viscosity.

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 unless turbidity levels show the need for an additional application. If PAM treated soil is left undisturbed, a reapplication may be necessary after two months. More PAM applications may be required for steep slopes, silty and clayey soils (USDA Classification Type "C" and "D" soils), long grades, and high precipitation areas. 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.
- PAM may affect the treatment efficiency of chitosan flocculent systems.

BMP C130: Surface Roughening

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.

Use this BMP in conjunction with other BMPs such as BMP C120: Temporary and Permanent Seeding, BMP C121: Mulching, or BMP C124: Sodding.

Conditions for Use

- All slopes steeper than 3H:1V and greater than 5 vertical feet require surface roughening 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.

Design and Installation Specifications

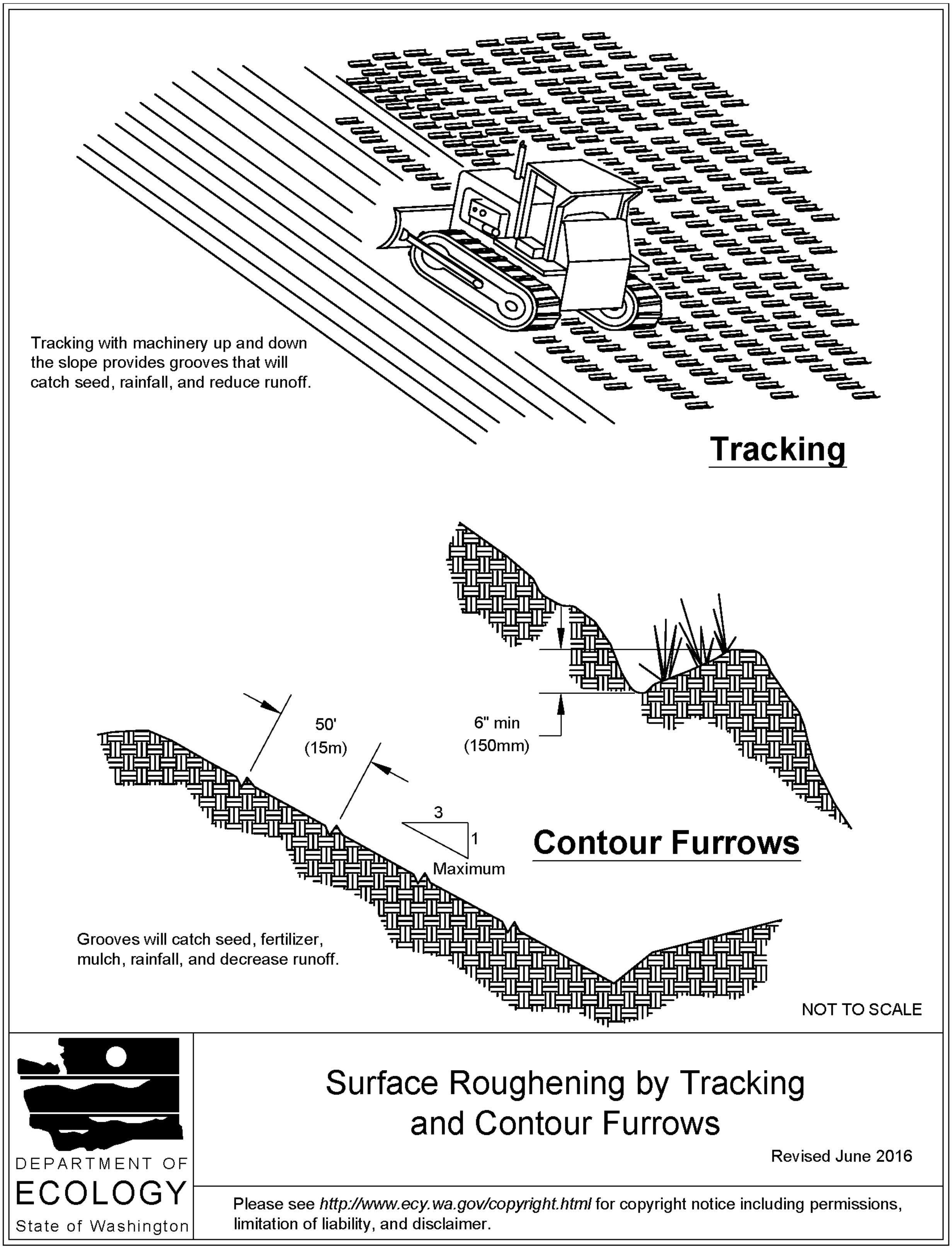
There are different methods for achieving a roughened soil surface on a slope, and the selection of an appropriate method depends upon the type of slope. Roughening methods include stair-step grading, grooving, contour furrows, and tracking. See Figure II-3.5: Surface Roughening by Tracking and Contour Furrows. Factors to be considered in choosing a roughening 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 3H:1V) may have small furrows left by disking, harrowing, raking, or seed-planting machinery operated on the contour.
- Graded areas with slopes steeper than 3H:1V but less than 2H:1V 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.

Maintenance Standards

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

Figure II-3.5: Surface Roughening by Tracking and Contour Furrows



BMP C131: Gradient Terraces

Purpose

Gradient terraces reduce erosion damage by intercepting surface runoff and conveying it to a stable outlet at a non-erosive velocity.

Conditions of Use

Gradient terraces are normally limited to bare 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 only be used where suitable outlets are or will be made available.

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 (0.6%). For short distances, terrace grades may be increased to improve alignment. The channel velocity should not exceed that which is nonerosive for the soil type.
- 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 and energy dissipators 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

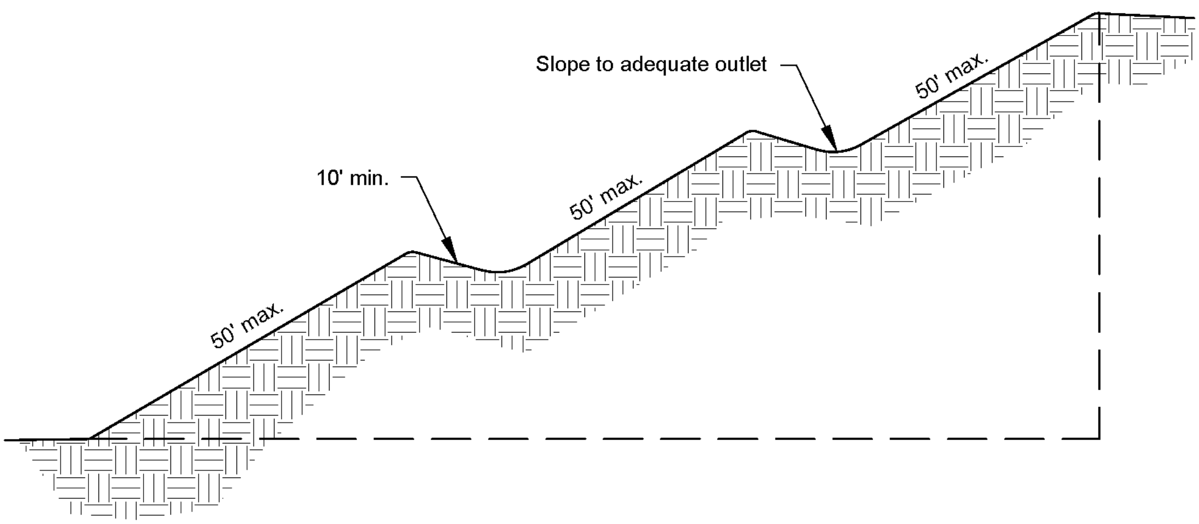
flow.

- 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, to avoid obstacles, to adjust for equipment size, or to reach a satisfactory outlet. The drainage area above the terrace 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 runoff expected from a 2-year, 24-hour design 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 vehicle.

Maintenance Standards

Maintenance should be performed as needed. Terraces should be inspected regularly; at least once per year, and after large storm events.

Figure II-3.6: Gradient Terraces



NOT TO SCALE

DEPARTMENT OF ECOLOGY
State of Washington

Gradient Terraces

Revised June 2016

BMP C140: Dust Control

Purpose

Dust control prevents wind transport of dust from disturbed soil surfaces onto roadways, drainage ways, and surface waters.

Conditions of Use

Use dust control in areas (including roadways) subject to surface and air movement of dust where on-site or off-site impacts to roadways, drainage ways, or surface waters are likely.

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 those areas where immediate activity will take place, leaving the remaining area(s) in the original condition. 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 the surface is wet. Repeat as needed. To prevent carryout of mud onto the street, refer to BMP C105: Stabilized Construction Access and BMP C106: Wheel Wash.
- Irrigation water can be used for dust control. Irrigation systems should be installed 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. Local governments may approve other dust palliatives such as calcium chloride or PAM.
- PAM (BMP C126: Polyacrylamide (PAM) for Soil Erosion Protection) added to water at a rate of 0.5 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 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 reduce the quantity of water needed for dust control. Note that the application rate specified here applies to this BMP, and is not the same application rate that is specified in BMP C126: Polyacrylamide (PAM) for Soil Erosion Protection, but the downstream protections still apply.

  Refer to BMP C126: Polyacrylamide (PAM) for Soil Erosion Protection for conditions of use. PAM shall not be directly applied to water or allowed to enter a water body.
- Contact your local Air Pollution Control Authority for guidance and training on other dust control measures. Compliance with the local Air Pollution Control Authority constitutes

compliance with this BMP.

- Use vacuum street sweepers.
- Remove mud and other dirt promptly so it does not dry and then turn into dust.
- Techniques that can be used for unpaved roads and lots include:
  - 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 (those smaller than .075 mm) 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.
  - 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.
  - Limit dust-causing work on windy days.
  - Pave unpaved permanent roads and other trafficked areas.

Maintenance Standards

Respray area as necessary to keep dust to a minimum.

BMP C150: Materials on Hand

Purpose

Keep quantities of erosion prevention and sediment control materials on the project site at all times to be used for regular maintenance and emergency situations such as unexpected heavy rains. Having these materials on-site reduces the time needed to replace existing or implement new BMPs when inspections indicate that existing BMPs are not meeting the Construction SWPPP requirements. In addition, contractors can save money by buying some materials in bulk and storing them at their office or yard.

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 should be stockpiled and readily available before any site clearing, grubbing, or earthwork begins. A large contractor or project proponent could keep a stockpile of materials that are available for use on several projects.
- If storage space at the project site is at a premium, the contractor could maintain the materials at their office or yard. The office or yard must be less than an hour from the project site.

Design and Installation Specifications

Depending on project type, size, complexity, and length, materials and quantities will vary. A good minimum list of items that will cover numerous situations includes:

- Clear Plastic, 6 mil
- Drainpipe, 6 or 8 inch diameter
- Sandbags, filled
- Straw Bales for mulching
- Quarry Spalls
- Washed Gravel
- Geotextile Fabric
- Catch Basin Inserts
- Steel "T" Posts
- Silt fence material
- Straw Wattles

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 as needed.

BMP C151: Concrete Handling

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.

Conditions of Use

Any time concrete is used, utilize these management practices. Concrete construction project components include, but are not limited to:

- Curbs
- Sidewalks
- Roads
- Bridges
- Foundations
- Floors
- Runways

Disposal options for concrete, in order of preference are:

1. Off-site disposal
2. Concrete wash-out areas (see BMP C154: Concrete Washout Area)
3. De minimus washout to formed areas awaiting concrete

Design and Installation Specifications

- Wash concrete truck drums at an approved off-site location or in designated concrete washout areas only. Do not wash out concrete trucks onto the ground (including formed areas awaiting concrete), or into storm drains, open ditches, streets, or streams. Refer to BMP C154: Concrete Washout Area for information on concrete washout areas.
    - Return unused concrete remaining in the truck and pump to the originating batch plant for recycling. Do not dump excess concrete on site, except in designated concrete washout areas as allowed in BMP C154: Concrete Washout Area.
- 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 drain 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, such as pilings, within 15-feet of surface waters.
- Refer to BMP C252: Treating and Disposing of High pH Water for pH adjustment requirements.
- Refer to the Construction Stormwater General Permit (CSWGP) for pH monitoring requirements if the project involves one of the following activities:
  - Significant concrete work (as defined in the CSWGP).
  - The use of 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.

Maintenance Standards

Check containers for holes in the liner daily during concrete pours and repair the same day.

BMP C152: Sawcutting and Surfacing Pollution Prevention

Purpose

Sawcutting and surfacing operations generate slurry and process water that contains fine particles and high pH (concrete cutting), both of which can violate the 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 process water and slurry created through sawcutting or surfacing from entering waters of the State.

Conditions of Use

Utilize these management practices anytime sawcutting or surfacing operations take place. Sawcutting and surfacing operations include, but are not limited to:

- Sawing
- Coring
- Grinding
- Roughening
- Hydro-demolition
- Bridge and road surfacing

Design and Installation Specifications

- Vacuum slurry and cuttings during cutting and surfacing operations.
- Slurry and cuttings shall not remain on permanent concrete or asphalt pavement overnight.
- Slurry and cuttings shall not drain to any natural or constructed drainage conveyance including stormwater systems. This may require temporarily blocking catch basins.
- Dispose of collected slurry and cuttings in a manner that does not violate ground water or surface water quality standards.
- Do not allow process water generated during hydro-demolition, surface roughening or similar operations to drain to any natural or constructed drainage conveyance including stormwater systems. Dispose of process water in a manner that does not violate ground water 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. Dispose of sweeping material from a pick-up sweeper at an appropriate disposal site.

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/or vacuum trucks.

BMP C153: Material Delivery, Storage, and Containment

Purpose

Prevent, reduce, or eliminate the discharge of pollutants to the stormwater system or watercourses from material delivery and storage. Minimize the storage of hazardous materials on-site, store materials in a designated area, and install secondary containment.

Conditions of Use

Use at 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

Design and Installation Specifications

- The temporary storage area should be located away from vehicular traffic, near the construction entrance(s), and away from waterways or storm drains.
- Safety Data Sheets (SDS) should be supplied for all materials stored. Chemicals should be kept in their original labeled containers.
- Hazardous material storage on-site should be minimized.
- Hazardous materials should be handled as infrequently as possible.
- During the wet weather season (Oct 1 – April 30), consider storing materials in a covered area.
- Materials should be stored in secondary containments, such as an earthen dike, horse trough, or even a children's wading pool for non-reactive materials such as detergents, oil, grease, and paints. Small amounts of material may be secondarily contained in "bus boy" trays or concrete mixing trays.
- Do not store chemicals, drums, or bagged materials directly on the ground. Place these items on a pallet and, when possible, within secondary containment.
- If drums must be kept uncovered, store them at a slight angle to reduce ponding of rainwater on the lids to reduce corrosion. Domed plastic covers are inexpensive and snap to the top of drums, preventing water from collecting.
- Liquids, petroleum products, and substances listed in 40 CFR Parts 110, 117, or 302 shall be stored in approved containers and drums and shall not be overfilled. Containers and drums shall be stored in temporary secondary containment facilities.
- Temporary secondary containment facilities shall provide for a spill containment volume able to contain 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.
- Sufficient separation should be provided between stored containers to allow for spill cleanup and emergency response access.
- During the wet weather season (Oct 1 – April 30), each secondary containment facility shall be covered during non-working days, prior to and during rain events.
- Keep material storage areas clean, organized and equipped with an ample supply of appropriate spill clean-up material (spill kit).
- The spill kit should include, at a minimum:

- 1-Water Resistant Nylon Bag
- 3-Oil Absorbent Socks 3”x 4’
- 2-Oil Absorbent Socks 3”x 10’
- 12-Oil Absorbent Pads 17”x19”
- 1-Pair Splash Resistant Goggles
- 3-Pair Nitrile Gloves
- 10-Disposable Bags with Ties
- Instructions

Maintenance Standards

- Secondary containment facilities shall be maintained free of accumulated rainwater and spills. In the event of spills or leaks, accumulated rainwater and spills shall be collected and placed into drums. These liquids shall be handled as hazardous waste unless testing determines them to be non-hazardous.
- Re-stock spill kit materials as needed.

BMP C154: Concrete Washout Area

Purpose

Prevent or reduce the discharge of pollutants from concrete waste to stormwater by conducting washout off-site, or performing on-site washout in a designated area.

Conditions of Use

Concrete washout areas are implemented on construction projects where:

- Concrete is used as a construction material
- It is not possible to dispose of all concrete wastewater and washout off-site (ready mix plant, etc.).
- Concrete truck drums are washed on-site.

  Note that auxiliary concrete truck components (e.g. chutes and hoses) and small concrete handling equipment (e.g. hand tools, screeds, shovels, rakes, floats, trowels, and wheel-barrows) may be washed 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.

Design and Installation Specifications

Implementation

- Perform washout of concrete truck drums at an approved off-site location or in designated concrete washout areas only.
- Do not wash out concrete onto non-formed areas, or into storm drains, open ditches, streets, or streams.
- 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 excess concrete to be dumped on-site, except in designated concrete washout areas as allowed above.
- 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.
- 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 Certified Erosion and Sediment Control Lead (CESCL) to oversee and enforce concrete waste management procedures.
- A sign should be installed adjacent to each concrete washout area 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

- Locate concrete washout areas at least 50 feet from sensitive areas such as storm drains, open ditches, water bodies, or wetlands.
- Allow convenient access to the concrete washout area for concrete trucks, preferably near the area where the concrete is being poured.
- If trucks need to leave a paved area to access the concrete washout area, prevent track-out with a pad of rock or quarry spalls (see BMP C105: Stabilized Construction Access). These areas should be far enough away from other construction traffic to reduce the likelihood of accidental damage and spills.
- The number of concrete washout areas you install should depend on the expected demand for storage capacity.
- On large sites with extensive concrete work, concrete washout areas should be placed in multiple locations for ease of use by concrete truck drivers.

Concrete Truck Washout Procedures

- Washout of concrete truck drums shall be performed 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 off-site.

Concrete Washout Area Installation

- Concrete washout areas should be constructed as shown in the figures below, with a recommended minimum length and minimum width of 10 ft, but with sufficient quantity and volume to contain all liquid and concrete waste generated by washout operations.
- Plastic lining material should be a minimum of 10 mil polyethylene sheeting and should be free of holes, tears, or other defects that compromise the impermeability of the material.
- Lath and flagging should be commercial type.
- Liner seams shall be installed in accordance with manufacturers' recommendations.
- Soil base shall be prepared free of rocks or other debris that may cause tears or holes in the plastic lining material.

Maintenance Standards

Inspection and Maintenance

- Inspect and verify that concrete washout areas are in place prior to the commencement of concrete work.
- Once concrete wastes are washed into the designated washout area 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 the concrete washout areas daily to verify continued performance.
  - Check overall condition and performance.
  - Check remaining capacity (% full).
  - If using self-installed concrete washout areas, verify plastic liners are intact and sidewalls are not damaged.
  - If using prefabricated containers, check for leaks.
- Maintain the concrete washout areas to provide adequate holding capacity with a minimum freeboard of 12 inches.
- Concrete washout areas must be cleaned, or new concrete washout areas must be constructed and ready for use once the concrete washout area is 75% full.
- If the concrete washout area is nearing capacity, vacuum and dispose of the waste material in an approved manner.
  - Do not discharge liquid or slurry to waterways, storm drains or directly onto ground.
  - Do not discharge to the sanitary sewer without local approval.
  - Place a secure, non-collapsing, non-water collecting cover over the concrete washout area 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 on-site or hauled away for disposal or recycling.
- When you remove materials from a self-installed concrete washout area, 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.

Removal of Concrete Washout Areas

- When concrete washout areas are no longer required for the work, the hardened concrete, slurries and liquids shall be removed and properly disposed of.
- Materials used to construct concrete washout areas shall be removed from the site of the work and disposed of or recycled.
- Holes, depressions or other ground disturbance caused by the removal of the concrete washout areas shall be backfilled, repaired, and stabilized to prevent erosion.

Figure II-3.7: Concrete Washout Area with Wood Planks

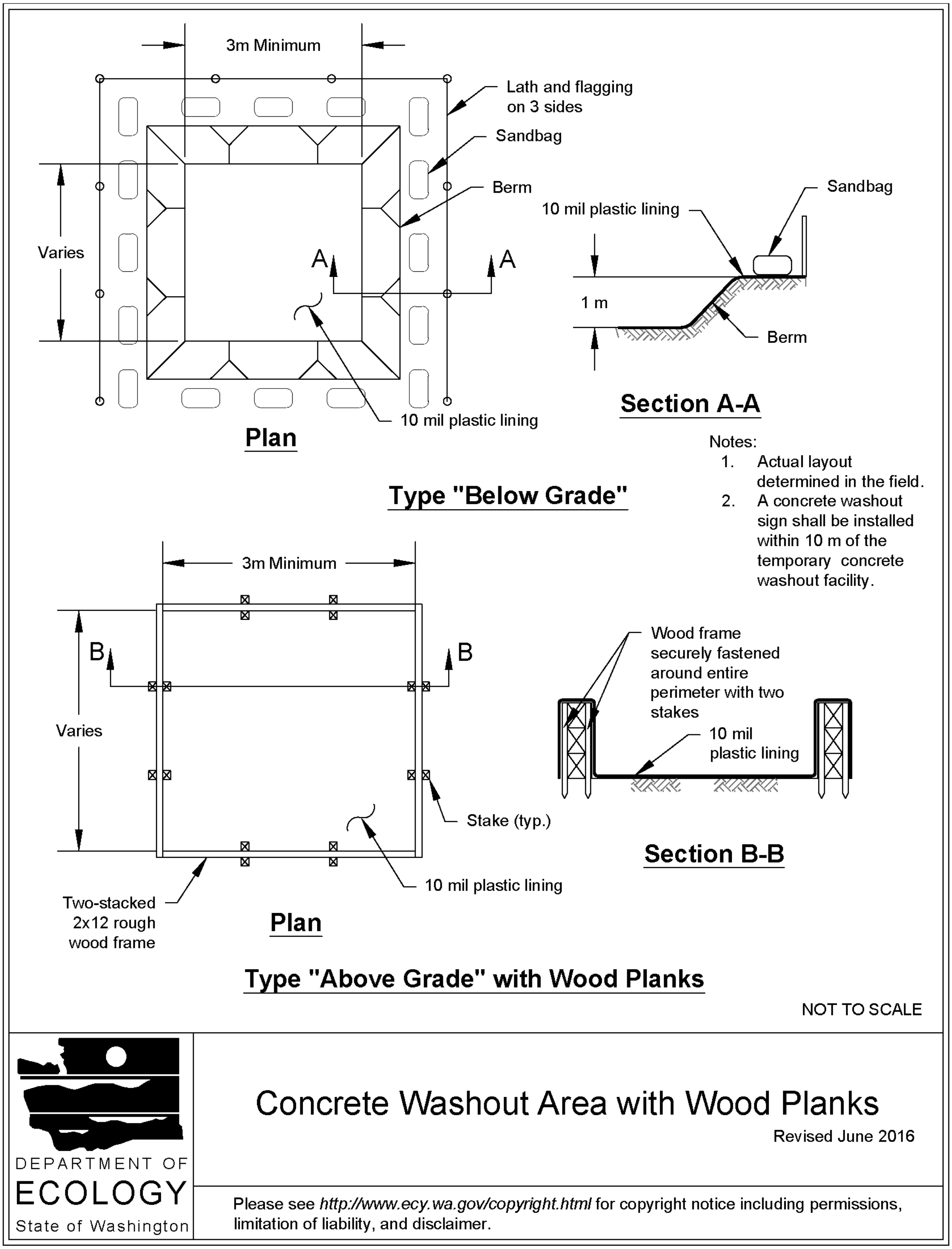


Figure II-3.8: Concrete Washout Area with Straw Bales

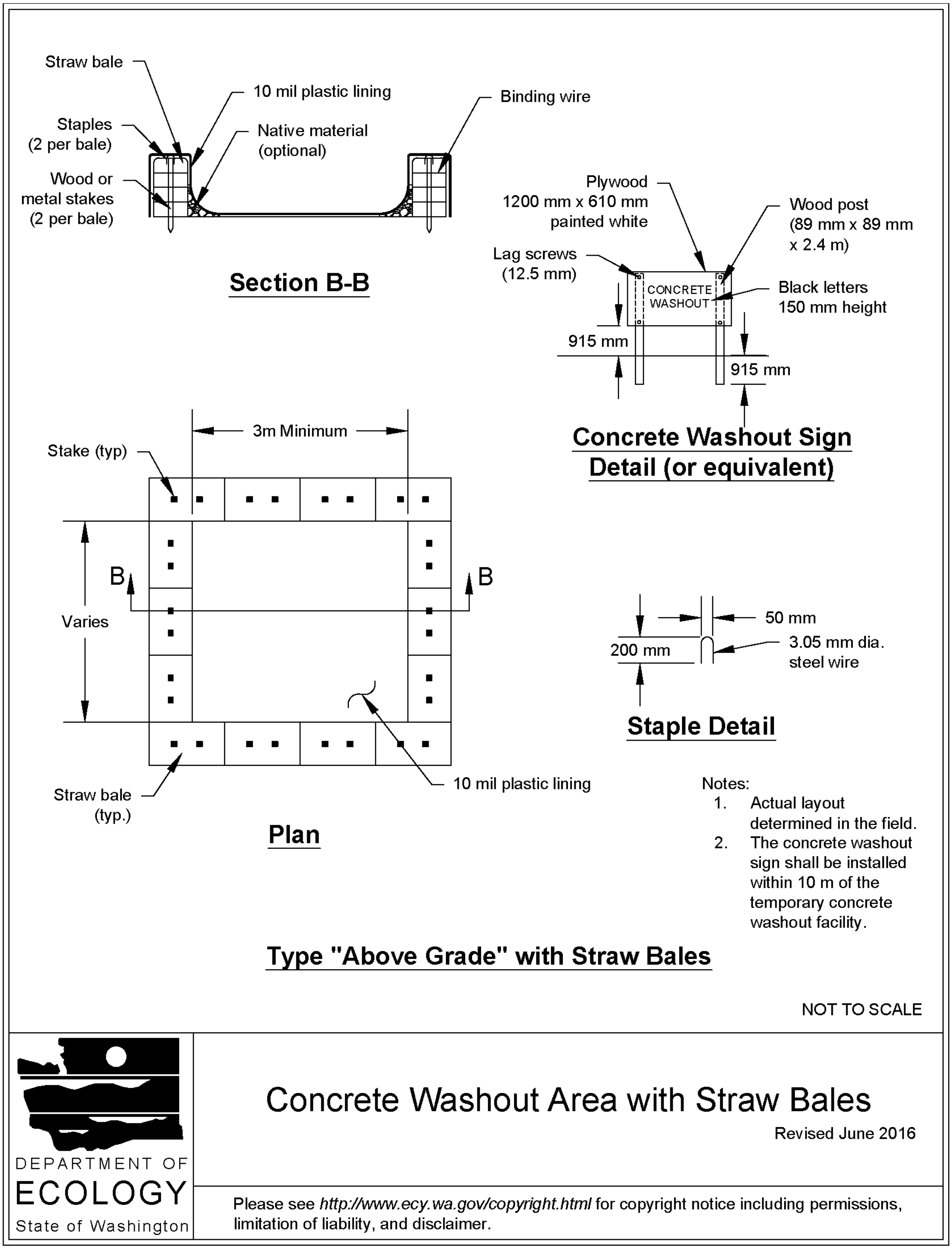
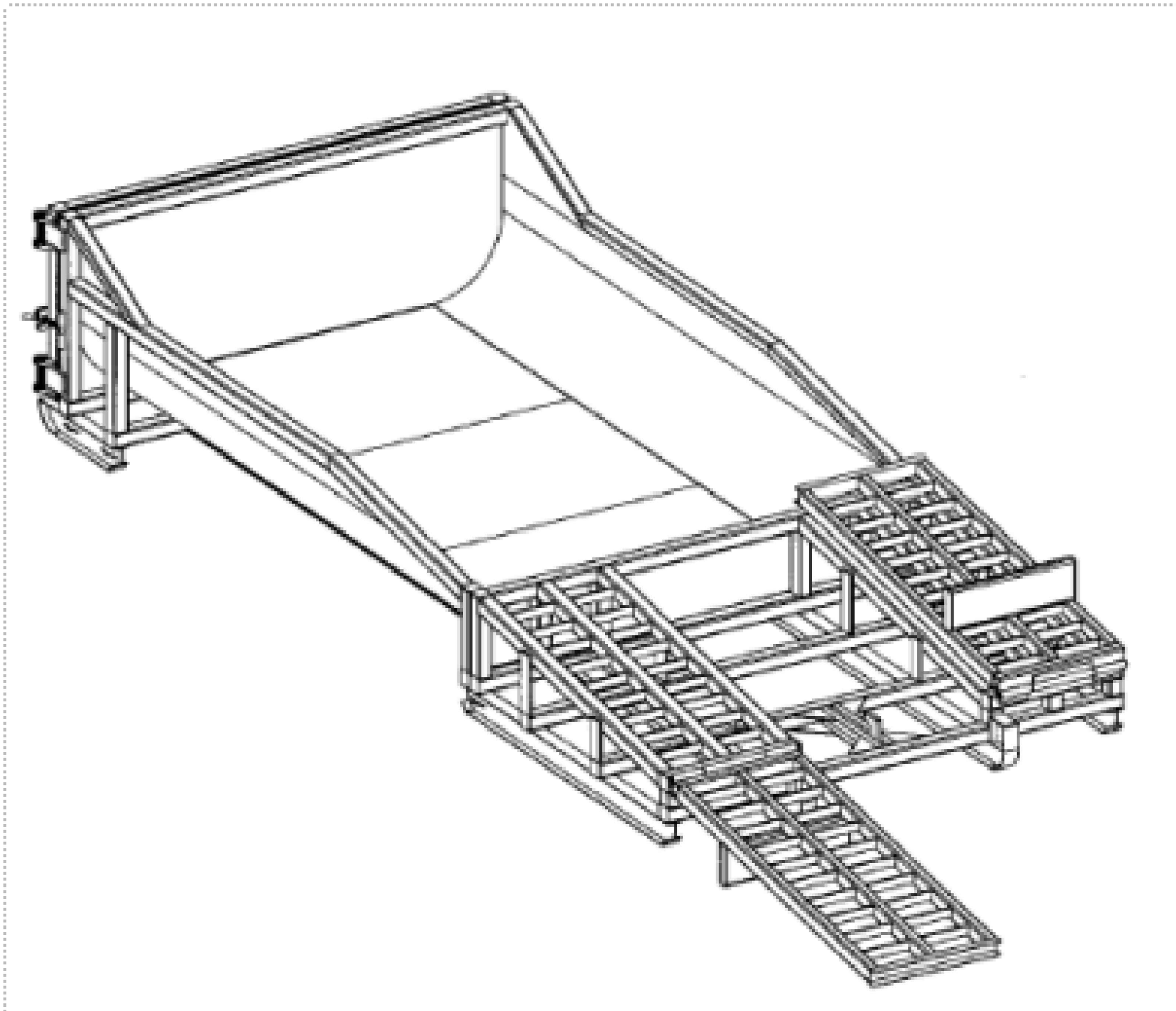


Figure II-3.9: Prefabricated Concrete Washout Container w/Ramp



NOT TO SCALE

Prefabricated Concrete Washout Container w/Ramp

Revised June 2016

DEPARTMENT OF ECOLOGY
State of Washington

BMP C160: Certified Erosion and Sediment Control Lead

Purpose

The project proponent designates 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 responsible for ensuring compliance with all local, state, and federal erosion and sediment control and water quality requirements. Construction sites one acre or larger that discharge to waters of the State must designate a Certified Erosion and Sediment Control Lead (CESCL) as the responsible representative.

Conditions of Use

A CESCL shall be made available on projects one acre or larger that discharge stormwater to surface waters of the state. Sites less than one acre may have a person without CESCL certification conduct inspections.

The CESCL shall:

- Have a current certificate proving attendance in an erosion and sediment control training course that meets the minimum ESC training and certification requirements established by Ecology.

  Ecology has provided the minimum requirements for CESCL course training, as well as a list of ESC training and certification providers at:

  https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Certified-erosion-sediment-control

  OR

- Be a Certified Professional in Erosion and Sediment Control (CPESC). For additional information go to:

  http://www.envirocertintl.org/cpesc/

Specifications

- CESCL certification shall remain valid for three years.
- The CESCL shall have authority to act on behalf of the contractor or project proponent and shall be available, or on-call, 24 hours per day throughout the period of construction.
- The Construction SWPPP shall include the name, telephone number, fax number, and address of the designated CESCL. See II-2 Construction Stormwater Pollution Prevention Plans (Construction SWPPPs).
- A CESCL may provide inspection and compliance services for multiple construction projects in the same geographic region, but must be on site whenever earthwork activities are

occurring that could generate release of turbid water.

- Duties and responsibilities of the CESCL shall include, but are not limited to the following:
  - Maintaining a permit file on site at all times which includes the Construction 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.
  - Completing any sampling requirements including reporting results using electronic Discharge Monitoring Reports (WebDMR).
  - Facilitate, participate in, and take corrective actions resulting from inspections performed by outside agencies or the owner.
  - 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.
    - 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.
    - A summary or list of all BMPs implemented, including observations of all erosion/sediment control structures or practices. The following shall be noted:
      1. Locations of BMPs inspected.
      2. Locations of BMPs that need maintenance.
      3. Locations of BMPs that failed to operate as designed or intended.
      4. Locations of where additional or different BMPs are required.

BMP C162: Scheduling

Purpose

Sequencing a construction project reduces the amount and duration of soil exposed to erosion by wind, rain, runoff, and vehicle tracking.

Conditions of Use

The construction sequence schedule is an orderly listing of all major land-disturbing activities together with the necessary erosion and sedimentation control measures planned for the project. This type of schedule guides the contractor on work to be done before other work is started so that 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 ground cover leaves a site vulnerable to erosion. Construction sequencing that limits land clearing, provides timely installation of erosion and sedimentation controls, and restores protective cover quickly can significantly reduce the erosion potential of a site.

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.

II-3.3 Construction Runoff BMPs

BMP C200: Interceptor Dike and Swale

Purpose

Provide a dike of compacted soil or a 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 storm runoff from entering the work area or sediment-laden runoff from leaving the construction site.

Conditions of Use

Use an interceptor dike or swale where runoff from an exposed site or disturbed slope must be conveyed to an erosion control BMP which can safely convey the stormwater.

- Locate upslope of a construction site to prevent runoff from entering the 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 BMP (e.g. BMP C240: Sediment Trap or BMP C241: Sediment Pond (Temporary)).

Design and Installation Specifications

- Dike and/or swale and channel must be stabilized with temporary or permanent vegetation or other channel protection during construction.
- Steep grades require channel protection and check dams.
- Review construction for areas where overtopping may occur.
- Can be used at the top of new fill before vegetation is established.
- May be used as a permanent diversion channel to carry the runoff.
- Contributing area for an individual dike or swale should be one acre or less.
- Design the dike and/or swale to contain flows calculated by one of the following methods:
    - Single Event Hydrograph Method: The peak volumetric flow rate calculated using a 10-minute time step from a Type 1A, 10-year, 24-hour frequency storm for the worst-case land cover condition.

      OR

    - Continuous Simulation Method: The 10-year peak flow rate, as determined by an approved continuous runoff model with a 15-minute time step for the worst-case land cover condition.

  Worst-case land cover conditions (i.e., producing the most runoff) should be used for analysis (in most cases, this would be the land cover conditions just prior to final landscaping).

Interceptor Dikes

Interceptor dikes shall meet the following criteria:

- Top Width: 2 feet minimum.
- Height: 1.5 feet minimum on berm.
- Side Slope: 2H:1V 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.
- Stabilization: Depends on velocity and reach. Inspect regularly to ensure stability.
- Ground Slopes <5%: Seed and mulch applied within 5 days of dike construction (see BMP C121: Mulching).
- Ground 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.
- The upslope side of the dike shall provide positive drainage to 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.
- See Table II-3.8: Horizontal Spacing of Interceptor Dikes Along Ground Slope for recommended horizontal spacing between dikes.

Table II-3.8: Horizontal Spacing of Interceptor Dikes Along Ground Slope

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

Interceptor Swales

Interceptor swales shall meet the following criteria:

- Bottom Width: 2 feet minimum; the cross-section bottom shall be level.
- Depth: 1-foot minimum.
- Side Slope: 2H:1V or flatter.
- Grade: Maximum 5 percent, with positive drainage to a suitable outlet (such as BMP C241: Sediment Pond (Temporary)).
- Stabilization: Seed as per BMP C120: Temporary and Permanent Seeding, or BMP C202: Riprap Channel Lining, 12 inches thick riprap pressed into the bank and extending at least 8 inches vertical from the bottom.

Maintenance Standards

- Inspect diversion dikes and interceptor swales once a week and after every rainfall. Immediately remove sediment from the flow area.
- Damage caused by construction traffic or other activity must be repaired 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.

BMP C201: Grass-Lined Channels

Purpose

To provide a channel with a vegetative lining for conveyance of runoff. The purpose of the vegetative lining is to prevent transport of sediment and erosion.

Conditions of Use

This practice applies to construction sites where concentrated runoff needs to be directed to prevent erosion or flooding.

- Use this BMP when a vegetative lining can provide sufficient stability for the channel cross section and at 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 drainage 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 unless BMP C122: Nets and Blankets is used to protect the channel. 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.

Design and Installation Specifications

See Figure II-3.10: Typical Grass-Lined Channels

Locate channels where they can conform to the topography and other features such as roads. Use natural drainage 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 drainage channel.
- The maximum design velocity shall be based on soil conditions, type of vegetation, and method of revegetation, but at no time shall velocity exceed 5 feet/second. The channel shall not be overtopped by the peak volumetric flow rate calculated by one of the following methods:
    - Single Event Hydrograph Method: The peak volumetric flow rate calculated using a 10-minute time step from a Type 1A, 10-year, 24-hour frequency storm for the worst-case land cover condition.

      OR
    - Continuous Simulation Method: The 10-year peak flow rate, as determined by an

approved continuous runoff model with a 15-minute time step for the worst-case land cover condition..

Worst-case land cover conditions (i.e., producing the most runoff) should be used for analysis (in most cases, this would be the land cover conditions just prior to final landscaping).

- Where the grass-lined channel will also function as a permanent stormwater conveyance facility, consult the drainage conveyance requirements of the local jurisdiction.
- An established grass or vegetated lining is required before the channel can be used to convey stormwater, unless stabilized with nets or blankets (See BMP C122: Nets and Blankets).
- If design velocity of a channel to be vegetated by seeding exceeds 2 ft/sec, a temporary channel liner is required. Geotextile or special mulch protection such as fiberglass roving or straw and netting provides stability until the vegetation is fully established. See Figure II-3.11: Temporary Channel Liners.
- Check dams shall be removed when the grass has matured sufficiently to protect the ditch or swale unless the slope of the swale is greater than 4 percent. The area beneath the check dams shall be seeded and mulched 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 the 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 drainage 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 peak runoff for temporary construction drainage facilities from the 10-year, 24-hour storm without eroding. Where flood hazard exists, increase the capacity according to the potential damage.
- Grassed channel side slopes generally are constructed 3H:1V 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.

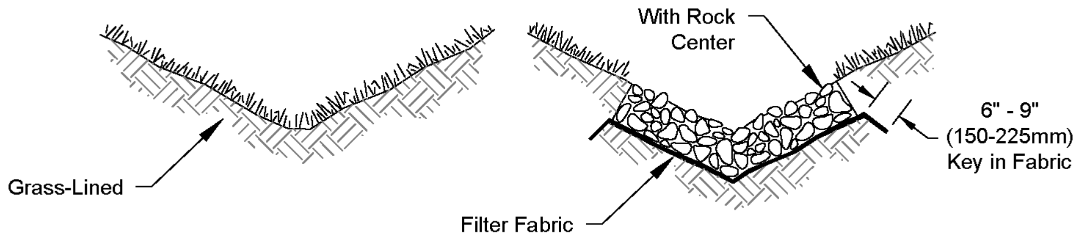
Maintenance Standards

During the establishment period, check grass-lined channels after every rainfall.

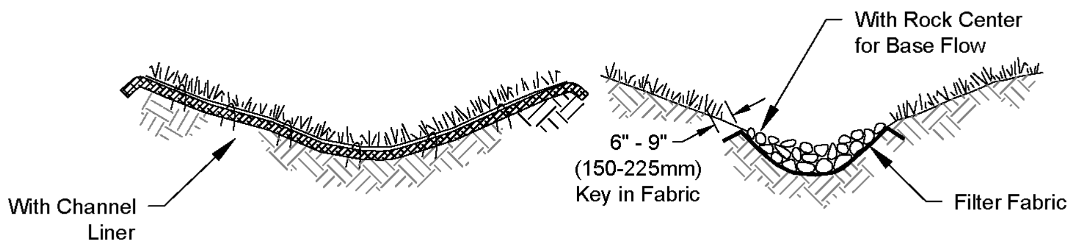
- After grass is established, periodically check the channel; check it after every heavy rainfall event. Immediately make repairs.
- Check the channel outlet and all road crossings for bank stability and evidence of piping or scour holes.
- Remove all significant sediment accumulations to maintain the 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 II-3.10: Typical Grass-Lined Channels

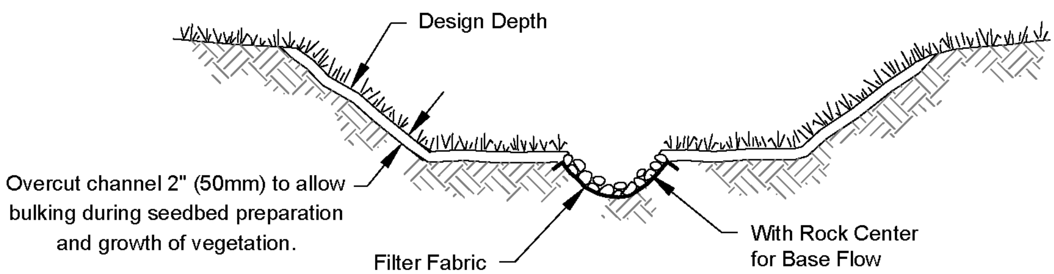
Typical V-Shaped Channel Cross-Section



Typical Parabolic Channel Cross-Section



Typical Trapezoidal Channel Cross-Section



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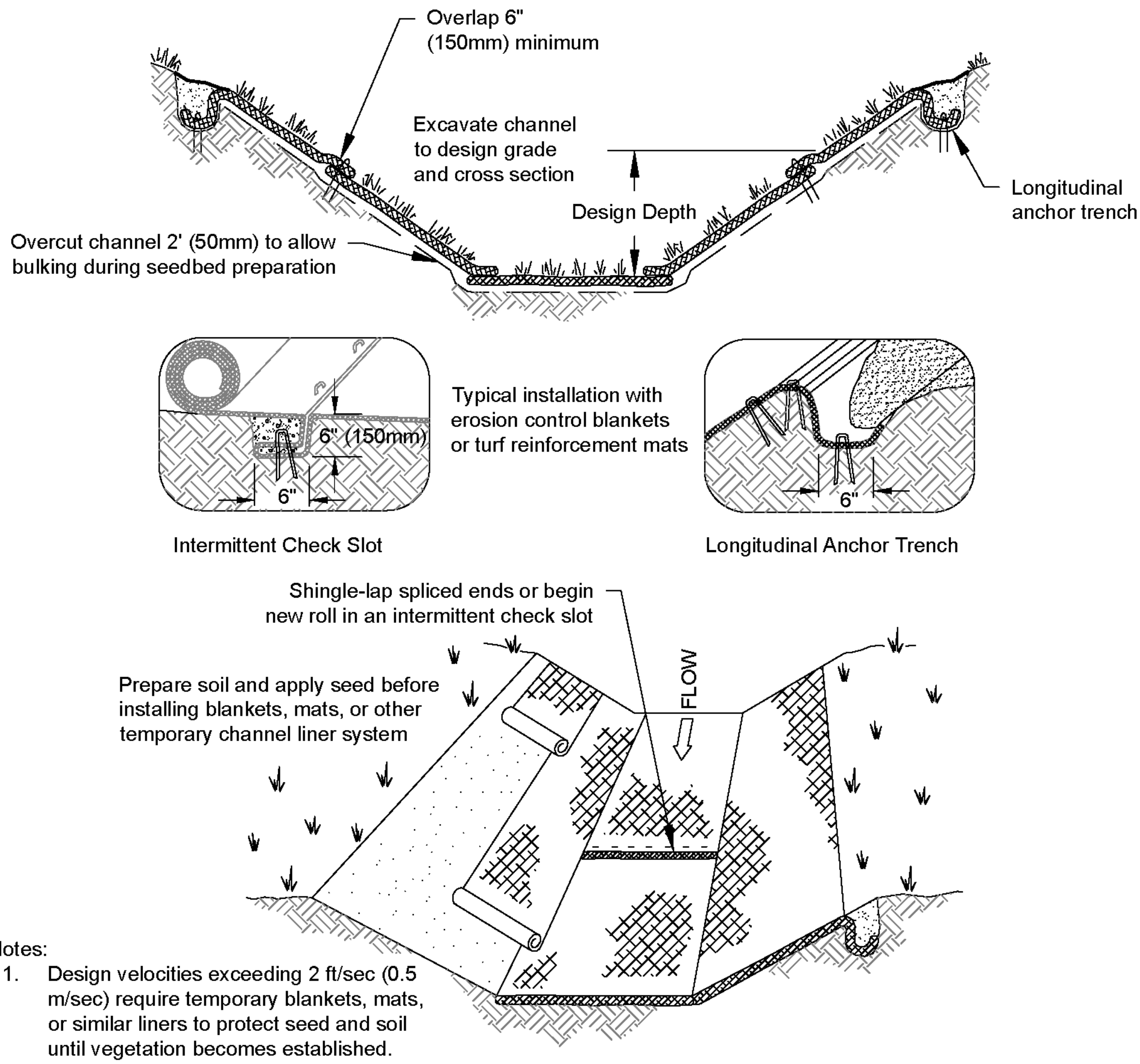
Typical Grass-Lined Channels

Revised June 2016

Figure II-3.11: Temporary Channel Liners



Notes:

1. Design velocities exceeding 2 ft/sec (0.5 m/sec) require temporary blankets, mats, or similar liners to protect seed and soil until vegetation becomes established.
2. Grass-lined channels with design velocities exceeding 6 ft/sec (2 m/sec) should include turf reinforcement mats.

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Temporary Channel Liners

Revised July 2016

BMP C202: Riprap Channel Lining

Purpose

To protect channels by providing a channel liner using riprap.

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.

An alternative to riprap channel lining is BMP C122: Nets and Blankets.

The Federal Highway Administration recommends not using geotextile liners whenever the slope exceeds 10 percent or the shear stress exceeds 8 lbs/ft^2.

Design and Installation Specifications

- Since riprap is typically used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum possible delay.
- Disturb areas awaiting riprap only when final preparation and placement of the riprap can follow immediately behind the initial disturbance. Where riprap is used for outlet protection, the riprap should be placed before or in conjunction with the construction of the pipe or channel so that it is in place when the pipe or channel begins to operate.
- The designer, after determining the riprap size that will be stable under the flow conditions, 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. The possibility of drainage structure damage by others shall be considered in selecting a riprap size, especially if there is nearby water or a gully in which to toss the stones.
- Stone for riprap shall consist of field stone or quarry stone of approximately rectangular shape. The stone shall be hard and angular and of such quality that it will not disintegrate on exposure to water or weathering and it shall be suitable in all respects for the purpose intended. See Section 9-13 of WSDOT's *Standard Specifications for Road, Bridge, and Municipal Construction* (WSDOT, 2016).
- A lining of engineering filter fabric (geotextile) shall be placed 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.
- Filter fabric shall not be used on slopes greater than 1.5H: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.

Maintenance Standards

Replace riprap as needed.

BMP C203: Water Bars

Purpose

A water bar is a small ditch or ridge of material that 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. See Figure II-3.12: Water Bar.

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.

Design and Installation Specifications

- Height: 8-inch minimum, measured from the channel bottom to the ridge top.
- Side slope of channel: 2H:1V maximum; 3H:1V or flatter when vehicles will cross.
- Top width of ridge: 6-inch minimum.
- Locate water bars to use natural drainage systems and to discharge into well vegetated stable areas.
- See Table II-3.9: Water Bar Spacing Guidelines:

Table II-3.9: Water Bar Spacing Guidelines

Slope Along Road (%)	Spacing (ft)
< 5	125
5 - 10	100
10 - 20	75
20 - 35	50
> 35	Use rock lined ditch

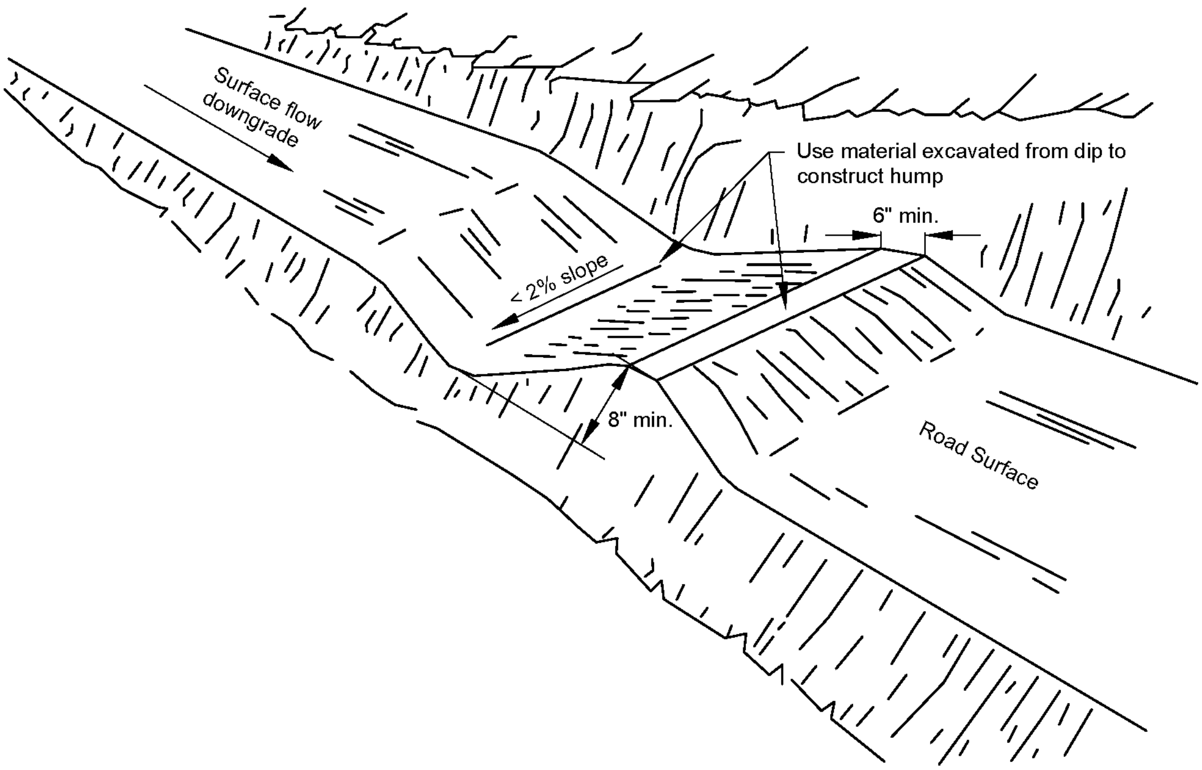
- Grade of water bar and angle: Select an angle that results in a ditch slope less than 2 percent.
- Install the water bar as soon as the clearing and grading is complete. When utilities are being installed, reconstruct the water bar as construction is complete in each section.
- Compact the water bar ridge.
- Stabilize, seed, and mulch the portions that are not subject to traffic. Gravel the areas crossed by vehicles.
- Note that BMP C208: Triangular Silt Dike (TSD) can be used to create the ridge for the water bar.

Maintenance Standards

Periodically inspect water bars after every heavy rainfall for wear and 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 drainage is established and the area above the temporary water bar is permanently stabilized, remove the dikes and fill the channel to blend with the natural ground, and appropriately stabilize the disturbed area.

Figure II-3.12: Water Bar



Water Bar

Revised July 2017

BMP C204: Pipe Slope Drains

Purpose

The purpose of pipe slope drains is to prevent gullies, channel erosion, and saturation of slide-prone soils by using a pipe to convey stormwater away from or over bare soil.

Conditions of Use

Pipe slope drains should be used when a temporary or permanent stormwater conveyance is needed to move water down a steep slope to avoid erosion.

Pipe slope drains should be used at bridge ends to collect runoff and convey it to the base of the fill slopes along the bridge approaches. Another use on road projects is to collect runoff from pavement in a pipe slope drain and convey it away from side slopes.

Temporary installations of pipe slope drains can be useful because there is generally a time lag between having the first lift of asphalt installed and the curbs, gutters, and permanent drainage installed. Used in conjunction with sand bags, or other temporary diversion devices, these will prevent massive amounts of sediment from leaving a project.

Pipe slope drains can serve the following purposes:

- Connection to new catch basins and temporarily use until permanent piping is installed.
- Drainage of water collected from aquifers exposed on cut slopes and conveyance of water to the base of the slope.
- Collection of clean runoff from plastic sheeting and routing the runoff away from exposed soil.
- Installation in conjunction with silt fence to drain collected water to a controlled area.
- Diversion of 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.
- Connection to existing downspouts and roof drains and diversion of water away from work areas during building renovation, demolition, and construction projects.

There are several commercially available collectors that attach to the pipe inlet and help prevent erosion at the inlet.

Design and Installation Specifications

See Figure II-3.13: Pipe Slope Drain.

Size the pipe to convey the projected flow. The capacity for temporary drains shall be sufficient to handle flows calculated by one of the following methods:

  - Single Event Hydrograph Method: The peak volumetric flow rate calculated using a 10-minute time step from a Type 1A, 10-year, 24-hour frequency storm for the worst-case land cover condition.

OR

- ◦ Continuous Simulation Method: The 10-year peak flow rate, as determined by an approved continuous runoff model with a 15-minute time step for the worst-case land cover condition.

Worst-case land cover conditions (i.e., producing the most runoff) should be used for analysis (in most cases, this would be the land cover conditions just prior to final landscaping).

Consult local drainage requirements for sizing permanent pipe slope drains.

- Use care in clearing vegetated slopes for installation.
- Re-establish cover immediately on areas disturbed by installation.
- Use temporary drains on new cut or fill slopes.
- Use BMP C200: Interceptor Dike and Swale 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.
- The soil around and under the pipe and entrance section shall be thoroughly compacted to prevent undercutting.
- The flared inlet section shall be securely connected to the slope drain and have watertight connecting bands.
- Slope drain sections shall be securely fastened together, fused or have gasketed watertight fittings, and shall be securely anchored into the soil.
- Thrust blocks should be installed 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. Install a post on each side of the pipe and wire the pipe to them. This should be done every 10-20 feet of pipe length or so, depending on the size of the pipe and quantity of water to divert.
- BMP C200: Interceptor Dike and Swale shall be used to direct runoff into a pipe slope drain. The height of the dike shall be at least 1 foot higher at all points than the top of the inlet pipe.
- The area below the outlet must be stabilized. See BMP C209: Outlet Protection.
- If the pipe slope drain is conveying sediment-laden water, direct all flows into a sediment trap-

ping facility.

- Materials specifications for any permanent piped system shall be set by the local government.

Maintenance Standards

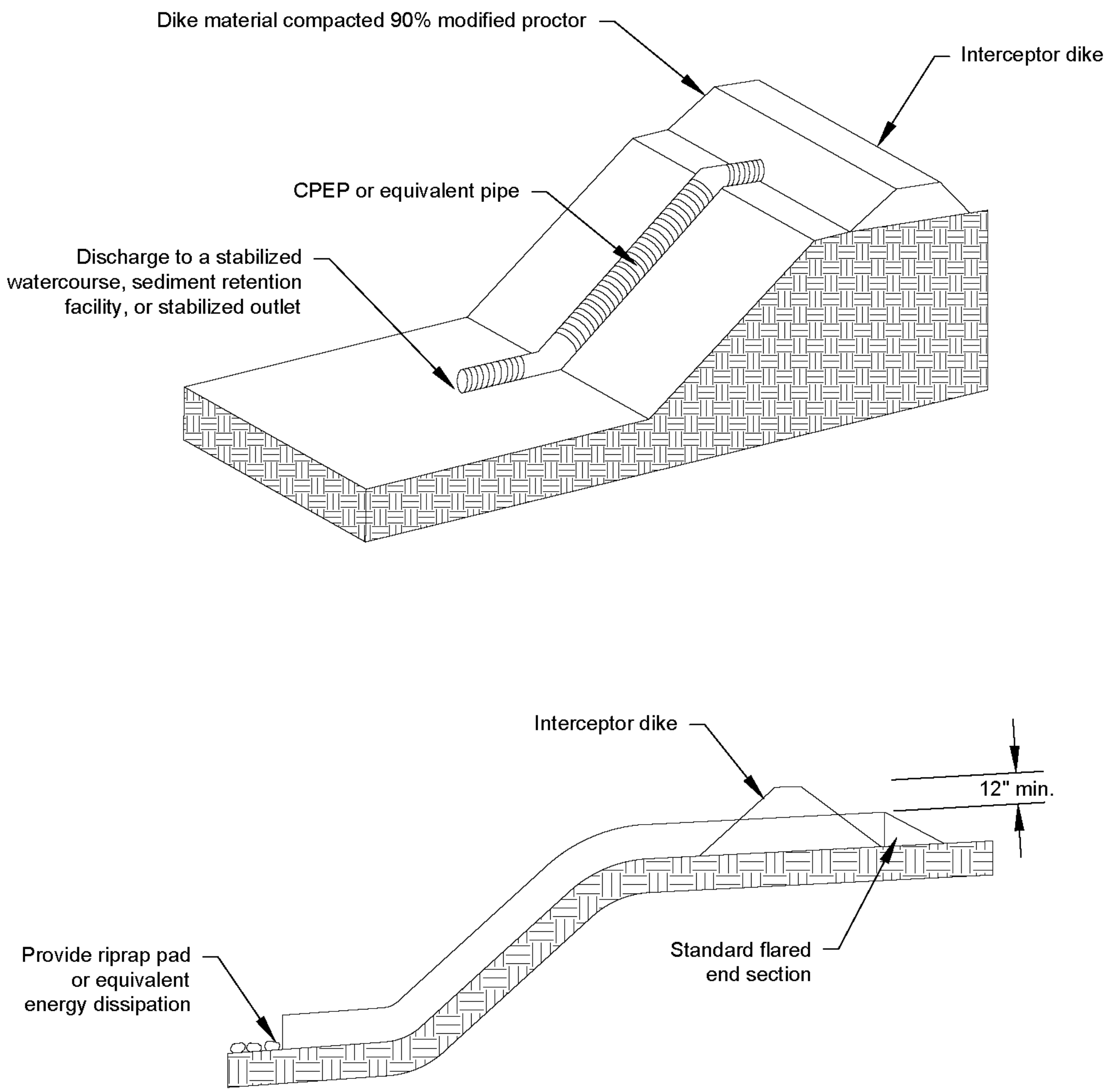
Check inlet and outlet points regularly, especially after storms.

- 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 the pipe periodically for vandalism and physical distress such as slides and wind-throw. Clean the pipe and outlet structure at the completion of construction.

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 II-3.13: Pipe Slope Drain



Notes:

1. Inlet and all sections must be securely fastened together with gasketed watertight fittings

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Pipe Slope Drain

Revised June 2016

BMP C205: Subsurface Drains

Purpose

The purpose of subsurface drains is to intercept, collect, and convey ground water to a satisfactory outlet, using a perforated pipe or other 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, improve stability of structures with shallow foundations, or to reduce hydrostatic pressure to improve slope stability.

Conditions of Use

Use subsurface drains 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.

Design and Installation Specifications

Subsurface Drain Type: Relief Drains

Relief drains are used to lower the water table in large, relatively flat areas, improve the growth of vegetation, or to remove surface water.

Relief drains are installed along a slope and drain in the direction of the slope.

Relief drains can be installed in a grid pattern, a herringbone pattern, or a random pattern.

Subsurface Drain Type: Interceptor Drains

Interceptor drains are used to remove excess ground water from a slope, stabilize steep slopes, and lower the water table immediately below a slope to prevent the soil from becoming saturated.

Interceptor drains are installed perpendicular to a slope and drain to the side of the slope.

Interceptor drains usually consist of a single pipe or series of single pipes instead of a patterned layout.

Subsurface Drain Depth and Spacing

- The depth of a subsurface 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 drainage system at a depth of 2 to 6 feet.

Subsurface Drain Sizing and Placement

- The quantity and quality of discharge needs to be accounted for in the receiving stream (additional detention may be required).
- The size of a subsurface drain is determined by first calculating the maximum rate of ground water flow to be intercepted, and then choosing a subsurface drain pipe (or pipes) with enough capacity to convey that flow. Therefore, it is good practice to make complete subsurface investigations, including hydraulic conductivity of the soil, before designing a subsurface drainage system.
- Size subsurface drains to carry the required capacity without pressure flow. Minimum diameter for a subsurface drain is 4 inches.
- The minimum velocity in the pipe required to prevent silting is 1.4 ft/sec. Grade the subsurface drain to achieve this velocity at a minimum. The maximum allowable velocity using a sand-gravel filter or envelope is 9 ft/sec.
- Filter material and fabric shall be used around all drains for proper bedding and filtration of fine materials. Envelopes and filters should surround the drain to a minimum of 3-inch thickness.
- The trench shall be constructed on a continuous grade with no reverse grades or low spots.
- Soft or yielding soils under the subsurface drain shall be stabilized with gravel or other suitable material.
- Backfilling shall be done immediately after placement of the pipe. No sections of pipe shall remain uncovered overnight or during a rainstorm. Backfill material shall be placed in the trench in such a manner that the drain pipe is not displaced or damaged.
- Do not install permanent drains near trees to avoid the tree roots that tend to clog the line. Use solid pipe with watertight connections where it is necessary to pass a subsurface drainage system through a stand of trees.

Subsurface Drain Outlets

- An adequate outlet for the subsurface drain must be available either by gravity or by pumping.
- The outlet of the subsurface drain shall empty 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.
- Ensure that the outlet of a subsurface drain empties into a channel or other watercourse above the normal water level.
- Secure an animal guard to the outlet end of the pipe to keep out rodents.
- Use outlet pipe of corrugated metal, cast iron, or heavy-duty plastic without perforations and at least 10 feet long. 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, outlet protection must be provided.

Maintenance Standards

Subsurface drains shall be checked periodically to ensure that they are free-flowing and not clogged with sediment or roots.

- The outlet shall be kept clean and free of debris.
- Surface inlets shall be kept 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 drain becomes clogged, relocate the drain or remove the trees as a last resort. Drain placement should be planned to minimize this problem.
- Where drains are crossed by heavy vehicles, the line shall be checked to ensure that it is not crushed.

BMP C206: Level Spreader

Purpose

The purpose of a level spreader as a Construction Stormwater BMP is to provide a temporary outlet for dikes and diversions and convert concentrated runoff to sheet flow prior to releasing it to stabilized areas.

Conditions of Use

Use level spreaders when a concentrated flow of water needs to be dispersed over a large area with existing stable vegetation.

Use only where the slopes are gentle, the water volume is relatively low, and the soil will adsorb most of the low flow events.

Items to consider are:

- What is the risk of erosion or damage if the flow becomes concentrated?
- Is an easement required if discharged to adjoining property?

Design and Installation Specifications

- Use above undisturbed areas that are stabilized by existing vegetation.
- Discharge area below the outlet must be uniform with a slope flatter than 5H:1V.
- Do not allow any low points in the level spreader. If the level spreader has any low points, flow will concentrate, create channels and may cause erosion.
- Ensure the outlet is level in a stable, undisturbed soil profile (not on fill).

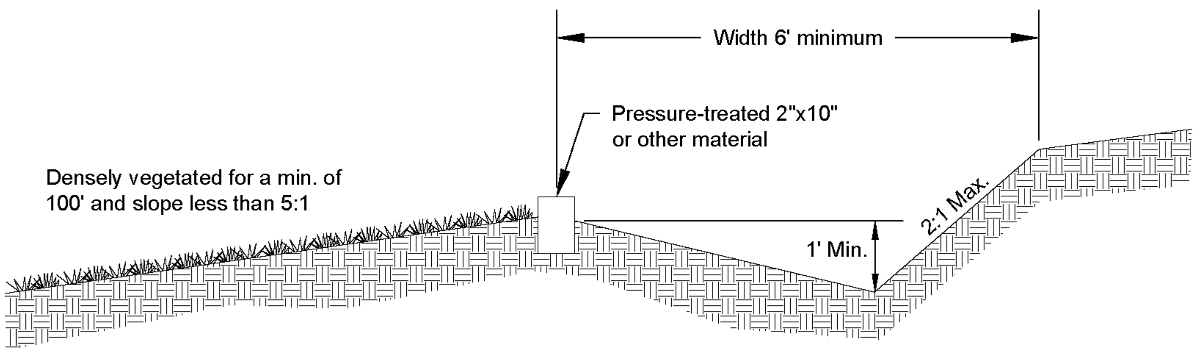
- The runoff shall not re-concentrate on site after release from the level spreader unless it is intercepted by another downstream measure.
- The grade of the channel for the last 20 feet of the dike or interceptor entering the level spreader shall be less than or equal to 1 percent. The grade of the level spreader shall be 0 percent to ensure uniform spreading of 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.
- The spreader length shall be determined by calculating the peak volumetric flow rate using a 10-minute time step from a Type 1A, 10-year, 24-hour design storm. The length of the spreader shall be a minimum of 15 feet for 0.1 cfs and shall increase by 10 feet for each 0.1 cfs thereafter to a maximum of 0.5 cfs per spreader. Use multiple spreaders for higher flows.
- The width of the approach to 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 set back from the property line unless there is an easement for flow.
- Materials that can be used for level spreaders include sand bags, lumber, logs, concrete, pipe, and capped perforated pipe. To function properly, the material needs to be installed level and on contour.
- See Figure II-3.14: Cross Section of Level Spreader and Figure II-3.15: Detail of Level Spreader.

Maintenance Standards

The level spreader should be inspected during and after runoff events to ensure that it is functioning correctly.

- The contractor should avoid the placement of any material on the level spreader, and should prevent construction traffic from crossing over the level spreader.
- If the level spreader is damaged by construction traffic, it shall be immediately repaired.

Figure II-3.14: Cross Section of Level Spreader



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Cross Section of Level Spreader

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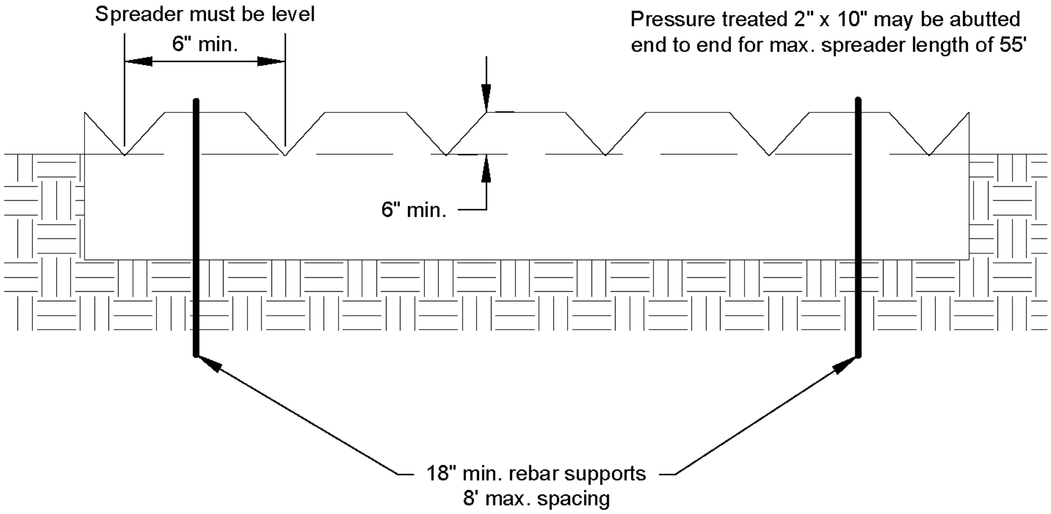
Figure II-3.15: Detail of Level Spreader



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Detail of Level Spreader

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BMP C207: Check Dams

Purpose

Construction of check dams across a swale or ditch reduces the velocity of concentrated flow and dissipates energy at the check dam.

Conditions of Use

Use check dams where temporary or permanent channels are not yet vegetated, channel lining is infeasible, and/or velocity checks are required.

- Check dams may not be placed in streams unless approved by the State Department of Fish and Wildlife.
- Check dams may not be placed in wetlands without approval from a permitting agency.
- Do not place check dams below the expected backwater from any salmonid bearing water between October 1 and May 31 to ensure that there is no loss of high flow refuge habitat for overwintering juvenile salmonids and emergent salmonid fry.

Design and Installation Specifications

- Construct rock check dams from appropriately sized rock. 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 (do not dump the rock to form the dam) to achieve complete coverage of the ditch or swale and to ensure that the center of the dam is lower than the edges.
- Check dams may also 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.
- Place check dams perpendicular to the flow of water.
- The check dam should form a triangle when viewed from the side. This prevents undercutting as water flows over the face of the check dam rather than falling directly onto the ditch bottom.
- Before installing check dams, impound and bypass upstream water flow away from the work area. Options for bypassing include pumps, siphons, or temporary channels.
- Check dams combined with sumps work more effectively at slowing flow and retaining sediment than 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.
- The maximum spacing between check dams shall be such that the downstream toe of the

upstream dam is at the same elevation as the top of the downstream dam.

- Keep the maximum height at 2 feet at the center of the check 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, filter fabric 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, all check dams and accumulated sediment shall be removed when the grass has matured sufficiently to protect the ditch or swale - unless the slope of the swale is greater than 4 percent. The area beneath the check dams shall be seeded and mulched 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.
- See Figure II-3.16: Rock Check Dam.

Maintenance Standards

Check dams shall be monitored for performance and sediment accumulation during and after each rainfall that produces runoff. Sediment shall be removed when it reaches one half the sump depth.

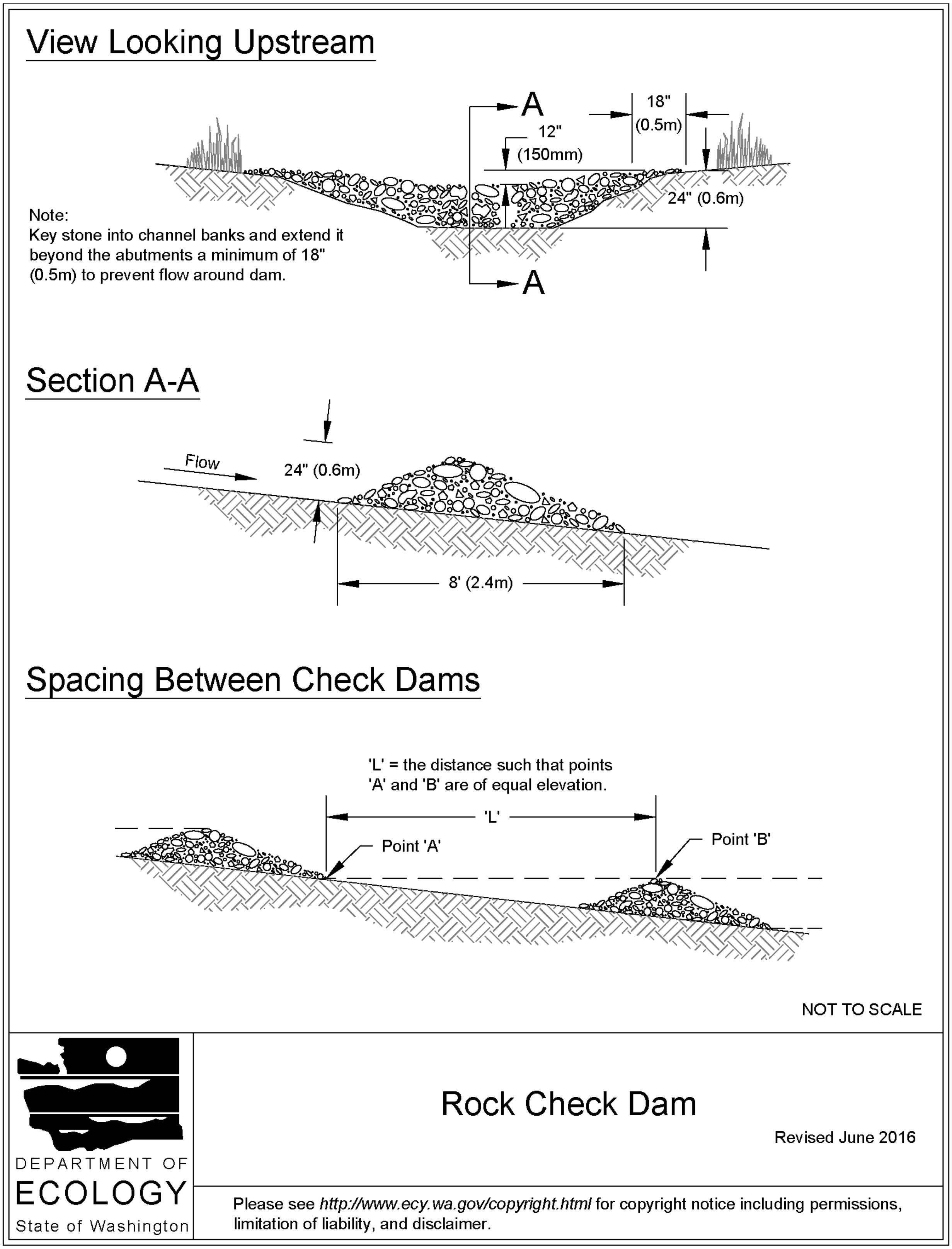
- Anticipate submergence and deposition above the check dam and erosion from high flows around the edges of the dam.
- If significant erosion occurs between dams, install a protective riprap liner in that portion of the channel. See BMP C202: Riprap Channel Lining.

Approved as Functionally Equivalent

Ecology has approved products as able to meet the requirements of this BMP. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept these products, or may require additional testing prior to consideration for local use. Products that Ecology has approved as functionally equivalent are available for review on Ecology's website at:

https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies

Figure II-3.16: Rock Check Dam



BMP C208: Triangular Silt Dike (TSD)

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.

Conditions of Use

- TSDs may be used on soil or pavement with adhesive or staples.
- TSDs have been used to build temporary:
    - BMP C241: Sediment Pond (Temporary);
    - BMP C200: Interceptor Dike and Swale;
    - BMP C154: Concrete Washout Area;
    - BMP C203: Water Bars;
    - BMP C206: Level Spreader;
    - BMP C220: Inlet Protection;
    - BMP C207: Check Dams
    - curbing; and
    - berms.

Design and Installation Specifications

- TSDs are made of urethane foam sewn into a woven geosynthetic fabric.
- TSDs are 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.

    - In the case of grass-lined ditches and swales, check dams and accumulated sediment shall be removed when the grass has matured sufficiently to protect the ditch or swale unless the slope of the swale is greater than 4 percent. The area beneath the check dams shall be seeded and mulched immediately after dam removal.

Maintenance Standards

- Inspect TSDs for performance and sediment accumulation during and after each rainfall that produces runoff. Remove sediment when it reaches one half the height of the TSD.
- Anticipate submergence and deposition above the TSD and erosion from high flows around the edges of the TSD. Immediately repair any damage or any undercutting of the TSD.

BMP C209: Outlet Protection

Purpose

Outlet protection prevents scour at conveyance outlets and minimizes the potential for downstream erosion by reducing the velocity of concentrated stormwater flows.

Conditions of Use

Use outlet protection at the outlets of all ponds, pipes, ditches, or other conveyances that discharge to a natural or manmade drainage feature such as a stream, wetland, lake, or ditch.

Design and Installation Specifications

- The receiving channel at the outlet of a pipe shall be protected from erosion by lining a minimum of 6 feet downstream and extending up the channel sides a minimum of 1–foot above the maximum tailwater elevation, or 1-foot above the crown, whichever is higher. For pipes larger than 18 inches in diameter, the outlet protection lining of the channel shall be four times the diameter of the outlet pipe.
- Standard wingwalls, tapered outlets, and paved channels should also be considered when appropriate for permanent culvert outlet protection (WSDOT, 2015).
- BMP C122: Nets and Blankets or BMP C202: Riprap Channel Lining provide suitable options for lining materials.
- With low flows, BMP C201: Grass-Lined Channels can be an effective alternative for lining material.
- The following guidelines shall be used for outlet protection with riprap:
    - If the discharge velocity at the outlet is less than 5 fps, use 2-inch to 8-inch riprap. Minimum thickness is 1-foot.
    - For 5 to 10 fps discharge velocity at the outlet, use 24-inch to 48-inch riprap. Minimum

thickness is 2 feet.

    - For outlets at the base of steep slope pipes (pipe slope greater than 10 percent), use an engineered energy dissipator.

    - Filter fabric or erosion control blankets should always be used under riprap to prevent scour and channel erosion. See BMP C122: Nets and Blankets.

- 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. See I-2.11 Hydraulic Project Approvals.

Maintenance Standards

- Inspect and repair as needed.
- Add rock as needed to maintain the intended function.
- Clean energy dissipator if sediment builds up.

BMP C220: Inlet Protection

Purpose

Inlet protection prevents coarse sediment from entering drainage systems prior to permanent stabilization of the disturbed area.

Conditions of Use

Use inlet protection at inlets that are operational before permanent stabilization of the disturbed areas that contribute runoff to the inlet. Provide protection for all storm drain inlets downslope and within 500 feet of a disturbed or construction area, unless those inlets are preceded by a sediment trapping BMP.

Also consider inlet protection for lawn and yard drains on new home construction. These small and numerous drains coupled with lack of gutters can add significant amounts of sediment into the roof drain system. If possible, delay installing lawn and yard drains until just before landscaping, or cap these drains to prevent sediment from entering the system until completion of landscaping. Provide 18-inches of sod around each finished lawn and yard drain.

Table II-3.10: Storm Drain Inlet Protection lists several options for inlet protection. All of the methods for inlet protection tend to plug and require a high frequency of maintenance. Limit contributing drainage areas for an individual inlet to one acre or less. If possible, provide emergency overflows with additional end-of-pipe treatment where stormwater ponding would cause a hazard.

Table II-3.10: Storm Drain Inlet Protection

Type of Inlet Protection	Emergency Overflow	Applicable for Paved/ Earthen Surfaces	Conditions of Use
Drop Inlet Protection			
Excavated drop inlet protection	Yes, temporary flooding may occur	Earthen	Applicable for heavy flows. Easy to maintain. Large area requirement: 30'x30'/acre
Block and gravel drop inlet protection	Yes	Paved or Earthen	Applicable for heavy concentrated flows. Will not pond.
Gravel and wire drop inlet protection	No	Paved or Earthen	Applicable for heavy concentrated flows. Will pond. Can withstand traffic.
Catch basin filters	Yes	Paved or Earthen	Frequent maintenance required.
Curb Inlet Protection			
Curb inlet protection with wooden weir	Small capacity overflow	Paved	Used for sturdy, more compact installation.
Block and gravel curb inlet protection	Yes	Paved	Sturdy, but limited filtration.
Culvert Inlet Protection			
Culvert inlet sediment trap	N/A	N/A	18 month expected life.

Design and Installation Specifications

Excavated Drop Inlet Protection

Excavated drop inlet protection consists of an excavated impoundment around the storm drain inlet. Sediment settles out of the stormwater prior to entering the storm drain. Design and installation specifications for excavated drop inlet protection include:

- Provide a depth of 1-2 ft as measured from the crest of the inlet structure.
- Slope sides of excavation should be no steeper than 2H:1V.
- Minimum volume of excavation is 35 cubic yards.
- Shape the excavation to fit the site, with the longest dimension oriented toward the longest inflow area.
- Install provisions for draining to prevent standing water.
- Clear the area of all debris.

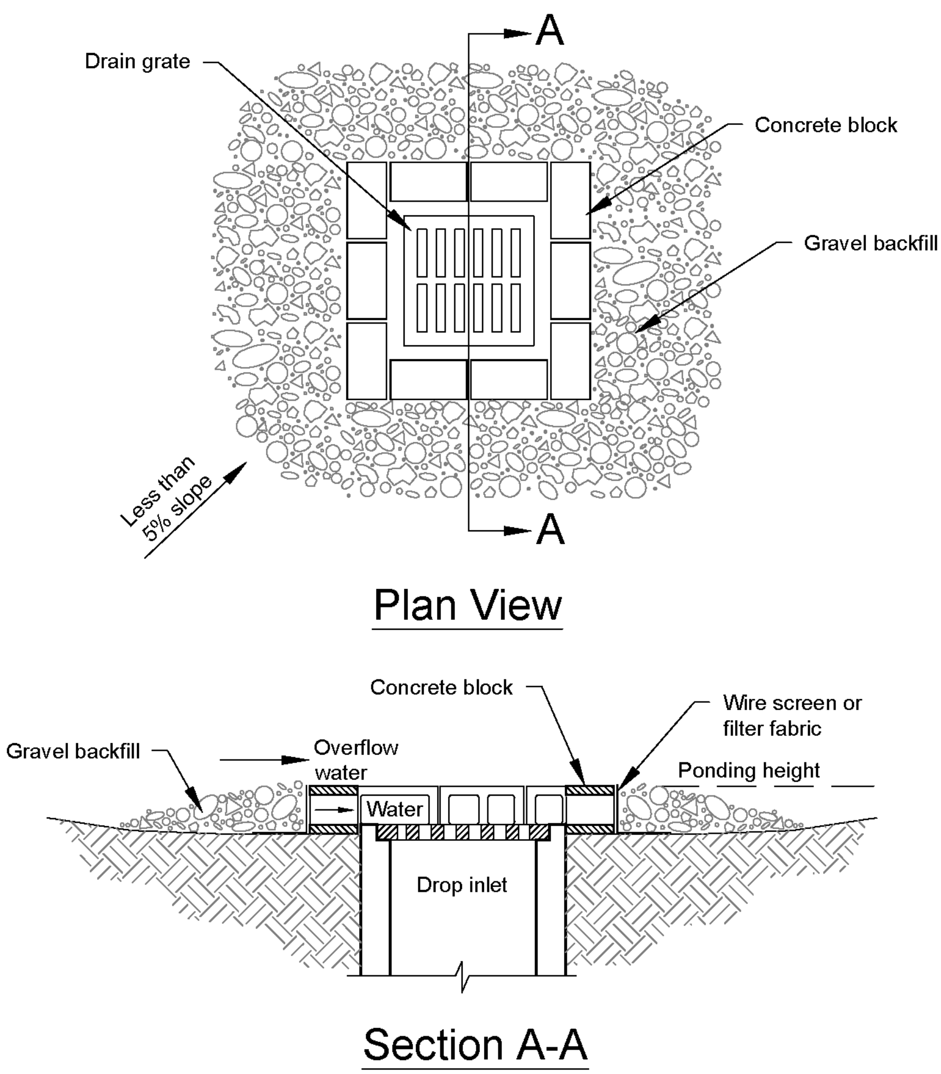
- Grade the approach to the inlet uniformly.
- Drill weep holes into the side of the inlet.
- Protect weep holes with screen wire and washed aggregate.
- Seal weep holes when removing structure and stabilizing area.
- Build a temporary dike, if necessary, to the down slope side of the structure to prevent bypass flow.

Block and Gravel Filter

A block and gravel filter is a barrier formed around the inlet with standard concrete blocks and gravel. See Figure II-3.17: Block and Gravel Filter. Design and installation specifications for block gravel filters include:

- Provide a height of 1 to 2 feet above the inlet.
- Recess the first row of blocks 2-inches into the ground for stability.
- Support subsequent courses by placing a pressure treated wood 2x4 through the block opening.
- Do not use mortar.
- Lay some blocks in the bottom row on their side to allow for dewatering the pool.
- Place hardware cloth or comparable wire mesh with ½-inch openings over all block openings.
- Place gravel to just below the top of blocks on slopes of 2H:1V or flatter.
- An alternative design is a gravel berm surrounding the inlet, as follows:
    - Provide a slope of 3H:1V on the upstream side of the berm.
    - Provide a slope of 2H:1V on the downstream side of the berm.
    - Provide a 1-foot wide level stone area between the gravel berm and the inlet.
    - Use stones 3 inches in diameter or larger on the upstream slope of the berm.
    - Use gravel ½- to ¾-inch at a minimum thickness of 1-foot on the downstream slope of the berm.

Figure II-3.17: Block and Gravel Filter



Notes:

1. Drop inlet sediment barriers are to be used for small, nearly level drainage areas. (less than 5%)
2. Excavate a basin of sufficient size adjacent to the drop inlet.
3. The top of the structure (ponding height) must be well below the ground elevation downslope to prevent runoff from bypassing the inlet. A temporary dike may be necessary on the downslope side of the structure.

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Block and Gravel Filter

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Gravel and Wire Mesh Filter

Gravel and wire mesh filters are gravel barriers placed over the top of the inlet. This method does not provide an overflow. Design and installation specifications for gravel and wire mesh filters include:

- Use a hardware cloth or comparable wire mesh with ½-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

Catch basin filters are designed by manufacturers for construction sites. The limited sediment storage capacity increases the amount of inspection and maintenance required, which may be daily for heavy sediment loads. To reduce maintenance requirements, combine 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. Design and installation specifications for catch basin filters include:

- Provides 5 cubic feet of storage.
- Requires dewatering provisions.
- Provides a high-flow bypass that will not clog under normal use at a construction site.
- Insert the catch basin filter in the catch basin just below the grating.

Curb Inlet Protection with Wooden Weir

Curb inlet protection with wooden weir is an option that consists of a barrier formed around a curb inlet with a wooden frame and gravel. Design and installation specifications for curb inlet protection with wooden weirs include:

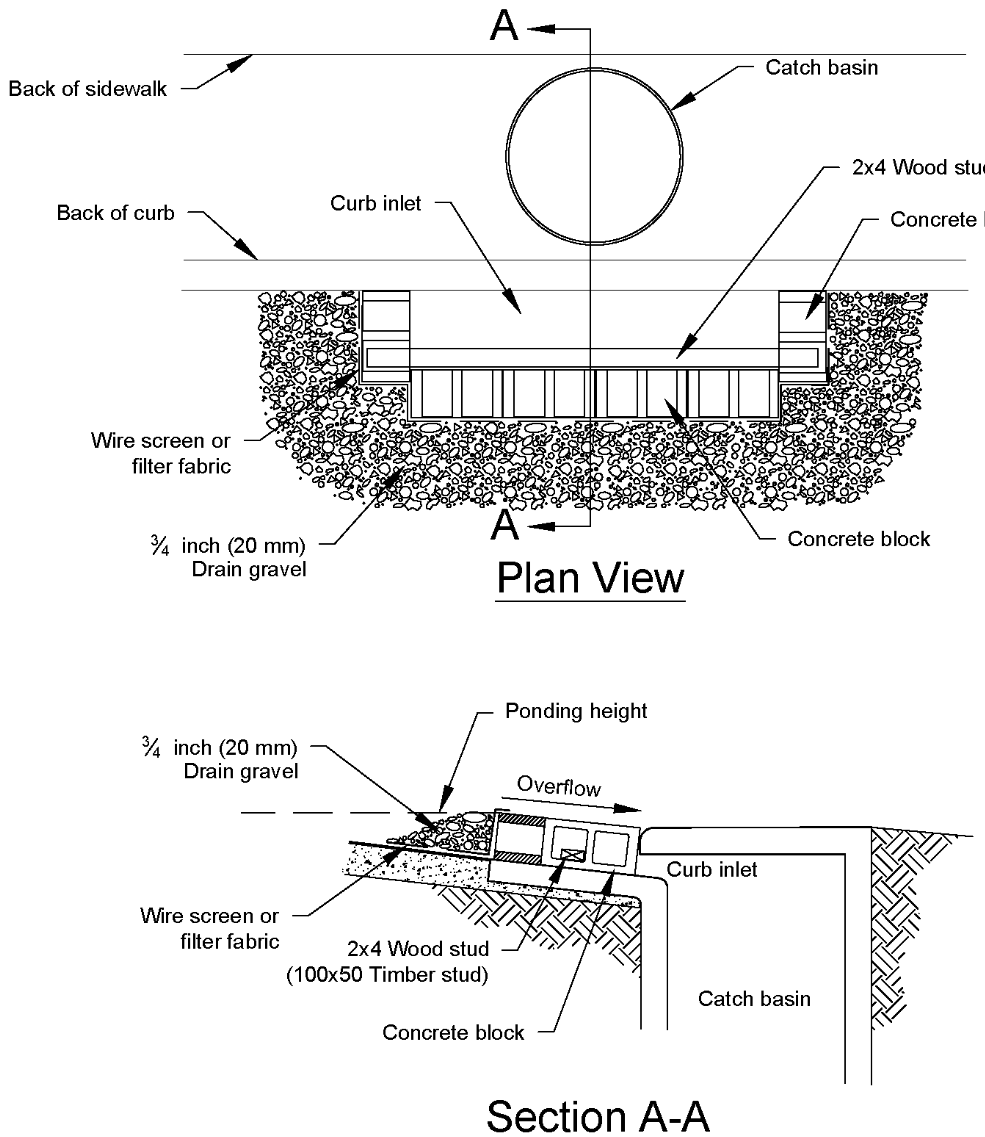
- Use wire mesh with ½-inch openings.
- Use extra strength filter cloth.
- Construct a frame.
- Attach the wire and filter fabric to the frame.
- Pile coarse washed aggregate against the wire and fabric.
- Place weight on the frame anchors.

Block and Gravel Curb Inlet Protection

Block and gravel curb inlet protection is a barrier formed around a curb inlet with concrete blocks and gravel. See Figure II-3.18: Block and Gravel Curb Inlet Protection. Design and installation specifications for block and gravel curb inlet protection include:

- 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 II-3.18: Block and Gravel Curb Inlet Protection



Notes:

1. Use block and gravel type sediment barrier when curb inlet is located in gently sloping street segment, where water can pond and allow sediment to separate from runoff.
2. Barrier shall allow for overflow from severe storm event.
3. Inspect barriers and remove sediment after each storm event. Sediment and gravel must be removed from the traveled way immediately.

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Block and Gravel Curb Inlet Protection

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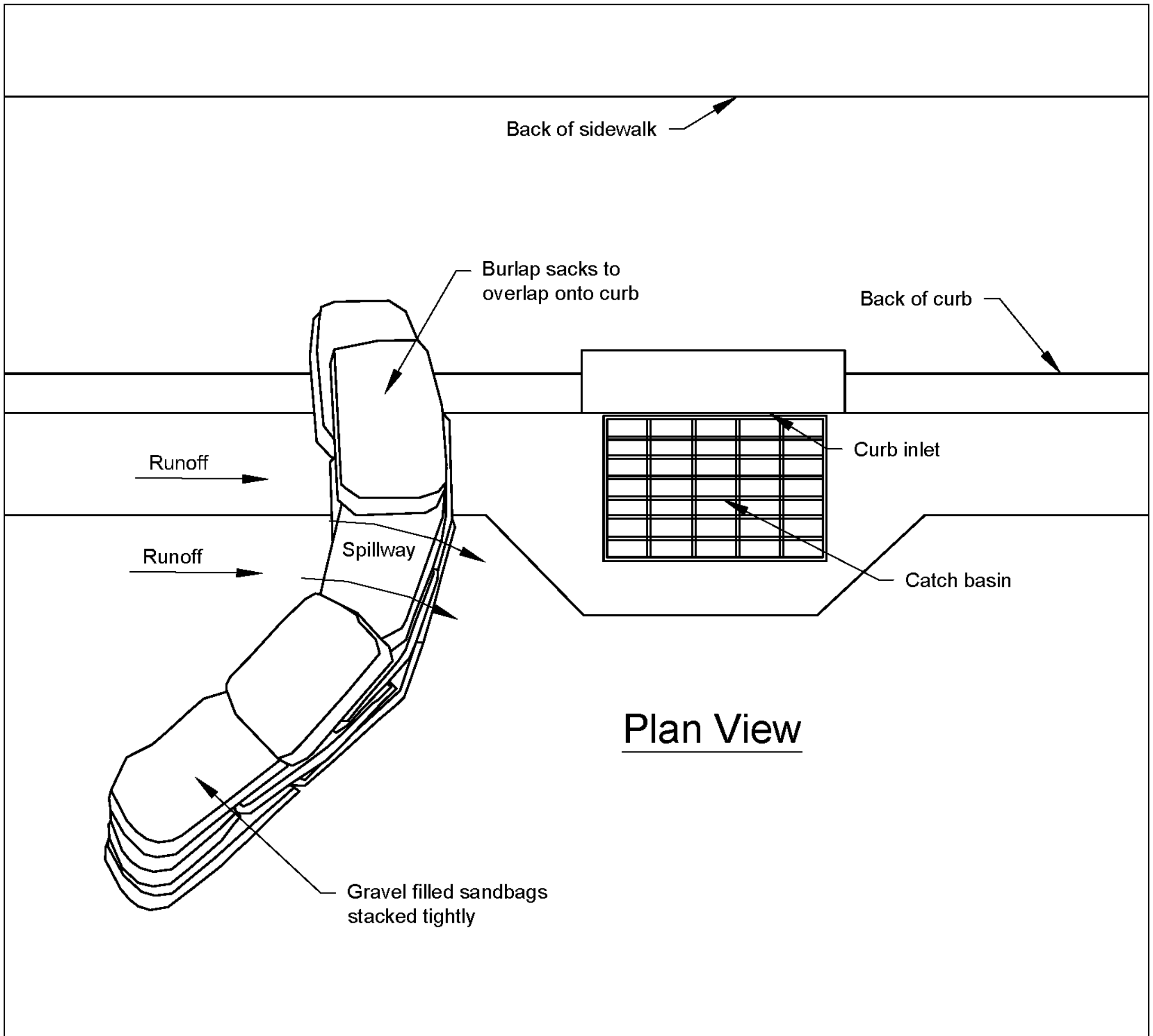
Curb and Gutter Sediment Barrier

Curb and gutter sediment barrier is a sandbag or rock berm (riprap and aggregate) 3 feet high and 3 feet wide in a horseshoe shape. See Figure II-3.19: Curb and Gutter Barrier. Design and installation specifications for curb and gutter sediment barrier include:

- 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 upstream side of the berm. Size the trap to sediment trap standards for protecting a culvert inlet.

Figure II-3.19: Curb and Gutter Barrier



Notes:

1. Place curb type sediment barriers on gently sloping street segments, where water can pond and allow sediment to separate from runoff.
2. Sandbags of either burlap or woven 'geotextile' fabric, are filled with gravel, layered and packed tightly.
3. Leave a one sandbag gap in the top row to provide a spillway for overflow.
4. Inspect barriers and remove sediment after each storm event. Sediment and gravel must be removed from the traveled way immediately.

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Curb and Gutter Barrier

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Maintenance Standards

- Inspect all forms of inlet protection frequently, especially after storm events. Clean and replace clogged catch basin filters. For rock and gravel filters, pull away the rocks from the inlet and clean or replace. An alternative approach would be to use the clogged rock as fill and put fresh rock around the inlet.
- Do not wash sediment into storm drains while cleaning. Spread all excavated material evenly over the surrounding land area or stockpile and stabilize as appropriate.

Approved as Functionally Equivalent

Ecology has approved products as able to meet the requirements of this BMP. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept these products, or may require additional testing prior to consideration for local use. Products that Ecology has approved as functionally equivalent are available for review on Ecology's website at:

https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies

BMP C231: Brush Barrier

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.

Conditions of Use

- Brush barriers may be used downslope of disturbed areas that are 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 directed to a sediment trapping BMP. The only circumstance in which overland flow can be treated solely by a brush barrier, rather than by a sediment trapping BMP, is when the area draining to the barrier is small.
- Brush barriers should only be installed on contours.

Design and Installation Specifications

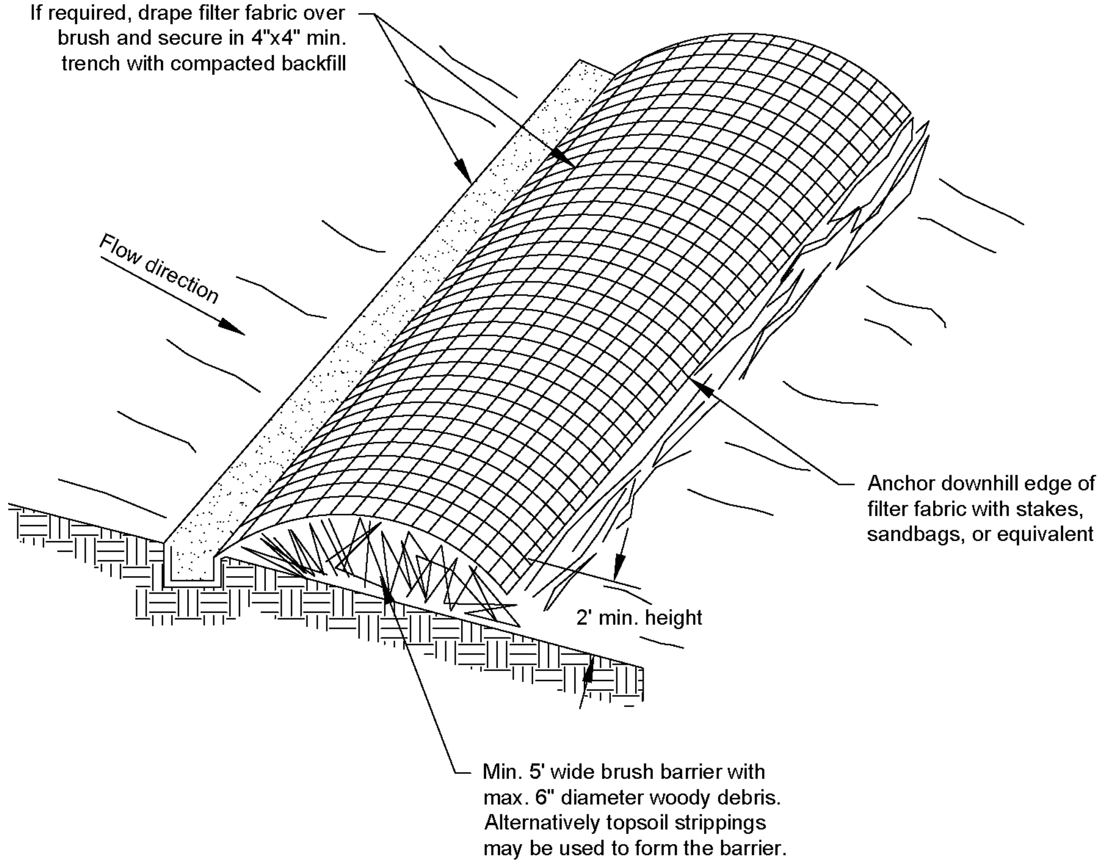
- Height: 2 feet (minimum) to 5 feet (maximum).
- Width: 5 feet at base (minimum) to 15 feet (maximum).
- Filter fabric (geotextile) may be anchored over the brush berm to enhance the filtration ability of the barrier. Ten-ounce burlap is an adequate alternative to filter fabric.

- Chipped site vegetation, composted mulch, or wood-based mulch (hog fuel) are acceptable materials to construct brush barriers.
- A 100 percent biodegradable installation can be constructed using 10-ounce burlap held in place by wooden stakes.
- Figure II-3.20: Brush Barrier depicts a typical brush barrier.

Maintenance Standards

- There shall be no signs of 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.
- The dimensions of the barrier must be maintained.

Figure II-3.20: Brush Barrier



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Brush Barrier

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BMP C232: Gravel Filter Berm

Purpose

A gravel filter berm retains sediment by filtering runoff through a berm of gravel or crushed rock.

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.

Design and Installation Specifications

- Berm material shall be ¾ to 3 inches in size, washed well-grade 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 cfs runoff based on the 10-year, 24-hour design storm
- See Figure II-3.21: Gravel Filter Berm for a photo of a gravel filter berm application.

Maintenance Standards

Regular inspection is required. Sediment shall be removed and filter material replaced as needed.

Figure II-3.21: Gravel Filter Berm

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Gravel Filter Berm

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BMP C233: Silt Fence

Purpose

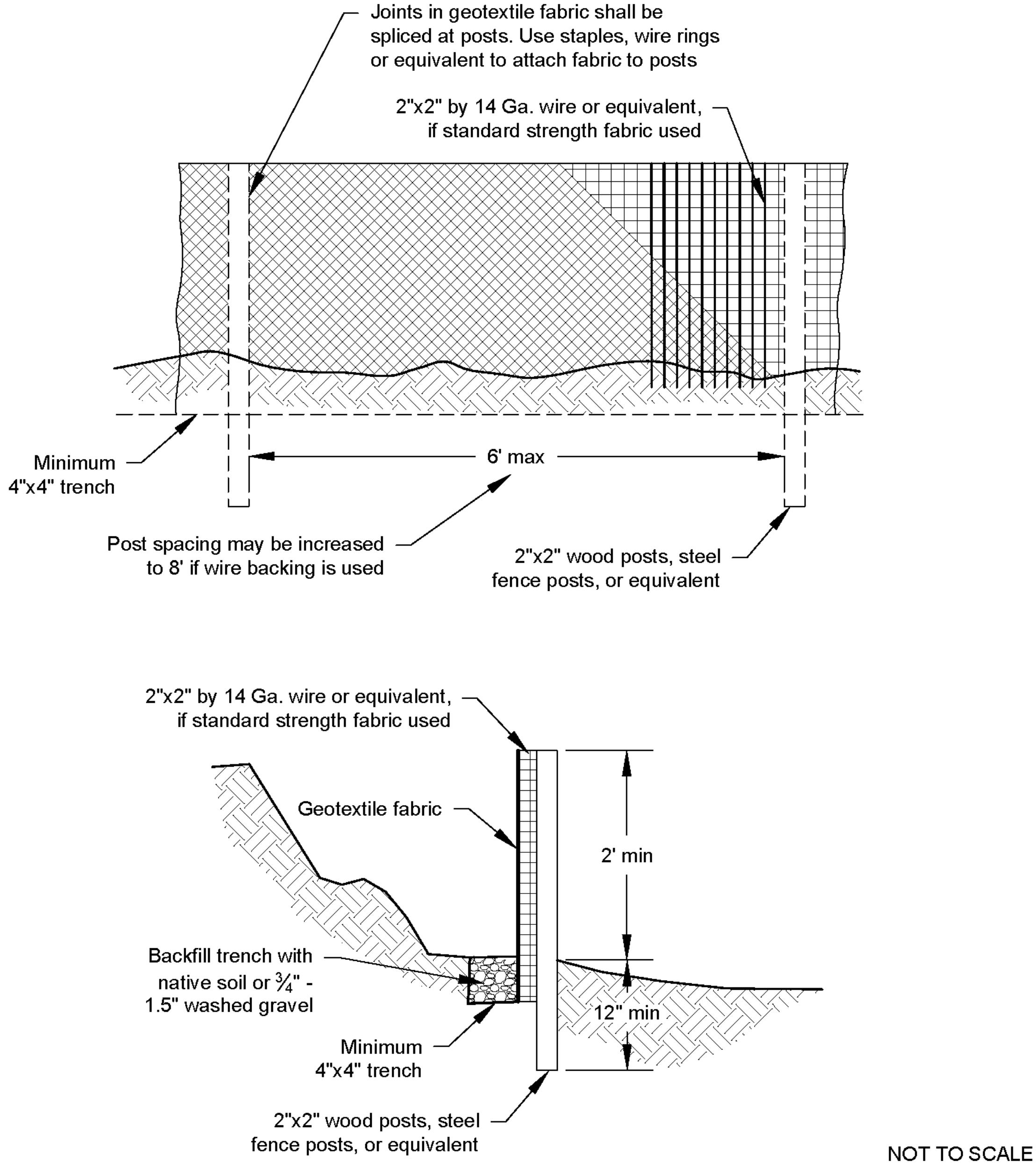
Silt fence reduces the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow.

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 any concentrated flows through the drainage system to a sediment trapping BMP.
- Do not construct silt fences in streams or use in V-shaped ditches. Silt fences do not provide an adequate method of silt control for anything deeper than sheet or overland flow.

Figure II-3.22: Silt Fence



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Silt Fence

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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. 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 II-3.11: Geotextile Fabric Standards for Silt Fence):

Table II-3.11: Geotextile Fabric Standards for Silt Fence

Geotextile Property	Minimum Average Roll Value
Polymeric Mesh AOS (ASTM D4751)	0.60 mm maximum for slit film woven (#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 geotextiles 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.
- One-hundred 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 II-3.22: Silt Fence for standard silt fence details. Include the following Standard Notes for silt fence on construction plans and specifications:
    1. The Contractor shall install and maintain temporary silt fences at the locations shown in the Plans.
    2. Construct silt fences in areas of clearing, grading, or drainage prior to starting those activities.

3. The silt fence shall have a 2-feet min. and a 2½-feet max. height above the original ground surface.
4. 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.
5. 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.
6. 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.
7. 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.
8. 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.
9. 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.
10. Use wood, steel or equivalent posts. The spacing of the support posts shall be a maximum of 6-feet. Posts shall consist of either:
    - 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.
11. Locate 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.

12. 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 II-3.23: Silt Fence Installation by Slicing Method for slicing method details. The following are specifications for silt fence installation using the slicing method:

    1. 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.

    2. Install posts 3- to 4-feet apart in critical retention areas and 6- to 7-feet apart in standard applications.

    3. 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.

    4. Install posts with the nipples facing away from the geotextile fabric.

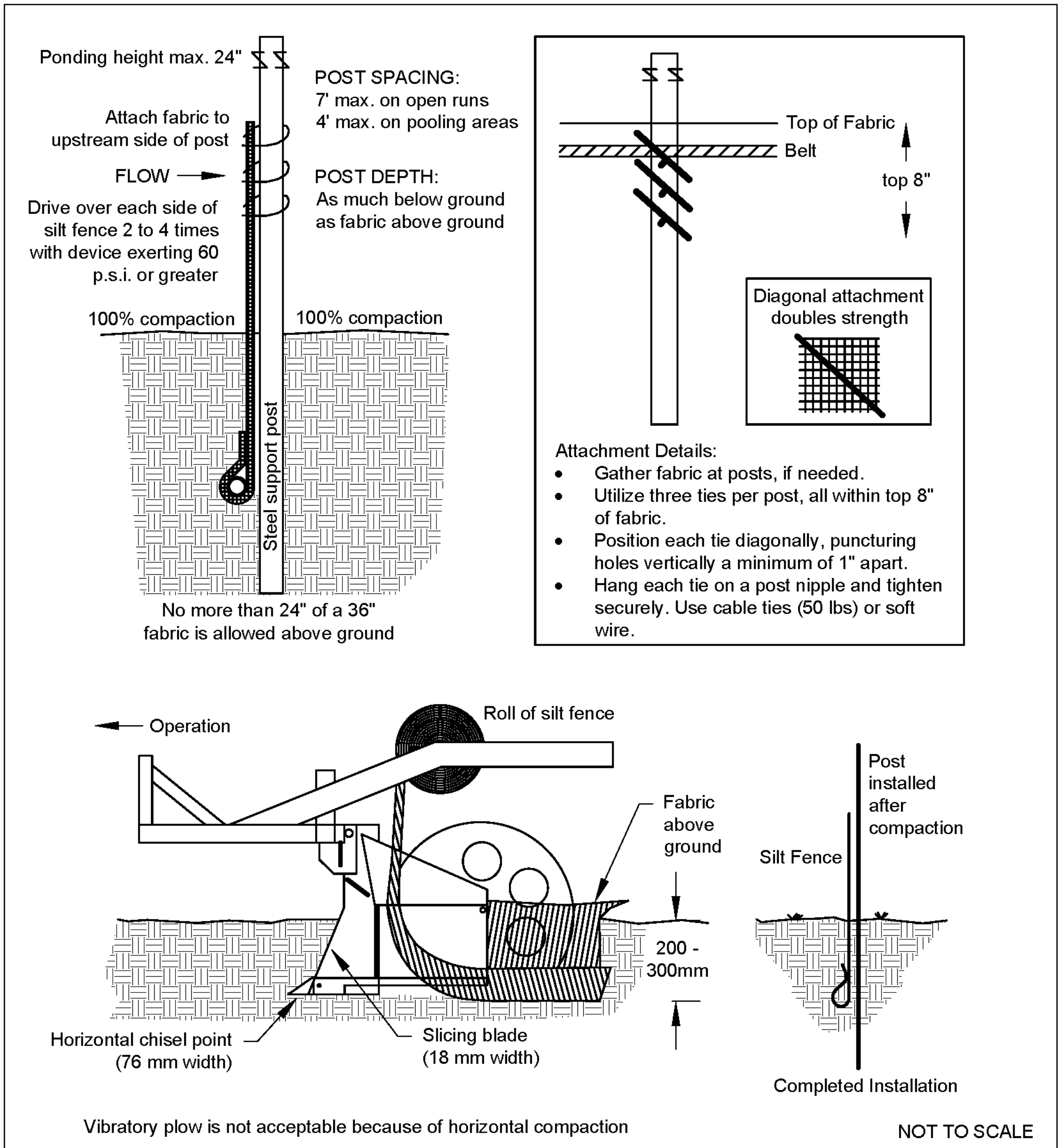
    5. Attach the geotextile fabric to each post with three ties, all spaced within the top 8-inches of the fabric. Attach each tie diagonally 45 degrees through the fabric, with each puncture at least 1-inch vertically apart. Each tie should be positioned to hang on a post nipple when tightening to prevent sagging.

    6. Wrap approximately 6-inches of the geotextile fabric around the end posts and secure with 3 ties.

    7. No more than 24-inches of a 36-inch geotextile fabric is allowed above ground level.

    8. Compact the soil immediately next to the geotextile fabric with the front wheel of the 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.

Figure II-3.23: Silt Fence Installation by Slicing Method



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Silt Fence Installation by Slicing Method

Revised June 2016

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 silt 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.

BMP C234: Vegetated Strip

Purpose

Vegetated strips reduce the transport of coarse sediment from a construction site by providing a physical barrier to sediment and reducing the runoff velocities of overland flow.

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. Any concentrated flows must be conveyed through the drainage system to BMP C241: Sediment Pond (Temporary) or other sediment trapping BMP. The only circumstance in which overland flow can be treated solely by a vegetated strip, rather than by a sediment trapping BMP, is when the following criteria are met (see Table II-3.12: Contributing Drainage Area for Vegetated Strips):

Table II-3.12: Contributing Drainage Area for Vegetated Strips

Average Contributing Area Slope	Average Contributing Area Percent Slope	Max Contributing area Flowpath Length
1.5H : 1V or flatter	67% or flatter	100 feet
2H : 1V or flatter	50% or flatter	115 feet
4H : 1V or flatter	25% or flatter	150 feet
6H : 1V or flatter	16.7% or flatter	200 feet
10H : 1V or flatter	10% or flatter	250 feet

Design and Installation Specifications

- The vegetated strip shall consist of a continuous strip of dense vegetation with topsoil for a minimum of a 25-foot length along the flowpath. 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 vegetated strip shall not exceed 4H:1V.
- The uphill boundary of the vegetated strip shall be delineated with clearing limits.

Maintenance Standards

- Any areas damaged by erosion or construction activity shall be seeded immediately and protected by mulch.
- If more than 5 feet of the original vegetated strip width has had vegetation removed or is being eroded, sod must be installed.
- If there are indications that concentrated flows are traveling across the vegetated strip, stormwater runoff controls must be installed to reduce the flows entering the vegetated strip, or additional perimeter protection must be installed.

BMP C235: Wattles

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.

Conditions of Use

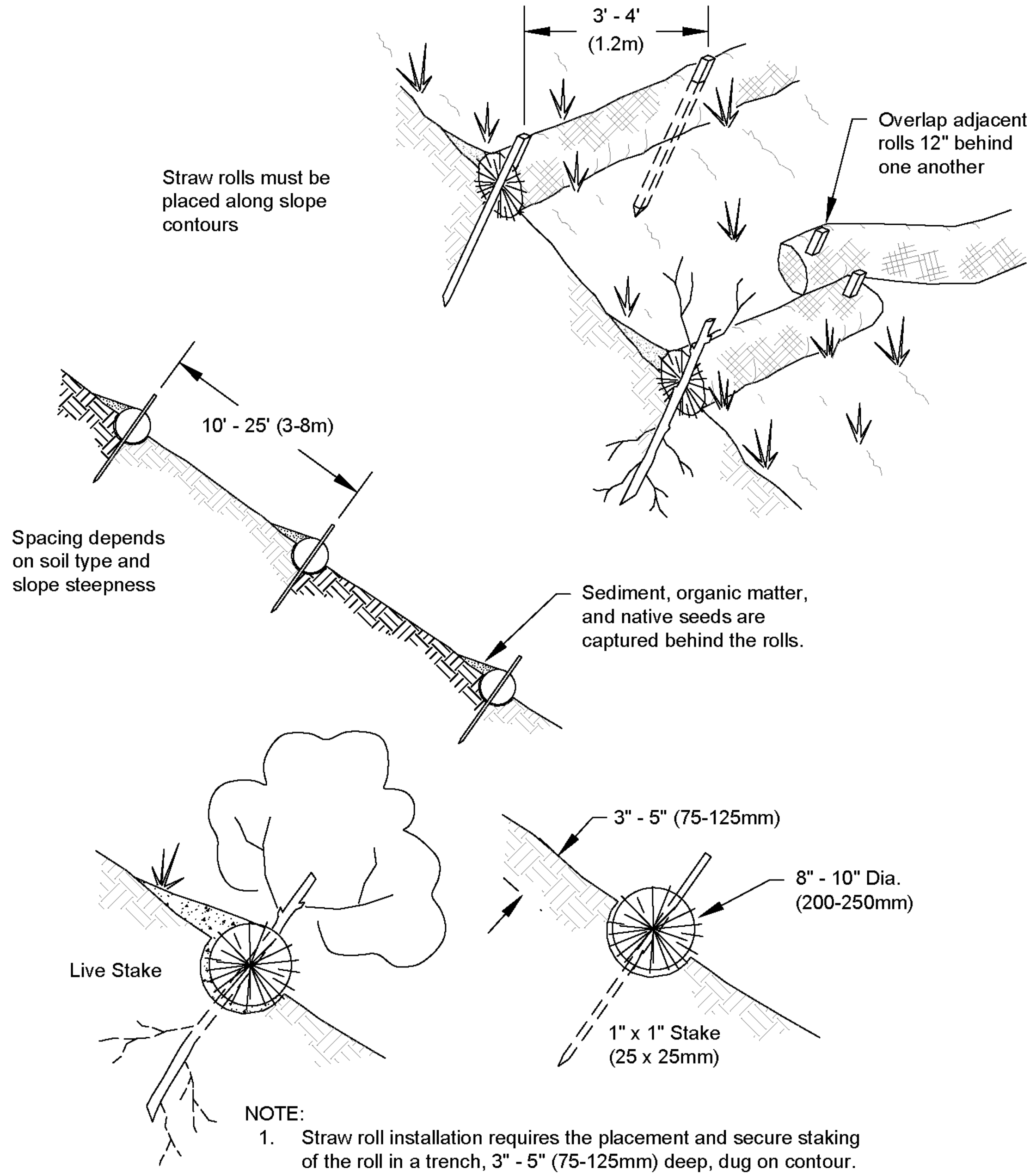
- Wattles shall consist of cylinders of plant material such as weed-free straw, coir, wood chips, excelsior, or wood fiber or shavings encased within netting made of natural plant fibers unaltered by synthetic materials.
- Use wattles:
  - In disturbed areas that require immediate erosion protection.
  - 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.

Design Criteria

- See Figure II-3.24: 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, the trenches should be dug 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 intervals of 10- to 25-feet 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. Willow 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.

Figure II-3.24: Wattles



NOTE:

1. Straw roll installation requires the placement and secure staking of the roll in a trench, 3" - 5" (75-125mm) deep, dug on contour. Runoff must not be allowed to run under or around roll.

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Wattles

Revised December 2016

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.

Approved as Functionally Equivalent

Ecology has approved products as able to meet the requirements of this BMP. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept these products, or may require additional testing prior to consideration for local use. Products that Ecology has approved as functionally equivalent are available for review on Ecology's website at:

https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies

BMP C236: Vegetative Filtration

Purpose

Vegetative filtration as a BMP is used in conjunction with detention storage in the form of portable tanks or BMP C241: Sediment Pond (Temporary), 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.

Conditions of Use

- For every five acres of disturbed soil use one acre of grass field, farm pasture, or wooded area. Reduce or increase this area depending on project size, ground water table height, and other site conditions.
- Wetlands shall not be used for vegetative filtration.
- Do not use this BMP in areas with a high ground water table, or in areas that will have a high seasonal ground water 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 filtration 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.

Design Criteria

- Find land adjacent to the project site 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), swaged-fit common septic tight-lined sewer line, or 6-inch diameter fire hose, which can convey the turbid water out to various sections of the field. See Figure II-3.25: 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 the 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 perforated pipe may be used as an alternative option to the sprinkler head setup. Install drain 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 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 II-3.13: Flowpath Guidelines for Vegetative Filtration

Average Slope	Average Area % Slope	Estimated Flowpath Length (ft)
1.5H:1V	67%	250
2H:1V	50%	200
4H:1V	25%	150
6H:1V	16.7%	115
10H:1V	10%	100

Figure II-3.25: Manifold and Branches in a Wooded, Vegetated Spray Field

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Manifold and Branches in a Wooded, Vegetated Spray Field

Revised June 2016

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.
- Ecology recommends 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.

BMP C240: Sediment Trap

Purpose

A sediment trap is a small temporary ponding area with a gravel outlet used to collect and store sediment from sites during construction. Sediment traps, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.

Conditions of Use

- Sediment traps are intended for use on sites where the tributary drainage area is less than 3 acres, with no unusual drainage 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 tributary area is permanently protected against erosion by 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.
- Projects that are constructing permanent Flow Control BMPs, or Runoff Treatment BMPs that use ponding for treatment, may use the rough-graded or final-graded permanent BMP footprint for the temporary sediment trap. When permanent BMP footprints are used as temporary sediment traps, the surface area requirement of the sediment trap must be met. If the surface area requirement of the sediment trap is larger than the surface area of the permanent BMP, then the sediment trap shall be enlarged beyond the permanent BMP footprint to comply with the surface area requirement.

- A floating pond skimmer may be used for the sediment trap outlet if approved by the Local Permitting Authority.
- Sediment traps may not be feasible on utility projects due to the limited work space or the short-term nature of the work. Portable tanks may be used in place of sediment traps for utility projects.

Design and Installation Specifications

- See Figure II-3.26: Cross Section of Sediment Trap and Figure II-3.27: Sediment Trap Outlet for details.
- 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:

  $$SA = FS(Q_2/V_s)$$

  where

  Q_2 =

  - Option 1 - Single Event Hydrograph Method:

    Q_2 = Peak volumetric flow rate calculated using a 10-minute time step from a Type 1A, 2-year, 24-hour frequency storm for the developed condition. The 10-year peak volumetric flow rate shall be used if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection.

  - Option 2 - For construction sites that are less than 1 acre, the Rational Method may be used to determine Q_2.

  V_s = The settling velocity of the soil particle of interest. The 0.02 mm (medium silt) particle with an assumed density of 2.65 g/cm3 has been selected as the particle of interest and has a settling velocity (Vs) of 0.00096 ft/sec.

  FS = A safety factor of 2 to account for non-ideal settling.

  Therefore, the equation for computing sediment trap surface area becomes:

  $$SA = 2 \text{ x } Q_2/0.00096$$

  or

  2080 square feet per cfs of inflow

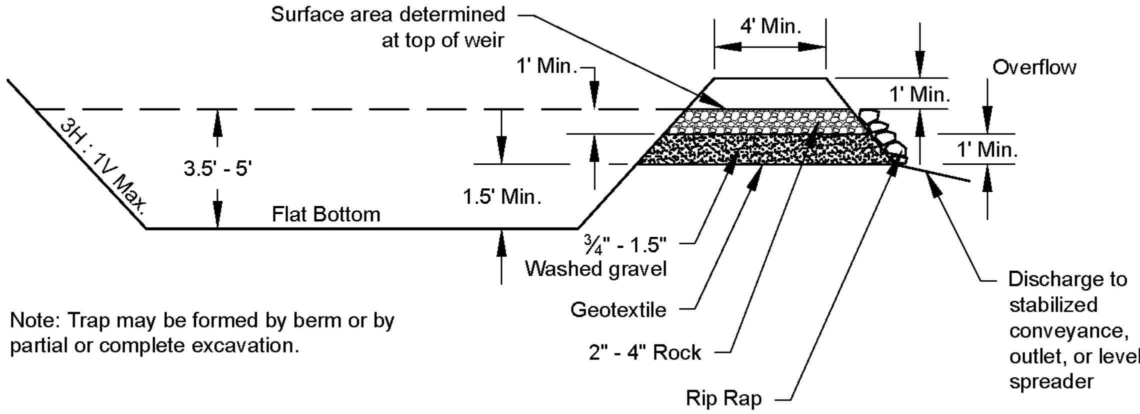
- Sediment trap depth shall be 3.5 feet minimum from the bottom of the trap to the top of the overflow weir.
- To aid in determining sediment depth, all sediment traps shall have a staff gauge with a prominent mark 1-foot above the bottom of the trap.

- Design the discharge from the sediment trap by using the guidance for discharge from temporary sediment ponds in BMP C241: Sediment Pond (Temporary).

Maintenance Standards

- Sediment shall be removed from the trap when it reaches 1-foot in depth.
- Any damage to the trap embankments or slopes shall be repaired.

Figure II-3.26: Cross Section of Sediment Trap



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Cross Section of Sediment Trap

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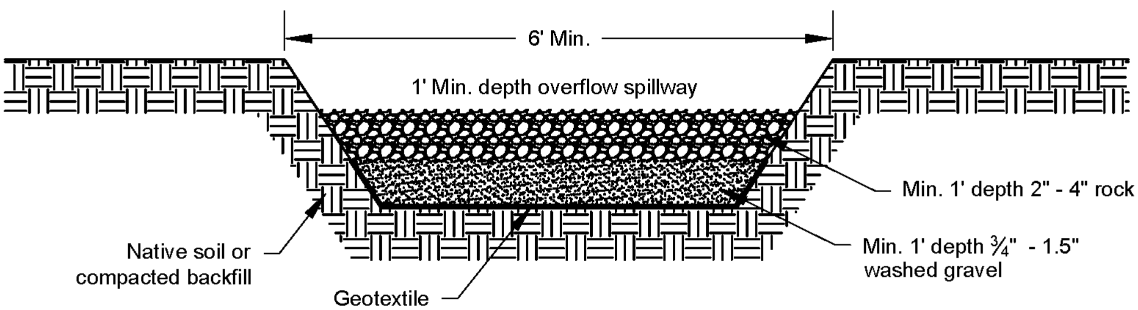
Figure II-3.27: Sediment Trap Outlet



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Sediment Trap Outlet

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BMP C241: Sediment Pond (Temporary)

Purpose

Sediment ponds are temporary ponds used during construction to remove sediment from runoff originating from disturbed areas of the project site. Sediment ponds are typically designed to remove sediment no smaller than medium silt (0.02 mm). Consequently, they usually reduce turbidity only slightly.

Conditions of Use

- Use a sediment pond where the contributing drainage area to the pond is 3 acres or more. Ponds must be used in conjunction with other Construction Stormwater BMPs to reduce the amount of sediment flowing into the pond.

- Do not install sediment ponds on sites where failure of the BMP would result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities. Also, sediment ponds are attractive to children and can be 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 drawings in the Construction SWPPP.

- Sediment ponds that can impound 10 acre-ft (435,600 cu-ft, or 3.26 million gallons) or more, or have an embankment of more than 6 feet, are subject to the Washington Dam Safety Regulations (Chapter 173-175 WAC). See BMP D.1: Detention Ponds for more information regarding dam safety considerations for detention ponds.

- Projects that are constructing permanent Flow Control BMPs or Runoff Treatment BMPs that use ponding for treatment may use the rough-graded or final-graded permanent BMP footprint for the temporary sediment pond. When permanent BMP footprints are used as temporary sediment ponds, the surface area requirement of the temporary sediment pond must be met. If the surface area requirement of the sediment pond is larger than the surface area of the permanent BMP, then the sediment pond shall be enlarged beyond the permanent BMP footprint to comply with the surface area requirement.

  The permanent control structure must be temporarily replaced with a control structure that only allows water to leave the temporary sediment pond from the surface or by pumping. Alternatively, the permanent control structure may used if it is temporarily modified by plugging any outlet holes below the riser. The permanent control structure must be installed as part of the permanent BMP after the site is fully stabilized.

Design and Installation Specifications

General

- See Figure II-3.28: Sediment Pond Plan View, Figure II-3.29: Sediment Pond Cross Section, and Figure II-3.30: Sediment Pond Riser Detail for details.

- Use of permanent infiltration BMP footprints for temporary sediment ponds during construction tends to clog the soils and reduce their capacity to infiltrate. If permanent infiltration BMP footprints are used, the sides and bottom of the temporary sediment pond must only be rough excavated to a minimum of 2 feet above final grade of the permanent infiltration BMP. Final grading of the permanent infiltration BMP shall occur only when all contributing drainage areas are fully stabilized. Any proposed permanent pretreatment BMP prior to the infiltration BMP should be fully constructed and used with the temporary sediment pond to help prevent clogging of the soils. See Element 13: Protect Low Impact Development BMPs for more information about protecting permanent infiltration BMPs.

- 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 the cells. The divider shall be at least one-half the height of the riser, and at least one foot below the top of the riser. Wire-backed, 2- to 3-foot high, high strength geotextile fabric supported by treated 4"x4"s can be used as a divider. Alternatively, staked straw bales wrapped with geotextile fabric may be used. If the pond is more than 6 feet deep, a different divider design 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 and around the divider.
- The most common structural failure of sediment ponds 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 practices to prevent piping are:

  - Tight connections between the riser and outlet pipe, and other pipe connections.
  - Adequate anchoring of the riser.
  - Proper soil compaction of the embankment and riser footing.
  - Proper construction of anti-seep devices.

Sediment Pond Geometry

To determine the sediment pond geometry, first calculate the design surface area (SA) of the pond, measured at the top of the riser pipe. Use the following equation:

$$SA = 2 \times Q_2/0.00096$$

or

2080 square feet per cfs of inflow

See BMP C240: Sediment Trap for more information on the above equation.

The basic geometry of the pond can now be determined using the following design criteria:

- Required surface area SA (from the equation above) at the top of the riser.
- Minimum 3.5-foot depth from the top of the riser to the bottom of the 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.

Sediment Pond Discharge

The outlet for the pond consists of a combination of principal and emergency spillways. These outlets must pass the peak runoff expected from the contributing drainage area for a 100-year storm. If, due to site conditions and basin geometry, a separate emergency spillway is not feasible, the principal spillway must pass the entire peak runoff expected from the 100-year storm. However, an attempt to provide a separate emergency spillway should always be made. Base the runoff 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 described below will result in some reduction in the peak rate of runoff. However, the design will not control the discharge flow rates to the extent required to comply with I-3.4.7 MR7: Flow Control. The size of the contributing 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 for 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 flow rate using a 15-minute time step from a Type 1A, 10-year, 24-hour frequency storm for the developed condition. Use Figure II-3.31: Riser Inflow Curves to determine the riser diameter.

To aid in determining sediment depth, one-foot intervals shall be prominently marked on the riser.

Emergency Overflow Spillway: Size the emergency overflow spillway for the peak volumetric flow rate using a 10-minute time step from a Type 1A, 100-year, 24-hour frequency storm for the developed condition. See BMP D.1: Detention Ponds for additional guidance for Emergency Overflow Spillway design

Dewatering Orifice: 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:

$$A_o = \frac{A_S(2h)^{0.5}}{0.6 \times 3600 T g^{0.5}}$$

where

A_o = orifice area (square feet)

A_S = pond surface area (square feet)

h = head of water above orifice (height of riser in feet)

T = dewatering time (24 hours)

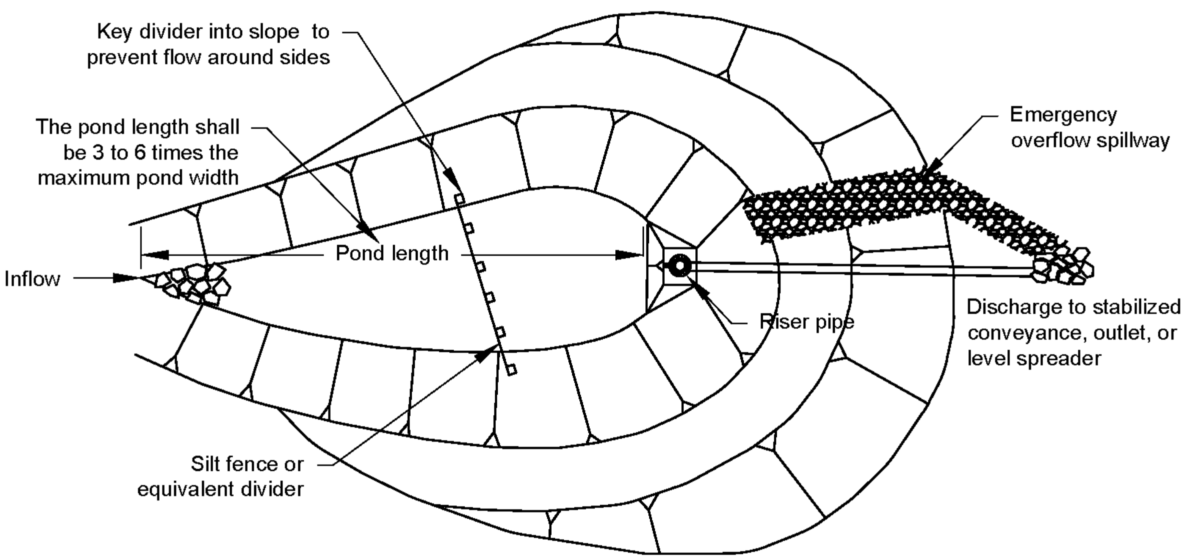
g = acceleration of gravity (32.2 feet/second^2)

Convert the orifice area (in square feet) to the orifice diameter D (in inches):

$$D = 24 \times \sqrt{\frac{A_o}{\pi}} = 13.54 \times \sqrt{A_o}$$

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 should be large enough so that the tubing does not restrict flow. The orifice should control the flow rate.

Figure II-3.28: Sediment Pond Plan View



Note: Pond may be formed by berm or by partial or complete excavation

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Sediment Pond Plan View

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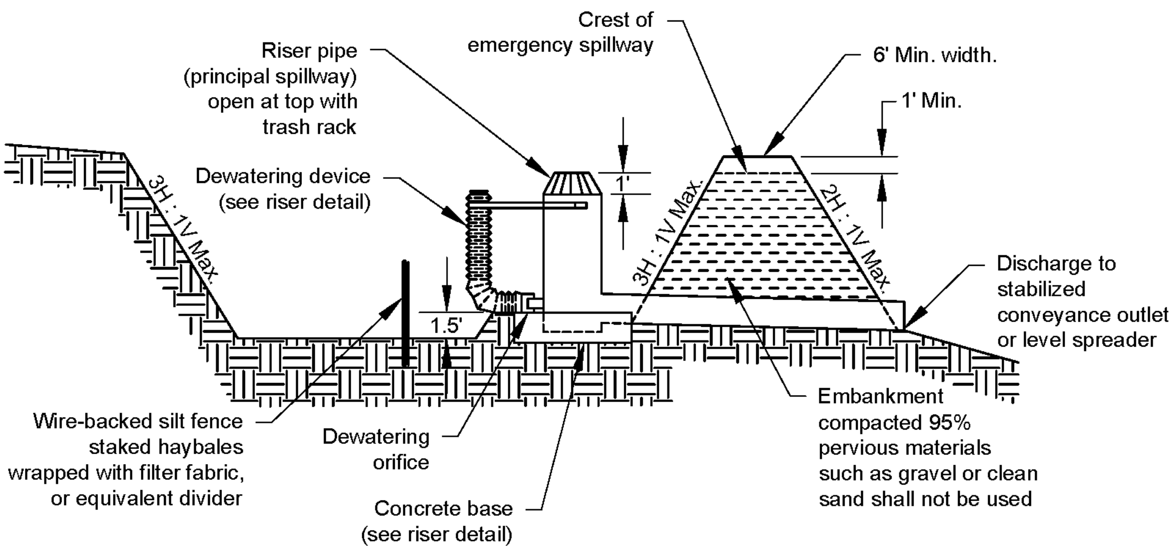
Figure II-3.29: Sediment Pond Cross Section



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Sediment Pond Cross Section

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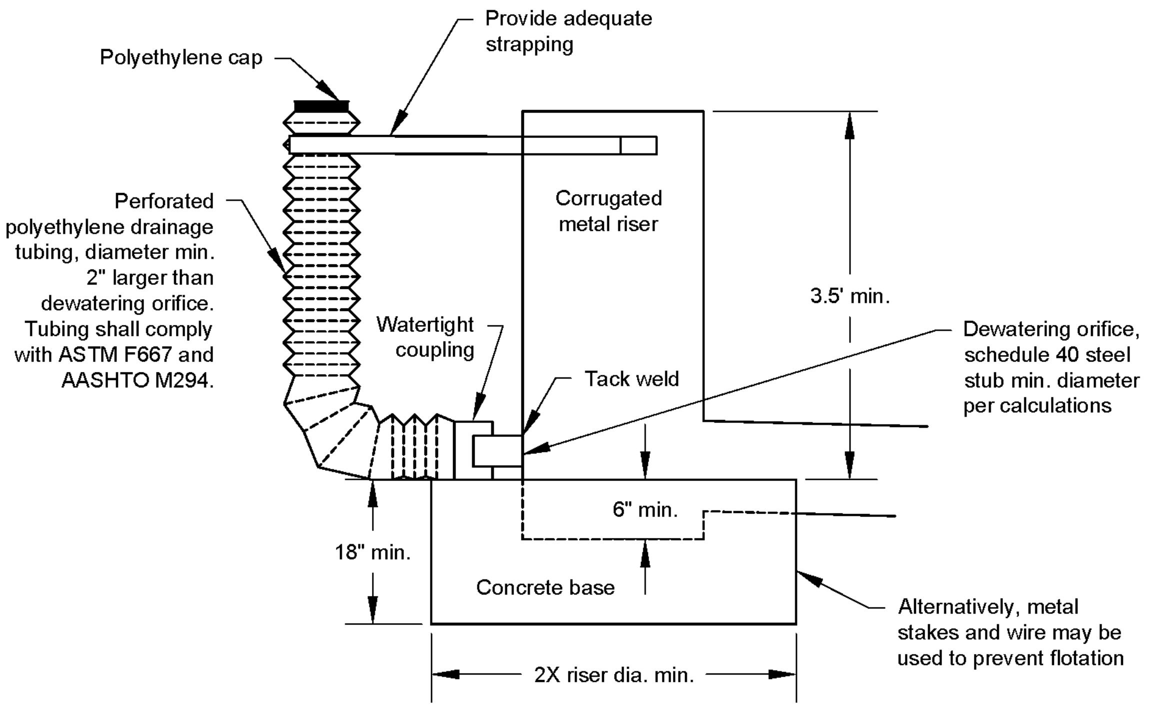
Figure II-3.30: Sediment Pond Riser Detail



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Sediment Pond Riser Detail

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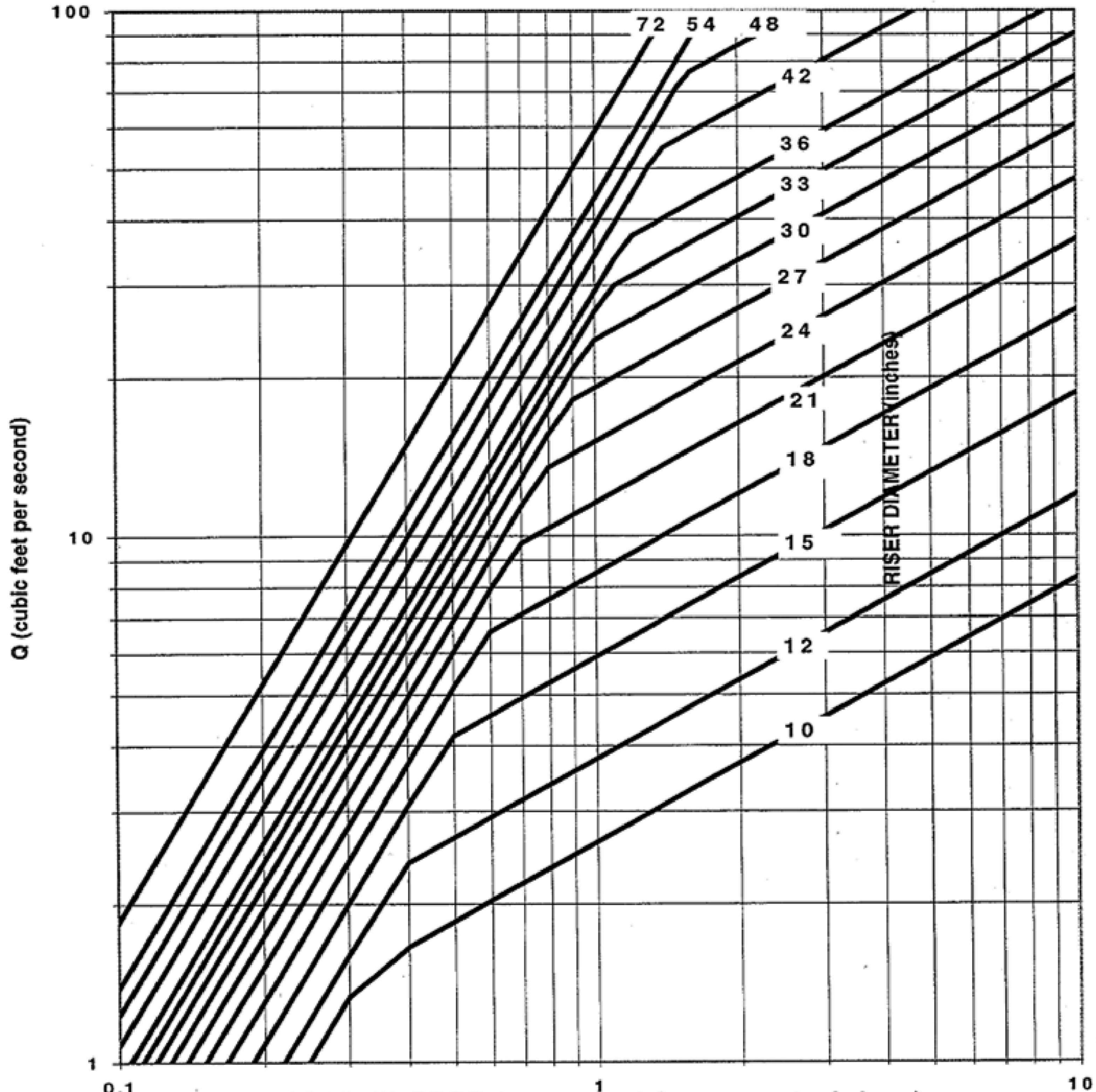
Figure II-3.31: Riser Inflow Curves



HEAD IN FEET (measured from crest of riser)

$Q_{weir} = 9.739\ DH^{3/2}$

$Q_{orifice} = 3.782\ D^2 H^{1/2}$

Q in cfs, D and H in feet

Slope change occurs at weir-orifice transition

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Riser Inflow Curves

Revised June 2016

Maintenance Standards

- Remove sediment from the pond when it reaches 1 foot in depth.
- Repair any damage to the pond embankments or slopes.

BMP C250: Construction Stormwater Chemical Treatment

Purpose

This BMP applies when using chemicals to treat turbidity in stormwater by either batch or flow-through chemical treatment.

Turbidity is difficult to control once fine particles are suspended in stormwater runoff from a construction site. BMP C241: Sediment Pond (Temporary) is effective at removing larger particulate matter by gravity settling, but is ineffective at removing smaller particulates such as clay and fine silt. Traditional Construction Stormwater BMPs may not be adequate to ensure compliance with the water quality standards for turbidity in the receiving water.

Chemical treatment can reliably provide exceptional reductions of turbidity and associated pollutants. Chemical treatment may be required to meet turbidity stormwater discharge requirements, especially when construction proceeds through the wet season.

Conditions of Use

Formal written approval from Ecology is required for the use of chemical treatment, regardless of site size. See https://fortress.wa.gov/ecy/publications/SummaryPages/ecy070258.html for a copy of the Request for Chemical Treatment form. The Local Permitting Authority may also require review and approval. When authorized, the chemical treatment systems must be included in the Construction Stormwater Pollution Prevention Plan (SWPPP).

Chemically treated stormwater discharged from construction sites must be nontoxic to aquatic organisms. The Chemical Technology Assessment Protocol - Ecology (CTAPE) must be used to evaluate chemicals proposed for stormwater treatment. Only chemicals approved by Ecology under the CTAPE may be used for stormwater treatment. The approved chemicals, their allowable application techniques (batch treatment or flow-through treatment), allowable application 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

Background on Chemical Treatment Systems

Coagulation and flocculation have been used for over a century to treat water. The use of coagulation and flocculation to treat stormwater is a very recent application. Experience with the treatment of water and wastewater has resulted in a basic understanding of the process, in particular factors that affect performance. This experience can provide insights as to how to most effectively design and operate similar systems in the treatment of stormwater.

Fine particles suspended in water give it a milky appearance, measured as *turbidity*. Their small size, often much less than 1 µm in diameter, give them a very large surface area relative to their volume. These fine particles typically carry a negative surface charge. Largely because of these two factors (small size and negative charge), these particles tend to stay in suspension for extended periods of time. Thus, removal is not practical by gravity settling. These are called stable suspensions. Chemicals like polymers, as well as inorganic chemicals such as alum, speed the settling process. The added chemical destabilizes the suspension and causes the smaller particles to flocculate. The process consists of three primary steps: *coagulation*, *flocculation*, and settling or *clarification*. Ecology requires a fourth step, *filtration*, on all stormwater chemical treatment systems to reduce floc discharge and to provide monitoring prior to discharge.

General Design and Installation Specifications

- Chemicals approved for use in Washington State are listed on Ecology's TAPE website, http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html, under the "Construction" tab.
- 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 through BMP C251: Construction Stormwater Filtration for filtration and monitoring prior to discharge.
- System discharge rates must take into account downstream conveyance integrity.
- The following equipment should be located on site 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 the chemical treatment process to stormwater: the batch chemical treatment system and the flow-through chemical treatment system. See below for further details for both types of systems.

Batch Chemical Treatment Systems

A batch chemical treatment system consists of four steps: *coagulation*, *flocculation*, *clarification*, and polishing and monitoring via *filtration*.

Step 1: Coagulation

Coagulation is the process by which negative charges on the fine particles are disrupted. By disrupting the negative charges, the fine particles are able to flocculate. Chemical addition is one method of destabilizing the suspension, and polymers are one class of chemicals that are generally effective. Chemicals that are used for this purpose are called coagulants. Coagulation is complete when the suspension is destabilized by the neutralization of the negative charges. Coagulants perform best when they are thoroughly and evenly dispersed under relatively intense mixing. This rapid mixing involves adding the coagulant in a manner that promotes rapid dispersion, followed by a short time period for destabilization of the particle suspension. The particles are still very small and are not readily separated by clarification until flocculation occurs.

Step 2: Flocculation

Flocculation is the process by which fine particles that have been destabilized bind together to form larger particles that settle rapidly. Flocculation begins naturally following coagulation, but is enhanced by gentle mixing of the destabilized suspension. Gentle mixing helps to bring particles in contact with one another such that they bind and continually grow to form "flocs." As the size of the flocs increase, they become heavier and settle.

Step 3: Clarification

The final step is the settling of the particles, or clarification. Particle density, size and shape are important during settling. Dense, compact flocs settle more readily than less dense, fluffy flocs. Because of this, flocculation to form dense, compact flocs is particularly important during chemical treatment. Water temperature is important during settling. Both the density and viscosity of water are affected by temperature; these in turn affect settling. Cold temperatures increase viscosity and density, thus slowing down the rate at which the particles settle.

The conditions under which clarification is achieved can affect performance. Currents can affect settling. Currents can be produced by wind, by differences between the temperature of the incoming water and the water in the clarifier, and by flow conditions near the inlets and outlets. Quiescent water, such as that which occurs during batch clarification, provides a good environment for settling. One source of currents in batch chemical treatment systems is movement of the water leaving the clarifier unit. Because flocs are relatively small and light, the velocity of the water must be as low as possible. Settled flocs can be resuspended and removed by fairly modest currents.

Step 4: Filtration

After clarification, Ecology requires stormwater that has been chemically treated to be filtered and monitored prior to discharge. 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.

Design and Installation of Batch Chemical Treatment Systems

A batch chemical treatment system consists of a stormwater collection system (either a temporary diversion or the permanent site drainage system), an untreated stormwater storage pond, pumps, a chemical feed system, treatment cells, a filtering and monitoring system, and interconnecting piping.

The batch treatment system uses a storage pond for untreated stormwater, followed by a minimum of two lined treatment cells. Multiple treatment cells allow for clarification of chemically treated water in one cell, while other cells are being filled or emptied. Treatment cells may be ponds or tanks. Ponds with constructed earthen embankments greater than six feet high or which impound more than 10 acre-feet are subject to the Washington Dam Safety Regulations (Chapter 173-175 WAC).

See BMP D.1: Detention Ponds for more information regarding dam safety considerations for ponds.

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 storage pond is 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 untreated 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 adjustments as a part of chemical treatment.

Once the stormwater is within the desired pH range (which is dependant on the coagulant being used), the stormwater is pumped from the untreated stormwater storage pond to a lined treatment cell as a coagulant is added. The coagulant is added upstream of the pump to facilitate rapid mixing.

The water is kept in the 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 these 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 floc from the bottom of the cell. 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, a long floating or fixed pipe with many small holes in it, 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, ladders, or steps extending from the bottom to the top.

Sizing Batch Chemical Treatment Systems

Chemical treatment systems must be designed to control the velocity and peak volumetric flow rate that is discharged from the system and consequently the project site. See Element 3: Control Flow Rates for further details on this requirement.

The total volume of the untreated stormwater storage pond and treatment cells must be large enough to treat stormwater that is produced during multiple day storm events. It is recommended that at a minimum the untreated stormwater storage pond be sized to hold 1.5 times the volume of runoff generated from the site during the 10-year, 24-hour storm event. Bypass should be provided around the chemical treatment system to accommodate extreme storm events. Runoff volume shall be calculated using the methods presented in III-2.3 Single Event Hydrograph Method. Worst-case land cover conditions (i.e., producing the most runoff) should be used 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 may be 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 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 flow rate (as determined by the guidance in Element 3: Control Flow Rates) 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 two hours of settling.

See BMP C251: Construction Stormwater Filtration for details on sizing the filtration system at the end of the batch chemical treatment system.

If the chemical treatment system design 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 planned development, 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.

Flow-Through Chemical Treatment Systems

Background on Flow-Through Chemical Treatment Systems

A flow-through chemical treatment system adds a sand filtration component to the batch chemical treatment system's treatment train following flocculation. The coagulant is added to the stormwater upstream of the sand filter so that the coagulation and flocculation step occur immediately prior to the filter. The advantage of a flow-through chemical treatment system is the time saved by immediately filtering the water, as opposed to waiting for the clarification process necessary in a batch chemical treatment system. See BMP C251: Construction Stormwater Filtration for more information on filtration.

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 site drainage system), an untreated stormwater storage pond, and a chemically enhanced sand filtration system.

As with a batch treatment system, 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.

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 Flow-Through Chemical Treatment Systems

Refer to BMP C251: Construction Stormwater Filtration for sizing requirements of flow-through chemical treatment systems.

Factors Affecting the Chemical Treatment Process

Coagulants

Cationic polymers can be used as coagulants to destabilize negatively charged turbidity particles present in natural waters, wastewater and stormwater. Polymers are large organic molecules that are made up of subunits linked together in a chain-like structure. Attached to these chain-like structures are other groups that carry positive or negative charges, or have no charge. Polymers that carry groups with positive charges are called cationic, those with negative charges are called anionic, and those with no charge (neutral) are called nonionic. In practice, the only way to determine whether a polymer is effective for a specific application is to perform preliminary or on-site testing.

Aluminum sulfate (alum) can also be used as a coagulant, as this chemical becomes positively charged when dispersed in water.

Polymers are available as powders, concentrated liquids, and emulsions (which appear as milky liquids). The latter are petroleum based, which are not allowed for construction stormwater treatment. Polymer effectiveness can degrade with time and also from other influences. Thus, manufacturers' recommendations for storage should be followed. Manufacturer’s recommendations usually do not provide assurance of water quality protection or safety to aquatic organisms. Consideration of water quality protection is necessary in the selection and use of all polymers.

Application

Application of coagulants at the appropriate concentration or dosage rate for optimum turbidity removal is important for management of chemical cost, for effective performance, and to avoid aquatic toxicity. The optimum dose in a given application depends on several site-specific features. Turbidity of untreated water can be important with turbidities greater than 5,000 NTU. The surface charge of particles to be removed is also important. Environmental factors that can influence dosage rate are water temperature, pH, and the presence of constituents that consume or otherwise affect coagulant effectiveness. Laboratory experiments indicate that mixing previously settled sediment (floc sludge) with the untreated stormwater significantly improves clarification, therefore reducing the effective dosage rate. Preparation of working solutions and thorough dispersal of coagulants in water to be treated is also important to establish the appropriate dosage rate.

For a given water sample, there is generally an optimum dosage rate that yields the lowest residual turbidity after settling. When dosage rates below this optimum value (underdosing) are applied, there is an insufficient quantity of coagulant to react with, and therefore destabilize, all of the turbidity present. The result is residual turbidity (after flocculation and settling) that is higher than with the optimum dose. Overdosing, application of dosage rates greater than the optimum value, can also negatively impact performance. Like underdosing, the result of overdosing is higher residual turbidity than that with the optimum dose.

Mixing

The G-value, or just "G", is often used as a measure of the mixing intensity applied during coagulation and flocculation. The symbol G stands for “velocity gradient”, which is related in part to the degree of turbulence generated during mixing. High G-values mean high turbulence, and vice versa.

High G-values provide the best conditions for coagulant addition. With high G's, turbulence is high and coagulants are rapidly dispersed to their appropriate concentrations for effective destabilization of particle suspensions.

Low G-values provide the best conditions for flocculation. Here, the goal is to promote formation of dense, compact flocs that will settle readily. Low G's provide low turbulence to promote particle collisions so that flocs can form. Low G's generate sufficient turbulence such that collisions are effective in floc formation, but do not break up flocs that have already formed.

pH Adjustment

The pH must be in the proper range for the coagulants to be effective, which is typically 6.5 to 8.5. As polymers tend to lower the pH, it is important that the stormwater have sufficient buffering capacity. Buffering capacity is a function of alkalinity. Without sufficient alkalinity, the application of the polymer may lower the pH to below 6.5. A pH below 6.5 not only reduces the effectiveness of the polymer as a coagulant, but it may also create a toxic condition for aquatic organisms. Stormwater may not be discharged without readjustment of the pH to above 6.5. The target pH should be within 0.2 standard units of the receiving water's pH.

Experience gained at several projects in the City of Redmond has shown that the alkalinity needs to be at least 50 mg/L to prevent a drop in pH to below 6.5 when the polymer is added.

Maintenance Standards

Monitoring

At a minimum, the following monitoring shall be conducted. Test results shall be recorded 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.
    - Type and amount of coagulant used for treatment.
    - Settling time.
- Compliance Monitoring
    - Influent and effluent pH, flocculent chemical concentration, and turbidity must be continuously monitored and recorded at not greater than 15-minute intervals.
    - pH and turbidity of the receiving water.
- Biomonitoring
    - Treated stormwater must be non-toxic to aquatic organisms. Treated stormwater must be tested for aquatic toxicity or residual chemicals. 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 and Appendix G of *Whole Effluent Toxicity Testing Guidance and Test Review Criteria* (Marshall, 2016).

Discharge Compliance

Prior to discharge, treated stormwater must be sampled and tested for compliance with pH, flocculent chemical concentration, 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 by 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 water shall not be taken from the treatment pond prior to decanting. Compliance with the water quality standards is determined in the receiving water.

Operator Training

Each project site using chemical treatment must have a trained operator who is certified for operation of an Enhanced Chemical Treatment system. The operator must be trained and certified by an organization approved by Ecology. Organizations approved for operator training are found at the following website:

https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Contaminated-water-on-construction-sites

Sediment Removal and Disposal

- Sediment shall be removed from the untreated stormwater storage pond and treatment cells as necessary. Typically, sediment removal is required at least once during a wet season and at the decommissioning of the chemical treatment system. 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 drainages.

BMP C251: Construction Stormwater Filtration

Purpose

Filtration removes sediment from runoff originating from disturbed areas of the site.

Conditions of Use

Traditional Construction Stormwater BMPs used to control soil erosion and sediment loss from construction sites 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 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 Ecology must be obtained at each site where chemical use is proposed prior to use. See https://fortress.wa.gov/ecy/publications/SummaryPages/ecy070258.html for a copy of the Request for Chemical Treatment form.

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.

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 have generally been used as post construction BMPs to treat stormwater (see V-6 Filtration BMPs). Slow filtration is mechanically simple in comparison to rapid filtration, but requires a much larger filter area.

Filter Types and Efficiencies

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 and Description

Stormwater is collected at interception point(s) on the site and 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. In a rapid filtration system, the untreated stormwater is pumped from the pond or tank through the filtration media. Slow filtration systems are designed using gravity to convey water from the pond or tank to and through the filtration media.

Sizing

Filtration treatment systems must be designed to control the velocity and peak volumetric flow rate that is discharged from the system and consequently the project site. See Element 3: Control Flow Rates for further details on this requirement.

The untreated stormwater storage pond or tank should be sized to hold 1.5 times the volume of runoff generated from the site during the 10-year, 24-hour storm event, minus the filtration treatment system flowrate for an 8-hour period. For a chitosan-enhanced sand filtration system, the filtration treatment system flowrate should be sized using a hydraulic loading rate between 6-8 gpm/ft^2. Other hydraulic loading rates may be more appropriate for other systems. Bypass should be provided around the filtration treatment system to accommodate extreme storm events. Runoff volume shall be calculated using the methods presented in III-2.3 Single Event Hydrograph Method. Worst-case land cover conditions (i.e., producing the most runoff) should be used for analyses (in most cases, this would be the land cover conditions just prior to final landscaping).

If the filtration treatment system design 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 planned development, the discharge from the filtration 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.

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.
- Screen, bag, and fiber filters must be cleaned and/or replaced when they become clogged.
- Sediment shall be removed 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.
- Disposal of filtration equipment must comply with applicable local, state, and federal regulations.

BMP C252: Treating and Disposing of High pH Water

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 ground water. A pH level range of 6.5 to 8.5 is typical for most natural watercourses, and this neutral pH range is required for the survival of aquatic organisms. Should the pH rise or drop out of this range, fish and other aquatic organisms may become stressed and may die.

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 sanitary sewer or concrete batch plant with pH neutralization capabilities.
- Neutralized stormwater may be discharged to surface waters under the Construction Stormwater General permit.
- Neutralized process water such as concrete truck wash-out, hydro-demolition, or saw-cutting 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.

- The process used for neutralizing and/or disposing of high pH stormwater from the site must be documented in the Construction Stormwater Pollution Prevention Plan.

Causes of High pH

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. Ground water standard for calcium and other dissolved solids in Washington State is less than 500 mg/l.

Treating High pH Stormwater by Carbon Dioxide Sparging

Advantages of Carbon Dioxide 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 Carbon Dioxide 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. 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.

The Treatment Process of Carbon Dioxide 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:

1. Prior to treatment, the appropriate jurisdiction should be notified in accordance with the regulations set by the jurisdiction.
2. Every effort should be made to isolate the potential high pH water in order to treat it separately from other stormwater on-site.
3. Water should be stored in an acceptable storage facility, detention pond, or containment cell prior to pH treatment.
4. 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.
5. 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.
6. In the pH treatment structure, add CO_2 until the pH falls into 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 pH treatment structure, this will allow carbon dioxide to bubble up through the water and diffuse more evenly.
7. 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. If turbidity remains above the maximum allowable, consider adding filtration to the treatment train. See BMP C251: Construction Stormwater Filtration.
8. Discharge treated water through a pond or drainage system.
9. 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 the treatment structure for the next batch treatment. Dispose of sludge when it fills 50% of the treatment structure volume.
10. Disposal must comply with applicable local, state, and federal regulations.

Treating High pH Stormwater by 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 with the remainder being water. Food grade vinegar may be used if dosed just enough to lower pH sufficiently. Use a treatment process as described above for CO_2 sparging, but add food grade vinegar instead of CO_2.

This treatment option for high pH stormwater does not apply to anything but food grade vinegar. Acetic acid does not equal vinegar. Any other product or waste containing acetic acid must go through the evaluation process in Appendix G of *Whole Effluent Toxicity Testing Guidance and Test Review Criteria* (Marshall, 2016).

Disposal of High pH Stormwater

Sanitary Sewer Disposal

Local sewer authority approval is required prior to disposal via the sanitary sewer.

Concrete Batch Plant Disposal

- Only permitted facilities may accept high pH water.
- Contact the facility to ensure they can accept the high pH water.

Maintenance Standards

Safety and materials handling:

- All equipment should be handled in accordance with OSHA rules and regulations.
- Follow manufacturer guidelines for materials handling.

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 or food grade vinegar needed to adjust water to a pH range of 6.9-7.1.
- pH of treated water.
- Discharge point location and description.

A copy of this record should be given to the client/contractor who should retain the record for three years.

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Appendix II-A: Recommended Standard Notes for Construction SWPPP Drawings

The following standard notes are suggested for use in Construction SWPPP Drawings (also referred to as erosion/sedimentation control or ESC plans). Local jurisdictions may have other mandatory notes that are applicable. Drawings should also identify, with phone numbers, the person or firm responsible for the preparation of and maintenance of the Construction SWPPP Drawings.

Standard Notes

Approval of this erosion/sedimentation control (ESC) plan does not constitute an approval of permanent road or drainage design (e.g. size and location of roads, pipes, restrictors, channels, retention facilities, utilities).

The implementation of this ESC plan and the construction, maintenance, replacement, and upgrading of these ESC BMPs is the responsibility of the applicant until all construction is completed and approved and vegetation/landscaping is established.

Clearly flag the boundaries of the clearing limits shown on this plan in the field prior to construction. During the construction period, no disturbance beyond the flagged clearing limits shall be permitted. The flagging shall be maintained by the applicant for the duration of construction.

Construct the ESC BMPs shown on this plan in conjunction with all clearing and grading activities, and in such a manner as to ensure that sediment and sediment laden water do not enter the drainage system, roadways, or violate applicable water standards.

The ESC BMPs shown on this plan are the minimum requirements for anticipated site conditions. During the construction period, upgrade these ESC BMPs as needed for unexpected storm events and to ensure that sediment and sediment-laden water do not leave the site.

The applicant shall inspect the ESC BMPs daily and maintain them as necessary to ensure their continued functioning.

Inspect and maintain the ESC BMPs on inactive sites a minimum of once a month or within the 48 hours following a major storm event (i.e. a 24-hour storm event with a 10-yr or greater recurrence interval).

At no time shall the sediment exceed 60-percent of the sump depth or have less than 6-inches of clearance from the sediment surface to the invert of the lowest pipe. All catch basins and conveyance lines shall be cleaned prior to paving. The cleaning operation shall not flush sediment laden water into the downstream system.

Install stabilized construction entrances at the beginning of construction and maintained for the duration of the project. Additional measures may be required to ensure that all paved areas are kept clean for the duration of the project.

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Volume III

Choosing, Modeling, and Documenting Your BMPs

Stormwater Management Manual for Western Washington

Prepared by:

Washington State Department of Ecology
Water Quality Program

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Executive Summary of Volume III

Welcome to Volume III of Ecology's 2019 Stormwater Management Manual for Western Washington. Volume III provides guidance for designers on how to choose, model, and document stormwater BMPs in a stormwater site plan. In this Volume you will find the following:

III-1 Choosing Your BMPs provides guidance on how to choose the most appropriate BMPs to meet Construction Stormwater, Source Control, On-Site Stormwater Management, Runoff Treatment, and Flow Control requirements for the site conditions.

III-2 Modeling Your BMPs provides an overview of hydrologic analysis, and describes the modeling options available for BMP design that are approved by Ecology.

III-3 Stormwater Site Plans outlines what is included in a stormwater site plan and what to do when corrections are needed to an existing stormwater site plan.

Appendix III-A: Basic Treatment Receiving Waters lists receiving waters that require Runoff Treatment BMPs that meet the Basic Treatment Performance Goal.

Appendix III-B: Isopluvial Maps for Design Storms presents the 2, 10 and 100-year, 24-hour design storm and mean annual precipitation isopluvial maps for Western Washington.

Appendix III-C: Rainfall Amounts and Statistics presents data for 24-hour rainfall amounts at locations throughout Washington State.

Refer to Volumes I, II, IV, and V for information on the following:

Volume I introduces the measures necessary to control the quantity and quality of stormwater produced by new development and redevelopment. It includes an introduction to stormwater management, guidance on regulatory requirements for stormwater management, and details the minimum requirements for new development and redevelopment sites.

Volume II focuses on managing stormwater impacts associated with construction activities. It discusses the need for pollution prevention for construction stormwater, details how to document construction BMPs in a construction stormwater pollution prevention plan, and includes information on how to implement construction stormwater BMPs.

Volume IV contains a library of source control BMPs, categorized by types of activities.

Volume V contains a library of design criteria for BMPs that project proponents can use to meet I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.6 MR6: Runoff Treatment, and/or I-3.4.7 MR7: Flow Control.

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III-1 Choosing Your BMPs

III-1.1 Choosing Your Source Control BMPs

This section provides guidance to the following users for selecting Source Control Best Management Practices (BMPs):

- Project proponents with new development or redevelopment, to meet I-3.4.3 MR3: Source Control of Pollution.
- Permittees under the following Ecology NPDES Permits, to meet SWPPP requirements of their Permit:
    - Industrial Stormwater General Permit
    - Industrial Stormwater Individual Permit
    - Boatyard General Permit
    - Sand and Gravel General Permit
- Permittees under Ecology's Phase I or Phase II Municipal Stormwater Permits, to comply with the Permit's Source Control Program Requirements

When are Source Control BMPs Required?

Where required by local code or by an Ecology NPDES Stormwater General Permit, implement Source Control BMPs at:

- Commercial properties
- Industrial properties
- Multifamily properties
- Boatyards
- Sand and gravel mining operations

Note that single family residential sites may not be required to provide Source Control BMPs. Ecology encourages single family residential sites and other sites not required by an NPDES permit or local government to select Source Control BMPs using the information provided in this section to the maximum extent practical.

Regulatory programs such as the State Environmental Policy Act (SEPA), Water Quality Certifications (see I-2.9 Section 401 Water Quality Certifications), and Hydraulic Project Approvals (see I-2.11 Hydraulic Project Approvals) may require use of Source Control BMPs.

Local governments may require commercial, industrial, and multifamily properties to implement Source Control BMPs through ordinances or other documents. Operators of these property types should check with their jurisdiction about local requirements related to Source Control BMPs and SWPPPs.

How to Determine Which Source Control BMPs are Appropriate for the Site

Volume IV provides Ecology's library of Source Control BMPs. These BMPs are categorized as either "operational" or "structural", and either "applicable" or "recommended".

For the sites listed above that must implement Source Control BMPs, use the following steps to guide selection of appropriate Source Control BMPs:

1. All sites must implement the Source Control BMPs listed in IV-1 Source Control BMPs Applicable to All Sites.
2. Next, base selection of additional Source Control BMPs on land use and the pollutant generating sources at the site.
   - Use Appendix IV-A: Urban Land Uses and Pollutant Generating Sources to help determine activities and the potential pollutant generating sources associated with those activities for various land uses.
   - Applicable operational and structural Source Control BMPs for each pollutant source can then be selected by reviewing the BMPs in Volume IV, which are categorized by activity. Land uses not included in Appendix IV-A: Urban Land Uses and Pollutant Generating Sources should also consider implementing Source Control BMPs for their pollutant sources.

   For example, if a commercial printing business conducts weed control with herbicides, loading and unloading of materials, and vehicle washing, it should refer to the following BMP sections for these activities:

   - S411 BMPs for Landscaping and Lawn / Vegetation Management
   - S412 BMPs for Loading and Unloading Areas for Liquid or Solid Material
   - S431 BMPs for Washing and Steam Cleaning Vehicles / Equipment / Building Structures
   - S404 BMPs for Commercial Printing Operations
3. Within the text for each Source Control BMP, there are "applicable" and "recommended" BMPs listed.

   The reader should interpret the term “applicable” when referring to specific operational or structural Source Control BMPs as meaning “mandatory” or “required”. These BMPs must be implemented at the site.

   Ecology offers "recommended" Source Control BMPs as approaches that go beyond or complement the applicable (mandatory) BMPs. Implementing the recommended Source Control BMPs may improve control of pollutants and provide a more comprehensive and environmentally effective stormwater management program. Ecology encourages all operators to review their SWPPPs and use recommended BMPs where possible.

4. The project may have additional source control responsibilities as a result of area-specific pollution control plans (e.g., watershed or basin plans, water clean-up plans, ground water management plans, lakes management plans), ordinances, and regulations.

Additional Guidance Specific to Industrial Stormwater Permit Permittees

- Operators under the Industrial Stormwater General Permit should take special care to review the Source Control BMPs in Volume IV to ensure that all of the applicable (mandatory) Source Control BMPs are included within their Industrial SWPPP, regardless of the listings in Appendix IV-A: Urban Land Uses and Pollutant Generating Sources.
- Under the Industrial Stormwater General Permit, if a facility's sampling triggers Level 1 or Level 2 Corrective Action requirements, operators should consider the *recommended* operational (Level 1) and structural (Level 2) Source Control BMPs to fulfill permit requirements and reduce pollutant concentrations.
- All sites covered under the Industrial Stormwater General Permit must include and implement the applicable (mandatory) BMPs in their Industrial SWPPP.
- Industrial sites covered by individual industrial stormwater permits must comply with the specific Source Control and Runoff Treatment BMPs listed in their permits. Operators under individual industrial stormwater permits may include additional BMPs from this manual, if desired.

Additional Guidance Specific to Boatyard General Permit Permittees

- Operators under the Boatyard General Permit should take special care to review the Source Control BMPs in Volume IV to ensure that all of the applicable (mandatory) Source Control BMPs are included within their Boatyard SWPPP, regardless of the listings in Appendix IV-A: Urban Land Uses and Pollutant Generating Sources.
- All sites covered under the Boatyard General Permit must include and implement the applicable (mandatory) BMPs in their Boatyard SWPPP.

Additional Guidance Specific to Sand and Gravel General Permit Permittees

- Facilities covered under the Sand and Gravel General Permit must include Source Control BMPs as necessary in their Sand and Gravel SWPPP to achieve AKART and compliance with the stormwater discharge limits in their permit.

Additional Guidance Specific to New and Redevelopment Project Proponents

- If the project involves any of the activities described in Volume IV, the "applicable" structural Source Control BMPs described in that section must be constructed as part of the project. In addition, if the specific business enterprise that will occupy the site is known, the “applicable” operational Source Control BMPs must also be identified.

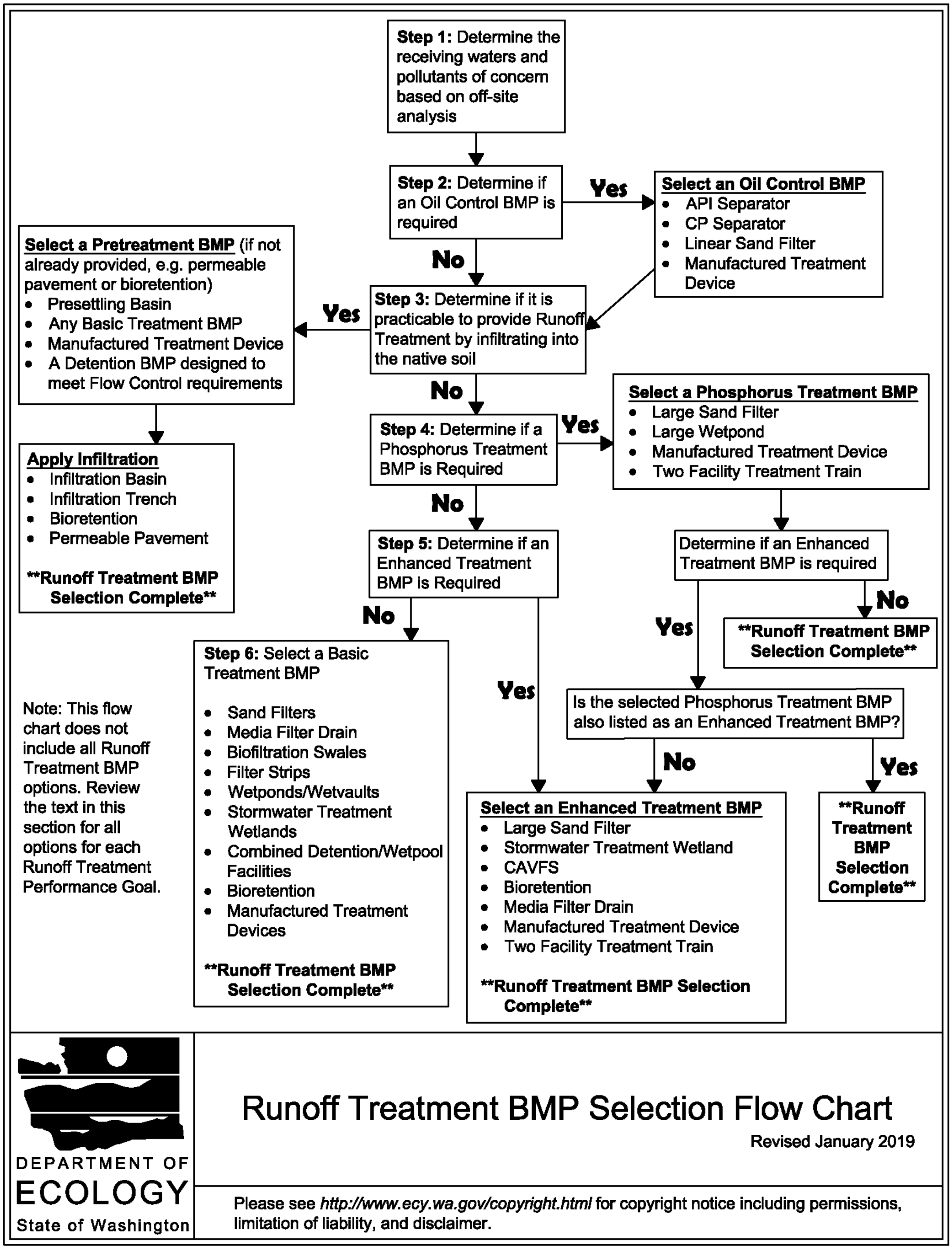
III-1.2 Choosing Your Runoff Treatment BMPs

Use the step-by-step process outlined below to determine the type of Runoff Treatment BMPs applicable to the project.

Runoff Treatment BMPs might apply to the project (or a TDA within the project) if directed by I-3.3 Applicability of the Minimum Requirements, I-3.4.6 MR6: Runoff Treatment, and/or I-3.4.8 MR8: Wetlands Protection, or if the project is using an infiltration BMP per V-5 Infiltration BMPs.

This section may also be referred to as directed by I-4 UIC Program to determine acceptable Runoff Treatment BMPs prior to UIC wells.

Figure III-1.1: Runoff Treatment BMP Selection Flow Chart



Step 1: Determine the Receiving Waters and Pollutants of Concern Based on Off-Site Analysis

To obtain a more complete determination of the potential impacts of a stormwater discharge, Ecology encourages local governments to require an off-site analysis similar to that in I-3.5.3 APM2: Off-Site Analysis Report. Even without an off-site analysis requirement, the project proponent must determine the natural receiving water for the stormwater drainage from the project site (ground water, wetland, lake, stream, or salt water). This is necessary to determine the level of Runoff Treatment applicable to your site. The identification of the receiving water should be verified by the local government agency with review responsibility. If the discharge is to the local municipal storm drainage system, the receiving water for the drainage system must be determined.

The local government should verify whether any type of water quality management plans and/or local ordinances or regulations have established specific requirements for that (those) receiving water(s). Examples of plans to be aware of include:

- Watershed or Basin Plans: These can be developed to cover a wide variety of geographic scales (e.g., Water Resource Inventory Areas, or sub-basins of a few square miles), and can be focused solely on establishing stormwater requirements (e.g., “Stormwater Basin Plans”), or can address a number of pollution and water quantity issues, including urban stormwater (e.g., Puget Sound Non-Point Action Plans).
- Water Clean-up Plans: These plans establish a Total Maximum Daily Load (TMDL) of a pollutant or pollutants in a specific receiving water or basin, and identify actions necessary to remain below that maximum loading. The plans may identify discharge limitations or management limitations (e.g., use of specific treatment facilities) for stormwater discharges from new and redevelopment projects.
- Ground Water Management Plans (Wellhead Protection Plans): To protect ground water quality and/or quantity, these plans may identify actions required of stormwater discharges.
- Lake Management Plans: These plans are developed to protect lakes from eutrophication due to inputs of phosphorus and other nutrients from the drainage basin. Control of nutrients from new development is a likely requirement in a lake management plan.

An analysis of the proposed land use(s) of the project should also be used to determine the stormwater pollutants of concern.

Step 2: Determine if an Oil Control BMP is Required

The use of Oil Control BMPs is dependent upon the specific land use proposed for development. Note that when an Oil Control BMP is required, it is in addition to Runoff Treatment BMPs required to meet other applicable Runoff Treatment Performance Goals (Basic, Enhanced, or Phosphorus).

If an Oil Control BMP is required, select and apply an appropriate Oil Control BMP from the options below. After selecting an Oil Control BMP, proceed to Step 3.

If an Oil Control BMP is not required, proceed directly to Step 3.

The Oil Control Performance Goal

Oil Control is intended to achieve the goals of no ongoing or recurring visible sheen, and to have a 24-hour average Total Petroleum Hydrocarbon (TPH) concentration no greater than 10 mg/l, and a maximum of 15 mg/l for a discrete sample (grab sample).

Note: Use the method for NWTPH-Dx in *Analytical Methods for Petroleum Hydrocarbons* (Ecology, 1997). If the concentration of gasoline is of interest, the method for NWTPH-Gx should be used to analyze grab samples.

When is Oil Control Required?

Oil Control BMPs are required for areas that typically generate high concentrations of oil due to high traffic turnover or the frequent transfer of oil. These types of areas 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 trip ends per day. Gasoline stations, with or without small food stores, will likely exceed this threshold.
- 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. 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.
- 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.). In general, all-day parking areas are not intended to require Oil Control BMPs.
- 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. The traffic count can be estimated using information from *Trip Generation Manual* (ITE, 2012), or from a traffic study prepared by a professional engineer or transportation specialist with experience in traffic estimation.

The following land uses may have areas that require Oil Control BMPs. Further, these sites require special attention to the Oil Control BMP selected.

- Industrial machinery and equipment, and railroad equipment maintenance areas
- Log storage and sorting yards
- Aircraft maintenance areas
- Railroad yards
- Fueling stations

- Vehicle maintenance and repair sites
- Junkyards and areas with vehicle recycling operations
- Construction businesses (paving, heavy equipment storage and maintenance, storage of petroleum products.)

Some land use types require the use of a spill control (SC-type) oil/water separator. Those situations are described in Volume IV and are separate from this Runoff Treatment requirement.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

How Do I Apply Oil Control to My Project Site?

Place Oil Control BMPs upstream of other BMPs, as close to the source of oil generation as practical.

For sites that require oil control located within a large commercial center, Oil Control BMPs are only required for the impervious surface(s) subject to the activities listed above. If common parking for multiple businesses is provided, Oil Control BMPs shall be applied to the number of parking stalls required for the business that requires oil control. However, if the runoff contributing to the Oil Control BMP includes runoff from other areas, the Oil Control BMP must be sized to treat all water passing through it.

Roadway intersections that trigger the above thresholds shall provide oil control for lanes where vehicles accumulate during the 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 area treated 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, oil control treatment may be limited to any two of the collection areas.

Oil Control BMP Options

Ecology currently recognizes the following BMPs as providing Runoff Treatment that meets the Oil Control Performance Goal:

- BMP T11.10: API (Baffle type) Separator
- BMP T11.11: Coalescing Plate (CP) Separator
- BMP T8.30: Linear Sand Filter

  Note: BMP T8.30: Linear Sand Filter may also be used to meet the Basic, Enhanced, or Phosphorus Treatment performance goals. If used to satisfy one of those performance goals, the same BMP shall not also be used to satisfy the oil control requirement unless increased maintenance is assured. This increase in maintenance is to prevent clogging of the filter by oil so that it will function for suspended solids, metals and phosphorus removal as well. Quarterly cleaning is required unless specified otherwise by the designer.

- Manufactured Treatment Devices - See V-10.4 Which Manufactured Treatment Devices Have Ecology Approval?

Step 3: Determine if it is Practicable to Provide Runoff Treatment by Infiltrating into the Native Soil

Due to the hydrologic benefits of infiltration, Ecology recommends evaluating whether it is practicable to provide Runoff Treatment by infiltrating into the site's native soils before considering other Runoff Treatment BMPs. If Runoff Treatment by infiltrating into the native soil is practicable, it has the advantage that it is presumed to meet the Phosphorus, Enhanced, and Basic Treatment Performance Goals.

The guidance in V-5 Infiltration BMPs must be followed for designing infiltration BMPs. V-5.6 Site Suitability Criteria (SSC) details the site conditions that must be met for infiltration to be practicable for the site, and includes conditions specific to using the native soil for Runoff Treatment. Runoff Treatment may be provided by infiltrating into the native soil if the conditions below the infiltration BMP meet the criteria for Runoff Treatment per V-5.6 Site Suitability Criteria (SSC).

Most infiltration BMPs should be preceded by a pretreatment BMP to reduce the occurrence of plugging. Some infiltration BMPs have pretreatment integrated into the BMP, such as BMP T5.15: Permeable Pavements and BMP T7.30: Bioretention, and therefore it is not necessary to provide additional pretreatment prior to infiltration. Any Basic Treatment BMPs, or detention ponds, vaults, or tanks designed to meet Flow Control requirements, can also be used for pre-treatment. If an oil/water separator is necessary for oil control, it could also function as the pre-settling basin as long as the influent suspended solids concentrations are not high. However, frequent inspections are necessary to determine when accumulated solids exceed the 6-inch depth at which clean-out is recommended (See Appendix V-A: BMP Maintenance Tables).

If infiltration is planned, also refer to the guidance in V-1 General BMP Design and Appendix V-A: BMP Maintenance Tables. This guidance may affect the design and placement of infiltration BMPs on the site.

Infiltration through soils that do not meet the criteria for Runoff Treatment per V-5.6 Site Suitability Criteria (SSC) is allowable as a Flow Control BMP only. Use of infiltration through such soils is acceptable provided the appropriate type of Runoff Treatment BMP (Enhanced, Phosphorus, or Basic) is provided as directed in the steps below.

If it is practicable to provide Runoff Treatment by infiltrating into the native soil, select and apply a Pretreatment BMP and an infiltration BMP. You have completed the Runoff Treatment selection process.

If it is not practicable to provide Runoff Treatment by infiltrating into the native soil, proceed to Step 4.

Step 4: Determine if a Phosphorus Treatment BMP is Required

The use of Phosphorus Treatment BMPs is dependent upon the location of the site proposed for development. Note that when a Phosphorus Treatment BMP is required, a separate Basic Treatment BMP is not also required. Phosphorus Treatment BMPs meet both the Phosphorus Treatment Performance Goal as well as the Basic Treatment Performance Goal.

The plans, ordinances, and regulations identified in Step 1 are a good reference to help determine if the subject site is in an area where a Phosphorus Treatment BMP is required.

If a Phosphorus Treatment BMP is required, select and apply an appropriate Phosphorus Treatment BMP from the options below. After selecting a Phosphorus Treatment BMP, proceed to Step 5.

If a Phosphorus Treatment BMP is not required, proceed directly to Step 5.

The Phosphorus Treatment Performance Goal

Phosphorus Treatment is intended to achieve a goal of 50% total phosphorus removal for a range of influent concentrations of 0.1 to 0.5 mg/l total phosphorus. In addition, Phosphorus Treatment BMPs are also intended to achieve the Basic Treatment Performance Goal.

The Phosphorus Treatment Performance Goal applies to the water quality design storm volume or flow rate, whichever is applicable. The incremental portion of runoff in excess of the water quality design storm volume or flow rate can be routed around the BMP (creating an off-line Runoff Treatment BMP), or can be passed through the BMP (creating an on-line Runoff Treatment BMP) provided a net pollutant reduction is maintained. Ecology encourages the design and operation of Runoff Treatment BMPs that engage a bypass at flow rates higher than the water quality design flow rate. This is acceptable provided that the overall reduction in phosphorus loading (treated plus bypassed) is at least equal to that achieved with initiating bypass at the water quality design flow rate. Note that Wetpool BMPs are always designed to be on-line.

When is Phosphorus Treatment Required?

Phosphorus Treatment BMPs are required for projects (or portions of projects) within watersheds that have been determined by local governments (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 government can use for determining whether a water body is sensitive to phosphorus:

- Those waterbodies reported under section 305(b) of the Clean Water Act, and designated as not supporting beneficial uses due to phosphorous or other water quality criteria related to excessive phosphorus;
- Those listed in Washington State's Nonpoint Source Assessment required under section 319(a) of the Clean Water Act due to nutrients.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

How Do I Apply Phosphorus Treatment to My Project Site?

If Phosphorus Treatment BMPs are required, select and apply a Phosphorous Treatment BMP from the options listed below. Select an option from the list after reviewing the BMP design guidance of each for compatibility with the site.

After you have selected a Phosphorus Treatment BMP, also refer to the guidance in V-1 General BMP Design and Appendix V-A: BMP Maintenance Tables. This guidance may affect the design and placement of BMPs on the site.

Phosphorus Treatment BMP Options

Ecology currently recognizes the following BMPs as providing Runoff Treatment that meets the Phosphorus Treatment Performance Goal:

- Infiltration (see V-5 Infiltration BMPs) through soils that meet the criteria for Runoff Treatment per V-5.6 Site Suitability Criteria (SSC)

  Pretreatment must precede infiltration through soils that meet the criteria for Runoff Treatment per V-5.6 Site Suitability Criteria (SSC). A presettling basin or a Basic Treatment BMP can serve for pretreatment.

- Infiltration (see V-5 Infiltration BMPs) through soils that do NOT meet the criteria for Runoff Treatment per V-5.6 Site Suitability Criteria (SSC), paired with:
  - a Basic Treatment BMP, AND
  - a minimum distance of 1/4 mile between the infiltration location and the phosphorus sensitive receiving water (or tributary to that water)
- BMP T8.11: Large Sand Filter Basin
- Large Wetpond - see BMP T10.10: Wetponds - Basic and Large
- Manufactured Treatment Devices approved for phosphorus treatment - See V-10.4 Which Manufactured Treatment Devices Have Ecology Approval?
- Two-Facility Treatment Trains – See Table III-1.1: Treatment Trains for Phosphorus Treatment

Table III-1.1: Treatment Trains for Phosphorus Treatment

First Basic Treatment BMP	Second Treatment BMP
BMP T9.10: Basic Biofiltration Swale or BMP T9.20: Wet Biofiltration Swale or BMP T9.30: Continuous Inflow Biofiltration Swale or Basic Wetpond - see BMP T10.10: Wetponds - Basic and Large or BMP T10.20: Wetvaults or	BMP T8.10: Basic Sand Filter Basin or BMP T8.20: Sand Filter Vault

Table III-1.1: Treatment Trains for Phosphorus Treatment (continued)

First Basic Treatment BMP	Second Treatment BMP
BMP T10.30: Stormwater Treatment Wetlands or BMP T10.40: Combined Detention and Wetpool Facilities (Basic)	
BMP T9.40: Vegetated Filter Strip	BMP T8.30: Linear Sand Filter (no presettling needed)
BMP T8.30: 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 basic filter strip. See V-1.4.2 Flow Spreaders.	BMP T9.40: Vegetated Filter Strip

Step 5: Determine if an Enhanced Treatment BMP is Required

The use of Enhanced Treatment BMPs is dependent upon the specific land use proposed for development. Note that when an Enhanced Treatment BMP is required, a separate Basic Treatment BMP is not also required. Enhanced Treatment BMPs meet both the Enhanced Treatment Performance Goal as well as the Basic Treatment Performance Goal.

If a Phosphorus Treatment BMP is required (per Step 4 above), and an Enhanced Treatment BMP is also required, note that some BMPs can provide both Enhanced Treatment and Phosphorus Treatment. If a BMP is listed in both the Phosphorus Treatment BMP options list and the Enhanced Treatment BMP options list, then that BMP may be used to provide both Phosphorus Treatment and Enhanced Treatment (as well as Basic Treatment). If a site that requires both Phosphorus Treatment BMPs and Enhanced Treatment BMPs selects an Enhanced Treatment BMP that is not also on the Phosphorus Treatment BMP options list, then a separate Phosphorus Treatment BMP must also be provided.

If an Enhanced Treatment BMP is required, select and apply an appropriate Enhanced Treatment BMP from the options below. You have completed the Runoff Treatment selection process.

If an Enhanced Treatment BMP is not required, but a Phosphorus Treatment BMP was required, selected, and applied per Step 4 above, you have completed the Runoff Treatment selection process.

If neither an Enhanced Treatment or Phosphorus Treatment BMP is required, proceed to Step 6.

The Enhanced Treatment Performance Goal

Enhanced Treatment BMPs are intended to provide a higher rate of removal of dissolved metals than Basic Treatment BMPs. Based on a review of dissolved metals removal from Basic Treatment BMPs, a “higher rate of removal” is currently defined as greater than 30% dissolved copper removal (assuming a dissolved copper influent range of 0.005 to 0.02 mg/l), and greater than 60% dissolved zinc removal (assuming a dissolved zinc influent range of 0.02 to 0.3 mg/l). In addition, Enhanced Treatment BMPs are also intended to achieve the Basic Treatment Performance Goal.

The Enhanced Treatment Performance Goal applies to the water quality design storm volume or flow rate, whichever is applicable. The incremental portion of runoff in excess of the water quality design storm volume or flow rate can be routed around the BMP (creating an off-line Runoff Treatment BMP), or can be passed through the BMP (creating an on-line Runoff Treatment BMP) provided a net pollutant reduction is maintained. Ecology encourages the design and operation of Runoff Treatment BMPs that engage a bypass at flow rates higher than the water quality design flow rate as long as the reduction in dissolved metals loading exceeds that achieved with initiating bypass at the water quality design flow rate. Note that Wetpool BMPs are always designed to be on-line.

When is Enhanced Treatment Required?

Enhanced Treatment BMPs are 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 a fresh water designated for aquatic life use or that has an existing aquatic life use.

The types of project sites are:

- Industrial project sites,
- Commercial project sites,
- Multifamily residential project sites, and
- High AADT roads as follows:
    - Within Urban Growth Areas:
        - Fully controlled and partially controlled limited access highways with Annual Average Daily Traffic (AADT) counts of 15,000 or more;
        - All other roads with an AADT of 7,500 or greater.
    - Outside of Urban Growth Areas:
        - Roads with an AADT of 15,000 or greater unless the site discharges to a 4th Strahler order stream or larger;
        - Roads with an AADT of 30,000 or greater if the site discharges to a 4th Strahler order stream or larger (as determined using 1:24,000 scale maps to delineate stream order).

The following areas of the above-listed project sites do not require Enhanced 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.
- Landscaped areas of industrial, commercial, and multi-family project sites that do not involve any other pollution-generating sources (e.g., industrial activities, customer parking, storage of erodible or leachable material, wastes or chemicals).
- Parking lots of industrial and commercial project sites, dedicated solely to parking of employees' private vehicles that do not involve any other pollution-generating sources (e.g., industrial activities, customer parking, storage of erodible or leachable material, wastes or chemicals).

For TDAs with a mix of land use types, Enhanced Treatment BMPs are required when the runoff from the areas subject to the Enhanced Treatment Performance Goal comprises 50% or more of the total runoff from the TDA.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

How Do I Apply Enhanced Treatment to My Project Site?

If Enhanced Treatment BMPs are required, select and apply an Enhanced Treatment BMP from the options listed below. Select an option from the list after reviewing the BMP design guidance of each for compatibility with the site.

After you have selected an Enhanced Treatment BMP, also refer to the guidance in V-1 General BMP Design and Appendix V-A: BMP Maintenance Tables. This guidance may affect the design and placement of BMPs on the site.

Enhanced Treatment BMP Options

Ecology currently recognizes the following BMPs as providing Runoff Treatment that meets the Enhanced Treatment Performance Goal:

- Infiltration (see V-5 Infiltration BMPs) through soils that meet the criteria for Runoff Treatment per V-5.6 Site Suitability Criteria (SSC)

  Pretreatment must precede infiltration through soils that meet the criteria for Runoff Treatment per V-5.6 Site Suitability Criteria (SSC). A presettling basin or a Basic Treatment BMP can serve for pretreatment.
- BMP T8.11: Large Sand Filter Basin
- BMP T10.30: Stormwater Treatment Wetlands
- BMP T7.40: Compost-Amended Vegetated Filter Strips (CAVFS)
- BMP T7.30: Bioretention

Note: Stormwater runoff that filters through the bioretention soil mix will receive Enhanced Treatment. Where bioretention is intended to meet Runoff Treatment requirements for its drainage area, it must be designed, using an approved continuous runoff model, to pass at least 91% of the influent runoff file through the bioretention soil mix.

- BMP T8.40: Media Filter Drain
- Manufactured Treatment Devices approved for enhanced treatment - See V-10.4 Which Manufactured Treatment Devices Have Ecology Approval?
- Two Facility Treatment Trains - See Table III-1.2: Treatment Trains for Enhanced Treatment

Table III-1.2: Treatment Trains for Enhanced Treatment

First Runoff Treatment BMP	Second Runoff Treatment BMP
BMP T9.10: Basic Biofiltration Swale or BMP T9.20: Wet Biofiltration Swale or BMP T9.30: Continuous Inflow Biofiltration Swale or Basic Wetpond - see BMP T10.10: Wetponds - Basic and Large or BMP T10.20: Wetvaults or BMP T10.40: Combined Detention and Wetpool Facilities (Basic)	BMP T8.10: Basic Sand Filter Basin or BMP T8.20: Sand Filter Vault or Manufactured Treatment Devices - See V-10.4 Which Manufactured Treatment Devices Have Ecology Approval?. The Manufactured Treatment Device must be a type approved for basic or enhanced treatment use by Ecology.
BMP T9.40: Vegetated Filter Strip	BMP T8.30: Linear Sand Filter (no pre-settling cell needed)
BMP T8.30: 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 basic filter strip. See V-1.4.2 Flow Spreaders.	BMP T9.40: Vegetated Filter Strip
BMP T8.10: Basic Sand Filter Basin or BMP T8.20: Sand Filter Vault **These options must include a presettling cell if the filter isn't preceded by a detention BMP	Manufactured Treatment Devices - See V-10.4 Which Manufactured Treatment Devices Have Ecology Approval?. The Manufactured Treatment Device must be a type approved for basic or enhanced treatment use by Ecology.

Step 6: Select a Basic Treatment BMP

Note that if an Enhanced Treatment BMP or a Phosphorus Treatment BMP have been applied, an additional Basic Treatment BMP is not required. Phosphorus Treatment and Enhanced Treatment BMPs meet both the Basic Treatment Performance Goal as well as their own respective Performance Goals.

The Basic Treatment Performance Goal

Basic Treatment BMPs are intended 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 BMPs are intended to achieve an effluent goal of 20 mg/l total suspended solids.

The Basic Treatment Performance Goal applies to the water quality design storm volume or flow rate, whichever is applicable. The incremental portion of runoff in excess of the water quality design storm volume or flow rate can be routed around the BMP (creating an off-line Runoff Treatment BMP), or can be passed through the BMP (creating an on-line Runoff Treatment BMP) provided a net TSS reduction is maintained. Ecology encourages the design and operation of Runoff Treatment BMPs that engage a bypass at flow rates higher than the water quality design flow rate as long as the reduction in TSS loading exceeds that achieved with initiating bypass at the water quality design flow rate. Note that wetpool facilities are always designed to be on-line. The Basic Treatment Performance Goal assumes that the BMP is treating stormwater with a typical particle size distribution. For a description of a typical particle size distribution, please refer to Ecology's *Technical Guidance Manual for Evaluating Emerging Stormwater Treatment Technologies* (Ecology, 2011b).

When is Basic Treatment Required?

Areas that must provide Phosphorus Treatment BMPs or Enhanced Treatment BMPs do NOT have to provide additional Basic Treatment BMPs to meet the Basic Treatment Performance Goal.

If Phosphorus Treatment BMPs or Enhanced Treatment BMPs are not provided, Basic Treatment BMPs are required before discharging runoff off site through either infiltration or surface flow.

For TDAs with a mix of land use types, Basic Treatment BMPs are required when the runoff from the areas subject to the Basic Treatment Performance Goal comprises 50% or more of the total runoff from the TDA.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

How Do I Apply Basic Treatment to My Project Site?

If Basic Treatment BMPs are required, select and apply a Basic Treatment BMP from the options listed below. Select an option from the list after reviewing the BMP design guidance of each for compatibility with your site.

After selecting a Basic Treatment BMP, also refer to the guidance in V-1 General BMP Design and Appendix V-A: BMP Maintenance Tables. This guidance may affect the design and placement of BMPs on the site.

Basic Treatment BMP Options

Ecology currently recognizes the following BMPs as providing Runoff Treatment that meets the Basic Treatment Performance Goal:

- Infiltration (see V-5 Infiltration BMPs) into soils that meet the criteria for Runoff Treatment per V-5.6 Site Suitability Criteria (SSC).

  Pretreatment must precede infiltration through soils that meet the criteria for Runoff Treatment per V-5.6 Site Suitability Criteria (SSC). A presettling basin or a Basic Treatment BMP can serve for pretreatment.
- BMP T8.10: Basic Sand Filter Basin
- BMP T8.11: Large Sand Filter Basin
- BMP T8.20: Sand Filter Vault
- BMP T8.30: Linear Sand Filter
- BMP T8.40: Media Filter Drain
- BMP T9.10: Basic Biofiltration Swale
- BMP T9.20: Wet Biofiltration Swale
- BMP T9.30: Continuous Inflow Biofiltration Swale
- BMP T9.40: Vegetated Filter Strip
- BMP T7.40: Compost-Amended Vegetated Filter Strips (CAVFS)
- BMP T10.10: Wetponds - Basic and Large
- BMP T10.20: Wetvaults

  Note: A wetvault may be used for commercial, industrial, or road projects if there are space limitations. Ecology discourages the use of wetvaults for residential projects.
- BMP T10.30: Stormwater Treatment Wetlands
- BMP T10.40: Combined Detention and Wetpool Facilities
- BMP T5.15: Permeable Pavements

- BMP T7.30: Bioretention

  Note: Where bioretention is intended to fully meet Runoff Treatment requirements for its drainage area, it must be designed, using an approved continuous runoff model, to pass at least 91% of the influent runoff file through the imported soil mix.

- Manufactured Treatment Devices approved for basic, phosphorus, or enhanced treatment - See V-10.4 Which Manufactured Treatment Devices Have Ecology Approval?

Congratulations! You have completed Ecology's Runoff Treatment BMP selection process.

Other Runoff Treatment BMP Selection Factors

The selection of a Runoff Treatment BMP should be based on site physical factors and pollutants of concern. The requirements for use of Enhanced Treatment BMPs or Phosphorus Treatment BMPs represents BMP selection based on pollutants of concern. Even if the site is not subject to those requirements, try to choose a BMP that is likely to remove the types of pollutants generated on the site. The types of site physical factors that influence BMP selection are summarized below.

Soil Type

The permeability of the soil underlying a Runoff Treatment BMP has a profound influence on its effectiveness. This is particularly true for infiltration BMPs that are sited in sandy to loamy sand soils. They are not generally appropriate for sites that have a design infiltration rate less than 0.3 inches per hour. Wetpool BMPs situated on coarser soils will need a synthetic liner or the soils amended to reduce the infiltration rate and provide treatment. Maintaining a permanent pool in the first cell is necessary to avoid resuspension of settled solids. Biofiltration swales in coarse soils can also be amended to reduce the infiltration rate.

High Sediment Input

High TSS loads can clog infiltration soil, sand filters and coalescing plate oil & water separators. Pretreatment with a presettling basin, wet vault, or another Basic Treatment BMP would typically be necessary.

Other Physical Factors

Slope: Steep slopes restrict the use of several BMPs. For example, biofiltration swales are usually situated on sites with slopes of less than 6%, although greater slopes can be considered. Infiltration BMPs are not suitable when the slope exceeds 15%.

High Water Table: Unless there is sufficient horizontal hydraulic receptor capacity the water table acts as an effective barrier to exfiltration and can sharply reduce the efficiency of an infiltration system. If the high water table extends to within five (5) feet of the bottom of an infiltration BMP, the site is seldom suitable.

Depth to Bedrock/ Hardpan/Till: The downward exfiltration of stormwater is also impeded if a bedrock or till layer lies too close to the surface. If the impervious layer lies within five feet below the bottom of the infiltration BMP, the site is not suitable. Similarly, pond BMPs are often not feasible if bedrock lies within the area that must be excavated.

Proximity to Foundations and Wells: Since infiltration BMPs convey runoff back into the soil, some sites may experience problems with local seepage. This can be a real problem if the BMP is located too close to a building foundation. Another risk is ground water pollution; hence, the requirement to site infiltration systems more than 100 feet away from drinking water wells.

Maximum Depth: Wet ponds are also subject to a maximum depth limit for the "permanent pool" volume. Deep ponds (greater than 8 feet) may stratify during summer and create low oxygen conditions near the bottom resulting in re-release of phosphorus and other pollutants back into the water.

Table III-1.3: Screening Runoff Treatment BMP Types Based on Soil Type

Soil Type	Infiltration/Bioretention	Wet Pond*	Biofiltration* (Swale or Filter Strip)
Coarse Sand or Cobbles	X	X	X
Sand	✓	X	X
Loamy Sand	✓	X	✓
Sandy Loam	✓	X	✓
Loam	X	X	✓
Silt Loam	X	X	✓
Sandy Clay Loam	X	✓	✓
Silty Clay Loam	X	✓	✓
Sandy Clay	X	✓	✓
Silty Clay	X	✓	X
Clay	X	✓	X
Notes:			

Table III-1.3: Screening Runoff Treatment BMP Types Based on Soil Type (continued)

Soil Type	Infiltration/Bioretention	Wet Pond*	Biofiltration* (Swale or Filter Strip)
✓ Indicates that the BMP type is generally appropriate for this soil type. **X** Indicates that the BMP type is generally not appropriate for this soil type. * Coarser soils may be used for these BMPs if a liner is installed to prevent infiltration, or if the soils are amended to reduce the infiltration rate. Note: Sand filtration is not listed because its feasibility is not dependent on soil type.			

III-1.3 Choosing Your Flow Control BMPs

Use this section to determine the type of Flow Control BMPs most appropriate for the project.

Flow Control BMPs might apply to the project (or a TDA within the project) if directed by I-3.3 Applicability of the Minimum Requirements, I-3.4.7 MR7: Flow Control, and/or I-3.4.8 MR8: Wetlands Protection.

Step 1: Determine Whether the Site is Suitable for Infiltration

Due to the multiple hydrologic benefits of infiltration, Ecology recommends first evaluating whether infiltration is practicable to provide Flow Control. Flow Control may be required to comply with I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.7 MR7: Flow Control, and/or I-3.4.8 MR8: Wetlands Protection. Note that Flow Control BMPs provided to meet I-3.4.5 MR5: On-Site Stormwater Management can also be used in the analysis to help meet I-3.4.7 MR7: Flow Control.

The guidance in V-5 Infiltration BMPs must be followed for designing infiltration BMPs. V-5.6 Site Suitability Criteria (SSC) details the site conditions that must be met for infiltration to be practicable for the site, and includes conditions specific to using the native soil for Runoff Treatment.

Infiltration through soils that do not meet the criteria for Runoff Treatment per V-5.6 Site Suitability Criteria (SSC) is allowable as a Flow Control BMP only. Use of infiltration through such soils is acceptable provided the appropriate type of Runoff Treatment BMP (Enhanced, Phosphorus, or Basic) is provided as directed in III-1.2 Choosing Your Runoff Treatment BMPs.

Infiltration BMPs must be preceded by a pretreatment BMP, such as a presettling basin, manufactured treatment device, or vault, to reduce the occurrence of plugging. Any Basic Treatment BMPs, or detention ponds, vaults, or tanks designed to meet Flow Control requirements, can also be used for pre-treatment. If an oil/water separator is necessary for oil control, it could also function as the pre-settling basin as long as the influent suspended solids concentrations are not high. However, frequent inspections are necessary to determine when accumulated solids exceed the 6-inch depth at which clean-out is recommended (See Appendix V-A: BMP Maintenance Tables).

If infiltration is planned, also refer to the guidance in V-1 General BMP Design and Appendix V-A: BMP Maintenance Tables. This guidance may affect the design and placement of infiltration BMPs on the site.

If it is practicable to provide Flow Control by infiltration, use an Ecology approved continuous simulation model and the guidance provided in V-5 Infiltration BMPs to size the infiltration BMP to meet the requirements in I-3.4.7 MR7: Flow Control and/or I-3.4.8 MR8: Wetlands Protection.

If it is not practicable to provide Flow Control by infiltration, proceed to Step 2.

Step 2: Choose a Detention BMP to Provide Flow Control

Use an Ecology approved continuous simulation model and the guidance provided in V-12 Detention BMPs to size a detention BMP to meet the requirements in I-3.4.7 MR7: Flow Control and/or I-3.4.8 MR8: Wetlands Protection.

III-1.4 Review and Document Your BMP Choices

The list of BMPs chosen for the site should be reviewed. The site designer may want to re-evaluate site layout to reduce the need for construction of BMPs. The site designer may be able to reduce the size of the BMPs by reducing the amount of impervious surfaces created, providing more LID BMPs, and/or decreasing the areas disturbed.

The design and location of the BMPs on the site must be determined using the detailed guidance in Volumes II, IV, and V.

The site designer must document the site's BMP selection and design decisions and calculations. Types of documentation for Stormwater BMPs include:

- Stormwater Site Plans, as required per I-3.4.1 MR1: Preparation of Stormwater Site Plans and as described in III-3 Stormwater Site Plans
- Construction Stormwater Pollution Prevention Plans, as required per I-3.4.2 MR2: Construction Stormwater Pollution Prevention Plan (SWPPP) and as described in II-2 Construction Stormwater Pollution Prevention Plans (Construction SWPPPs)
- Operation and Maintenance Manuals, as required per I-3.4.9 MR9: Operation and Maintenance

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III-2 Modeling Your BMPs

III-2.1 An Overview of Hydrologic Analysis

The broad definition of hydrology is "the science which studies the source, properties, distribution, and laws of water as it moves through its closed cycle on the earth (the hydrologic cycle)". As applied in this manual, however, the term "hydrologic analysis" addresses and quantifies only a small portion of this cycle. That portion is the relatively short-term movement of water over the land resulting directly from precipitation and called surface water or stormwater runoff. Localized and long-term ground water movement must also be of concern, but generally only as this relates to the movement of water on or near the surface, such as stream base flow or infiltration systems.

Hydrologic Modeling Options

The Ecology approved methods available to compute stormwater infiltration and runoff, which is then used to size Runoff Treatment and Flow Control BMPs depends on the type of information required and the size of the drainage area to be analyzed, as follows:

- For the purpose of designing flow-based Runoff Treatment BMPs, an Ecology approved continuous simulation hydrologic model based on the EPA's HSPF (Hydrologic Simulation Program-Fortran) program, or an approved equivalent model, must be used to calculate runoff and determine the water quality design flow rate.
- For the purpose of designing volume-based Runoff Treatment BMPs (i.e. V-8 Wetpool BMPs), there are two acceptable methods to calculate the water quality design storm volume:
    - An Ecology approved continuous simulation hydrologic model based on the EPA's HSPF (Hydrologic Simulation Program-Fortran) program, or an approved equivalent model. (See III-2.2 Continuous Simulation Models).
    - The single event hydrograph method, using the precipitation depth from the 6-month 24-hour storm and NRCS curve number equations. (See III-2.3 Single Event Hydrograph Method).
- For the purpose of designing Flow Control BMPs, an Ecology approved continuous simulation hydrologic model, based on the EPA's HSPF program, or an approved equivalent model, must be used.
- If a basin plan is being prepared, then a hydrologic analysis should be performed using a continuous simulation model such as the EPA's HSPF model, the EPA's Stormwater Management Model (SWMM), or an equivalent model as approved by the local government.

  Where large master-planned developments are proposed, local governments should consider requiring a basin-specific calibration of the EPA's HSPF program, rather than use of the default parameters from Ecology approved continuous simulation hydrologic models based on the EPA's HSPF program. Ecology suggests such basin-specific calibrations should be considered for projects that will occupy more than 320 acres.

Continuous Simulation Modeling Vs. Single Event Hydrograph Method

A continuous simulation model has considerable advantages over the single event-based methods such as the SCSUH, SBUH, or the Rational Method. HSPF is a continuous simulation model that is capable of simulating a wider range of hydrologic responses than the single event models. Single event models cannot take into account storm events that may occur just before or just after the single event (the design storm) that is under consideration. In addition, the runoff files generated by the HSPF models are the result of a considerable effort to introduce local parameters and actual rainfall data into the model and therefore produce better estimations of runoff than the SCSUH, SBUH, or Rational methods.

While SBUH may give acceptable estimates of total runoff volumes, it tends to overestimate peak flow rates from pervious areas because it cannot adequately model subsurface flow (which is a dominant flow regime for pre-development conditions in western Washington basins). One reason SBUH overestimates the peak flow rate for pervious areas is that the actual time of concentration is typically greater than what is assumed. Better flow estimates could be made if a longer time of concentration was used. This would change both the peak flow rate (i.e., it would be lower) and the shape of the hydrograph (i.e., peak occurs somewhat later) such that the hydrograph would better reflect actual pre-developed conditions.

Another reason for overestimation of the runoff is the curve numbers (CN) in the 1992 Manual (Ecology, 1992). These curve numbers were developed by US-Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service (SCS), and published as the Western Washington Supplemental Curve Numbers. These CN values are typically higher than the standard CN values published in Technical Release 55 (USDA et al., 1986). In 1995, the NRCS recalled the use of the western Washington CNs for floodplain management and found that the standard CNs better describe the hydrologic conditions for rainfall events in western Washington. However, based on runoff comparisons with the King County Runoff Time Series (KCRTS), better estimates of runoff are obtained when using the western Washington CNs for the developed areas such as parks, lawns, and other landscaped areas. Accordingly, the CNs in this manual (see Table III-2.5: Post-Development Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas) are changed to those in the Technical Release 55 except for the open spaces category for the developed areas which include, lawn, parks, golf courses, cemeteries, and landscaped areas. For these areas, the western Washington CNs are used. These changes are intended to provide better runoff estimates using the single event hydrograph method.

Another major weakness of SBUH is that it is used to model a 24-hour storm event, which is too short to model longer-term storms in western Washington. The use of a longer-term (e.g., 3- or 7-day storm) is perhaps better suited for western Washington.

Related to the last concern is the fact that single event approaches, such as SBUH, assume that Flow Control ponds/vaults/tanks are empty at the start of the design event. Continuous runoff models are able to simulate a continuous long-term record of runoff and soil moisture conditions. They simulate situations where the ponds/vaults/tanks are not empty when another rain event begins.

Finally, single event models do not allow for estimation and analyses of flow durations nor water level fluctuations. Flow durations are necessary for discharges to streams. Estimates of water level fluctuations are necessary for discharges to wetlands and for tracking influent water elevations and bypass quantities to properly size stormwater BMPs.

III-2.2 Continuous Simulation Models

Continuous Simulation Model Approval Status

Ecology has reviewed the following continuous simulation modeling programs. The approval status for the programs is provided in the “Additional Resources” folder in the interactive online SWMMWW.

- Western Washington Hydrology Model (WWHM)
- MGSFlood
- King County Runoff Time Series (KCRTS)

The approval status is specific to whether the program may be used to gain compliance with the 2019 – 2024 Municipal Stormwater General Permit requirements.

Note that the approval status may change. Check the “Additional Resources” folder in the interactive online SWMMWW (as noted above) for the current status of model approvals.

Basis for Approval

Ecology will review new continuous simulation modeling programs, as they become available, for approval.

Some of the components that a continuous simulation modeling program must have in order to gain Ecology approval include:

- HSPF based,
- Algorithms must be equivalent to approved model(s),
- Rainfall data must be equivalent to approved model(s),
- Ability to compute compliance with Ecology’s flow related performance standards,
- Ability to compute the water quality design volume and the water quality design flow rate.

About the Western Washington Hydrology Model (WWHM)

Ecology has coordinated the development of the Western Washington Hydrology Model (WWHM) based on the EPA's HSPF (Hydrologic Simulation Program-Fortran) for use in western Washington. WWHM uses rainfall/runoff relationships developed for specific basins in the Puget Sound region to all parts of western Washington. Where field monitoring establishes basin-specific rainfall/runoff parameter calibrations, those can be entered into the model, superseding the default input parameters. Note that basin-specific rainfall/runoff parameter calibrations must be prepared by the jurisdiction and approved by Ecology.

Since the first version of WWHM was developed and released to the public in 2001, the WWHM program has gone through several upgrades incorporating new features and capabilities including low impact development (LID) modeling capability. Designers should periodically check Ecology's WWHM web site for the latest releases of WWHM, the WWHM user manual, and any supplemental instructions. The web address for WWHM is:

https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Stormwater-manuals/Western-Washington-Hydrology-Model.

Using WWHM to Model Flow-Related Standards

Flow-related standards are used to determine whether or not a proposed Flow Control BMP will provide a sufficient level of mitigation for the additional runoff from land development. There are three flow-related standards described in this Manual: The LID performance standard as described in I-3.4.5 MR5: On-Site Stormwater Management; the Flow Control performance standard as described in I-3.4.7 MR7: Flow Control; and the wetlands protection standards as described in I-3.4.8 MR8: Wetlands Protection.

- I-3.4.5 MR5: On-Site Stormwater Management allows the user to demonstrate compliance with the LID Performance Standard by sizing Flow Control BMPs to match developed discharge durations to pre-developed discharge durations for the range of pre-developed discharge rates from 8% of the 2-year peak flow to 50% of the 2-year peak flow. If the developed flow duration values exceed any of the pre-developed flow duration values between 8% and 50% of the 2-year pre-developed peak flow values, then the LID performance standard has not been met.

- I-3.4.7 MR7: Flow Control specifies that stormwater discharges to streams shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow. This is the Flow Control Performance Standard.

  WWHM computes the pre-development and post-development runoff for the 2- through 100-year flow frequency values from the outlet of the proposed stormwater facility, as follows:

  - WWHM uses the pre-development peak flow value for each water year to compute the pre-development 2- through 100-year flow frequency values. The post-development runoff 2- through 100-year flow frequency values are computed from the outlet of the proposed Flow Control BMP. The user must enter the stage-surface area-storage-discharge table (HSPF FTABLE) for the Flow Control BMP. The model then routes the post-development runoff through the Flow Control BMP. As with the pre-development peak flow values, the model will select the maximum developed flow value for each water year to compute the developed 2- through 100-year flow frequency.

  - The actual flow frequency calculations are made using the federal standard Log Pearson Type III distribution described in *Guidelines For Determining Flood Flow Frequency* (Interagency Advisory Committee on Water Data, 1982). This standard flow frequency distribution is provided in U.S. Geological Survey program J407, version 3.9A-P, revised 8/9/89. The *Guidelines For Determining Flood Flow Frequency* (Interagency

Advisory Committee on Water Data, 1982) algorithms in program J407 are included in the WWHM calculations.

The Flow Control Performance Standard is based on flow duration. WWHM uses the entire pre-development and post-development runoff record, and computes flow durations by counting the number of flow values that exceed a specified flow level. The specified flow levels used by WWHM in the flow duration analysis are:

- 50% of the 2-year pre-development peak flow.
- 100% of the 2-year pre-development peak flow.
- 100% of the 50-year pre-development peak flow.

In addition, flow durations are computed for 97 other incremental flow values between 50 percent of the 2-year pre-development peak flow and 100 percent of the 50-year pre-development peak flow.

There are three criteria by which flow duration values are compared:

1. If the post-development flow duration values exceed any of the pre-development flow levels between 50% and 100% of the 2-year pre-development peak flow values (100 Percent Threshold) then the flow duration requirement has not been met.
2. If the post-development flow duration values exceed any of the pre-development flow levels between 100% of the 2-year and 100% of the 50-year pre-development peak flow values more than 10 percent of the time (110 Percent Threshold) then the flow duration requirement has not been met.
3. If more than 50 percent of the flow duration levels exceed the 100 percent threshold then the flow duration requirement has not been met.

The results are provided in the WWHM report.

- I-3.4.8 MR8: Wetlands Protection refers to Appendix I-C: Wetland Protection Guidelines, which includes measures to protect the hydroperiod of the wetland. Flow components feeding the wetland under both pre- and post-development scenarios are assumed to be the sum of the surface, interflow, and ground water flows from the project site. WWHM has the capability to model flows to wetlands and analyze the criteria described in Appendix I-C: Wetland Protection Guidelines.

  As of the publication date of this manual (July 1, 2019), the algorithms needed to perform the analysis associated with the hydroperiod protection guidelines described in I-C.4 Wetland Hydroperiod Protection are not available in WWHM. However, WWHM can be used to provide model simulation of flows to wetlands under both existing condition and post development condition. The analysis and comparisons of those flows (under existing and post development conditions) must be conducted outside WWHM; for example, by using a spreadsheet.

Limitations to WWHM

Ecology created WWHM for the specific purpose of sizing stormwater control facilities for new development and redevelopment projects in western Washington. WWHM can be used for a range of conditions and developments; however, certain limitations are inherent in this software.

WWHM uses the EPA HSPF software program to do all of the rainfall-runoff and routing computations. Therefore, HSPF limitations are included in WWHM. For example, backwater or tailwater control situations are not explicitly modeled by HSPF. This is also true in WWHM.

Earlier versions of WWHM, i.e. WWHM1 and WWHM2, had limited routing capabilities. The routing capabilities have since improved. The designer can now input multiple stormwater control facilities and the model will route the runoff through them. If the proposed development site involves routing through a natural lake or wetland in addition to multiple stormwater control facilities, WWHM can be used to do the routing computations and additional analysis.

Assumptions Made in Creating WWHM

Precipitation Data

- *Length of record:* WWHM uses long-term (50 - 70 years) precipitation data to simulate the potential impacts of land use development in western Washington. A minimum period of 20 years is sufficient to simulate enough peak flow events to produce accurate flow frequency results. A 40 to 50-year record is preferred. The actual length of record of each precipitation station varies, but all the ones used in WWHM exceed 50 years.

- *Computational time step:* The computational time step used in earlier versions of WWHM was one hour. The one-hour time step was selected to better represent the temporal variability of actual precipitation than daily data. WWHM now incorporates 15-minute time steps.

  The 15-minute time step was selected to better represent the temporal variability of actual precipitation. These data are used in WWHM computations to generate runoff hydrographs. The computations include generating the water quality design flow rates and volumes for sizing Runoff Treatment BMPs.

- *Rainfall distribution:* WWHM uses over 17 precipitation stations, representing the different rainfall regimes found in western Washington. These stations represent rainfall at elevations below 1500 feet. WWHM does not include snowfall and melt. Ecology encourages local governments to use more detailed local precipitation data when available.

  The primary source for precipitation data is National Weather Service stations. The secondary source is precipitation data collected by local jurisdictions. During development of WWHM, county engineers at 19 western Washington counties were contacted to obtain local precipitation data.

  Earlier versions of WWHM used hourly data from the precipitation stations in Table III-2.1: Precipitation Stations Used in WWHM Creation to generate precipitation timeseries for use in WWHM. WWHM now uses more recent precipitation data to generate precipitation timeseries in 15-minute time steps.

  The records were reviewed for length, quality, and completeness of record. Annual totals were checked along with hourly maximum totals. Using these checks, data gaps and errors were corrected, where possible. A "Quality of Record" summary was produced for each precipitation record reviewed.

The reviewed and corrected data were placed in multiple WDM (Watershed Data Management) files. One WDM file was created per county and contains all of the precipitation data to be used by WWHM for that particular county. A local government that believes that it has a more accurate precipitation record to use with WWHM should petition Ecology to allow use of that record, and to possibly incorporate that record into WWHM. This may be more easily done in the future if WWHM is upgraded to allow use of custom precipitation time series.

Table III-2.1: Precipitation Stations Used in WWHM Creation

Precipitation Station	Years of Data	County Coverage
Astoria, OR	1955-1998 = 43	Wahkiakum
Blaine	1948-1998 = 50	Whatcom, San Juan
Burlington	1948-1998 = 50	Skagit, Island
Clearwater	1948-1998 = 50	Jefferson (west)
Darrington	1948-1996 = 48	Snohomish (northeast)
Everett	1948-1996 = 48	Snohomish (excluding northeast)
Frances	1948-1998 = 50	Pacific
Landsburg	1948-1997 = 49	King (east)
Longview	1955-1998 = 43	Cowlitz, Lewis (south)
McMillian	1948-1998 = 50	Pierce
Montesano	1955-1998 = 43	Grays Harbor
Olympia	1955-1998 = 43	Thurston, Mason (south), Lewis (north)
Port Angeles	1948-1998 = 50	Clallam (east)
Portland, OR	1948-1998 = 50	Clark, Skamania
Quilcene	1948-1998 = 50	Jefferson (east), Mason (north), Kitsap
Sappho	1948-1998 = 50	Clallam (west)
SeaTac	1948-1997 = 49	King (west)

Precipitation Multiplication Factors

- WWHM uses precipitation multiplication factors to increase or decrease recorded precipitation data to better represent local rainfall conditions. This is particularly important when the precipitation gage is located some distance from the study area.
- The multiplication factors were created for the Puget Sound lowlands plus all western Washington valleys and hillside slopes below 1500 feet elevation.
- The factors are based on the ratio of the 24-hour, 25-year rainfall intensities for the representative precipitation gage and the surrounding area represented by that gage's record. The 24-hour, 25-year rainfall intensities were determined from *NOAA ATLAS 2, Precipitation - Frequency Atlas of the Western United States, Volume IX - Washington* (Miller et al., 1973).
- The factors have been placed in the WWHM database and linked to each county's map. They

are transparent to the general user. However, the advanced user has the ability to change the precipitation multiplication factor for a specific site where justified and approved by the reviewing jurisdiction. Changes made by the user are recorded in the WWHM output. By default, WWHM does not allow the precipitation multiplication factor to be below 0.8 or above 2.

Pan Evaporation Data

- Pan evaporation data are used to determine the potential evapotranspiration (PET) of a study area. Actual evapotranspiration (AET) is computed by the WWHM based on PET and available moisture supply. AET accounts for the precipitation that returns to the atmosphere without becoming runoff. Soil moisture conditions and runoff are directly influenced by PET and AET.
- Evaporation is not highly variable like rainfall. WWHM's default setting uses Puyallup pan evaporation data for all of the 19 western Washington counties.
- Pan evaporation data were assembled and checked for the same time period as the precipitation data and placed in the appropriate county WDM files.
- Pan evaporation data are collected in the field, but PET is used by the WWHM. PET is equal to pan evaporation times a pan evaporation coefficient. Depending on climate, pan evaporation coefficients for western Washington range from 0.72 to 0.82.
- *NOAA Technical Report NWS 33: Evaporation Atlas for the Contiguous 48 United States* (Farnsworth et al., 1982) was used as the source for the pan evaporation coefficients. Pan evaporation coefficient values are shown on Map 4 of that publication.
- As with the precipitation multiplication factors, the pan evaporation coefficients have been placed in the WWHM database and linked to each county's map. They are transparent to the general user. However, the advanced user has the ability to change the pan evaporation coefficient for a specific site where justified and approved by the reviewing jurisdiction. Changes made by the user are recorded in the WWHM output.

Soil Data

- Soil type, along with vegetation type, greatly influences the rate and timing of the transformation of rainfall to runoff. Sandy soils with high infiltration rates produce little or no surface runoff; almost all runoff is from ground water. Soils with a compressed till layer slowly infiltrate water and produce larger amounts of surface runoff during storm events.
- WWHM uses three predominant soil types to represent the soils of western Washington: till, outwash, and saturated.
    - *Till* soils have been compacted by glacial action. Under a layer of newly formed soil lies a compressed soil layer commonly called "hardpan". This hardpan has very poor infiltration capacity. As a result, till soils produce a relatively large amount of surface runoff and interflow. A typical example of a till soil is an Alderwood soil (SCS class C). Where field infiltration tests indicate a measured (initial) infiltration rate less than 0.30 in/hr, the user may model the site as a class C soil.
    - *Outwash* soils have a high infiltration capacity due to their sand and gravel composition.

Outwash soils have little or no surface runoff or interflow. Instead, almost all of their runoff is in the form of ground water. An Everett soil (SCS class A) is a typical outwash soil.

Outwash soils over high ground water or an impervious soil layer have low infiltration rates and act like till soils. Where ground water or an impervious soil layer is within 5 feet from the surface, outwash soils may be modeled as till soils in the WWHM.

- *Saturated* soils are usually found in wetlands. They have a low infiltration rate and a high ground water table. When dry, saturated soils have a high storage capacity and produce very little runoff. However, once they become saturated they produce surface runoff, interflow, and ground water in large quantities. Mukilteo muck (SCS class D) is a typical saturated/wetland soil.

- The user will be required to investigate actual local soil conditions for the specific development planned. The user will then input the number of acres of outwash (A/B), till (C/D), and saturated/wetland soils for the site conditions.
- Alluvial soils are found in valley bottoms. These are generally fine-grained and often have a high seasonal water table. There has been relatively little experience in calibrating the HSPF to model runoff from these soils, so in the absence of better information, these soils may be modeled as till soils.
- Additional soils will be included in WWHM if appropriate HSPF parameter values are found to represent other major soil groups.
- The three predominant soil types are represented in the WWHM by specific HSPF parameter values that represent the hydrologic characteristics of these soils. More information on these parameter values is presented below.

Vegetation Data

- As with soil type, vegetation types greatly influence the rate and timing of the transformation of rainfall to runoff. Vegetation intercepts precipitation, increases its ability to percolate through the soil, and evaporates and transpires large volumes of water that would otherwise become runoff.
- WWHM represents the vegetation of western Washington with three predominant vegetation categories: forest, pasture, and lawn (also known as grass).
  - *Forest* vegetation represents the typical second growth Douglas fir found in the Puget Sound lowlands. Forest has a large interception storage capacity. This means that a large amount of precipitation is caught in the forest canopy before reaching the ground and becoming available for runoff. Precipitation intercepted in this way is later evaporated back into the atmosphere. Forest also has the ability to transpire moisture from the soil via its root system. This leaves less water available for runoff.

    Forest vegetation is represented by specific HSPF parameter values that represent the forest hydrologic characteristics. As described above, the existing regional HSPF parameter values for forest are based on undisturbed second-growth Douglas fir forest found today in western Washington lowland watersheds.

- *Pasture* vegetation is typically found in rural areas where the forest has been cleared and replaced with shrub or grass lots. Some pasture areas may be used to graze livestock. The interception storage and soil evapotranspiration capacity of pasture are less than forest. Soils may have also been compressed by mechanized equipment during clearing activities. Livestock can also compact soil. Pasture areas typically produce more runoff (particularly surface runoff and interflow) than forest areas.

- *Lawn* vegetation is representative of the suburban vegetation found in typical residential developments. Soils have been compacted by earth moving equipment, often with a layer of topsoil removed. Sod and ornamental bushes replace native vegetation. The interception storage and evapotranspiration of lawn vegetation is less than pasture, more runoff results.

- The pre-development land conditions are generally assumed as forest (the default condition), however, the user has the ability to specify pasture or the existing land cover, when appropriate. See I-3.4.7 MR7: Flow Control for guidance on when Ecology allows the designer to use pasture or the existing land cover as the pre-developed land condition.

- Post-development vegetation will reflect the new vegetation planned for the site. The user has the choice of forest, pasture, and landscaped vegetation. Forest and pasture are only appropriate for post-development vegetation in parcels separate from standard residential or non-standard residential/commercial developments. WWHM assumes the pervious land portion of developed areas is covered with lawn vegetation, as described above.

  Post-development vegetative areas must only be designated as forest or pasture where legal restrictions can be documented that protect these areas from future disturbances; unless, these areas are amended in accordance with BMP T5.13: Post-Construction Soil Quality and Depth. Where lawn/landscaped areas use BMP T5.13: Post-Construction Soil Quality and Depth, they may be entered into approved runoff models as “Pasture” rather than “Lawn/Landscaping”.

Development Land Use Data

- Development land use data are used to represent the type of development planned for the site and are used to determine the appropriate size of the required Stormwater BMP.

- The WWHM user must enter land use information for the pre-developed condition and the proposed development condition into the model. WWHM users must select the appropriate land use category and slope, where:

  - A slope of 0-5% is "flat", 5-15% is "moderate", and greater than 15% is "steep".

  - The land use categories include: Impervious areas such as Roads, Roof, Driveways, Sidewalks, Parking, Ponds; and Pervious areas such as Lawn (this includes lawn, garden, areas with ornamental plants, and any natural areas not legally protected from future disturbance), Forest, and Pasture.

    Impervious, as the name implies, allows no infiltration of water into the pervious soil. All runoff is surface runoff. Impervious land typically consists of paved roads, sidewalks, driveways, and parking lots. Roofs are also impervious.

For the purposes of hydrologic modeling, only effective impervious area is categorized as impervious. Effective impervious area (EIA) is the area where there is no opportunity for surface runoff from an impervious site to infiltrate into the soil before it reaches a conveyance system (pipe, ditch, stream, etc.). An example of an EIA is a shopping center parking lot where the water runs off the pavement and directly goes into a catch basin where it then flows into a pipe and eventually to a stream. In contrast, some homes with impervious roofs collect the roof runoff into roof gutters and send the water down downspouts. When the water reaches the base of the downspout it can be directed into an infiltration system. If roof runoff is infiltrated according to the requirements of BMP T5.10A: Downspout Full Infiltration, the roof area can be considered ineffective impervious area. The roof area may be discounted from the project area entered into WWHM.

The non-effective impervious area uses the adjacent or underlying soil and vegetation properties. Vegetation often varies by the type of land use. The assumption is made in WWHM that the EIA equals the TIA (total impervious area). This is consistent with King County's determination of EIA acres for new developments.

Forest and pasture vegetation areas are only appropriate for separate undeveloped parcels dedicated as open space, wetland buffer, or park within the total area of the standard residential development. ***Development areas (except as specified in LID modeling, such as BMP T5.13: Post-Construction Soil Quality and Depth) must only be modeled as forest or pasture where legal restrictions can be documented that protect these areas from future disturbances.***

  - The soils types available are A/B (outwash), C (Till), and Saturated (wetland).

- Earlier versions of WWHM included a standard residential development option which made specific assumptions about the amount of impervious area per lot and its division between driveways and rooftops. Streets and sidewalk areas were input separately. Ecology had selected a standard impervious area of 4200 square feet per residential lot, with 1000 square feet of that as driveway, walkways, and patio area, and the remainder as rooftop area.

  WWHM no longer includes the standard residential development category. Designers can use the above land use assumptions when modeling runoff from standard residential development, or, where better land use information is available, use that information to model and estimate runoff from the residential development.

- Previous guidance for modeling LID BMPs in WWHM directed users to apply runoff credits for BMPs that WWHM was unable to model (such as dispersion and permeable pavements). WWHM now allows direct modeling of some LID BMPs through use of LID Elements. If an LID BMP does not have a modeling element in WWHM, guidance is provided within the BMP in Volume V for how to model the BMP.

Pervious and Impervious Land Categories (PERLND and IMPLND) Parameter Values

- In WWHM (and HSPF), pervious land categories are represented by PERLNDs; impervious land categories by IMPLNDs.
- An example of a PERLND is a till soil covered with forest vegetation. This PERLND has a

unique set of HSPF parameter values. For each PERLND there are over 20 parameters that describe various hydrologic factors that influence runoff. These range from interception storage to infiltration to active ground water evapotranspiration. Only four parameters are required to represent IMPLND.

- The PERLND and IMPLND parameter values are based on regional parameter values developed by the U.S. Geological Survey for watersheds in western Washington (Dinicola, 1990), plus additional HSPF modeling work conducted by AQUA TERRA Consultants.
- Surface runoff and interflow are computed based on the PERLND and IMPLND parameter values. Ground water flow can also be computed and added to the total runoff from a development if there is a reason to believe that ground water would be surfacing (such as where there is a cut in a slope). However, the default condition in WWHM assumes that no ground water flow from small catchments reaches the surface to become runoff.
- The PERLND and IMPLND parameter values are transparent to the general user. However, the advanced user has the ability to change the value of a particular parameter for that specific site. The only PERLND and IMPLND parameters that are authorized to be adjusted by the user are LSUR, SLSUR, and NSUR. These are parameters whose values are observable at an undeveloped site, and whose values can be reasonably estimated for the proposed development site. Any such changes are recorded in the WWHM output. The user should submit justifications for changes with their project submittal to the reviewing jurisdiction. Ecology will issue guidance within the WWHM Users Manual on the range of and methods for estimating acceptable parameter changes.
- The 16 PERLND and four IMPLND parameter values originally used when creating WWHM are listed in Table III-2.2: Original WWHM PERLND Parameters. A more complete description of these PERLND parameters is found in the HSPF User Manual (Bicknell et al., 1997). Since the original creation of WWHM, new PERLND parameters for other soil/vegetation categories have been added.
- The four IMPLND parameter values originally used when creating WWHM are listed in Table III-2.3: Original WWHM IMPLND Parameters. A more complete description of these IMPLND parameters is found in the HSPF User Manual (Bicknell et al., 1997). No new IMPLND parameters have been added since the original creation of WWHM.

Table III-2.2: Original WWHM PERLND Parameters

PERLND Parameters	Land Types								
	Till Soils			Outwash Soils			Saturated Soils		
	Forest	Pasture	Lawn	Forest	Pasture	Lawn	Forest	Pasture	Lawn
	TF	TP	TL	OF	OP	OL	SF	SP	SL
LZSN Lower Zone Storage Nominal (inches)	4.5	4.5	4.5	5.0	5.0	5.0	4.0	4.0	4.0
INFILT	0.08	0.06	0.03	2.0	1.6	0.80	2.0	1.8	1.0

Table III-2.2: Original WWHM PERLND Parameters (continued)

PERLND Parameters	Land Types								
	Till Soils			Outwash Soils			Saturated Soils		
	Forest	Pasture	Lawn	Forest	Pasture	Lawn	Forest	Pasture	Lawn
	TF	TP	TL	OF	OP	OL	SF	SP	SL
Infiltration Capacity (inches/hour)									
LSUR Length of Surface Overland Flow Plane (feet)	400	400	400	400	400	400	100	100	100
SLSUR Slope of Surface Overland Flow Plane (feet/feet)	0.10	0.10	0.10	0.10	0.10	0.10	0.001	0.001	0.001
KVARY Ground Water Exponent Variable ($inch^{-1}$)	0.5	0.5	0.5	0.3	0.3	0.3	0.5	0.5	0.5
AGWRC Active Ground Water Recession Constant (day^{-1})	0.996	0.996	0.996	0.996	0.996	0.996	0.996	0.996	0.996
INFEXP Infiltration Exponent	2.0	2.0	2.0	2.0	2.0	2.0	10.0	10.0	10.0
INFILD Ratio of Maximum to Mean Infiltration	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
BASETP Base Flow Evapotranspiration (fraction)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AGWETP Active Ground Water Evapotranspiration (fraction)	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.7	0.7
CEPSC Interception Storage (inches)	0.20	0.15	0.10	0.20	0.15	0.10	0.18	0.15	0.10
UZSN Upper Zone Storage Nominal (inches)	0.5	0.4	0.25	0.5	0.5	0.5	3.0	3.0	3.0

Table III-2.2: Original WWHM PERLND Parameters (continued)

PERLND Parameters	Land Types								
	Till Soils			Outwash Soils			Saturated Soils		
	Forest	Pasture	Lawn	Forest	Pasture	Lawn	Forest	Pasture	Lawn
	TF	TP	TL	OF	OP	OL	SF	SP	SL
NSUR Roughness of Surface Overland Flow Plane (Manning's n)	0.35	0.30	0.25	0.35	0.30	0.25	0.50	0.50	0.50
INTFW Interflow Index	6.0	6.0	6.0	0.0	0.0	0.0	1.0	1.0	1.0
IRC Interflow Recession Constant (day^{-1})	0.5	0.5	0.5	0.7	0.7	0.7	0.7	0.7	0.7
LZETP Lower Zone Evapotranspiration (fraction)	0.7	0.4	0.25	0.7	0.4	0.25	0.8	0.8	0.8

Table III-2.3: Original WWHM IMPLND Parameters

IMPLND Parameters	Land Type = Impervious
LSUR Length of Surface Overland Flow Plane (feet)	400
SLSUR Slope of Surface Overland Flow Plane (feet/feet)	0.01
NSUR Roughness of Surface Overland Flow Plane (Manning's n)	0.10
RETSC Retention Storage (inches)	0.10

III-2.3 Single Event Hydrograph Method

Hydrograph analysis utilizes the standard plot of runoff flow versus time for a given design storm, thereby allowing the key characteristics of runoff such as peak, volume, and phasing to be considered in the design of drainage facilities. Because this manual only uses single event methods as an option for determining the Water Quality Design Storm Volume, which is then used to size volume based Runoff Treatment BMPs, only the subjects of design storms, curve numbers and calculating runoff volumes are presented. If single event methods are used to size temporary and permanent conveyances, the reader should reference other texts and software for assistance.

Water Quality Design Storm

As stated in III-2.6 Sizing Your Runoff Treatment BMPs, a single event design storm may be used for determining the Water Quality Design Storm Volume as an alternative to using an approved continuous simulation model. This design storm is the 6-month, 24-hour storm. Unless amended to reflect local precipitation statistics, the 6-month, 24-hour precipitation amount may be assumed to be 72 percent of the 2-year, 24-hour amount. Precipitation estimates of the 6-month and 2-year, 24-hour storms for certain towns and cities are listed in Appendix III-C: Rainfall Amounts and Statistics. For other areas, interpolating between isopluvials for the 2-year, 24-hour precipitation and multiplying by 72% yields the appropriate storm size. Isopluvials for 2-year, 24-hour amounts for Western Washington are reprinted in Appendix III-B: Isopluvial Maps for Design Storms.

The total depth of rainfall (in tenths of an inch) for storms of 24-hour duration and 2, 5, 10, 25, 50, and 100-year recurrence intervals are published by the National Oceanic and Atmospheric Administration (NOAA). The information is presented in the form of “isopluvial” maps for each state. Isopluvial maps are maps where the contours represent total inches of rainfall for a specific duration. Isopluvial maps for the 2, 5, 10, 25, 50, and 100-year recurrence interval and 24-hour duration storm events can be found in the *NOAA ATLAS 2, Precipitation - Frequency Atlas of the Western United States, Volume IX - Washington* (Miller et al., 1973). Appendix III-B: Isopluvial Maps for Design Storms provides the isopluvials for the 2, 10, and 100-year, 24-hour design storms. Other precipitation frequency data may be obtained through the Western Regional Climate Center (WRCC) at Tel: (775) 674-7010. WRCC can generate 1-30 day precipitation frequency data for the location of interest using data from 1880 to present (currently June 2012).

Curve Numbers

All single event hydrograph methods require input of parameters that describe the physical drainage basin characteristics. These parameters provide the basis from which the runoff hydrograph is developed. This section describes only the key parameter of curve number that is used to estimate the runoff volume from the water quality design storm.

The NRCS (formerly SCS) has, for many years, conducted studies of the runoff characteristics for various land types. After gathering and analyzing extensive data, NRCS has developed relationships between land use, soil type, vegetation cover, interception, infiltration, surface storage, and runoff. The relationships have been characterized by a single runoff coefficient called a “curve number.” The *SCS National Engineering Handbook Section 4: Hydrology* (Rallison et al., 1972) contains a detailed description of the development and use of the curve number method.

NRCS has developed “curve number” (CN) values based on soil type and land use. They can be found in *Technical Release No. 55: Urban Hydrology for Small Watersheds* (USDA et al., 1986). The combination of these two factors is called the “soil-cover complex.” The soil-cover complexes have been assigned to one of four hydrologic soil groups, according to their runoff characteristics. NRCS has classified over 4,000 soil types into these four soil groups. Table III-2.4: Hydrologic Soil Series for Selected Soils in Washington State shows the hydrologic soil group of most soils in the state of Washington and provides a brief description of the four groups. For details on other soil types refer to *Technical Release No. 55: Urban Hydrology for Small Watersheds* (USDA et al., 1986).

Table III-2.4: Hydrologic Soil Series for Selected Soils in Washington State

Soil Type	Hydrologic Soil Group	Soil Type	Hydrologic Soil Group	Soil Type	Hydrologic Soil Group
Agnew	C	Hoogdal	C	Raught	B
Ahl	B	Hoypus	A	Reed	D
Aits	C	Huel	A	Reed, Drained or Protected	C
Alderwood	C	Indianoloa	A	Renton	D
Arents, Alder-wood	B	Jonas	B	Republic	B
Arents, Everett	B	Jumpe	B	Riverwash	variable
Ashoe	B	Kalaloch	C	Rober	C
Baldhill	B	Kapowsin	C/D	Salal	C
Barneston	C	Kilchis	C	Salkum	B
Baumgard	B	Kitsap	C	Sammamish	D
Beausite	B	Klaus	C	San Juan	A
Belfast	C	Klone	B	Scamman	D
Bellingham	D	Lates	C	Schneider	B
Bellingham vari-ent	C	Lebam	B	Seattle	D
Boistfort	B	Lummi	D	Sekiu	D
Bow	D	Lynwood	A	Semiahmoo	D
Bristcot	D	Lystair	B	Shalcar	D
Buckley	C	Mal	C	Shano	B
Bunker	B	Manley	B	Shelton	C
Cagey	C	Mashel	B	Si	C
Carlsborg	A	Maytown	C	Sinclair	C
Casey	D	McKenna	D	Skipopa	D
Cassolary	C	McMurray	D	Skykomish	B
Cathcard	B	Melbourne	B	Snahopish	B
Centralia	B	Menzel	B	Snohomish	D
Chehalis	B	Mized Alluvial	variable	Solduc	B
Chesaw	A	Molson	B	Solleks	C

Table III-2.4: Hydrologic Soil Series for Selected Soils in Washington State (continued)

Soil Type	Hydrologic Soil Group	Soil Type	Hydrologic Soil Group	Soil Type	Hydrologic Soil Group
Cinebar	B	Mukilteo	C/D	Spana	D
Calallam	C	Naff	B	Spanaway	A/B
Clayton	B	Nargar	A	Springdale	B
Coastal beaches	variable	National	B	Sulavar	B
Colter	C	Neilton	A	Sultan	C
Custer	D	Newberg	B	Sultan variant	B
Custer, Drained	C	Nisqually	B	Sumas	C
Dabob	C	Nooksak	C	Swantown	D
Datula	C	Norma	C/D	Tacoma	D
Delphi	D	Ogarty	C	Tanwax	D
Dick	A	Olete	C	Tanwax, Drained	C
Dimal	D	Olomount	C	Tealwhit	D
Dupont	D	Olympic	B	Tenino	C
Earlmont	C	Orcas	D	Tisch	D
Edgewick	C	Oridia	D	Tokul	C
Eld	B	Orting	D	Townsend	C
Elwell	B	Oso	C	Trition	D
Esquatzel	B	Ovall	C	Tukwila	D
Everett	A	Pastik	C	Tukey	C
Everson	D	Pheeney	C	Urbana	C
Galvin	D	Phelan	D	Vailton	B
Getchell	A	Pilchuck	C	Verlot	C
Giles	B	Potchub	C	Wapato	D
Godfrey	D	Poulsbo	C	Warden	B
Greenwater	A	Prather	C	Whidbey	C
Grove	C	Puget	D	Wilkeson	B
Harstine	C	Puyallup	B	Winston	A

Table III-2.4: Hydrologic Soil Series for Selected Soils in Washington State (continued)

Soil Type	Hydrologic Soil Group	Soil Type	Hydrologic Soil Group	Soil Type	Hydrologic Soil Group
Hartnit	C	Queets	B	Woodinville	B
Hoh	B	Quilcene	C	Yelm	C
Holo	C	Ragnar	B	Zynbar	B
Hoodsport	C	Rainier	C		

Hydrologic Soil Group Classifications, as defined by the Soil Conservation Service:

A = (Low runoff potential). Soils having low runoff potential and high infiltration rates, even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/hr).

B =(Moderately low runoff potential). Soils having moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.3 in/hr).

C = (Moderately high runoff potential). Soils having low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine textures. These soils have a low rate of water transmission (0.05-0.15 in/hr).

D = (High runoff potential). Soils having high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a hardpan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

* = From *Technical Release No. 55: Urban Hydrology for Small Watersheds* (USDA et al., 1986), Exhibit A-1. Revisions made from SCS, Soil Interpretation Record, Form #5, September 1988 and various county soil surveys.

Additional Note: Where field infiltration tests indicate a measured (initial) infiltration rate less than 0.30 in/hr, the WWHM user may model the site as a C soil.

Table III-2.5: Post-Development Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas shows the CNs, by land use description, for the four hydrologic soil groups. These numbers are for a 24-hour duration storm and 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 lesser 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 subbasin.

Separate CN values must be selected for the pervious and impervious areas of an urban basin or subbasin. For residential districts the percent impervious area given in Table III-2.5: Post-Development Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas must be used to compute the respective pervious and impervious areas. For proposed commercial areas, planned unit developments, etc., the percent impervious area must be computed from the site plan. For all other land uses the percent impervious area must be estimated from best available aerial topography and/or field reconnaissance. The pervious area CN value must be a weighted average of all the pervious area CNs within the subbasin. The impervious area CN value shall be 98.

Table III-2.5: Post-Development Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas

	CNs for Hydrologic Soil Group			
Cover type and hydrologic condition	**A**	**B**	**C**	**D**
Pasture, grassland, or range-continuous forage for grazing:				
Poor Condition (ground cover <50% or heavy 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 (forest litter, small trees, and brush are destroyed by heavy grazing or regular burning).	45	66	77	83
Fair (woods are grazed but not burned, and some forest litter covers the soil)	36	60	73	79
Good (woods are protected from grazing, and litter and brush adequately cover the soil)	30	55	70	77
Open Space (Lawns, parks, golf courses, cemeteries, landscaping, etc.)[1]:				
Fair Condition (grass	77	85	90	92

Table III-2.5: Post-Development Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas (continued)

	CNs for Hydrologic Soil Group			
Cover type and hydrologic condition	**A**	**B**	**C**	**D**
cover 50% to 75% of the area)				
Good Condition (grass cover >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[2], driveways, etc. (excluding right-of-way)	98	98	98	98
Paved	98	98	98	98
Gravel (including right-of-way)	76	85	89	91
Dirt (including right-of-way)	72	82	87	89
Permeable Pavement:				
Porous Asphalt, Porous Concrete, or Grid/Lattice Systems (without underlying perforated drain pipes to collect stormwater) *(use landscape area CNs)*	77	85	90	92
Paving Blocks (without underlying perforated drain pipes to collect stormwater) *(use 50% landscaped area/50% impervious CNs)*	87	91	94	96
All Permable Pavement Types (with underlying perforated drain pipes to collect stormwater)	98	98	98	98

Table III-2.5: Post-Development Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas (continued)

	CNs for Hydrologic Soil Group			
Cover type and hydrologic condition	**A**	**B**	**C**	**D**
(use impervious area CNs)				
Single Family Residential[3]:				
Should only be used for subdivisions > 50 acres				
Dwelling Unit/Gross Acre	Average Percent impervious area[3,4]			
1.0 DU/GA	15	Separate curve number shall be selected for pervious & impervious portions of the site or basin		
1.5 DU/GA	20			
2.0DU/GA	25			
2.5 DU/GA	30			
3.0 DU/GA	34			
3.5 DU/GA	38			
4.0 DU/GA	42			
4.5 DU/GA	46			
5.0 DU/GA	48			
5.5 DU/GA	50			
6.0 DU/GA	52			
6.5 DU/GA	54			
7.0 DU/GA	56			
7.5 DU/GA	58			
PUD's condos, apartments, commercial businesses, industrial areas & subdivisions < 50 acres:				
% impervious must be computed	Separate curve numbers shall be selected for pervious and impervious portions of the site			

Notes:

1. Composite CN's may be computed for other combinations of open space cover type.

2. Where roof runoff and driveway runoff are infiltrated or dispersed according to the requirements in BMP T5.10A: Downspout Full Infiltration, BMP T5.10B: Downspout Dispersion Systems, or BMP T5.30: Full Dispersion, the average percent impervious area may be adjusted in accordance with the procedures described in BMP T5.10A: Downspout Full Infiltration, BMP T5.10B: Downspout Dispersion Systems, or BMP T5.30: Full Dispersion.

3. Assumes roof and driveway runoff is directed into street/storm system.

4. All the remaining pervious area (lawn) are considered to be in good condition for these curve numbers.

Table III-2.5: Post-Development Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas (continued)

	CNs for Hydrologic Soil Group			
Cover type and hydrologic condition	A	B	C	D
5. (Sources: (USDA et al., 1986), and (Ecology, 1992). See III-2.1 An Overview of Hydrologic Analysis) for explanations)				
6. For a more detailed and complete description of land use curve numbers refer to chapter 2 of *Technical Release No. 55: Urban Hydrology for Small Watersheds* (USDA et al., 1986).				

Curve Number Selection Example

The following is an example of how CN values are selected for a sample project.

Select CNs for the following development:

- Existing Land Use: forest (undisturbed)
- Future Land Use: residential plat (3.6 DU/GA)
- Basin Size: 60 acres
- Soil Type: 80 percent Alderwood, 20 percent Ragnor

The following steps are used to determine the CNs:

1. Table III-2.4: Hydrologic Soil Series for Selected Soils in Washington State shows that Alderwood soil belongs to the “C” hydrologic soil group and Ragnor soil belongs to the “B” group.
2. For the existing condition, CNs of 70 and 55 are read from Table III-2.5: Post-Development Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas and areal weighted to obtain a CN value for the existing condition of 67.
3. For the developed condition with 3.6 DU/GA the percent impervious of 39 percent is interpolated from Table III-2.5: Post-Development Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas and used to compute pervious and impervious areas of 36.6 acres and 23.4 acres, respectively. The 36.6 acres of pervious area is assumed to be in Fair condition (for a conservative design) with residential yards and lawns covering the same proportions of Alderwood and Ragnor soil (80 percent and 20 percent respectively). Therefore, CNs of 90 and 85 are read from Table III-2.5: Post-Development Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas and areal weighted to obtain a pervious area CN value of 89. The impervious area CN value is 98. The result of this example is summarized below:

Table III-2.6: Summary of Curve Number Selection Example

On-Site Condition	Existing	Developed
Land use	Forest	Residential
Pervious area	60 ac.	36.6 ac.
CN of pervious area	67	89
Impervious area	0 ac.	23.4 ac.
CN of impervious area	--	98

Calculating the Water Quality Design Storm Volume Using the NRCS Curve Number Equations

The rainfall-runoff equations of the NRCS curve number method relates a land area's runoff depth (precipitation excess) to the precipitation it receives and to its natural storage capacity, as follows:

$$Q_d = (P - 0.2S)^2/(P + 0.8S) \text{ , for } P \geq 0.2S$$

and

$$Q_d = 0 \text{ , for } P < 0.2S$$

Where:

Q_d = runoff depth in inches over the area,

P = precipitation depth in inches over the area. For calculating the water quality design storm volume, this number is the 6-month 24-hour storm (in inches), as described in III-2.6 Sizing Your Runoff Treatment BMPs, and

S = potential maximum natural detention, in inches over the area, due to infiltration, storage, etc.

The area's potential maximum detention, S, is related to its curve number, CN:

$$S = (1000 / CN) - 10$$

The combination of the above equations allows for estimation of the total runoff volume by computing total runoff depth, Q_d, given the total precipitation depth, P. For example, if the curve number of the area is 70, then the value of S is 4.29. With a total precipitation for the design event of 2.0 inches, the total runoff depth would be:

$$Q_d = [2.0 - 0.2\,(4.29)]^2 / [2.0 + 0.8\,(4.29)] = 0.24 \text{ inches}$$

This computed runoff represents inches over the tributary area.

Therefore, the total volume of runoff is found by multiplying Q_d by the tributary area (with necessary conversions):

$$\text{Total Runoff Volume (cu. ft.)} = 3{,}630 \text{ (cu. ft./ac. in.)} \times Q_d \text{ (in)} \times A \text{ (ac)}$$

If the area is 10 acres, the total runoff volume is:

3,630 (cu. ft./ac. in.) x 0.24 (in.) x 10 (ac.) = 8,712 cu. ft.

This is the Water Quality Design Storm Volume used to size volume based Runoff Treatment BMPs.

III-2.4 Flow Bypass and Additional Area Inflow

Bypassing Areas that Require Flow Control

This guidance applies to Flow Control BMPs that are not receiving flow from the entire amount of area that must be mitigated.

A portion of an area that requires a Flow Control BMP to meet I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.7 MR7: Flow Control, and/or I-3.4.8 MR8: Wetlands Protection may bypass the Flow Control BMP, provided that all of the following conditions are met:

1. Runoff from both the bypass area and the Flow Control BMP converges within a quarter-mile downstream of the project site discharge location.
2. The Flow Control BMP is designed to compensate for the uncontrolled bypass area such that the net effect at the point of convergence downstream is the same with or without bypass.
3. The 100-year peak discharge from the bypass area will not exceed 0.4 cfs.
4. Runoff from the bypass area will not create a significant adverse impact to downstream drainage systems or properties.
5. Runoff Treatment requirements applicable to the bypass area are met.

Inflow From Areas that Don't Require Flow Control

This guidance applies to Flow Control BMPs that are receiving flow from areas 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. In previous versions of the SWMMWW, this was referred to as "off-site inflow", however, 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 hard surfaces), but the proposed Flow Control BMP is placed such that flow from the new AND replaced hard surfaces is directed to it. The flow from the replaced hard surfaces would be considered additional flow to the Flow Control BMP.

Runoff from these additional areas must be modeled using the acreages associated with the existing land use areas. For the purposes of modeling in an Ecology approved continuous simulation model, these additional areas 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 flow rate from the additional area is **greater** than 50% of the 100-year developed peak flow rate (undetained) from the area requiring mitigation, then the runoff from the additional area must not flow to the Flow Control BMP. The bypass of the additional area must be designed to achieve both of the following:

1. Any existing contribution of flows to an on-site wetland must be maintained.
2. Flows from the additional areas that are naturally attenuated by the project site under pre-developed conditions must remain attenuated, either by natural means or by providing additional on-site Flow Control BMP(s) so that peak flows do not increase.

III-2.5 Closed Depression Analysis

The analysis of closed depressions requires careful assessment of the existing hydrologic performance in order to evaluate the impacts a proposed project will have. The applicable requirements (see I-3.3 Applicability of the Minimum Requirements) and the local government's Sensitive Areas Ordinance and Rules (if applicable) should be thoroughly reviewed prior to proceeding with the analysis.

Closed depressions generally facilitate infiltration of runoff. If a closed depression is classified as a wetland, then I-3.4.8 MR8: Wetlands Protection may apply. Review I-3.3 Applicability of the Minimum Requirements to determine which Minimum Requirements apply to the site.

An Ecology approved continuous simulation hydrologic model must be used for closed depression analysis and design of mitigation facilities. If a closed depression is not classified as a wetland, model the ponding area at the bottom of the closed depression as an infiltration pond using an approved continuous simulation hydrologic model.

III-2.6 Sizing Your Runoff Treatment BMPs

Size Runoff Treatment BMPs for the entire area that drains to them, even if some of those areas are not pollution-generating.

Runoff Treatment BMPs are sized by using either a volume (the Water Quality Design Volume) or a flow rate (the Water Quality Design Flow Rate), depending on the Runoff Treatment BMP selected. Refer to the selected Runoff Treatment BMP to determine whether the BMP is sized based on a volume or a flow rate. See below for details about the Water Quality Design Volume and the Water Quality Design Flow Rate used to size Runoff Treatment BMPs.

Water Quality Design Volume

The Water Quality Design Volume may be calculated by either of the following methods:

- *Continuous Simulation Method:* Using an approved continuous runoff model, the Water Quality Design Volume shall be the simulated daily volume that represents the upper limit of the range of daily volumes that accounts for 91% of the entire runoff volume over a multi-decade period of record.
- *Single Event Hydrograph Method:* The Water Quality Design Volume shall be the volume of runoff predicted by the Natural Resource Conservation Service (NRCS) curve number

equations in III-2.3 Single Event Hydrograph Method. The precipitation depth used in the equations shall be as predicted from a 24-hour storm with a 6-month return frequency (a.k.a., 6-month, 24-hour storm). Unless amended to reflect local precipitation statistics, the 6-month, 24-hour precipitation amount may be assumed to be 72 percent of the 2-year, 24-hour amount. Precipitation estimates of the 6-month and 2-year, 24-hour storms for certain towns and cities are listed in Appendix III-C: Rainfall Amounts and Statistics. For other areas, interpolating between isopluvials for the 2-year, 24-hour precipitation and multiplying by 72% yields the appropriate storm size. Isopluvials for 2-year, 24-hour amounts for Western Washington are reprinted in Appendix III-B: Isopluvial Maps for Design Storms.

Water Quality Design Flow Rate

The Water Quality Design Flow Rate is dependent on the location of the Runoff Treatment BMP relative to Detention BMP(s):

- *Upstream of Detention BMPs or when there are no Detention BMPs:* The Water Quality Design Flow Rate shall be the flow rate at or below which 91% of the total runoff volume, as estimated by an approved continuous runoff model, will be treated.

  Ecology has assigned design criteria for Runoff Treatment BMPs to achieve the BMP's Runoff Treatment Performance Goal (e.g., Basic Treatment Performance Goal, Enhanced Treatment Performance Goal, etc.) at the Water Quality Design Flow Rate. At a minimum, 91% of the total runoff volume, as estimated by an approved continuous runoff model, must pass through Runoff Treatment BMP(s) at or below the approved hydraulic loading rate for the BMP(s).

- *Downstream of Detention BMPs:* The Water Quality Design Flow Rate shall be the full 2-year release rate from the Detention BMP.

The text in this box originates from one or more of the following Permits:
Appendix 1 of the Phase I / Phase II Municipal Stormwater Permits
Construction Stormwater General Permit

The Water Quality Design Storm Volume and Water Quality Design Flow Rate are intended to capture and effectively treat about 90-95% of the annual runoff volume in western Washington.

Water Quality Design Flow Rate for On-Line and Off-Line Runoff Treatment BMPs

Approved continuous runoff models will calculate both an "on-line" and "off-line" Water Quality Design Flow Rate.

Off-Line Runoff Treatment BMPs

Off-line Runoff Treatment BMPs make use of a flow splitter directly upstream of the Runoff Treatment BMP to regulate the amount of flow entering the Runoff Treatment BMP. Design the flow splitter to direct flows up to and including the "off-line" Water Quality Design Flow Rate (as determined by an approved continuous runoff model) to the Runoff Treatment BMP. The Runoff Treatment BMP must be sized to treat the "off-line" Water Quality Design Flow Rate, per the individual BMP's design guidance.

If the off-line Runoff Treatment BMP is preceded by an equalization basin (that is, a basin that helps attenuate flow fluctuations to the BMP), Ecology will allow the designer to identify a lower "off-line" Water Quality Design Flow Rate. If you choose this option, you must provide a hydraulic analysis with your design documentation showing that the "off-line" Water Quality Design Flow Rate you identify will provide treatment for 91% of the runoff volume, as estimated by an approved continuous runoff model.

Ecology allows off-line designs in which the flow splitter directs flows higher than the "off-line" Water Quality Design Flow Rate to the Runoff Treatment BMP. Ecology assumes that these designs will act similarly to an "on-line" Runoff Treatment BMP, where flows higher than the "off-line" Water Quality Design Flow Rate will not achieve the full performance goal, but will achieve some level of pollutant removal. If you choose this design option, you must document that the higher flows will not damage the BMP, and you may need to consider an increased maintenance frequency to accommodate the increase in pollutant accumulation within the BMP.

On-Line Runoff Treatment BMPs

On-line Runoff Treatment BMPs do not make use of a flow splitter, and receive all of the stormwater runoff from the contributing basin. On-line Runoff Treatment BMPs must be designed using the "on-line" Water Quality Design Flow Rate (as determined by an approved continuous runoff model). On-line Runoff Treatment BMPs treat flows up to the "on-line" Water Quality Design Flow Rate to meet the performance goal, and flows higher than the "on-line" Water Quality Design Flow Rate pass through the BMP at a lower percent removal. Ecology does not give Runoff Treatment credit for the higher flows that pass through the BMP at a lower percent removal.

When designing on-line Runoff Treatment BMPs, you must ensure that the higher flows will not damage the BMPs. If higher flows will damage the proposed Runoff Treatment BMP, you should consider attenuating the flows to the BMP or using an off-line Runoff Treatment BMP.

Minimum Runoff Treatment BMP Size

The I-3.4.6 MR6: Runoff Treatment requirement is to treat at least 91% of the post-development runoff, as predicted by an approved continuous runoff model. If a BMP sized to meet I-3.4.5 MR5: On-Site Stormwater Management also qualifies as a Runoff Treatment BMP (i.e., bioretention, permeable pavement with a sand sublayer or native soils that meet the soil suitability requirement), the total amount of runoff that passes through the BMP sized to meet I-3.4.5 MR5: On-Site Stormwater Management counts towards meeting the 91% I-3.4.6 MR6: Runoff Treatment requirement.

When BMPs that are sized to meet I-3.4.5 MR5: On-Site Stormwater Management (that provide Runoff Treatment) do not quite achieve the 91% I-3.4.6 MR6: Runoff Treatment requirement, they can be upsized to meet the requirement (e.g., a larger bioretention BMP, or a deeper gravel subbase below permeable pavement to achieve more infiltration), or an additional Runoff Treatment BMP can be located to treat additional surface runoff. However, Ecology advises against using an additional Runoff Treatment BMP that is very small.

For volume-based Runoff Treatment BMPs, the minimum recommended size is 0.0093 ac-ft. For flow-rate based Runoff Treatment BMPs, the minimum recommended design flow rate is 0.0081 cubic feet per second (cfs). Rather than construct a Runoff Treatment BMP for a volume or flow rate below these minima, Ecology recommends expanding the size of the BMP sized to meet I-3.4.5 MR5: On-Site Stormwater Management. A second option is to build the Runoff Treatment BMP using the minimum volume or flow rate cited above.

III-3 Stormwater Site Plans

III-3.1 Introduction to Stormwater Site Plans

The Stormwater Site Plan is the comprehensive report containing all of the technical information and analysis necessary for regulatory agencies to evaluate a proposed new development or redevelopment project for compliance with stormwater requirements. Contents of the Stormwater Site Plan will vary with the type and size of the project, and individual site characteristics.

The scope of the Stormwater Site Plan also varies depending on the applicability of Minimum Requirements (see I-3.3 Applicability of the Minimum Requirements).

State law requires that engineering work be performed by or under the direction of a professional engineer licensed to practice in Washington State. Stormwater Site Plans involving construction of Runoff Treatment BMPs, Flow Control BMPs, structural Source Control BMPs, or drainage conveyance systems generally involve engineering principles and should be prepared by or under the direction of a licensed engineer in the state of Washington. Construction Stormwater Pollution Prevention Plans (Construction SWPPPs) that involve engineering calculations must also be prepared by or under the direction of a licensed engineer in the state of Washington.

III-3.2 Preparing a Stormwater Site Plan

The goal of this section is to provide a framework for uniformity in Stormwater Site Plan preparation. Such uniformity will promote predictability throughout the region and help secure prompt governmental review and approval. Properly drafted Stormwater Site Plans will also facilitate the operation and maintenance of the proposed stormwater system long after its review and approval.

The steps involved in developing a Stormwater Site Plan are listed below.

1. Step 1 – Analyze Existing Site Conditions to Determine LID Feasibility
2. Step 2 – Prepare the Preliminary Development Layout
3. Step 3 – Perform an Off-Site Analysis
4. Step 4 – Determine and Read the Applicable Minimum Requirements
5. Step 5 – Prepare a Permanent Stormwater Control Plan
6. Step 6 – Prepare a Construction Stormwater Pollution Prevention Plan
7. Step 7 – Complete the Stormwater Site Plan
8. Step 8 – Check Compliance with All Applicable Minimum Requirements

The level of detail needed for each step depends upon the project size as explained in the individual steps. A narrative description of each of these steps follows.

Step 1 – Analyze Existing Site Conditions to Determine LID Feasibility

Existing site analysis results shall be submitted as a narrative and site map as part of the Existing Conditions Summary within the Stormwater Site Plan submittal (see Step 7 – Complete the Stormwater Site Plan). Part of the information in this step should be used to help prepare the Construction Stormwater Pollution Prevention Plan (see Step 6 – Prepare a Construction Stormwater Pollution Prevention Plan). The authorized project reviewer for the local government with jurisdiction may choose to waive certain components of the existing site analysis as appropriate.

Purpose of the existing site analysis: The existing site analysis is intended to determine the pre-development conditions on the site in addition to determining the appropriateness for use of Low Impact Development (LID) techniques. Site conditions as identified in this step will determine the feasibility of the overall stormwater design including use of LID techniques. The development context shall be established by an existing site analysis consistent with the requirements detailed in this Step.

The initial inventory and analysis process will provide baseline information necessary to design strategies that utilize areas most appropriate to evaporate, transpire, and infiltrate stormwater, and achieve the goal of mimicking the pre-development natural hydrologic conditions on the site.

The existing site analysis shall include, at a minimum, the following information:

1. A survey prepared by a registered land surveyor, civil engineer, or other qualified professional showing:

    - Existing public and private development, including utility infrastructure on and adjacent to the site if publicly available,
    - Minor hydrologic features, including seeps, springs, closed depression areas, drainage swales.
    - Major hydrologic features with a stream, wetland, and water body survey and classification report showing wetland and buffer boundaries consistent with the requirements of the jurisdiction.

      Note that site visits should be conducted during winter months and after significant precipitation events to identify undocumented surface seeps or other indicators of near surface ground water.
    - Flood hazard areas on or adjacent to the site, if present.
    - Geologic Hazard areas and associated buffer requirements as defined by the local jurisdiction
    - Aquifer and wellhead protection areas on or adjacent to the site, if present.
    - Topographic features that may act as natural stormwater storage, infiltration or conveyance.

      Contours for the survey are as follows:

- Up to 10 percent slopes, two-foot contours.
- Over 10 percent to less than 20 percent slopes, five-foot contours.
- Twenty percent or greater slopes, 10-foot contours.
- Elevations shall be at 25-foot intervals.

2. A soils report prepared by a professional soil scientist certified by the Soil Science Society of America (or an equivalent national program), or by other suitably trained persons working under the supervision of a professional engineer, geologist, hydrogeologist, or engineering geologist registered in the State of Washington.

   If the Project is required to meet Minimum Requirements 1-5 only, this report may be prepared by a locally licensed on-site sewage designer.

   The report shall identify:

   a. Underlying soils on the site utilizing soil surveys, soil test pits, soil borings, or soil grain analyses (see http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm for soil survey information).

      If the Project is required to meet Minimum Requirements 1-9, the report must also include the following regarding underlying soils:

      - Prepare detailed logs for each test pit or soil boring and a map showing the location of the test pits or borings. Logs must include depth of pit or boring, soil descriptions, depth to water (if present), and presence of stratification. Depth should extend to 5 feet below estimated bottom elevation of proposed bioretention BMPs and road subgrades. Logs must substantiate whether stratification does or does not exist. The licensed professional may consider additional methods of analysis to substantiate the presence of stratification.
      - Soil stratigraphy should be assessed for low permeability layers, highly permeable sand/gravel layers, depth to ground water, and other soil structure variables necessary to assess subsurface flow patterns. Soil characterization for each soil unit (soil strata with the same texture, color, density, compaction, consolidation and permeability) should include:
        - Grain size distribution
        - Textural class
        - Percent clay content
        - Percent organic content
        - Cation exchange capacity
        - Color/mottling
        - Variations and nature of stratification

   b. The results of saturated hydraulic conductivity (K_{sat}) testing or calculation to:

- assess infiltration capability and the feasibility of BMP T5.14: Rain Gardens, BMP T7.30: Bioretention, and BMP T5.15: Permeable Pavements.
- use as input into Ecology-approved continuous simulation models to predict the benefits of infiltration BMPs.

This calculation is not required if other infeasibility criteria such as contaminated soils, high groundwater, nearby steep slopes, etc. preclude the use of infiltration BMPs.

Refer to V-5.4 Determining the Design Infiltration Rate of the Native Soils for additional guidance about determining K_{sat}.

Placement of K_{sat} tests should be carefully considered to reduce cost. A few strategically placed soil test pits and saturated hydraulic conductivity test sites are generally adequate for initial site assessment and for smaller sites (e.g., less than an acre). On larger project sites, a more detailed soil assessment and additional K_{sat} testing may be necessary to direct placement of impervious surfaces such as structures away from soils that can most effectively infiltrate stormwater, and placement of permeable pavement roads, parking lots, driveways, walks, and bioretention/rain gardens over those soils.

c. The results of testing for an hydraulic restriction layer (ground water, soil layer with less than 0.3 in/hr K_{sat}, bedrock, etc) under possible sites for a rain garden, bioretention facility, or permeable pavement. This analysis should be performed during the wet season prior to construction. The optimum time to test for depth to ground water is usually late winter and shortly after an extended wet period. Site historical data regarding ground water levels can be used in lieu of field testing if the data are reliable and sufficient. Also, soil evidence of historical ground water elevations may be used.

If the Project is required to meet Minimum Requirements 1-5 only, refer to the following additional guidance:

- Testing with a monitoring well or an excavated pit must extend to a depth at least 1 foot below the estimated bottom elevation of a rain garden/bioretention excavation and at least 1 foot below the subgrade surface of a permeable pavement. The horizontal locations of all monitoring wells and excavated pits shall be shown on the stormwater site plans.

If the Project is required to meet Minimum Requirements 1-9, refer to the following additional guidance:

- If the general site assessment cannot confirm that the seasonal high ground water or hydraulic restricting layer will be greater than 3 feet below the bottom of BMP T7.30: Bioretention, or greater than 1 foot below the bottom of the lowest gravel base course of BMP T5.15: Permeable Pavements, or greater than 5 feet below BMP T7.10: Infiltration Basins, monitoring wells or excavated pits should be placed strategically to assess depth to ground water.
- Monitoring with a continuously logging censor between Dec. 1 and Apr. 1 provides the most thorough information. Monitoring for lesser time periods can be accepted, but increases risk that you will not have valid information.

- Special considerations are necessary for highly permeable gravel areas (e.g. > 4 inches per hour). Signs of high ground water will likely not be present in gravelly soils lacking finer grain material such as sand and silt. Test pit and monitoring wells may not show high ground water levels during low precipitation years. Accordingly, sound professional judgment, considering these factors and water quality treatment needs, is required to design multiple and dispersed infiltration facilities on sites with gravel deposits.

d. *For projects required to meet Minimum Requirements 1-9:*

   If on-site infiltration may result in shallow lateral flow (interflow), the conveyance and possible locations where that interflow may re-emerge should be assessed by a professional engineer, geologist, hydrogeologist, or engineering geologist registered in the State of Washington. This will likely require placement of ground water monitoring wells to determine existing ground water gradients and flow. In general, a minimum of three wells associated with three hydraulically connected surface or ground water features, are needed to determine the direction of flow and gradient.

3. If there are native soil and vegetation protection areas proposed for the site, provide a survey of existing native vegetation cover by a licensed landscape architect, arborist, or qualified biologist identifying any forest areas on the site and a plan to protect those areas. The preserved area should be placed in a separate tract or protected through recorded easements for individual lots.

   If the Project is required to meet Minimum Requirements 1-5 only, this survey may be prepared by the project proponent.

Step 2 – Prepare the Preliminary Development Layout

Based upon the existing site analysis results, locate the buildings, roads, parking lots, landscaping features, LID BMPs, and preliminary location of Runoff Treatment and Flow Control BMPs for the proposed development. Consider the following points when laying out the site:

- Fit development to the terrain to minimize land disturbance; confine construction activities to the least area necessary, and away from critical areas.
- Preserve areas with natural vegetation (especially forested areas) as much as possible.
- On sites with a mix of soil types, locate impervious areas over less permeable soil (e.g., till), try to restrict development over more porous soils or take advantage of them by locating bioretention, rain gardens and/or permeable pavement over them.
- Cluster buildings together.
- Minimize impervious areas.
- Maintain and utilize the natural drainage patterns.

The development layout designed here will be used for determining Threshold Discharge Areas (TDAs), for calculating whether size and flow rate thresholds under Minimum Requirements #6, #7, and #8 are exceeded (see I-3 Minimum Requirements for New Development and Redevelopment), and for the drawings and maps required for the Stormwater Site Plan.

See Chapters 2 and 3 in the *LID Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012) for more detail on Preliminary Development Layout. Note that the *LID Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012) is for additional informational purposes only. You must follow the guidance within this manual if there are any discrepancies between this manual and the *LID Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012).

Step 3 – Perform an Off-Site Analysis

Ecology recommends that local governments require an off-site analysis for projects that add 5,000 square feet or more of new hard surface, or that convert ¾ acres of vegetation to lawn or landscaped areas, or convert 2.5 acres of forested area to pasture.

The phased off-site analysis approach outlined in I-3.5.3 APM2: Off-Site Analysis Report is recommended. This phased approach relies first on a qualitative analysis. If the qualitative analysis indicates a potential problem, the local government may require mitigation or a quantitative analysis. For more information, see I-3.5.3 APM2: Off-Site Analysis Report.

Step 4 – Determine and Read the Applicable Minimum Requirements

I-3.3 Applicability of the Minimum Requirements establishes project thresholds for the application of Minimum Requirements to new development and redevelopment projects. Figure I-3.1: Flow Chart for Determining Requirements for New Development and Figure I-3.2: Flow Chart for Determining Requirements for Redevelopment provide the same thresholds in a flow chart format. Based on the preliminary layout, determine whether Minimum Requirements #1 and #2 only apply to the project, or #1 through #5 only apply to the project, or #1 through #9 apply.

Step 5 – Prepare a Permanent Stormwater Control Plan

Select LID BMPs (all projects), and Runoff Treatment and Flow Control BMPs (projects subject to Minimum Requirements #1 through #9) that will serve the project site in its developed condition. The selection process for Runoff Treatment and Flow Control BMPs is presented in detail in III-1 Choosing Your BMPs.

A preliminary design of the LID, Runoff Treatment, and Flow Control BMPs is necessary to determine how they will fit within and serve the preliminary development layout. After a preliminary design is developed, the designer may want to reconsider the site layout to reduce the need for construction of BMPs, or the size of the BMPs by reducing the amount of hard - especially impervious - surfaces created, and increasing the areas to be left undisturbed. After the designer is satisfied with the BMP selections, the information must be presented within a Permanent Stormwater Control Plan. The Permanent Stormwater Control Plan should contain the following sections:

1. Existing Site Hydrology

   If Flow Control BMPs are proposed to comply with I-3.4.7 MR7: Flow Control, provide a listing of assumptions and site parameters used in analyzing the pre-developed site hydrology. The acreage, soil types, and land covers used to determine the pre-developed flow characteristics, along with basin maps, graphics, and exhibits for each subbasin affected by the project should be included. See the Flow Control Performance Standard within I-3.4.7 MR7: Flow Control for guidance on the pre-developed condition to be matched.

Provide a topographic map, of sufficient scale and contour intervals to determine basin boundaries accurately, showing:

- Delineation and acreage of areas contributing runoff to the site;
- Flow Control BMP location;
- Outfall;
- Overflow route; and
- All natural streams and drainage features.

The direction of flow, acreage of areas contributing drainage, and the limits of development should be indicated. Each basin within or flowing through the site should be named and model input parameters referenced.

2. Developed Site Hydrology

Reporting totals of new hard surfaces, replaced hard surfaces, and converted pervious surfaces are necessary to determine which Minimum Requirements apply to the project.

If the Project is required to meet Minimum Requirements 1-5 only, provide the following:

a. *Low Impact Development Features*

   - Provide a written summary of the proposed project and how it complies with the applicable stormwater management requirements.
   - Provide a description of the total area of Native Vegetation retained.
   - Provide a description of areas of disturbed soils to be amended. (NOTE: All lawn and landscaped areas are to meet BMP T5.13: Post-Construction Soil Quality and Depth. Use of compost is one way to meet the requirement).
   - Provide a scale drawing of the lot or lots, and any public-right-of-way that displays the location of LID BMPs (and Flow Control BMPs if using the LID Performance Standard to meet I-3.4.5 MR5: On-Site Stormwater Management) and the areas served by them. These documents must be suitable to serve as a recordable document that can be attached to a declaration of covenant and grant of easement or other legal agreement or recordable document, associated with each lot that includes LID and/or Flow Control BMPs.
   - Provide design details, figures, and maintenance instructions for each LID BMP (and Flow Control BMP if using the LID Performance Standard to meet I-3.4.5 MR5: On-Site Stormwater Management). These documents must also be suitable to serve as a recordable document that can be attached to a declaration of covenant and grant of easement or other legal agreement or recordable

document, associated with each lot.

- If using the List Approach to comply with I-3.4.5 MR5: On-Site Stormwater Management, provide written justification, including citation of site conditions identified in a soils report, for any LID BMPs that are determined to be “infeasible” for the project site. If the designer determines that the project is infeasible for on-site conditions that don’t involve the site soils, the proponent must site valid information for the determination, but doesn’t have to submit a soils report.
- If the applicant elects or must use the LID Performance Standard option to meet I-3.4.5 MR5: On-Site Stormwater Management, they shall provide design details of all Flow Control BMPs that are used to help achieve the standard, and a complete computer model report including input files and output files. Projects taking an impervious surface reduction credit for newly planted or retained trees per BMP T5.16: Tree Retention and Tree Planting must provide those calculations and documentation on site plans for the locations of the trees. Projects using BMP T5.30: Full Dispersion or BMP T5.10A: Downspout Full Infiltration must provide information to confirm conformance with design requirements that allow removal of the associated drainage areas from computer model input.
- Provide a summary of proposed public or private ownership of LID BMPs (and Flow Control BMP if using the LID Performance Standard to meet I-3.4.5 MR5: On-Site Stormwater Management) and areas serving a stormwater function within the project site both during and after construction.

If the Project is required to meet Minimum Requirements 1-9, provide the following:

a. *Summary Section*

By Threshold Discharge Area (TDA), provide totals of new pollution-generating hard surfaces, replaced pollution-generating hard surfaces (where the replaced hard surfaces have been determined to be subject to requirements per I-3.3 Applicability of the Minimum Requirements), effective impervious surfaces, and converted vegetated areas to determine whether Runoff Treatment and/or Flow Control BMPs are necessary to comply with I-3.4.6 MR6: Runoff Treatment and I-3.4.7 MR7: Flow Control. See I-3.4.6 MR6: Runoff Treatment, I-3.4.7 MR7: Flow Control, and III-1 Choosing Your BMPs for more specific directions concerning Runoff Treatment and Flow Control requirements, and selection of Runoff Treatment and Flow Control BMPs. For those TDAs that do not trigger Minimum Requirements #6, #7, or #8, follow the directions above for Projects that apply Minimum Requirements #1 through #5 only. Otherwise, provide narrative, mathematical, and graphic presentations of computer model input parameters selected for each TDA of the developed site condition, including acreage, soil types, and land covers, road layout, and all drainage facilities.

Developed TDAs and flow routing should be shown on a map and cross-referenced to computer input screens and printouts or calculation sheets.

Any documents used to determine the developed site hydrology should be included. Whenever possible, maintain the same basin name as used for the pre-developed site hydrology. If the boundaries of a basin have been modified by the project, that should be clearly shown on a map and the name modified to indicate the change.

Final grade topographic maps shall be provided. Ecology recommends local governments also require finished floor elevations.

b. *Performance Standards and Goals*

- If Runoff Treatment BMPs are proposed, describe the Performance Goal required for the site. See III-1.2 Choosing Your Runoff Treatment BMPs.
- If Flow Control BMPs are proposed, provide a confirmation of the flow control standard being achieved (e.g., the Flow Control Performance Standard). Indicate whether the design is using the List Approach or the LID Performance Standard option for Minimum Requirement #5.

c. *Low Impact Development Features*

Provide the information detailed above in Low Impact Development Features.

d. *Flow Control System*

Provide a drawing of all proposed Flow Control BMPs and their appurtenances. This drawing must be accompanied by basic measurements necessary to calculate the storage volumes available from zero to the maximum head, all orifice/restrictor sizes and head relationships, control structure/restrictor placement, and placement on the site. Provide sufficient details on the drawings to show how the BMP conforms with design criteria per V-12 Detention BMPs or V-5 Infiltration BMPs. If distributed bioretention BMPs and/or storage below permeable pavement are used to help meet the LID Performance Standard option of Minimum Requirement #5, and/or the Flow Control Performance Standard of Minimum Requirement #7, drawings are necessary to confirm accurate representation in the runoff model. Identify locations and approximate size of all permeable pavement surfaces and bioretention BMPs to be installed as part of this project, including those that will be installed on individual lots by subsequent contractors. Identify locations and species types for newly planted or retained trees for which impervious surface reduction credits are claimed, per BMP T5.16: Tree Retention and Tree Planting. Supporting areas such as the flow paths for dispersion BMPs should also be shown.

Include computer printouts, calculations, equations, references, storage/volume tables, graphs as necessary to show results and methodology used to determine the storage facility volumes. All documentation input and output files from Ecology approved continuous simulation models must be included.

e. *Runoff Treatment System*

Provide a drawing of the proposed Runoff Treatment BMPs, and any structural Source Control BMPs. The drawing must show overall measurements and dimensions, placement on the site, location of inflow, bypass, and discharge systems. If distributed bioretention BMPs and/or infiltration below pollution-generating hard surfaces are used to help meet Runoff Treatment requirements, drawings are necessary to confirm accurate representation in the runoff model. Identify locations and approximate dimensions of those BMPs to be installed as part of the project, including those that will be installed on individual lots by subsequent contractors.

Include Ecology approved modeling printouts, calculations, equations, references, and graphs as necessary to show the BMPs are designed consistent with the BMP requirements and design criteria. If bioretention and/or infiltration through adequate soils (see V-5.6 Site Suitability Criteria (SSC)) below pollution-generating hard surfaces will be used to help meet Runoff Treatment requirements, the runoff model output files must include the volume of water that has been treated through those BMPs. The summation of those volumes and the volume treated through a centralized, conventional treatment system must meet or exceed 91% of the total stormwater runoff file. The total stormwater runoff file includes:

- Stormwater that has infiltrated through a bioretention BMP and stormwater that has infiltrated through adequate soils below pollution-generating hard surfaces.
- Stormwater that passes through a properly sized Runoff Treatment BMP. Note that stormwater that is re-collected below a bioretention BMP and routed to a centralized Runoff Treatment BMP may not be counted twice.
- Stormwater that does not receive treatment due to bypass of, or overflow from a Runoff Treatment BMP (if the overflow is not subsequently routed to a Runoff Treatment BMP).

f. *Source Control*

For commercial, industrial, and multifamily projects, I-3.4.4 MR4: Preservation of Natural Drainage Systems and Outfalls requires the inclusion of Source Control BMPs. Provide a listing of the applicable operational and structural Source Control BMPs that apply to the project. Identify where the structural Source Control BMPs are constructed and provide information to ensure they will be installed correctly.

g. *Conveyance System Analysis and Design*

Present an analysis of any existing conveyance systems, and the analysis and design of the proposed drainage system for the project. At a minimum, present an analysis of on-site hydrologic connectivity of surficial conveyance channels and/or pipes, and points of concentration. If the local government requires an off-site analysis, include the results of that analysis here. This information should be presented in a clear, concise manner that can be easily followed, checked, and verified. All pipes, culverts, catch basins, channels, swales, and other stormwater conveyance appurtenances must be clearly labeled and correspond directly to the engineering plans.

Step 6 – Prepare a Construction Stormwater Pollution Prevention Plan

The Construction SWPPP for projects adding or replacing 2,000 square feet of hard surface or more, or clearing 7,000 square feet or more, must contain sufficient information to satisfy the local government Plan Approval Authority that the potential pollution problems have been adequately addressed for the proposed project. Local governments may adopt a standard SWPPP format for use by projects less than 1 acre. An adequate Construction SWPPP includes a narrative and drawings. The narrative is a written statement to explain and justify the pollution prevention decisions made for a particular project. The narrative contains concise information concerning existing site conditions, construction schedules, and other pertinent items that are not contained on the drawings. The drawings and notes describe where and when the various BMPs should be installed, the performance the BMPs are expected to achieve, and actions to be taken if the performance goals are not achieved.

See II-2.4 Preparing Construction SWPPPs for details about what to include in the project's Construction SWPPP.

Step 7 – Complete the Stormwater Site Plan

The Stormwater Site Plan encompasses the entire submittal to the local government agency with drainage review authority. It includes the following documents:

a. **Project Overview**

   The project overview must provide a general description of the project, pre-developed and developed conditions of the site, site area and size of the improvements, and the pre- and post-developed stormwater runoff conditions. The overview should summarize difficult site parameters, the natural drainage system, and drainage to and from adjacent properties, including bypass flows.

   A vicinity map should clearly locate the property, identify all roads bordering the site, show the route of stormwater off-site to the local natural receiving water, and show significant geographic features and sensitive/critical areas (streams, wetlands, lakes, steep slopes, etc.).

   A site map, using a minimum USGS 1:2400 topographic map as a base, should display:

   - Acreage and outlines of all drainage basins;
   - Existing stormwater drainage to and from the site;
   - Routes of existing, construction, and future flows at all discharge points; and
   - The length of travel from the farthest upstream end of a proposed drainage system to any proposed Flow Control or Runoff Treatment BMP.

   A soils map should show the soils within the project site as verified by field testing. It is the designer’s responsibility to ensure that the soil types of the site are properly identified and correctly used in the hydrologic analysis.

b. **Existing Conditions Summary**

   This is the summary described in Step 1 – Analyze Existing Site Conditions to Determine LID Feasibility (above). If the local government does not require a detailed off-site analysis, this summary should also describe:

   - The natural receiving waters that the stormwater runoff either directly or eventually (after flowing through the downstream conveyance system) discharges to, and

- Any area-specific requirements established in local plans, ordinances, or regulations or in Water Clean-up Plans approved by Ecology.

c. **Off-Site Analysis Report**

This is the report described under Step 3 – Perform an Off-Site Analysis (above).

d. **Permanent Stormwater Control Plan**

This is the plan described in Step 5 – Prepare a Permanent Stormwater Control Plan (above).

e. **Construction Stormwater Pollution Prevention Plan**

This is the plan described in Step 6 – Prepare a Construction Stormwater Pollution Prevention Plan (above).

f. **Special Reports and Studies**

Include any special reports and studies conducted to prepare the Stormwater Site Plan (e.g., a soils report that could include the results of soil sampling and testing, infiltration tests and/or soil gradation analyses, depth to ground water; wetlands delineation).

g. **Other Permits**

Include a list of other necessary permits and approvals as required by other regulatory agencies, if those permits or approvals include conditions that affect the drainage plan, or contain more restrictive drainage-related requirements.

h. **Operation and Maintenance Manual**

Submit an operations and maintenance manual for each Flow Control and Runoff Treatment BMP used to meet I-3.4.3 MR3: Source Control of Pollution, I-3.4.6 MR6: Runoff Treatment, I-3.4.7 MR7: Flow Control, and/or I-3.4.8 MR8: Wetlands Protection. The manual should contain a description of the BMP, what it does, and how it works. The manual must identify and describe the maintenance tasks, and the frequency of each task. The maintenance tasks and frequencies must meet the standards established in this manual or an equivalent manual adopted by the local government agency with jurisdiction.

Include a recommended format for a maintenance activity log that will indicate what actions will have been taken.

The manual must prominently indicate where it should be kept, and that it must be made available for inspection by the local government. The operation and maintenance manual should be conveyed with the property if the property changes ownership.

i. **Declaration of Covenant for Privately Maintained Flow Control and Runoff Treatment BMPs**

To ensure future maintenance and allow access for inspection by the local government, any Flow Control and Runoff Treatment BMPs for which the applicant identifies operation and maintenance to be the responsibility of a private party must have a declaration of covenant and grant of easement. After approval by the local government, the declaration of covenant and grant of easement, or other legal agreement or recordable document, must be signed and recorded at the appropriate records office of the local government.

j. **Declaration of Covenant for Privately Maintained LID BMPs**

To ensure future maintenance and allow access for inspection by the local government, any LID BMPs for which the applicant identifies operation and maintenance to be the responsibility of a private party must have a declaration of covenant and grant of easement or other legal agreement or recordable document. Design details, figures, and maintenance instructions for each LID BMP shall be attached. A map showing the location of newly planted and retained trees claimed as flow reduction credits per BMP T5.16: Tree Retention and Tree Planting shall also be attached. This applies to every lot within a subdivision on which an LID BMP is proposed. After approval by the local government, the declaration of covenant and grant of easement must be signed and recorded at the appropriate records office of the local government.

k. **Bond Quantities Worksheet**

If the local government adopts a requirement for a performance bond (or other financial guarantee) for proper construction and operation of Construction Stormwater BMPs, and proper construction of permanent Stormwater BMPs, the designer shall provide documentation to establish the appropriate bond amount.

Step 8 – Check Compliance with All Applicable Minimum Requirements

A Stormwater Site Plan as designed and implemented should specifically fulfill all Minimum Requirements applicable to the project. The Stormwater Site Plan should be reviewed to check that these requirements are satisfied.

III-3.3 Changes to a Previously Approved Stormwater Site Plan

This section includes the specifications and contents required of plans submitted after the local government agency with jurisdiction has approved the original Stormwater Site Plan.

If the designer wishes to make changes or revisions to the originally approved Stormwater Site Plan, the proposed revisions shall be submitted to the local government agency with review authority prior to construction. The submittals should include the following:

1. Substitute pages of the originally approved Stormwater Site Plan that include the proposed changes.
2. Revised drawings showing any structural changes.
3. Changes shall be “clouded” and noted in the revision block on the drawing.
4. Any other supporting information that explains and supports the reason for the change.

III-3.4 Final Corrected Plan Submittal

If the project included construction of:

- conveyance systems,
- Runoff Treatment BMPs,
- Flow Control BMPs,
- structural Source Control BMPs,
- BMP T7.30: Bioretention, even if only used to meet the requirements of I-3.4.5 MR5: On-Site Stormwater Management,
- BMP T5.15: Permeable Pavements, even if only used to meet the requirements of I-3.4.5 MR5: On-Site Stormwater Management,
- BMP T5.17: Vegetated Roofs,
- BMP T5.20: Rainwater Harvesting, and/or
- newly planted or retained trees for which a flow reduction credit was taken per BMP T5.16: Tree Retention and Tree Planting,

The applicant shall submit a final corrected plan ("record drawings") to the local government agency with jurisdiction when the project is completed. These should be engineering drawings that accurately represent the stormwater infrastructure of the project as constructed. These corrected drawings must be professionally drafted revisions that are stamped, signed, and dated by a licensed engineer registered in the state of Washington.

Appendix III-A: Basic Treatment Receiving Waters

Table III-A.1: Basic Treatment Receiving Waters

Waterbody Type	Details	
1. All Salt Waterbodies		
2. Rivers (as shown below):		
	River Name	**Basic Treatment Applies Downstream of This Location**
	Baker	Anderson Creek
	Bogachiel	Bear Creek
	Cascade	Marblemount
	Chehalis	Bunker Creek
	Clearwater	Town of Clearwater
	Columbia	Canadian Border
	Cowlitz	Skate Creek
	Elwha	Lake Mills
	Green	Howard Hanson Dam
	Hoh	South Fork Hoh River
	Humptulips	West and East Fork Confluence
	Kalama	Italian Creek
	Lewis	Swift Reservoir
	Muddy	Clear Creek
	Nisqually	Alder Lake
	Nooksack	Glacier Creek
	South Fork Nooksack	Hutchinson Creek
	North River	Raymond
	Puyallup	Carbon River
	Queets	Clearwater River
	Quillayute	Bogachiel River
	Quinalt	Lake Quinalt
	Sauk	Clear Creek

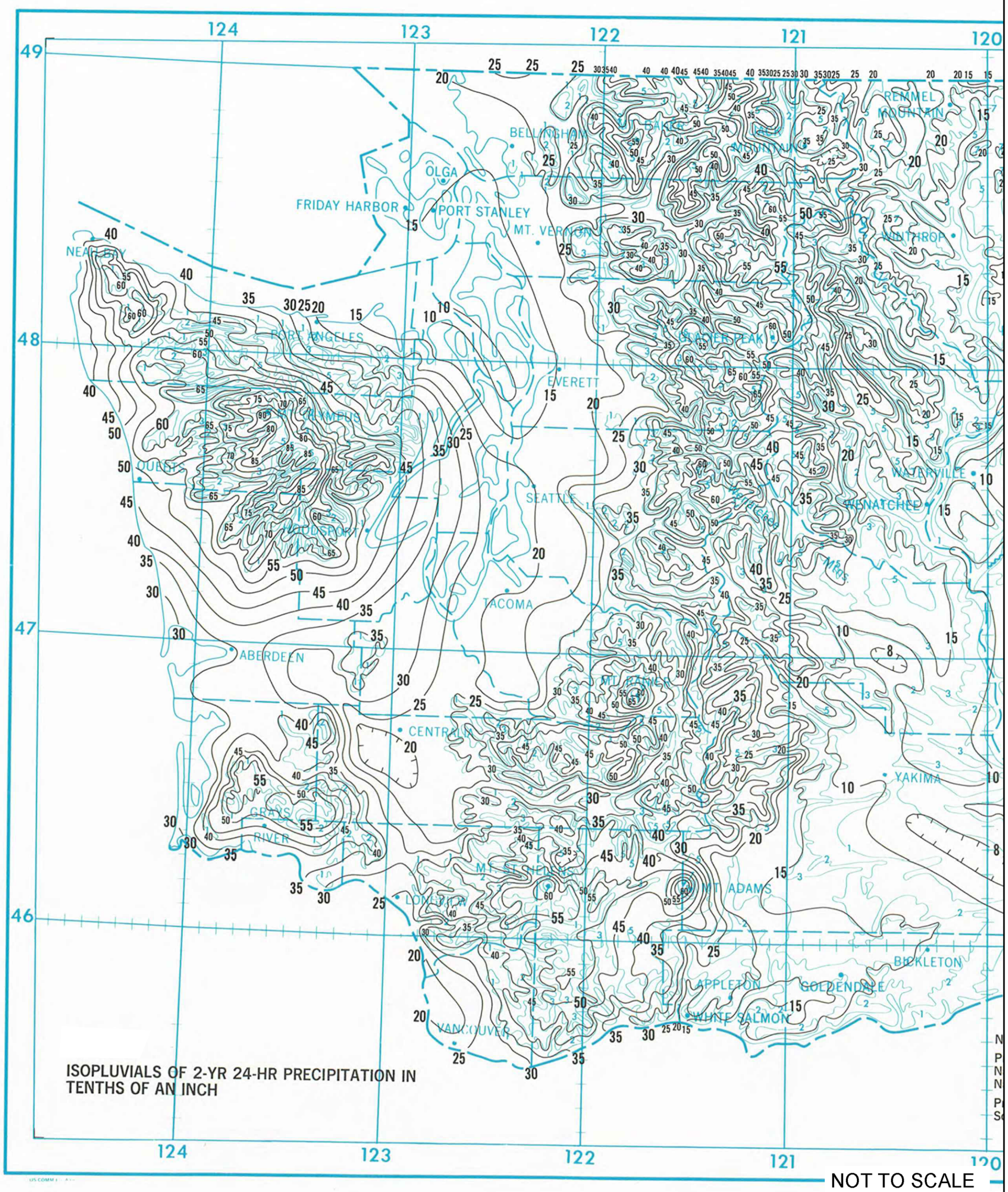
Table III-A.1: Basic Treatment Receiving Waters (continued)

Waterbody Type	Details	
	Satsop	Middle and East Fork Confluence
	Skagit	Cascade River
	Skokomish	Vance Creek
	Skykomish	Beckler River
	Snohomish	Snoqualmie River
	Snoqualmie	Middle and North Fork Con-fluence
	Sol Duc	Beaver Creek
	Stillaguamish	North and South Fork Confluence
	North Fork Stillaguamish	Boulder River
	South Fork Stillaguamish	Canyon Creek
	Suiattle	Darrington
	Tilton	Bear Canyon Creek
	Toutle	North and South Fork Confluence
	North Fork Toutle	Green River
	Washougal	Washougal
	White	Greenwater River
	Wind	Carson
	Wynoochee	Wishkah River Road Bridge
3. Lakes (as shown below):		
	Lake Name	**County**
	Washington	King
	Sammamish	King
	Union	King
	Whatcom	Whatcom
	Silver	Cowlitz
Note: Local governments may petition for the addition of more waters to this list. The initial criteria for this list are rivers whose mean annual flow exceeds 1,000 cfs, and lakes whose surface area exceeds 300 acres. Additional waters do not have to meet these criteria, but should have sufficient background dilution capacity to accommodate dissolved metals additions from build-out conditions in the watershed under the latest Comprehensive Land Use Plan and zoning regulations.		

Appendix III-B: Isopluvial Maps for Design Storms

Included in this appendix are the 2, 10 and 100-year, 24-hour design storm and mean annual precipitation isopluvial maps for western Washington. These have been taken from *NOAA ATLAS 2, Precipitation - Frequency Atlas of the Western United States, Volume IX - Washington* (Miller et al., 1973).

Figure III-B.1: Western Washington Isopluvial 2-year, 24 hour

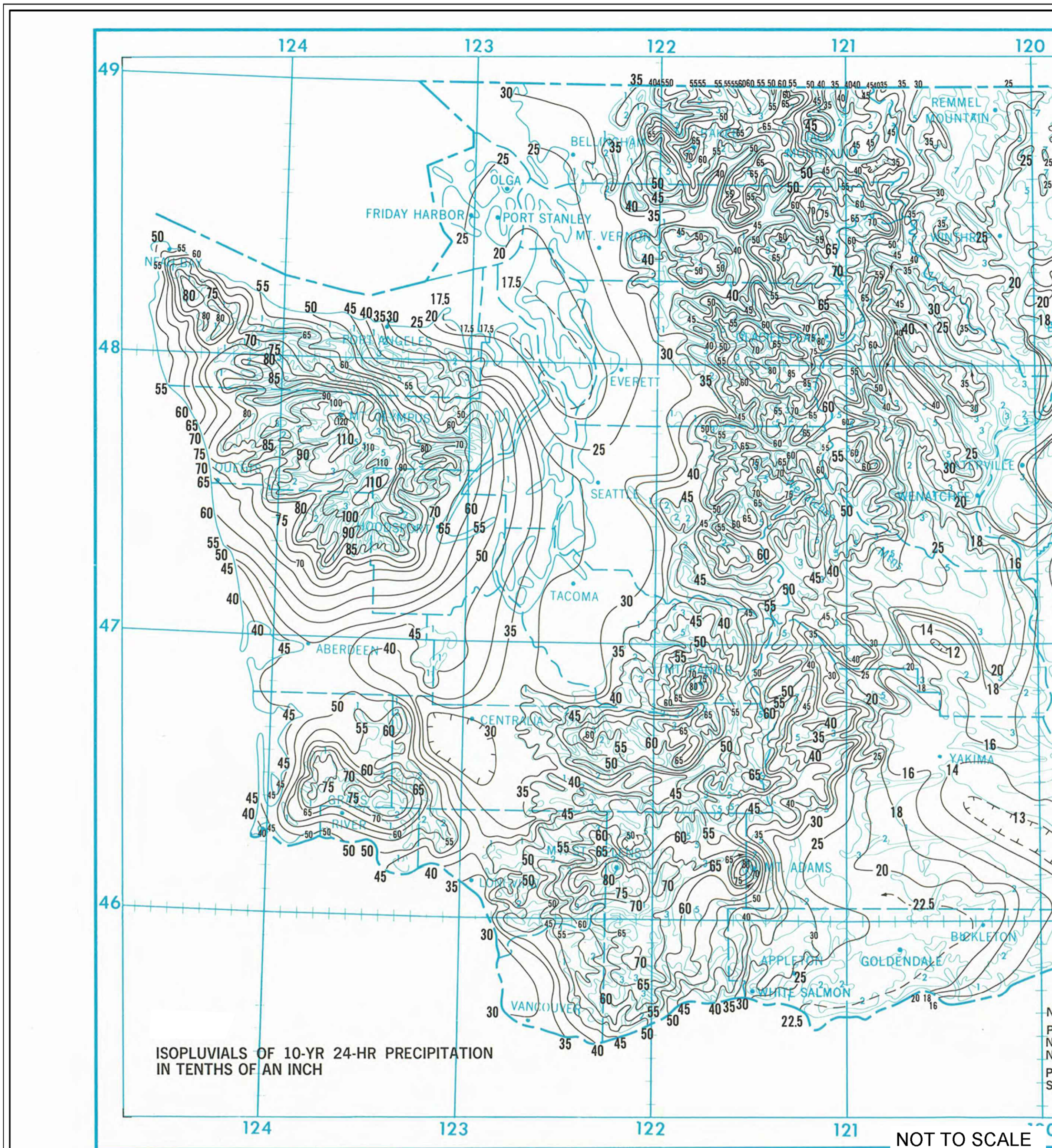


Western Washington Isopluvial 2-year, 24 hour

Revised June 2016

DEPARTMENT OF ECOLOGY
State of Washington

Figure III-B.2: Western Washington Isopluvial 10-year, 24 hour



Western Washington Isopluvial
10-year, 24 hour

Revised June 2016

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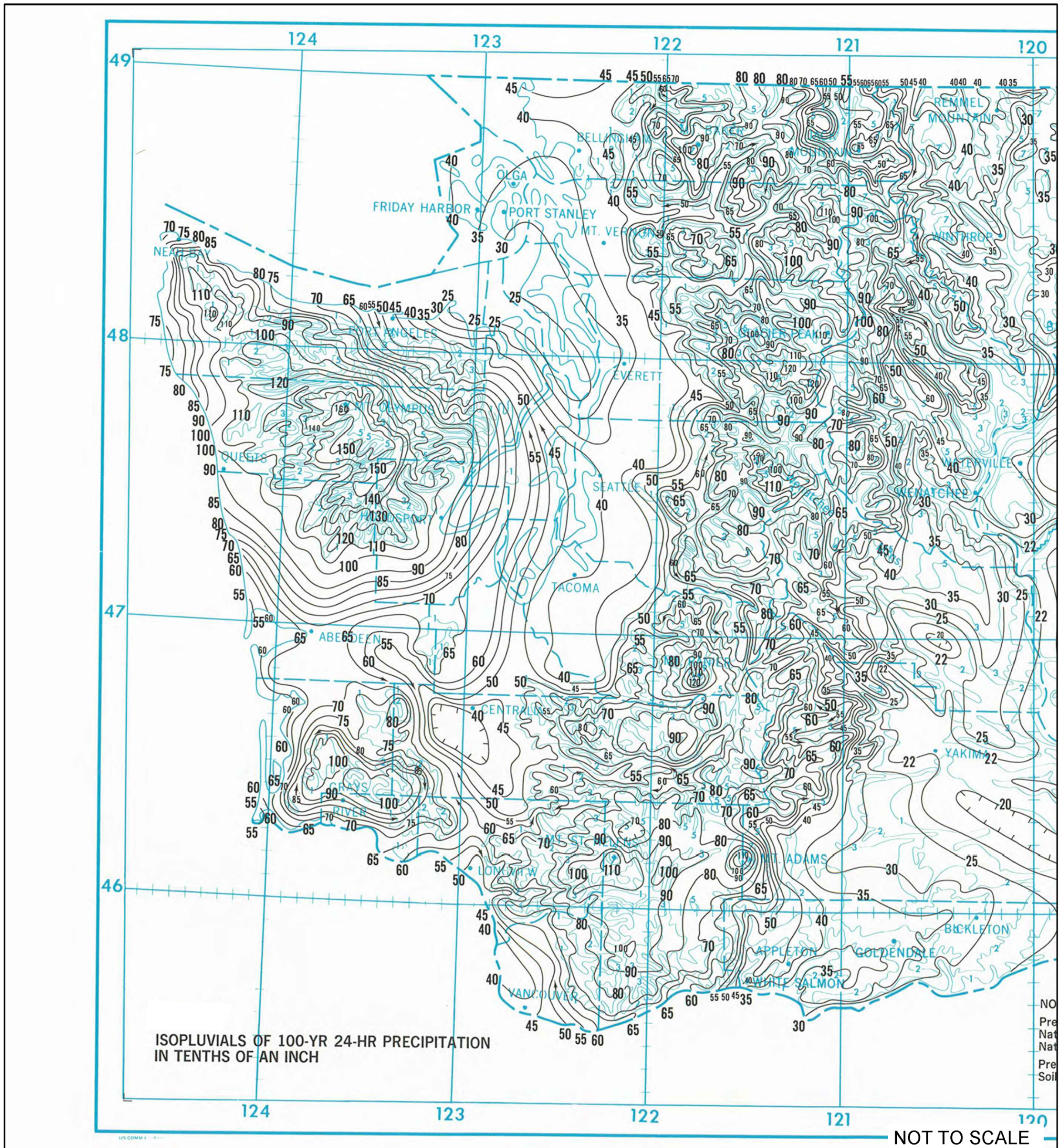
Figure III-B.3: Western Washington Isopluvial 100-year, 24 hour



Western Washington Isopluvial
100-year, 24 hour

Revised June 2016

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State of Washington

Appendix III-C: Rainfall Amounts and Statistics

Table III-C.1: 24-Hour Rainfall Amounts and Comparisons for Selected USGS Stations

Station Name	6 Month Storm Inches	6 Month % Rainfall Volume	2 Year Storm Inches	6 Month/ 2 year %	90% Rainfall Inches	95% Rainfall Inches	Mean Annual Pre-cip. Inches
Aberdeen	2.47	92.58%	3.43	72.0%	2.25	2.81	83.12
Arlington	1.28	93.42%	1.74	73.6%	1.11	1.40	46.46
Bellingham	1.27	90.78%	1.79	70.9%	1.23	1.63	35.82
Bremerton	1.87	90.75%	2.61	71.6%	1.83	2.22	49.97
Cathlamet	2.13	92.52%	3.47	61.4%	1.89	2.59	78.7
Centralia	1.49	91.81%	2.09	71.3%	1.40	1.78	45.94
Chelan	0.62	84.50%	0.96	64.6%	0.76	1.00	10.44
Chimacum	1.20	89.63%	1.73	69.4%	1.22	1.52	29.45
Clearwater	3.46	92.88%	4.75	72.8%	3.04	3.94	125.25
CleElum	1.06	86.85%	1.66	63.9%	1.20	1.64	22.17
Colfax	0.80	90.52%	1.07	74.8%	0.80	0.99	19.78
Colville	0.71	90.46%	0.97	73.2%	0.69	0.86	18.31
Cushman Dam	3.31	91.26%	5.29	62.6%	3.18	4.25	100.82
Cushman PwrH	3.17	90.81%	4.42	71.7%	3.08	4.00	85.71
Darrington	2.90	91.19%	4.01	72.3%	2.73	3.42	82.90
Ellensburg	0.50	84.63%	0.79	63.3%	0.62	0.81	8.75
Elwha RS	2.14	90.49%	2.80	76.4%	2.11	2.53	55.87
Everett	1.10	93.14%	1.46	75.3%	1.00	1.22	36.80
Forks	3.47	92.50%	5.07	68.4%	3.13	4.00	117.83
Goldendale	0.84	86.92%	1.29	65.1%	0.98	1.25	17.57
Hartline	0.61	84.85%	0.96	63.5%	0.77	0.97	10.67
Kennewick	0.46	84.10%	0.71	64.8%	0.55	0.72	7.57
Lk. Wen-atchee	2.20	85.87%	3.16	69.6%	2.58	3.16	42.72
Long	2.32	93.09%	3.08	75.3%	2.04	2.55	80.89

Table III-C.1: 24-Hour Rainfall Amounts and Comparisons for Selected USGS Stations (continued)

Station Name	6 Month Storm Inches	6 Month % Rainfall Volume	2 Year Storm Inches	6 Month/ 2 year %	90% Rainfall Inches	95% Rainfall Inches	Mean Annual Pre-cip. Inches
Beach							
Longview	1.41	92.02%	1.97	71.6%	1.29	1.67	45.62
McMillin	1.31	92.24%	1.82	72.0%	1.21	1.49	40.66
Monroe	1.38	92.90%	1.86	74.2%	1.26	1.53	48.16
Moses Lake	0.47	85.32%	0.70	67.1%	0.54	0.68	7.89
Oakville	1.81	92.86%	2.28	79.4%	1.62	1.98	57.35
Odessa	0.52	87.23%	0.76	68.4%	0.56	0.72	10.09
Olga	1.02	90.82%	1.52	67.1%	0.99	1.30	28.96
Olympia	1.74	91.13%	2.51	69.3%	1.65	2.19	50.68
Omak	0.66	85.89%	0.98	67.3%	0.79	0.98	11.97
Packwood	2.41	88.70%	3.52	68.5%	2.51	3.20	55.20
Pomeroy	0.75	89.29%	1.02	73.5%	0.78	0.98	16.04
Port Angeles	1.12	88.39%	1.66	67.5%	1.19	1.56	25.46
Port Town-send	0.77	90.56%	1.14	67.5%	0.76	0.95	19.13
Prosser	0.48	83.82%	0.74	64.9%	0.61	0.78	7.90
Quilcene	2.53	88.81%	3.40	74.4%	2.61	3.15	54.88
Quincy	0.53	82.12%	0.81	65.4%	0.68	0.90	8.07
Sea-Tac	1.32	91.13%	1.83	72.1%	1.27	1.63	38.10
Seattle JP	1.30	92.05%	1.74	74.7%	1.20	1.49	38.60
Sedro Woolley	1.50	92.07%	2.01	74.6%	1.41	1.80	46.97
Shelton	2.15	91.49%	3.13	68.7%	2.05	2.55	64.63
Smyrna	0.52	83.16%	0.76	68.4%	0.63	0.75	7.96
Spokane	0.68	89.54%	0.96	70.8%	0.70	0.88	16.04
Sunnyside	0.45	82.22%	0.73	61.6%	0.63	0.76	6.80
Tacoma	1.21	92.18%	1.61	75.2%	1.12	1.37	36.92
Toledo	1.36	92.73%	2.10	64.8%	1.25	1.68	50.18

Table III-C.1: 24-Hour Rainfall Amounts and Comparisons for Selected USGS Stations (continued)

Station Name	6 Month Storm Inches	6 Month % Rainfall Volume	2 Year Storm Inches	6 Month/ 2 year %	90% Rainfall Inches	95% Rainfall Inches	Mean Annual Precip. Inches
Vancouver	1.35	91.32%	1.93	69.9%	1.28	1.62	38.87
Walla Walla	0.90	88.60%	1.23	73.2%	0.94	1.18	19.50
Waterville	0.67	84.43%	1.04	64.4%	0.81	1.05	11.47
Wauna	1.82	91.37%	2.50	72.8%	1.72	2.18	51.61
Wenatchee	0.58	81.97%	0.92	63.0%	0.80	1.04	8.93
Winthrop	0.75	85.36%	1.13	66.4%	0.94	1.13	14.28
Yakima	0.53	81.44%	0.85	62.4%	0.72	1.03	8.16

Table III-C.2: 24 Hour Rainfall Amounts and Statistics

Station Name	Return 2-yr.	Freq 6-month	Knee-of- curve 24 hr. (in)	Mean Annual Storm (in)	Mean Annual Precip (in)
Aberdeen	3.32	2.53	2.81		83.1
Anacortes	1.33	0.99	1.20		25.9
Appleton	1.97	1.47	1.80		32.7
Arlington	1.79	1.35	1.40		46.5
Auburn	2.00	1.51		0.54	44.9
Battle Ground	2.12	1.60			52.0
Bellingham 3SSW -- F	1.70	1.27			35.0
Bellingham CAA AP	1.56	1.17	1.63		35.8
Benton City 2NW	0.79	0.53			8.0
Blaine 1ENE	1.89	1.42		0.46	39.9
Bremerton	2.31	1.74	2.22		50.0
Buckley 1NE	2.09	1.58			49.0
Burlington	1.75	1.31		0.40	35.0
Carnation 4NW	1.91	1.44		0.49	47.5

Table III-C.2: 24 Hour Rainfall Amounts and Statistics (continued)

Station Name	Return 2-yr.	Freq 6-month	Knee-of- curve 24 hr. (in)	Mean Annual Storm (in)	Mean Annual Pre-cip (in)
Cathlamet 6NE	3.84	2.93	2.59		79.0
Centralia 1W	2.10	1.59	1.78	0.44	47.6
Chelan	0.94	0.65	1.00		10.4
Colfax 1NW	1.18	0.86	0.99		19.8
Colville	1.02	0.74	0.86		18.3
Colville WB AP	1.01	0.73		0.35	17.4
Coupville 1S	1.08	0.79			21.0
Cushman Dam	4.61	3.52	4.25	1.23	99.7
Darrington RS	3.32	2.53	3.42	0.84	79.8
Duvall 3NE	1.99	1.50			50.0
Ellensburg	0.70	0.48	0.80	0.25	9.2
Ellensburg WB AP	0.72	0.51			12.0
Elwha RS	2.74	2.07	2.53		55.9
Everett Jr. Col.	1.48	1.11	1.22	0.41	34.4
Forks 1E	4.90	3.76	3.99		117.8
Goldendale	1.12	0.81	1.25		17.6
Goldendale 2E	1.31	0.95			18.0
Hartline	0.89	0.62	0.98		10.7
Hoquiam AP	2.85	2.17			71.0
Kennewick	0.71	0.48	0.71		7.6
Kent	1.87	1.40			36.0
Leavenworth	1.64	1.21			26.0
Long Beach Exp	2.99	2.28	2.54		80.0
Longview	2.20	1.66	1.67	0.48	48.1
Mazama 2W	1.59	1.17		0.41	22.7
McMillin Reser-voir	1.81	1.36	1.49	0.46	40.0

Table III-C.2: 24 Hour Rainfall Amounts and Statistics (continued)

Station Name	Return 2-yr.	Freq 6-month	Knee-of- curve 24 hr. (in)	Mean Annual Storm (in)	Mean Annual Precip (in)
Mill Creek	2.04	1.53			35.0
Monroe	1.91	1.44	1.52		48.2
Montesano 3NW	3.30	2.52		0.81	81.5
Moses Lake Devil Far	0.74	0.50	0.68		7.9
Mount Vernon 3WNW	1.60	1.20			32.0
Newport	1.41	1.05			29.0
Oakville	2.46	1.86	1.99		57.4
Odessa	0.80	0.55	0.72		10.1
Okanogan	0.90	0.63			12.0
Olga 2se	1.52	1.13	1.29		29.0
Olympia WB AP	2.62	1.98	2.18	0.62	51.1
Omak 2nw	0.99	0.70	0.98		12.0
Othello 5e	0.70	0.47			8.0
Packwood	2.92	2.21	3.16		55.2
Pomeroy	1.10	0.79	0.97		16.0
Port Angeles	1.69	1.26	1.56	0.42	24.2
Port Townsend	1.11	0.81	0.95	0.35	17.6
Prosser	0.74	0.49	0.78		7.9
Prosser 4NE	0.72	0.48			8.0
Pullman 2NW	1.17	0.86		0.41	22.3
Puyallup 2w Exp Stn	1.85	1.40			41.0
Quilcene 2SW	3.42	2.59	3.14		54.9
Quilcene Dam 5SW	3.84	2.92		0.77	69.4
Quincy 1S	0.77	0.52	0.90		8.1

Table III-C.2: 24 Hour Rainfall Amounts and Statistics (continued)

Station Name	Return 2-yr.	Freq 6-month	Knee-of- curve 24 hr. (in)	Mean Annual Storm (in)	Mean Annual Precip (in)
Republic	1.04	0.76			17.0
Seattle Jackson Park	1.49	1.12	1.49		38.6
Seattle Tac WB AP	1.90	1.42	1.62	0.49	37.4
Seattle U. of W.	1.72	1.29			36.0
Sedro Wolley 1E	2.05	1.55	1.80		47.0
Sequim	1.11	0.80			16.0
Shelton	3.15	2.39	2.54		64.6
Smyrna	0.79	0.53	0.75		8.0
Spokane	1.11	0.80	0.88		16.0
Spokane WB AP	0.97	0.70		0.35	17.0
Sunnyside	0.76	0.50	0.76	0.30	7.4
Tacoma City Hall	1.70	1.28	1.37		36.9
Toledo	1.99	1.51	1.68		50.2
Vancouver 4NNE	2.01	1.51	1.62		38.9
Walla Walla CAA AP	1.19	0.87	1.17		19.5
Waterville	1.00	0.70	1.05		11.5
Wauna	2.15	1.63	2.18		51.6
Wenatchee	0.95	0.65	1.04		8.9
Winthrop 1WSW	1.19	0.85	1.13		14.3
Yakima WB AP	0.81	0.54	1.03	0.33	8.2

Volume IV

Source Control BMP Library

Stormwater Management Manual for Western Washington

Prepared by:

Washington State Department of Ecology
Water Quality Program

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Executive Summary of Volume IV

Welcome to Volume IV of Ecology's 2019 Stormwater Management Manual for Western Washington. Volume IV contains a collection of operational and structural source control BMPs. Stormwater source control BMPs focus on preventing stormwater pollution from occurring, as opposed to other BMP types that reduce the volume, timing, or pollution in stormwater flows. In this Volume you will find the following:

IV-1 Source Control BMPs Applicable to All Sites through IV-7 Other Source Control BMPs provide BMPs grouped by types of activities that have the potential to produce pollution.

Appendix IV-A: Urban Land Uses and Pollutant Generating Sources identifies pollutant-generating sources at various land uses, i.e. manufacturing, transportation, communication, wholesale, retail, and service land uses.

Appendix IV-B: Management of Street Waste Solids and Liquids addresses what to do with waste generated from stormwater maintenance activities such as street sweeping, catch basin cleaning, and Flow Control and Runoff Treatment BMP maintenance.

Refer to Volumes I, II, III, and V for information on the following:

Volume I introduces the measures necessary to control the quantity and quality of stormwater produced by new development and redevelopment. It includes an introduction to stormwater management, guidance on regulatory requirements for stormwater management, and details the minimum requirements for new development and redevelopment sites.

Volume II focuses on managing stormwater impacts associated with construction activities. It discusses the need for pollution prevention for construction stormwater, details how to document construction BMPs in a construction stormwater pollution prevention plan, and includes information on how to implement construction stormwater BMPs.

Volume III provides guidance on how to choose, hydrologically model, and document stormwater BMPs in a stormwater site plan.

Volume V contains a library of design criteria for BMPs that project proponents can use to meet I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.6 MR6: Runoff Treatment, and/or I-3.4.7 MR7: Flow Control.

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IV-1 Source Control BMPs Applicable to All Sites

S410 BMPs for Correcting Illicit Discharges to Storm Drains

Description of Pollutant Sources: Illicit discharges are unpermitted sanitary or process wastewater discharges to a storm sewer or to surface water, rather than to a sanitary sewer, industrial process wastewater, 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.

Pollutant Control Approach: Identify and eliminate unpermitted discharges or obtain an NPDES permit, where necessary, particularly at industrial and commercial facilities.

Applicable Operational 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 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 storm sewer, ground water, or surface water.
- Convey unpermitted discharges to a sanitary sewer if allowed by the local sewer authority, or to other approved treatment.
- 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 sanitary sewer. It is the responsibility of the property owner or business operator to obtain the necessary permits and to replace the connection.
- Obtain appropriate state and local permits for these discharges.

Recommended Additional Operational BMPs:

At commercial and industrial facilities, conduct a survey of wastewater discharge connections to storm drains and to surface water as follows:

- Conduct a field survey of buildings, particularly older buildings, and other industrial areas to locate storm drains from buildings and paved surfaces. Note where these discharge.
- During non-stormwater conditions, inspect each storm drain 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 storm sewers, sanitary sewers, 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 storm drains 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 connections to storm sewers or to surface water and take the actions specified above as applicable BMPs.

S453 BMPs for Formation of a Pollution Prevention Team

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 permittee 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.

S454 BMPs for Preventive Maintenance / Good Housekeeping

Preventative maintenance and good housekeeping practices reduce the potential for stormwater to come into contact with pollutants and can reduce maintenance intervals for the drainage system and sewer system.

Applicable BMPs:

- Prevent the discharge of unpermitted liquid or solid wastes, process wastewater, and sewage to ground or surface water, or to storm drains that discharge 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 a sanitary sewer where allowed by local sewer authority, or to other approved treatment.
- 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 storm drains, or otherwise preventing discharge and pumping or vactoring up washwater, for discharge to sanitary sewer or for vactor truck transport to a waste water treatment plant for disposal).
- Do not hose down pollutants from any area to the ground, storm drains, conveyance ditches, or receiving water. 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 ground water 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. Refer to Ecology Requirements for Generators of Dangerous Wastes in I-2.15 Other Requirements for references to assist in handling potentially dangerous waste.
- Promptly repair or replace all substantially cracked or otherwise damaged paved secondary containment, high-intensity parking, and any other drainage areas, 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 storm drains, surface water, or to the ground.

Recommended 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.
- Empty drip pans immediately after a spill or leak is collected in an uncovered area.
- Stencil warning signs at stormwater catch basins and drains, e.g., “Dump no waste – Drains to waterbody”.
- 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.

S455 BMPs for Spill Prevention and Cleanup

Description of Pollutant Sources: 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.

Applicable 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.
- 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

- 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 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, 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.

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 drainage system or combined sewer.
- Use the appropriate material to clean up the spill.
- Do not use emulsifiers or dispersants such as liquid detergents or degreasers unless disposed of proplerly. Emulsifiers and dispersants are not allowed to be used on surface water, or in a place where they may enter storm drains, surface waters, treatments systems, or sanitary sewers.
- Immediately notify Ecology and the local jurisdiction if a spill has reached or may reach a sanitary or storm sewer, ground water, or surface water. Notification must comply with state and federal spill reporting requirements.
- Do not wash absorbent material into interior floor drains or inlets/catch basins.
- Place used spill control materials in appropriate containers and dispose of according to regulations.

S456 BMPs for Employee Training

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.

S457 BMPS for Inspections

Qualified personnel shall conduct inspections monthly. Make and maintain a record of each inspection on-site. The following requirements apply to inspections:

- 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 outside vehicle maintenance/repair; and liquid handling, and storage areas. 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 storm drains or receiving waters, such as process wastewater and vehicle/equipment washwater.
- Identify actions to address inspection deficiencies.

S458 BMPs for Record Keeping

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 Ecology regional office and ask for an oil spill operations or a dangerous waste specialist:

  - Northwest Region (425)649-7000
  - Southwest Region (360)407-6300
  - Eastern Region (509)329-3400
  - Central Region (509) 575-2490

  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).

The following is additional recommended record keeping:

Maintain records of all related pollutant control and pollutant generating activities such as training, materials purchased, material use and disposal, maintenance performed, etc.

IV-2 Cleaning or Washing Source Control BMPs

S431 BMPs for Washing and Steam Cleaning Vehicles / Equipment / Building Structures

Description of Pollutant Sources: Pollutant sources include the commercial cleaning of vehicles, aircraft, vessels, and other transportation, restaurant kitchens, carpets, and industrial equipment, and large buildings with low- or high-pressure water or steam. This includes "charity" car washes at gas stations and commercial parking lots. The cleaning can include hand washing, scrubbing, sanding, etc. Washwater from cleaning activities can contain oil and grease, suspended solids, heavy metals, soluble organics, soaps, and detergents that can contaminate stormwater.

Permitting Requirements: Obtain all necessary permits for installing, altering, or repairing onsite drainage and side sewers. Restrictions on certain types of discharges may require pretreatment before they enter the sanitary sewer.

Pollutant Control Approach: The preferred approach is to cover and/or contain the cleaning activity, or conduct the activity inside a building, to separate the uncontaminated stormwater from the washwater sources. Convey washwater to a sanitary sewer after approval by the local sewer authority. Provide temporary storage before proper disposal, or recycling. Under this preferred approach, no discharge to the ground, to a storm drain, or to surface water should occur.

The Industrial Stormwater General Permit prohibits the discharge of process wastewater (e.g., vehicle washing wastewater) to ground water or surface water. Stormwater that commingles with process wastewater is considered process wastewater.

Facilities not covered under the Industrial Stormwater General Permit that are unable to follow one of the preferred approaches listed above may discharge washwater to the ground only after proper treatment in accordance with *Vehicle and Equipment Washwater Discharges Best Management Practices Manual* (Ecology, 2012).

The quality of any discharge to the ground after proper treatment must comply with Ecology's Ground Water Quality Standards, Chapter 173-200 WAC.

Facilities not covered under the Industrial Stormwater General Permit that are unable to comply with one of the preferred approaches and want to discharge to storm sewer, must meet their local stormwater requirements. Local authorities may require treatment prior to discharge.

Contact the local Ecology Regional Office to discuss permitting options for discharge of washwater to surface water or to a storm drain after on-site treatment.

Applicable Structural Source Control BMPs:

Conduct vehicle/equipment washing in one of the following locations:

- At a commercial washing facility in which the washing occurs in an enclosure and drains to the sanitary sewer, or

- In a building constructed specifically for washing of vehicles and equipment, which drains to a sanitary sewer.

Conduct outside washing operations in a designated wash area with the following features:

- In a paved area, construct a spill containment pad to prevent the run-on of stormwater from adjacent areas. Slope the spill containment area to collect washwater in a containment pad drain system with perimeter drains, trench drains or catchment drains. Size the containment pad to extend out a minimum of four feet on all sides of the washed vehicles and/or equipment.

- Convey the washwater to a sump (like a grit separator) and then to a sanitary sewer (if allowed by the local Sewer Authority), or other appropriate wastewater treatment or recycle system. The containment sump must have a positive control outlet valve for spill control with live containment volume, and oil/water separation. Size the minimum live storage volume to contain the maximum expected daily washwater flow plus the sludge storage volume below the outlet pipe. Shut the outlet valve during the washing cycle to collect the washwater in the sump. The valve should remain shut for at least two hours following the washing operation to allow the oil and solids to separate before discharge to a sanitary sewer.

- Use a two way valve for discharges from the containment pad. This valve should be normally switched to direct water to treatment, but may be switched to the drainage system after that pad is clean to handle stormwater runoff. The stormwater can then drain into the conveyance/discharge system outside of the wash pad (essentially bypassing the sanitary sewer or recycle system). Post signs to inform people of the operation and purpose of the valve. Clean the concrete pad thoroughly until there is no foam or visible sheen in the washwater prior to closing the inlet valve and allowing uncontaminated stormwater to overflow and drain off the pad.

  Note that the purpose of the valve is to convey only washwater and contaminated stormwater to a treatment system.

- Collect the washwater from building structures and convey it to appropriate treatment such as a sanitary sewer system if it contains oils, soaps, or detergents. If the washwater does not contain oils, soaps, or detergents (in this case only a low pressure, clean, cold water rinse is allowed) then it could drain to soils that have sufficient natural attenuation capacity for dust and sediment.

- Sweep surfaces prior to cleaning/washing to remove excess sediment and other pollutants.

- If roof equipment or hood vents are cleaned, ensure that no washwater or process water is discharged to the roof drains or drainage systems.

- Label all mobile cleaning equipment as follows: "Properly dispose of all wastewater. Do not discharge to an inlet/catch basin, ditch, stream, or on the ground."

Recommended Additional BMPs:

- Mark the wash area at gas stations, multifamily residences and any other business where non-employees wash vehicles.

- Operators may use a manually operated positive control valve for uncovered wash pads, but a pneumatic or electric valve system is preferable. The valve may be on a timer circuit and opened upon completion of a wash cycle. After draining the sump or separator, the timer would then close the valve.
- Minimize the use of water and detergents in washing operations when practicable.
- Use phosphate-free biodegradable detergents when practicable.
- Use the least hazardous cleaning products available.
- Consider recycling the washwater.

Operators may use soluble/emulsifiable detergents in the wash medium and should use it with care and the appropriate treatment. Carefully consider the selection of soaps and detergents and treatment BMPs. Oil/water separators are ineffective in removing emulsified or water soluble detergents. Another treatment appropriate for emulsified and water soluble detergents may be required.

Exceptions:

- At gas stations (for charity car washes) or commercial parking lots, where it is not possible to discharge the washwater to a sanitary sewer, a temporary plug or a temporary sump pump can be used at the storm drain to collect the washwater for off-site disposal such as to a nearby sanitary sewer.
- New and used car dealerships may wash vehicles in the parking stalls as long as employees use a temporary plug system to collect the washwater for disposal as stated above, or an approved treatment system for the washwater is in place.

At industrial sites, contact Ecology for NPDES Permit requirements even when not using soaps, detergents, and/or other chemical cleaners in washing trucks.

S434 BMPs for Dock Washing

Description of Pollutant Sources: 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.

Pollutant Control Approach: Use dry methods and equipment (scraping, sweeping, vacuuming) to remove debris and contaminants prior to cleaning with water to prevent these substances from entering surface water.

Applicable Operational 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 surface waters 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 wash water 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 wash water 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.

S441 BMPs for Potable Water Line Flushing, Water Tank Maintenance, and Hydrant Testing

Description of Pollutant Sources: Flushing is a common maintenance activity used to improve pipe hydraulics and to remove pollutants in systems. Flushing done improperly can result in the discharge of solids to receiving waters. Hydrant testing may result in the discharge of rust particles.

Chemicals used in line flushing and tank maintenance are highly toxic to aquatic organisms and can degrade receiving waters.

Pollutant Control Approach: Dechlorinate and pH adjust water used for flushing, tank maintenance, or hydrant testing. Dispose of the water to the sanitary sewer if possible.

Applicable Operational BMPs:

- Remove solids from associated curbs and gutters before flushing water. Use erosion and sediment control BMPs such as BMP C235: Wattles, BMP C220: Inlet Protection, etc. to collect any solids resulting from flushing activities.
- If using super chlorination or chemical treatment as part of flushing, discharge water to the sanitary sewer. If sanitary sewer is not available, the water may be infiltrated to the ground as long as all of the following are met:
  - The water is dechlorinated to a total residual chlorine of 0.1 ppm or less.
  - Water quality standards are met.
  - A diffuser is used to prevent erosion.
  - The water does not cross property lines.
- Discharging water to a drainage system requires approval from the local jurisdiction. Check with the local jurisdiction to determine their requirements for approval. Most jurisdictions will require the water to be dechlorinated to a total residual chlorine concentration of 0.1 ppm or less and pH adjusted if necessary. Water must be volumetrically and velocity controlled to prevent resuspension of sediments or pollutants in the Municipal Separate Storm Sewer System (MS4).
- Do not over apply dechlorination agents. This can deplete the dissolved oxygen concentration and reduce the pH in discharge / receiving waters.

Optional Operational BMPs:

- If possible, design flushing to convey accumulated material to strategic locations, such as to the sanitary sewer or to a treatment facility; thus, preventing re-suspension and overflow of a portion of the solids during storm events.

- If possible, conduct flushing and tank maintenance activities on non-rainy days and during the time of year that poses the least risk to aquatic biota.

Optional Treatment BMPs:

- Treatment for dechlorinating can include an application of a stoichiometric quantity of:
    - Ascorbic Acid, Sodium Ascorbate (Vitamin C)
    - Calcium Thiosulfate
    - Sodium Sulfite tablets
    - Sodium Thiosulfate
    - Sodium Bisulfite
    - Alternate Dechlorination Solutions

IV-3 Roads, Ditches, and Parking Lot Source Control BMPs

S405 BMPs for Deicing and Anti-Icing Operations for Airports

Refer to 40 CFR Part 449 for EPA effluent limitations guidelines and new source performance standards to control discharges of pollutants from airport deicing operations.

Description of Pollutant Sources: Operators use deicing and/or apply anti-icing compounds on airport runways, taxiways, and on aircraft to control ice and snow. Typically, ethylene glycol and propylene glycol are deicers used on aircraft. Deicers commonly used on runways, taxiways, and other hard surfaces include calcium magnesium acetate (CMA), calcium chloride, magnesium chloride, sodium chloride, urea, and potassium acetate. The deicing and anti-icing compounds become pollutants when conveyed to storm drains or to surface water after application. Leaks and spills of these chemicals can also occur during their handling and storage.

Pollutant Control Approach for Aircraft: Spent glycol discharges in aircraft application areas are regulated process wastewaters under Ecology's Industrial Stormwater General Permit. BMPs for aircraft de/anti-icers must be consistent with aviation safety and the operational needs of the aircraft operator.

Applicable BMPs for Aircraft:

- Conduct aircraft deicing or anti-icing applications in impervious containment areas. Collect aircraft deicer or anti-icer spent chemicals, such as glycol, draining from aircraft in deicing or anti-icing application areas and convey to a sanitary sewer, treatment, or other approved disposal or recovery method. Divert deicing runoff from paved gate areas to appropriate collection areas or conveyances for proper treatment or disposal.
- Do not discharge spent deicer or anti-icer chemicals or stormwater contaminated with aircraft deicer or anti-icer chemicals from application areas, including gate areas into storm drains. No discharge to surface water, or ground water, directly or indirectly should occur.
- Transfer deicing and anti-icing chemicals on an impervious containment pad, or equivalent spill/leak containment area, and store in secondary containment areas. (See S428 BMPs for Storage of Liquids in Permanent Aboveground Tanks).

  Note this applicable containment BMP of aircraft de/anti-icing applications, and applicable treatment BMPs for de/anti-icer spent chemicals such as glycols.

Recommended Additional BMPs for Aircraft:

- Establish a centralized aircraft de/anti-icing facility, if practicable, or in designated areas of the tarmac equipped with separate collection drains for the spent deicer liquids.

- Consider installing an aircraft de/anti-icing chemical recovery system, or contract with a chemical recycler.

Applicable BMPs for Airport Runways/Taxiways:

- Avoid excessive application of all de/anti-icing chemicals, which could contaminate stormwater.
- Store and transfer de/anti-icing materials on an impervious containment pad or an equivalent containment area and/or under cover in accordance with S429 BMPs for Storage or Transfer (Outside) of Solid Raw Materials, Byproducts, or Finished Products. Consider other material storage and transfer approaches only if the de/anti-icer material will not contaminate stormwater.

Recommended Additional BMPs for Airport Runways/Taxiways:

- Include limits on toxic materials and phosphorous in the specifications for de/anti-icers, where applicable.
- Consider using anti-icing materials rather than deicers if it will result in less adverse environmental impact.
- Select cost-effective de/anti-icers that cause the least adverse environmental impact.

S406 BMPs for Streets and Highways

Description of Pollutant Sources: These BMPs apply to the maintenance and deicing/anti-icing of streets and highways. Deicing products can be conveyed during storm events to inlets/catch basins or to receiving waters after application. Leaks and spills of these products can also occur during their handling and storage. Equipment and processes using during maintenance can contribute pollutants such as oil and grease, suspended solids, turbidity, high pH, and metals.

Pollutant Control Approach: Apply good housekeeping practices, preventative maintenance, properly train employees, and use materials that cause less adverse effects on the environment.

Applicable BMPs:

Deicing and Anti-Icing Operations

- Adhere to manufacturer's guidelines and industry standards of use and application.
- Store and transfer de and anti-icing materials on impervious containment pads, or an equivalent spill/leak containment area in accordance with S429 BMPs for Storage or Transfer (Outside) of Solid Raw Materials, Byproducts, or Finished Products.
- Sweep/clean up accumulated de and anti-icing materials and grit from roads as soon as possible after the road surface clears.
- Minimize use in areas where runoff or spray from the roadway immediately enters sensitive areas such as fish-bearing streams.

Maintenance Operations

- Use drip pans or absorbents wherever concrete, asphalt, asphalt emulsion, paint product, and drips are likely to spill, such as beneath discharge points from equipment.
- Cover and contain nearby storm drains to keep runoff from entering the drainage system.
- Collect and contain all solids, slurry, and rinse water. Do not allow these to enter gutters, storm drains, or drainage 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.
- Conduct all fueling of equipment in accordance with S419 BMPs for Mobile Fueling of Vehicles and Heavy Equipment.
- Do not use diesel fuel for cleaning or prepping asphalt tools and equipment.
- Sweep areas as frequently as needed. Collect all loose aggregate and dust for disposal. Do not hose down areas into storm drains.
- Store all fuel, paint, and other products on secondary containment.
- Conduct paint striping operations during dry weather.

Recommended Additional BMPs:

- Where feasible and practicable, use roadway deicing chemicals that cause the least adverse environmental impact. Apply only as needed using minimum quantities. Consider the Pacific Northwest Snowfighters Qualified Products List when selecting roadway de-icers and anti-icers.
- Intensify roadway and drainage structure cleaning in early spring to help remove particulates from road surfaces.
- Include limits on toxic metals in the specifications for de/anti-icers.
- Install catch basin inserts to collect excess sediment and debris as necessary. Inspect and maintain catch basin inserts to ensure they are working correctly.
- Research admixtures (e.g. corrosion inhibitors, surfactants) to determine what additional pollutants may be an issue. Verify with the local jurisdiction if there are any restrictions on admixtures.

S415 BMPs for Maintenance of Public and Private Utility Corridors and Facilities

Description of Pollutant Sources: Corridors and facilities at petroleum product pipelines, natural gas pipelines, water pipelines, electrical power transmission corridors, and rights-of-way can be sources of pollutants such as herbicides used for vegetation management, and eroded soil particles from unpaved access roads. At pump stations, waste materials generated during maintenance activities may be temporarily stored outside. Additional potential pollutant sources include the leaching of preservatives from wood utility poles, PCBs in older transformers, water removed from underground transformer vaults, and leaks/spills from petroleum pipelines. The following are potential pollutants: oil and grease, TSS, BOD, organics, PCBs, pesticides, and heavy metals.

Pollutant Control Approach: Implementation of spill control plans as well as control of fertilizer and pesticide applications, soil erosion, and site debris that can contaminate stormwater.

Applicable Operational BMPs:

- Minimize the amount of herbicides and other pesticides used to maintain access roads and facilities.
- Implement S411 BMPs for Landscaping and Lawn / Vegetation Management.
- Comply with WSDA Pesticide Regulations (see I-2.15 Other Requirements).
- 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 via the sanitary sewer if the requirements, including applicable permits, for such a discharge are met. (See also Requirements for Stormwater Discharges to Public Sanitary Sewers, Septic Systems, Dead-End Sumps, and Industrial Waste Treatment Systems and Ecology Requirements for Generators of Dangerous Wastes in I-2.15 Other Requirements).
- 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.

Recommended Operational 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.

S416 BMPs for Maintenance of Roadside Ditches

Description of Pollutant Sources: Common road debris including eroded soil, oils, vegetative particles, and heavy metals can be sources of stormwater pollutants.

Pollutant Control Approach: Maintain roadside ditches to preserve the condition and capacity for which they were originally constructed, and to minimize bare or thinly vegetated ground surfaces. Maintenance practices should provide for erosion and sediment control (see S411 BMPs for Landscaping and Lawn / Vegetation Management).

Additional Regulations: Note that work in wet areas may be regulated by local, state, or federal regulations that impose additional obligations on the responsible party. Check with the appropriate authorities prior to beginning work in those areas.

Applicable Operational BMPs:

- Inspect roadside ditches regularly to identify sediment accumulations and localized erosion.
- Clean ditches on a regular basis, as needed. Keep ditches 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, fertilizer application, harvesting) in late spring and/or early fall, where possible. This allows re-establishment of vegetative cover by the next wet season thereby minimizing erosion of the ditch as well as making the ditch effective as a biofilter.
- Do not apply fertilizer unless needed to maintain vegetative growth.
- 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. Establish vegetation from the edge of the pavement, if possible, or at least from the top of the slope of the ditch.
- Maintain diversion ditches on top of cut slopes constructed to prevent slope erosion by

intercepting surface drainage to retain their diversion shape and capability.

- Use temporary erosion and sediment control measures or re-vegetate as necessary to prevent erosion during ditch reshaping.
- Do not leave ditch cleanings on the roadway surfaces. Sweep, collect, and dispose of dirt and debris remaining on the pavement at the completion of ditch cleaning operations as described below:
  - Consider screening roadside ditch cleanings, not contaminated by spills or other releases and not associated with a stormwater treatment system such as a bioswale, to remove litter. Separate screenings into soil and vegetative matter (leaves, grass, needles, branches, etc.) categories. Compost or dispose of the vegetative matter in a municipal waste landfill. Consult with the jurisdictional health department to discuss use or disposal options for the soil portion. For more information, see Appendix IV-B: Management of Street Waste Solids and Liquids.
  - 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). If testing determines materials are not dangerous waste but contaminants are present, consult with the jurisdictional health department for disposal options.
- Examine 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. Maintain trash racks to avoid damage, blockage, or erosion of culverts.

Recommended Treatment BMPs:

Install biofiltration swales and filter strips (see V-7 Biofiltration BMPs) 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.

S417 BMPs for Maintenance of Stormwater Drainage and Treatment Systems

Description of Pollutant Sources: Facilities include roadside catch basins on arterials and within residential areas, conveyance systems, detention facilities such as ponds and vaults, oil/water separators, biofilters, settling basins, infiltration systems, and all other types of stormwater treatment systems presented in Volume V. Oil and grease, hydrocarbons, debris, heavy metals, sediments and contaminated water are found in catch basins, oil and water separators, settling basins, etc.

Pollutant Control Approach: Provide maintenance and cleaning of debris, sediments, and other pollutants from stormwater collection, conveyance, and treatment systems to maintain proper operation.

Applicable Operational BMPs:

Maintain stormwater treatment facilities per the operations and maintenance (O&M) procedures presented in Appendix V-A: BMP Maintenance Tables in addition to the following BMPs:

- 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.
- Ensure adequacy of storm sewer capacities and prevent heavy sediment discharges to the sewer system.
- Regularly remove debris and sludge from BMPs used for peak-rate control, treatment, etc. and discharge to a sanitary sewer if approved by the sewer authority, or truck to an appropriate local or state government approved disposal site.
- 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 drainage 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 drainage system.
- Clean woody debris in a catch basin as frequently as needed to ensure proper operation of the catch basin.
- Post warning signs; “Dump No Waste - Drains to Ground Water,” “Streams,” “Lakes,” or emboss on or adjacent to all storm drain inlets where possible.
- Disposal of sediments and liquids from the catch basins must comply with Appendix IV-B: Management of Street Waste Solids and Liquids.

S421 BMPs for Parking and Storage of Vehicles and Equipment

Description of Pollutant Sources: Public and commercial parking lots such as retail store, 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, including oils and greases, metals, and suspended solids.

Pollutant Control Approach: If the parking lot meets the site use thresholds to determine if the site is expected to generate high concentrations of oil, as defined in Step 2: Determine if an Oil Control BMP is Required in III-1.2 Choosing Your Runoff Treatment BMPs, provide oil removal equipment for the contaminated stormwater runoff.

Applicable Operational BMPs:

- If a parking lot must be washed, discharge the washwater to a sanitary sewer, if allowed by the local sewer authority, or other approved wastewater treatment system, or collect washwater for off-site disposal.
- Do not hose down the area to a storm sewer or receiving water. Vacuum sweep parking lots, storage areas, and driveways regularly to collect dirt, waste, and debris. Mechanical or hand sweeping may be necessary for areas where a vacuum sweeper cannot reach.
- Clean up vehicle and equipment fluid drips and spills immediately.
- Place drip pans below leaking vehicles (including inoperative vehicles and equipment) in a manner that catches leaks or spills, including employee vehicles. Drip pans must be managed to prevent overfilling and the contents disposed of properly.

Recommended Operational BMPs:

- Encourage employees to repair leaking personal vehicles.
- Encourage employees to carpool or use public transit through incentives.
- Encourage customers to use public transit by rewarding valid transit pass holders with discounts.
- Install catch basin inserts to collect excess sediment and oil if necessary. Inspect and maintain catch basin inserts to ensure they are working correctly.

Applicable Treatment BMPs:

Establishments subject to high-use intensity are significant sources of oil contamination of stormwater. Examples of potential high use areas include customer parking lots at fast food stores, grocery stores, taverns, restaurants, large shopping malls, discount warehouse stores, quick-lube shops, and banks.

Refer to Step 2: Determine if an Oil Control BMP is Required in III-1.2 Choosing Your Runoff Treatment BMPs for the site use thresholds that determine if an oil control BMP is required, and for a list of oil control BMPs.

S430 BMPs for Urban Streets

Description of Pollutant Sources: Urban streets can be the source of vegetative debris, paper, fine dust, vehicle liquids, tire and brake wear residues, heavy metals (lead and zinc), soil particles, ice control salts, domestic wastes, lawn chemicals, and vehicle combustion products. Street surface contaminants contain significant concentrations of particle sizes less than 250 microns (Sartor and Boyd, 1972).

Pollutant Control Approach: Conduct efficient street sweeping where and when appropriate to minimize the contamination of stormwater. Do not wash street debris into storm drains.

Facilities not covered under the Industrial Stormwater General Permit may consider a minimum amount of water washing of streets. All facilities must comply with their local stormwater requirements for discharging to storm sewers. Municipal NPDES permittees are required to limit street wash water discharges and may have special conditions or treatment requirements.

Recommended BMPs:

- For maximum stormwater pollutant reductions on curbed streets and high volume parking lots, use efficient vacuum sweepers.

  Note: High-efficiency street sweepers utilize strong vacuums and the mechanical action of main and gutter brooms combined with an air filtration system that only returns clean air to the atmosphere (i.e., filters very fine particulates). They sweep dry and use no water since they do not emit any dust.

  High-efficiency vacuum sweepers have the capability of removing 80 percent or more of the accumulated street dirt particles whose diameters are less than 250 microns (Sutherland et al., 1998). This assumes pavements under good condition and reasonably expected accumulation conditions.

- For moderate stormwater pollutant reductions on curbed streets use regenerative air sweepers or tandem sweeping operations.

  Note: A tandem sweeping operation involves a single pass of a mechanical sweeper followed immediately by a single pass of a vacuum sweeper or regenerative air sweeper.

  - *A regenerative air sweeper blows air down on the pavement to entrain particles and uses a return vacuum to transport the material to the hopper.*
  - *These operations usually use water to control dust. This reduces their ability to pick up fine particulates.*

  These types of sweepers have the capability of removing approximately 25 to 50 percent of the accumulated street dirt particles whose diameters are less than 250 microns. (Sutherland et al., 1998). This assumes pavements under good conditions and typical accumulation conditions.

- For minimal stormwater pollutant reductions on curbed streets use mechanical sweepers.

  - *Note: The industry refers to mechanical sweepers as broom sweepers and uses the mechanical action of main and gutter brooms to throw material on a conveyor belt that transports it to the hopper.*
  - *These sweepers usually use water to control dust. This reduces their ability to pick up fine particulates.*

Mechanical sweepers have the capability of removing only 10 to 20 percent of the accumulated street dirt particles whose diameters are less than 250 microns (Sutherland et al., 1998). This assumes pavements under good condition and the most favorable accumulation conditions.

- Conduct vacuum 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, receiving water, 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.
- Consider the use of periodic parking restrictions in low to medium density single-family residential areas to ensure the sweeper's ability to sweep along the curb.
- Establish programs for prompt vacuum sweeping, removal, and disposal of debris from special events that will generate higher than normal loadings.
- Disposal of street sweeping solids must comply with Appendix IV-B: Management of Street Waste Solids and Liquids.
- Consider developing ordinances that prohibit citizens from putting yard debris in the street gutters, or doing vehicle maintenance on the street.
- Provide incentives to property owners for installing permeable pavement parking areas and driveways.
- Consider installing catch basin inserts in high use areas to remove trash and yard debris before it enters the system.
- Implement a storm drain stenciling program to label and educate the public not to dump materials into storm drains or onto sidewalks, streets, parking lots, and gutters.
- Provide household hazardous waste collection and used oil recycling for citizens to avoid illegal dumping.

IV-4 Soil Erosion, Sediment Control, and Landscaping Source Control BMPs

S407 BMPs for Dust Control at Disturbed Land Areas and Unpaved Roadways and Parking Lots

Note: Contact the local air quality authority for appropriate and required BMPs for dust control to implement at your project site. Use the following website to determine the air quality authority for the project site:

https://ecology.wa.gov/About-us/Our-role-in-the-community/Partnerships-committees/Clean-air-agencies

Description of Pollutant Sources: Dust can cause air and water pollution problems particularly at demolition sites and in arid areas where reduced rainfall exposes soil particles to transport by air.

Pollutant Control Approach: Minimize dust generation and apply environmentally friendly and government approved dust suppressant chemicals, if necessary.

Applicable Operational BMPs:

- Sprinkle or wet down soil or dust with water as long as it does not result in a wastewater discharge.
- Use only dust suppressant chemicals that are approved by the local jurisdiction and/or state government approved dust suppressant chemicals such as those listed in *Alternatives to Hazardous Materials: Techniques for Dust Prevention and Suppression* (Ecology, 2016b).
- 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.
- Apply stormwater containment to prevent the conveyance of sediment into storm drains or receiving waters.
- Protect inlets/catch basins during application of dust suppressants.
- Ecology prohibits the use of motor oil for dust control. Take care when using lignin derivatives and other high BOD chemicals in areas susceptible to contaminating surface water or ground water.
- Consult with Ecology and the local permitting authority on discharge permit requirements if the dust suppression process results in a wastewater discharge to the ground, ground water, storm drain, or surface water.
- Street gutters, sidewalks, driveways, and other paved surfaces in the immediate area of the activity must be swept regularly to collect and properly dispose of dust, dirt, loose debris, and garbage.

- Install catch basin filter socks on site and in surrounding catch basins to collect sediment and debris. Maintain the filters regularly to prevent plugging.

Recommended Additional Operational BMPs for Roadways and Other Trafficked Areas:

- Consider limiting use of off-road recreational vehicles on dust generating land.
- Consider graveling or paving unpaved permanent roads and other trafficked areas at municipal, commercial, and industrial areas.
- Consider paving or stabilizing shoulders of paved roads with gravel, vegetation, or local government approved chemicals.
- Encourage use of alternate paved routes, if available.
- Vacuum sweep fine dirt and skid control materials from paved roads soon after winter weather ends or when needed.
- Consider using pre-washed traction sand to reduce dust emissions.

Additional Recommended Operational 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* (USEPA, 1992).
- 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.

Note: Construction site dust control is covered in BMP C140: Dust Control.

S408 BMPs for Dust Control at Manufacturing Areas

Note: Contact the local air quality authority for appropriate and required BMPs for dust control to implement at your project site. Use the following website to determine the air quality authority for the project site:

https://ecology.wa.gov/About-us/Our-role-in-the-community/Partnerships-committees/Clean-air-agencies

Description of Pollutant Sources: Industrial material handling activities can generate considerable amounts of dust that is typically removed using exhaust systems. Mixing cement and concrete products and handling powdered materials can also generate dust. Particulate materials that can cause air pollution include grain dust, sawdust, coal, gravel, crushed rock, cement, and boiler fly ash. Air emissions can contaminate stormwater. The objective of this BMP is to reduce the stormwater pollutants caused by dust generation and control.

Pollutant Control Approach: Prevent dust generation and emissions where feasible, regularly clean-up dust that can contaminate stormwater, and convey dust contaminated stormwater to proper treatment.

Applicable BMPs:

- Clean, as needed, powder material handling equipment and vehicles.
- Regularly sweep dust accumulation areas that can contaminate stormwater. Conduct sweeping using vacuum filter equipment to minimize dust generation and to ensure optimal dust removal.
- Use dust filtration/collection systems such as baghouse filters, cyclone separators, etc. to control vented dust emissions that could contaminate stormwater. Control of zinc dusts in rubber production is one example.
- Maintain on-site controls to prevent vehicle track-out.
- Maintain dust collection devices on a regular basis.

Recommended BMPs:

- In manufacturing operations, train employees to handle powders carefully to prevent generation of dust.
- Use water spray to flush dust accumulations to sanitary sewers where allowed by the local sewer authority or to other appropriate treatment system.
- Use approved dust suppressants such as those listed in *Methods for Dust Control* (Ecology, 2016b). Application of some products may not be appropriate in close proximity to receiving waters or conveyances close to receiving waters. For more information check with Ecology or the local jurisdiction.

Recommended Treatment BMPs

Install sedimentation basins, wet ponds, wet vaults, catch basin filters, vegetated filter strips, or equivalent sediment removal BMPs.

S411 BMPs for Landscaping and Lawn / Vegetation Management

Description of Pollutant Sources: Landscaping can include grading, soil transfer, vegetation planting, and vegetation removal. Examples include weed control on golf course lawns, access roads, and utility corridors and during landscaping; and residential lawn/plant care. Proper management of vegetation can minimize excess nutrients and pesticides.

Pollutant Control Approach: Maintain appropriate vegetation to control erosion and the discharge of stormwater pollutants. Prevent debris contamination of stormwater. Where practicable, grow plant species appropriate for the site, or adjust the soil properties of the site to grow desired plant species.

Applicable BMPs:

- Install engineered soil/landscape systems to improve the infiltration and regulation of stormwater in landscaped areas.
- Select the right plants for the planting location based on proposed use, available maintenance,soil conditions, sun exposure, water availability, height, sight factors, and space available.
- Ensure that plants selected for planting are not on the noxious weed list. For example, butterfly bush often gets planted as an ornamental but is actually on the noxious weed list.

  The Washington State Noxious Weed List can be found at the following webpage:

  https://www.nwcb.wa.gov/printable-noxious-weed-list
- Do not dispose of collected vegetation into waterways or storm sewer systems.
- Do not blow vegetation or other debris into the drainage system.
- Dispose of collected vegetation such as grass clippings, leaves, sticks by composting or recycling.
- Remove, bag, and dispose of class A & B noxious weeds in the garbage immediately.
- Do not compost noxious weeds as it may lead to spreading through seed or fragment if the composting process is not hot enough.
- 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 eight-inch "topsoil" layer with at least 8 percent organic matter to provide a sufficient vegetation-growing medium.
  - Organic matter is 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 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.

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 watering.
- Use mulch or other erosion control measures on soils exposed for more than one week during the dry season (May 1 to September 30) or two days during the rainy season (October 1 to April 30).
- 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.
    - Reduces 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 (see

http://www.tcia.org/TCIA/BUSINESS/ANSI_A300_Standards_/TCIA/BUSINESS/A300_Standards/A300_Standards.aspx?hkey=202ff566-4364-4686-b7c1-2a365af59669) and International Society of Arboriculture BMPs to the extent practicable (e.g., take care to minimize any damage to tree roots and avoid compaction of soil).

- 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 drive, consider relocating the plant to a more appropriate location.
- Make reasonable attempts to remove and dispose of class C noxious weeds.
- Re-seed 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 reed canary grass to avoid invasions.
- Plant and protect trees per BMP T5.16: Tree Retention and Tree Planting.
- 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-inch 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 the 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 to remain healthy.

Additional BMP Information:

- King County's *Best Management Practices for Golf Course Development and Operation* (King County, 1993) has additional BMPs for Turfgrass Maintenance and Operation.
- King County, Seattle Public Utilities, and the Saving Water Partnership have created the following natural lawn and garden care resources that include guidance on building healthy soil with compost and mulch, selecting appropriate plants, watering, using alternatives to pesticides, and implementing natural lawn care techniques.

   - *Natural Yard Care - Five steps to make your piece of the planet a healthier place to live* (King County and SPU, 2008)
   - *The Natural Lawn & Garden Series: Smart Watering* (Saving Water Partnership, 2006)
   - *Natural Lawn Care for Western Washington* (Saving Water Partnership, 2007)
   - *The Natural Lawn & Garden Series: Growing Healthy Soil; Choosing the Right Plants; and Natural Pest, Weed and Disease Control* (Saving Water Partnership, 2012)

- The International Society of Arboriculture (ISA) is a group that promotes the professional practice of arboriculture and fosters a greater worldwide awareness of the benefits of trees through research, technology, and education. ISA standards used for managing trees, shrubs, and other woody plants are the American National Standards Institute (ANSI) A300 standards. The ANSI A300 standards are voluntary industry consensus standards developed by the Tree Care Industry Association (TCIA) and written by the Accredited Standards Committee (ASC). The ANSI standards can be found on the ISA website: www.isa-arbor.com/education/publications/index.aspx
- Washington State University's *Gardening in Washington State* website at http://gardening.wsu.edu contains Washington State specific information about vegetation management based on the type of landscape.
- See the *Pacific Northwest Plant Disease Management Handbook* (Pscheidt and Ocamb, 2016) for information on disease recognition and for additional resources.

S425 BMPs for Soil Erosion and Sediment Control at Industrial Sites

Description of Pollutant Sources: Industrial activities on soil areas; exposed and disturbed soils; steep grading; etc. can be sources of sediments that can contaminate stormwater runoff.

Pollutant Control Approach: Limit the exposure of erodible soil, stabilize, or cover erodible soil where necessary to prevent erosion, and/or provide treatment for stormwater contaminated with TSS caused by eroded soil.

Applicable BMPs:

- Limit the exposure of erodible soil.
- Stabilize entrances/exits to prevent track-out. See BMP C105: Stabilized Construction Access.
- Stabilize or cover erodible soil to prevent erosion. Cover practice options include:
   - Use vegetative cover such as grass, trees, shrubs, on erodible soil areas.
   - Cover exposed areas with mats such as clear plastic, jute, 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. Structural practice options 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

For design information refer to II-3 Construction Stormwater BMPs.

S435 BMPs for Pesticides and an Integrated Pest Management Program

Description of Pollutant Sources: Pesticides include herbicides, rodenticides, insecticides, fungicides, etc. Examples of pesticide uses include:

- Weed control on golf course lawns, access roads, utility corridors and landscaping.
- Sap stain and insect control on lumber and logs.
- Rooftop moss removal.
- Killing nuisance rodents.
- Fungicide application to patio decks.

It is possible to release toxic pesticides such as pentachlorophenol, carbamates, and organometallics 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 pesticides can cause appreciable stormwater contamination and unintended impacts to non-targeted organisms.

Pollutant Control Approach: Control of pesticide applications to prevent contamination of stormwater. Develop and implement an Integrated Pest Management (IPM) Plan. Carefully apply pesticides, in accordance with label requirements.

Applicable Operational 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 the 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 down to a storm drain, conveyance ditch, or water body.
- Remove weeds/vegetation in stormwater ditches, stormwater facilities, and drainage systems 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 S411 BMPs for 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 or ground waters, 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.

Recommended Additional Operational 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 water bodies. Spraying pesticides within 100 feet of water bodies including any drainage ditch or channel that leads to open water may have additional regulatory requirements beyond just following the pesticide product label. Additional requirements may include:
    - Obtaining a discharge permit from Ecology.
    - Obtaining a permit from the local jurisdiction.
    - 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 and 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.

Additional Information

For more information, refer to the Pesticide Information Center Online (PICOL) Databases at http://cru66.cahe.wsu.edu/LabelTolerance.html.

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.

S444 BMPs for the Storage of Dry Pesticides and Fertilizers

Description of Pollutant Sources: 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.

Pollutant Control Approach: Store fertilizer and pesticide properly to prevent stormwater contamination.

Applicable Structural BMPs:

Store pesticides and fertilizers in enclosed impervious containment areas that prevent precipitation or unauthorized personnel from coming into contact with the materials..

Applicable Operational BMPs:

- 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 storm sewers or to the sanitary sewer. 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.

S449 BMPs for Nurseries and Greenhouses

Description of Pollutant Sources: 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.

Pollutant Control Approach: Minimize the pollutants that leave the site by controlling the placement of materials, stabilizing the site, and managing irrigation water.

Applicable Operational BMPs:

- Establish nursery composting areas, soil storage, and mixing areas at least 100 feet away from any stream or other surface water body and as far away as possible from drainage systems.
- Do not dispose of collected vegetation into waterways or storm sewer systems.
- Do not blow, sweep, or otherwise allow vegetation or other debris into the drainage 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 S429 BMPs for Storage or Transfer (Outside) of Solid Raw Materials, Byproducts, 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 run-off 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 S450 BMPs for Irrigation for additional BMP considerations.

- Refer to S443 BMPs for Fertilizer Application and S435 BMPs for Pesticides and an Integrated Pest Management Program.

Applicable Structural BMPs:

- 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.
- 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)

S450 BMPs for Irrigation

Description of Pollutant Sources: 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 runoff into drainage systems; 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.

Pollutant Control Approach: Limit the amount and location of watering to prevent runoff and discharges to drainage systems.

Applicable Operational 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 drainage 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 fertilizer runoff occurs.
- 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.

Recommended Operational 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.

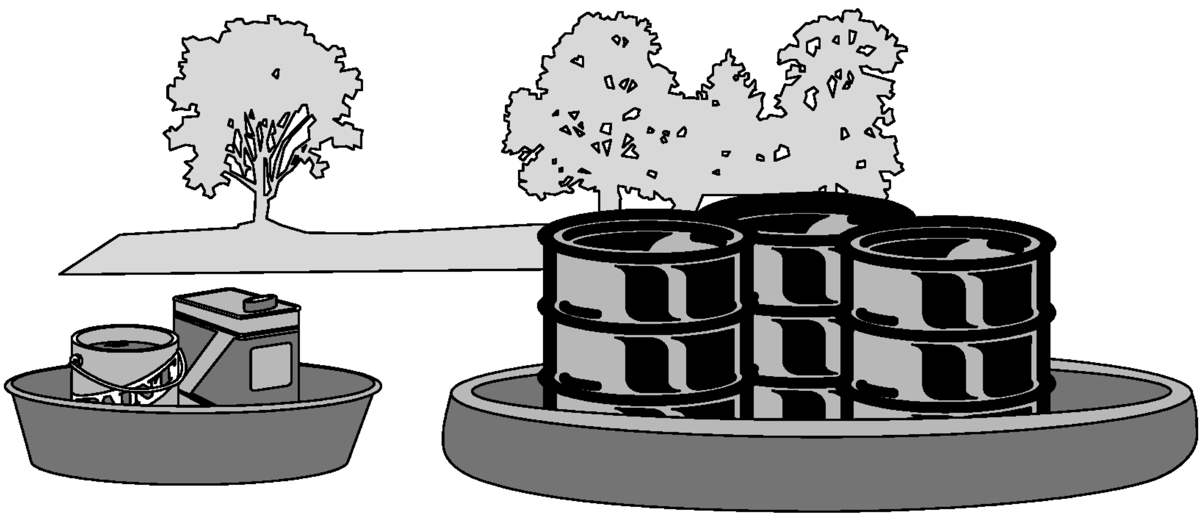
IV-5 Storage and Stockpiling Source Control BMPs

S427 BMPs for Storage of Liquid, Food Waste, or Dangerous Waste Containers

Description of Pollutant Sources: Steel and plastic drums with volumetric capacities of 55 gallons or less are typically used at industrial facilities for container storage of liquids and powders. The BMPs specified below apply to container(s) located outside a building. Use these BMPs when temporarily storing potential pollution generating materials or wastes. These BMPs do not apply when Ecology has permitted the business to store the wastes (see Standards for Solid Waste Containers in I-2.15 Other Requirements). Leaks and spills of pollutant materials during handling and storage are the primary sources of pollutants. Oil and grease, acid/alkali pH, BOD, COD are potential pollutant constituents.

Pollutant Control Approach: Store containers in impervious containment under a roof, or other appropriate cover, or in a building. For storage areas on-site for less than 30 days, consider using a portable temporary secondary system like that shown in Figure IV-5.1: Secondary Containment System in lieu of a permanent system as described above.

Figure IV-5.1: Secondary Containment System



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Secondary Containment System

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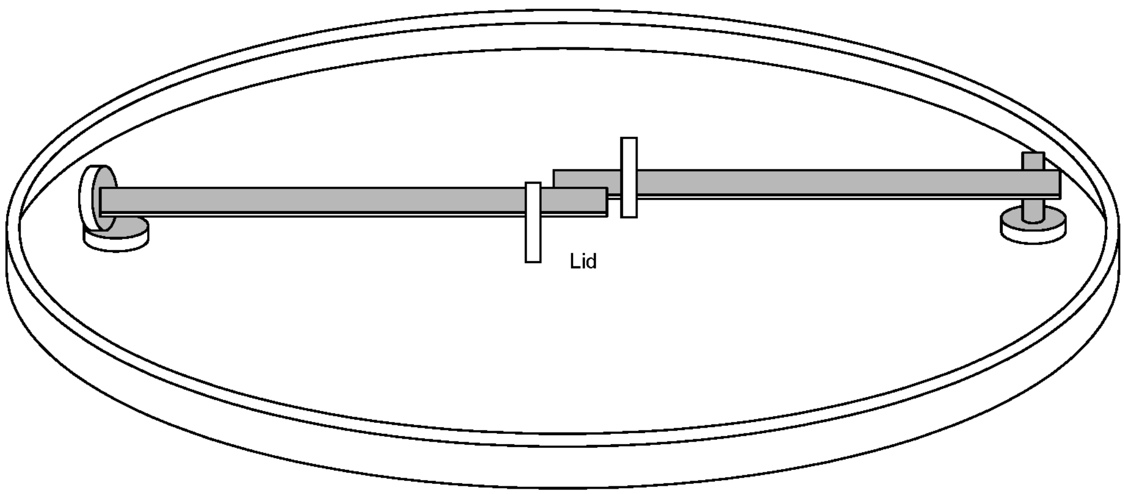
Applicable Operational BMPs:

- Place tight-fitting lids on all containers.
- 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, and replace and tighten bungs in drums as needed.
- Empty drums containing residues should be stored to prevent stormwater from entering drum closures. Cover or tilt drums to prevent stormwater from accumulating on the top of 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 local fire code.
- Secure drums when stored in an area where unauthorized persons may gain access in a manner that prevents accidental spillage, pilferage, or any unauthorized use (see Figure IV-5.2: Locking System for Drum Lid).

Figure IV-5.2: Locking System for Drum Lid



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Locking System for Drum Lid

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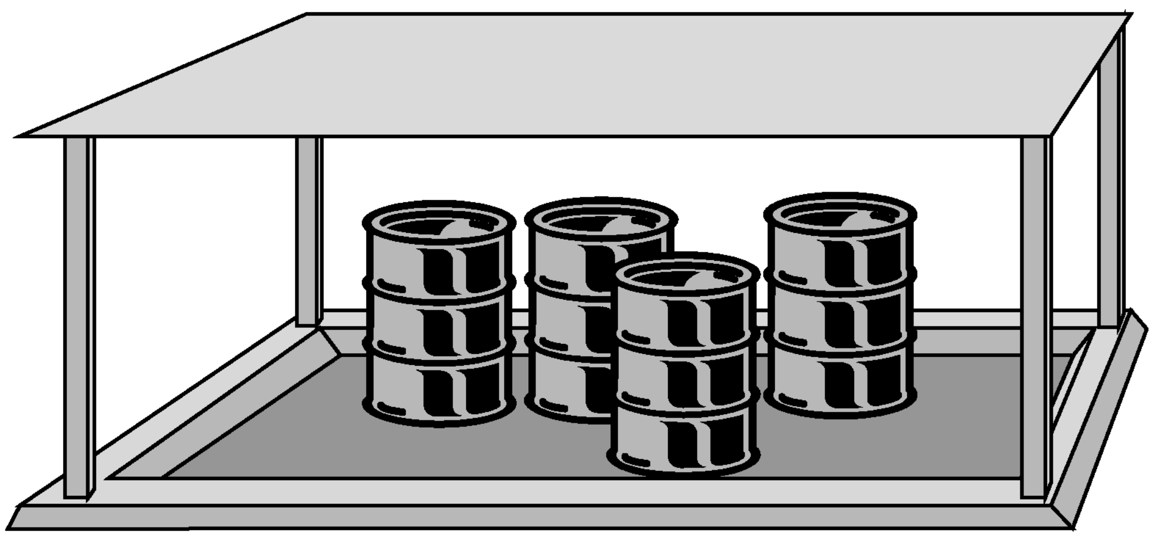
- If the material is a Dangerous Waste, the business owner must comply with any additional Ecology requirements as specified in Ecology Requirements for Generators of Dangerous Wastes within I-2.15 Other Requirements.
- Storage of flammable, ignitable, and reactive chemicals and materials must comply with the stricter of local zoning codes, local fire codes, the Uniform Fire Code (UFC), UFC standards, or the National Electric Code
- Have spill kits or cleanup materials near container storage areas.
- Clean up all spills immediately.
- Cover dumpsters, or keep them under cover such as a lean-to, to prevent the entry of stormwater. Keep dumpster lids closed.
- Replace or repair leaking garbage dumpsters, or install waterproof liners.
- Drain dumpsters and/or dumpster pads to sanitary sewer where approved by the sewer authority.
- When collection trucks directly pick up roll-containers, ensure a filet is on both sides of the curb to facilitate moving the dumpster.

Applicable Structural Source Control BMPs:

- Keep containers with Dangerous Waste, food waste, or other potential pollutant liquids inside a building unless this is not feasible due to site constraints or Uniform/International Fire Code requirements.
- Store containers in a designated area, which is covered, bermed or diked, paved and impervious in order to contain leaks and spills (see Figure IV-5.3: Covered and Bermed Containment Area). Slope the secondary containment to drain into a dead-end sump for the collection of leaks and small spills.
- For liquid materials, surround the containers with a dike as illustrated in Figure IV-5.3: 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.

Figure IV-5.3: Covered and Bermed Containment Area



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Covered and Bermed Containment Area

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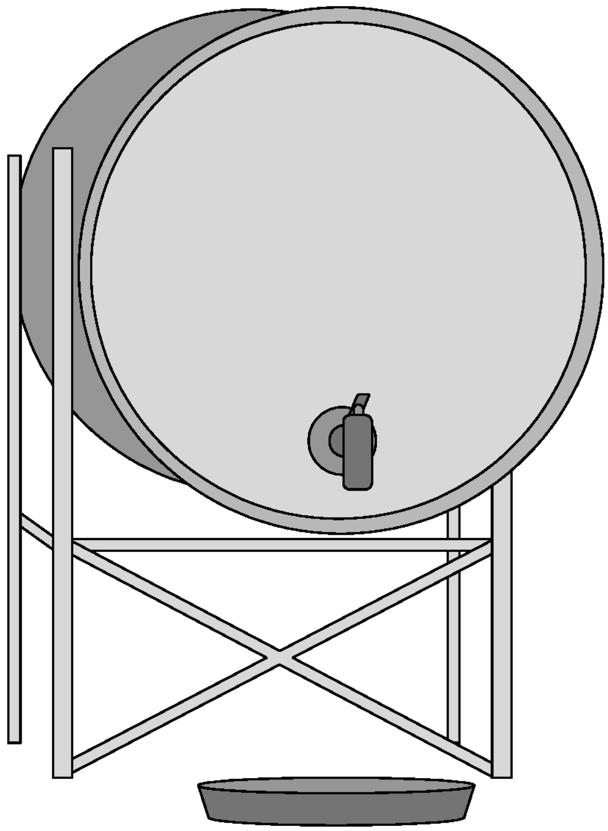
- Where material is temporarily stored in drums, use a containment system as illustrated, in lieu of the above system (see Figure IV-5.1: Secondary Containment System).
- Place containers mounted for direct removal of a liquid chemical for use by employees inside a containment area as described above. Use a drip pan during liquid transfer (see Figure IV-5.4: Mounted Container - With Drip Pan).

Figure IV-5.4: Mounted Container - With Drip Pan



*Note that the secondary containment is not shown in this figure

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Mounted Container - with Drip Pan

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Applicable Treatment BMP:

Note this treatment BMP is for contaminated stormwater from drum storage areas.

- To discharge contaminated stormwater, pump it from a dead-end sump or catchment and dispose of appropriately.

S428 BMPs for Storage of Liquids in Permanent Aboveground Tanks

Description of Pollutant Sources: Aboveground tanks containing liquids (excluding uncontaminated water) may be equipped with a valved drain, vent, pump, and bottom hose connection. Aboveground tanks may be heated with steam heat exchangers equipped with steam traps, if required. 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.

Pollutant Control Approach: Install secondary containment or a double-walled tank. Slope the containment area to a drain with a sump. Operators may need to discharge stormwater collected in the containment area to a Runoff Treatment BMP such as BMP T11.10: API (Baffle type) Separator or BMP T11.11: Coalescing Plate (CP) Separator, or an equivalent BMP. Add safeguards against accidental releases including protective guards around tanks to protect against vehicle or forklift damage, and tagging valves to reduce human error. *Tank water and condensate discharges are process wastewater that may need an NPDES Permit.*

Applicable Operational BMPs:

- Inspect the tank containment areas regularly for leaks/spills, cracks, corrosion, etc. to identify problem components such as fittings, pipe connections, and valves.
- Place adequately sized drip pans beneath all mounted taps and drip/spill locations during filling/unloading of tanks. Operators may need valved drain tubing in mounted drip pans.
- Vacuum sweep and clean the tank storage area regularly, if paved.
- Replace or repair tanks that are leaking, corroded, or otherwise deteriorating.
- Storage of flammable, ignitable, and reactive chemicals and materials must comply with the stricter of local zoning codes, local fire codes, the Uniform Fire Code (UFC), UFC standards, or the National Electric Code.

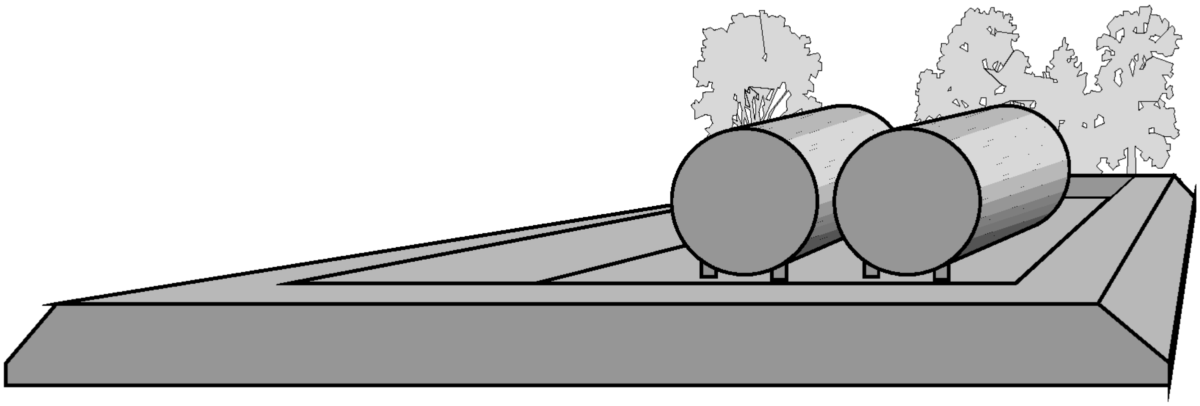
Applicable Structural BMPs:

- Locate permanent tanks in impervious (Portland cement concrete or equivalent) secondary containment surrounded by dikes as illustrated in Figure IV-5.5: Above-Ground Tank Storage, or use UL Approved double-walled tanks. The dike must be of sufficient height to provide a containment volume of either 10 percent of the total enclosed tank volume or 110 percent of the volume contained in the largest tank, whichever is greater.
- Slope the secondary containment to drain to a normally closed valve, for the collection of small

spills.

- Include a tank overfill protection system to minimize the risk of spillage during loading.

Figure IV-5.5: Above-Ground Tank Storage



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Above-Ground Tank Storage

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Applicable Treatment BMPs:

- Depending on the kind of liquid being stored, the potential and type of stormwater contamination will vary and may require specialized treatment.
- For an uncovered tank containment area, equip the outlet from the spill-containment sump with a normally closed shutoff valve. Operators may open this valve manually or automatically, only to convey contaminated stormwater to approved treatment or disposal, or to convey uncontaminated stormwater to a storm sewer. Evidence of contamination can include the presence of visible sheen, color, or turbidity in the runoff, or existing or historical operational problems at the facility. Use simple pH tests with litmus or pH paper for areas subject to acid or alkaline contamination.
- At petroleum tank farms, convey stormwater contaminated with floating oil or debris in the contained area to a sanitary sewer with the sewer authority's approval or through BMP T11.10: API (Baffle type) Separator or BMP T11.11: Coalescing Plate (CP) Separator, or other approved treatment prior to discharge to the storm drain or surface water.

S429 BMPs for Storage or Transfer (Outside) of Solid Raw Materials, Byproducts, or Finished Products

Description of Pollutant Sources: Some pollutant sources stored outside in large piles, stacks, etc. at commercial or industrial establishments include:

- Solid raw materials
- Byproducts
- Gravel
- Sand
- Salts
- Topsoil
- Compost
- Logs
- Sawdust
- Wood chips
- Lumber
- Concrete
- Metal products

Contact between outside bulk materials and stormwater can cause leachate, and erosion of the stored materials. Contaminants may include TSS, BOD, organics, and dissolved salts (sodium, calcium, and magnesium chloride, etc.).

Pollutant Control Approach: Provide impervious containment with berms, dikes, etc. and/or cover to prevent run-on and discharge of leachate pollutant(s) and TSS.

Applicable Operational BMPs:

- Do not hose down the contained stockpile area to a storm drain or a conveyance to a storm drain, or to a receiving water.
- Maintain drainage areas in and around storage of solid materials with a minimum slope of 1.5 percent to prevent pooling and minimize leachate formation. Areas should be sloped to drain stormwater to the perimeter for collection or to internal drainage “alleyways” where no stockpiled material exists.
- Sweep paved storage areas regularly for collection and disposal of loose solid materials.
- If and when feasible, collect and recycle water-soluble materials (leachates).
- Stock cleanup materials, such as brooms, dustpans, and vacuum sweepers near the storage area.

Applicable Structural BMPs:

For stockpiles less than 5 cubic yards, place temporary plastic sheeting (polyethylene, polypropylene, hypalon, or equivalent) over the material as shown in Figure IV-5.7: Material Covered with Plastic Sheeting.

The source control BMP options listed below are applicable to:

- Stockpiles greater than 5 cubic yards of erodible or water soluble materials such as:
    - Soil
    - Road deicing salts
    - Compost
    - Unwashed sand and gravel
    - Sawdust
- Outside storage areas for solid materials such as:
    - Logs
    - Bark
    - Lumber
    - Metal products

Choose one or more of the following Source Control BMPs:

- Store in a building or paved and bermed covered area as shown in Figure IV-5.6: Covered Storage Area for Bulk Solids.
- Place temporary plastic sheeting (polyethylene, polypropylene, hypalon, or equivalent) over the material as shown in Figure IV-5.7: Material Covered with Plastic Sheeting.
- Pave the area and install a drainage system. Place curbs or berms along the perimeter of the area to prevent the run-on of uncontaminated stormwater and to collect and convey runoff to treatment. Slope the paved area in a manner that minimizes the contact between stormwater (e.g., pooling) and leachable materials in compost, logs, bark, wood chips, etc.
- For large uncovered stockpiles, implement containment practices at the perimeter of the site and at any catch basins as needed to prevent erosion and discharge of the stockpiled material off-site or to a storm drain. Ensure that no direct discharge of contaminated stormwater to catch basins exists without conveying runoff through an appropriate treatment BMP.

Figure IV-5.6: Covered Storage Area for Bulk Solids

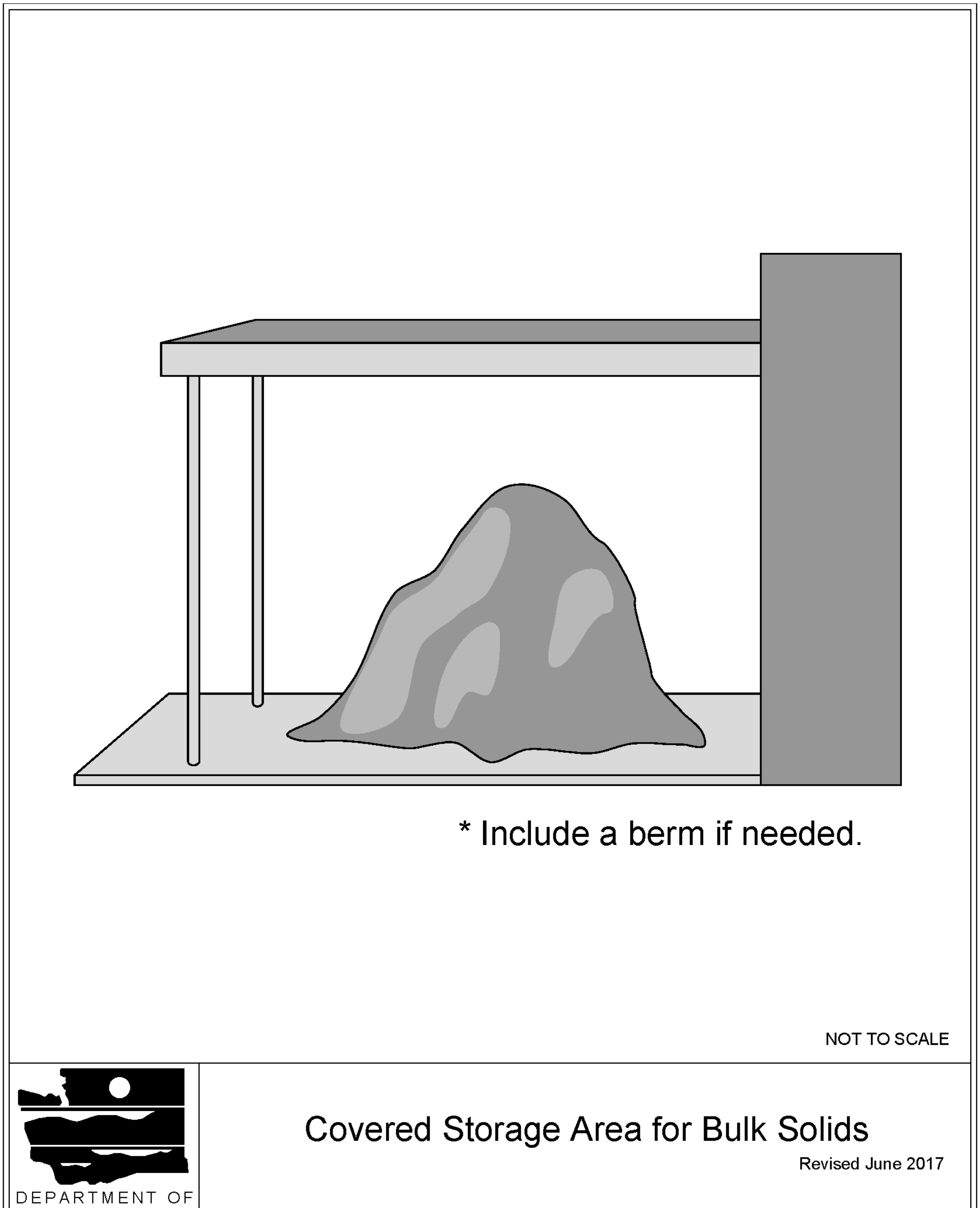
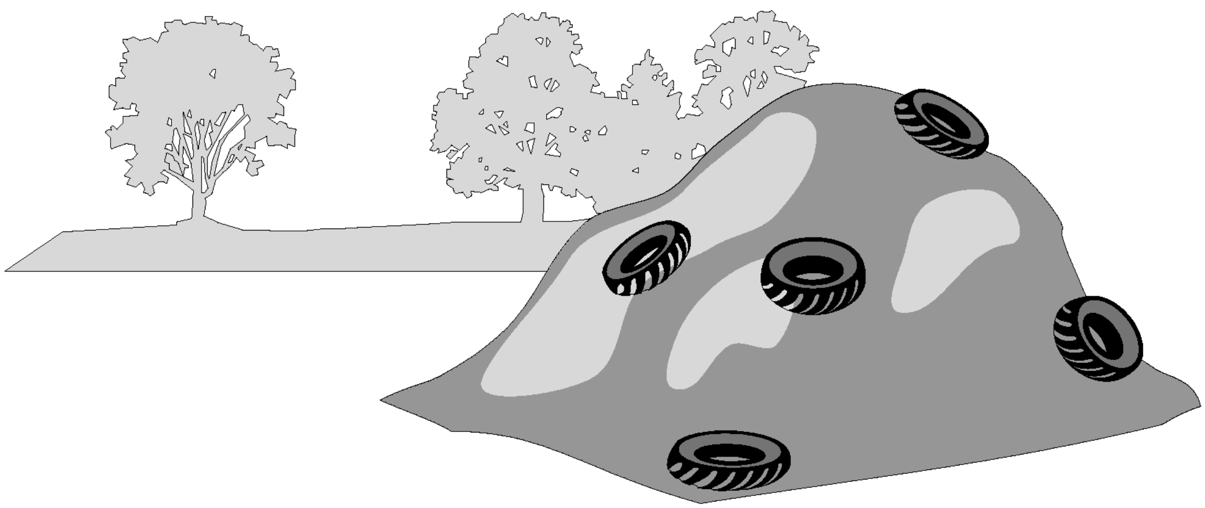


Figure IV-5.7: Material Covered with Plastic Sheeting



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Material Covered with Plastic Sheeting

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Applicable Treatment BMPs:

Convey contaminated stormwater from the stockpile area to:

- BMP T10.10: Wetponds - Basic and Large,
- BMP T10.20: Wetvaults,
- BMP T6.10: Presettling Basin,
- Manufactured Treatment Device (see V-10 Manufactured Treatment Devices as BMPs, or
- other appropriate treatment system depending on the contamination.

S445 BMPs for Temporary Fruit Storage

Description of Pollutant Sources: This activity applies to businesses that temporarily store fruits and vegetables outdoors prior to or after packing, processing, or sale, or that crush, cut, or shred fruits or vegetables for wines, frozen juices, and other food and beverage products.

Activities involving the storage or processing of fruits, vegetables, and grains can potentially result in the delivery of pollutants to stormwater. Potential pollutants of concern from all fruit and vegetable storage and processing activities include nutrients, suspended solids, substances that increase biological oxygen demand (BOD), and color. These pollutants must not be discharged to the drainage system or directly into receiving waters.

Pollutant Control Approach: Store and process fruits and vegetables indoors or under cover whenever possible. Educate employees about proper procedures. Cover and contain operations and apply good housekeeping and preventive maintenance practices to prevent the contamination of stormwater.

Applicable Operational 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, within a week).
- Make sure all outside materials that have the potential to leach or spill to the drainage 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 coverings 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 the storage of wastewater, pump out the contents before the tank is full and dispose of wastewater to a sanitary sewer or approved wastewater treatment system.

Applicable Structural BMPs:

- Enclose the processing area in a building or shed, or cover the area with provisions for stormwater run-on prevention. Alternatively, pave and slope the area to drain to the sanitary sewer, holding tank, or process treatment system collection drain.

Optional Structural BMPs:

- Cover outdoor storage areas for fruits and vegetables.
- Use a containment curb, dike, or berm to prevent off-site runoff from storage or processing areas and to prevent stormwater run-on.

IV-6 Transfer of Liquid or Solid Materials Source Control BMPs

S409 BMPs for Fueling At Dedicated Stations

Description of Pollutant Sources: 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. Fueling may occur at:

- General service gas stations
- 24-hour convenience stores
- Construction sites
- Maintenance yards
- Warehouses
- Car washes
- Manufacturing establishments
- Port facilities
- Marinas
- Boatyards
- Businesses with fleet vehicles.

Typical causes of stormwater contamination at fueling stations include leaks/spills of fuels, lubrication oils, radiator coolants, and vehicle washwater.

Pollutant Control Approach: New or substantially remodeled* fueling stations must be constructed on an impervious concrete pad under a roof to keep out rainfall and stormwater run-on. The facility must use a treatment BMP for contaminated stormwater and wastewaters in the fueling containment area.

** Substantial remodeling includes (but is not limited to) replacing the canopy, or relocating or adding one or more fuel dispensers in such a way that modifies the Portland cement concrete (or equivalent) paving in the fueling area.*

Applicable Operational BMPs:

- Prepare an emergency spill response and cleanup plan (spill plan) per S426 BMPs for Spills of Oil and Hazardous Substances.
- Train employees on the proper use of fuel dispensers and on the spill plan.
- Have a designated trained person(s) available either on site or on call at all times to promptly

and properly implement the spill plan and immediately 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 using the station, and the spill kit must also be accessible and fully stocked at all times.
- The person conducting the fuel transfer must be present at the fueling pump during fuel transfer, particularly at unattended or self-serve stations.
- Keep suitable cleanup materials, such as dry adsorbent materials, on site to allow prompt cleanup of a spill.
- Do not use dispersants to clean up spills or sheens unless properly removed for disposal following application. Dispersants are not allowed to enter storm drains, surface waters, treatment systems, or sanitary sewers.
- Post signs in accordance with the requirements in the Uniform Fire Code (UFC) or International Fire Code (IFC). For example, post “No Topping Off” signs (topping off gas tanks causes spillage and vents gas fumes to the air).
- Make sure that the automatic shut-off on the fuel nozzle is functioning properly.
- Refer to S439 BMPs for In-Water and Over-Water Fueling for BMPs for in-water or over-water fueling operations

Applicable Structural Source Control BMPs:

For new or substantially remodeled fueling stations:

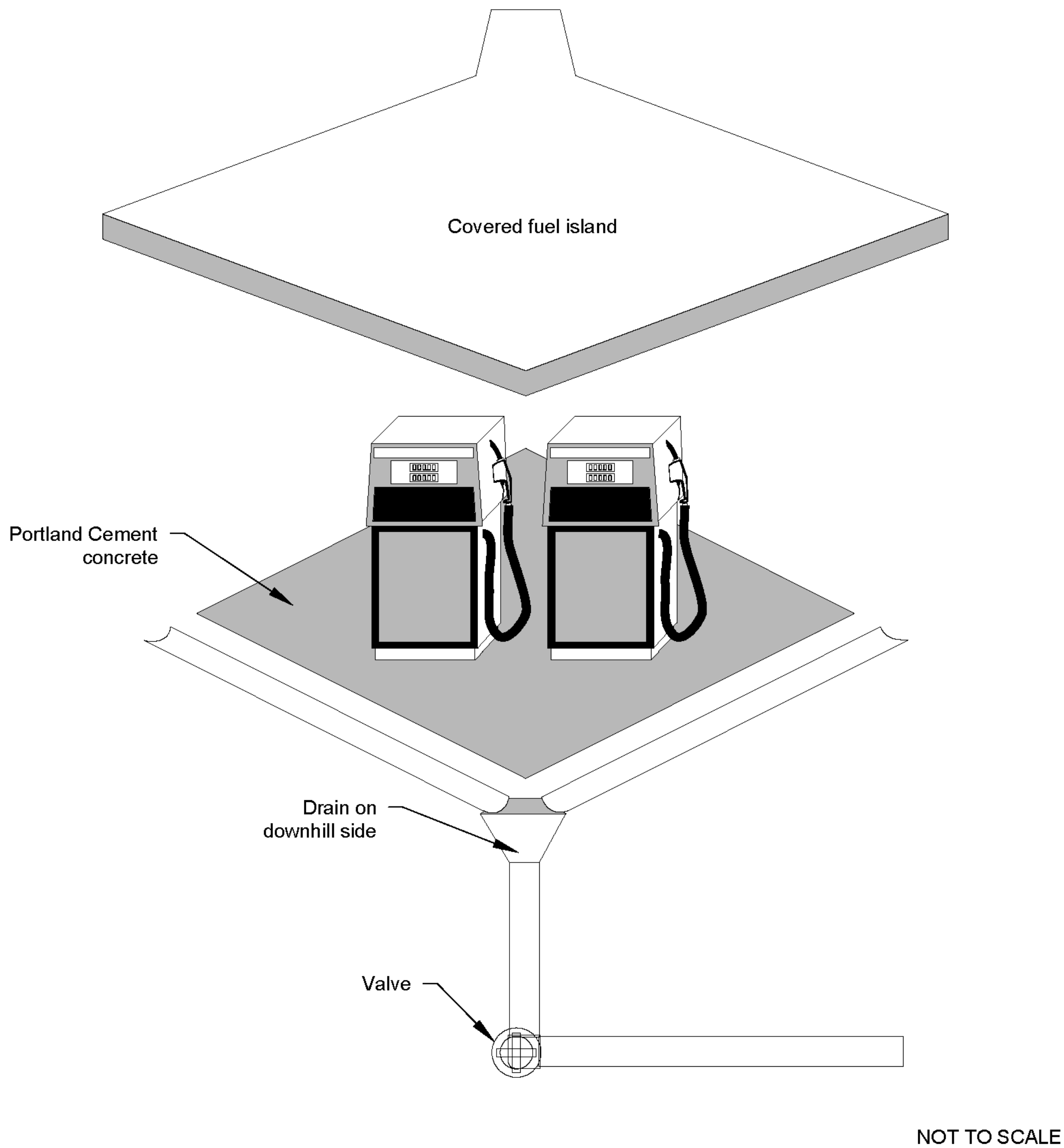
- Design the fueling island to:
  - Minimize stormwater contamination.
  - Control spills (dead-end sump or spill control separator in compliance with the UFC or IFC).
  - Collect stormwater and/or wastewater and direct it to an appropriate treatment system.
- Slope the concrete containment pad around the fueling island toward drains; either trench drains, catch basins and/or a dead-end sump. The slope of the drains shall not be less than 1 percent (Section 7901.8 of the UFC, Section 5703.6.8 of the IFC).
- Drains from containment pads must have a normally closed shutoff valve. The valve may be opened to convey contaminated stormwater to oil removal treatment such as an API or CP oil/water separator (see V-13 Oil and Water Separator BMPs), catchbasin insert, or equivalent treatment, and then to a basic treatment BMP (as described in III-1.2 Choosing Your Runoff Treatment BMPs) or to a sanitary sewer, if approved by the sewer authority. Discharges from treatment systems to storm sewer or surface water or to the ground must not display ongoing or recurring visible sheen and must not contain a significant amount of oil and grease.
- The spill control capacity must be sized in compliance with Section 7901.8 of the UFC. The

spill control capacity may be acquired by either an underground system including a sump, or an above ground containment area consisting of a containment pad with berms.

The fueling island may be designed as a spill containment pad with a sill or berm raised to a minimum of four inches (per Section 7901.8 of the UFC) to prevent the runoff of spilled liquids and to prevent run-on of stormwater from the surrounding area. All stormwater collected on the containment pad must discharge to treatment with a normally closed valve downstream of the treatment.

- The fueling pad must be paved with Portland cement concrete, or equivalent. Ecology does not consider asphalt an equivalent material.
- The fueling island must have a roof or canopy to prevent the direct entry of precipitation onto the spill containment pad (see Figure IV-6.1: Covered Fuel Island). The roof or canopy should, at a minimum, cover the spill containment pad (within the grade break or fuel dispensing area) and preferably extend 3 feet on each side for roofs and canopies 10 feet or less in height and 5 feet on each side for roofs and canopies greater than 10 feet in height. Overhangs reduce the introduction of windblown rain. Measure the overhang relative to the berm or other hydraulic grade break for the spill containment pad.

Figure IV-6.1: Covered Fuel Island



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Covered Fuel Island

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- Convey all roof drains to storm drains outside the fueling containment area.
- Convey stormwater collected on the fuel island containment pad to a sanitary sewer system, if approved by the sanitary authority, or to an approved treatment system such as an oil/water separator and a basic treatment BMP. (Basic treatment BMPs are listed in III-1.2 Choosing Your Runoff Treatment BMPs). Discharges from treatment systems to storm drains or surface water or to the ground must not display ongoing or recurring visible sheen and must not contain oil and grease.
- Alternatively, collect stormwater from the fuel island containment pad and hold for proper off-site disposal.
- Approval from the local sewer authority is required for conveyance of any fuel-contaminated stormwater to a sanitary sewer. The discharged stormwater must comply with pretreatment regulations (WAC 173-216-060). These regulations prohibit discharges that could "cause fire or explosion." State and federal pretreatment regulations define an explosive or flammable mixture, based on a flash point determination of the mixture. Stormwater could be conveyed to a sanitary sewer system if it is determined not to be explosive.
- Transfer the fuel from the delivery tank trucks to the fuel storage tank in impervious contained areas and ensure that appropriate overflow protection is used. Alternatively, cover nearby storm drains during the filling process and use drip pans under all hose connections.

Additional BMP for Vehicles 10 feet in height or greater

A roof or canopy may not be feasible at fueling stations that regularly fuel vehicles that are 10 feet in height or greater, particularly at industrial or WSDOT sites. At those types of fueling facilities, the following BMPs apply, as well as the applicable BMPs and fire prevention (UFC requirements) of this BMP for fueling stations:

- If a roof or canopy is impractical, the concrete fueling pad must be equipped with emergency spill control including a shutoff valve for drainage from the fueling area. Maintain the valve in the closed position in the event of a spill. Clean up spills and dispose of materials off-site in accordance with S426 BMPs for Spills of Oil and Hazardous Substances.
- The valve may be opened to convey contaminated stormwater to a sanitary sewer, if approved by the sewer authority, or to oil removal treatment such as an API or CP oil/water separator (see V-13 Oil and Water Separator BMPs), catchbasin insert, or equivalent treatment, and then to a basic treatment BMP (as described in III-1.2 Choosing Your Runoff Treatment BMPs). Discharges from treatment systems to storm sewer or surface water or to the ground must not display ongoing or recurring visible sheen and must not contain a significant amount of oil and grease.

S412 BMPs for Loading and Unloading Areas for Liquid or Solid Material

Description of Pollutant Sources: Operators typically conduct loading/unloading of liquid and solid materials at industrial and commercial facilities 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 may cause stormwater contamination. Spills from hydraulic line breaks are a common problem at loading docks.

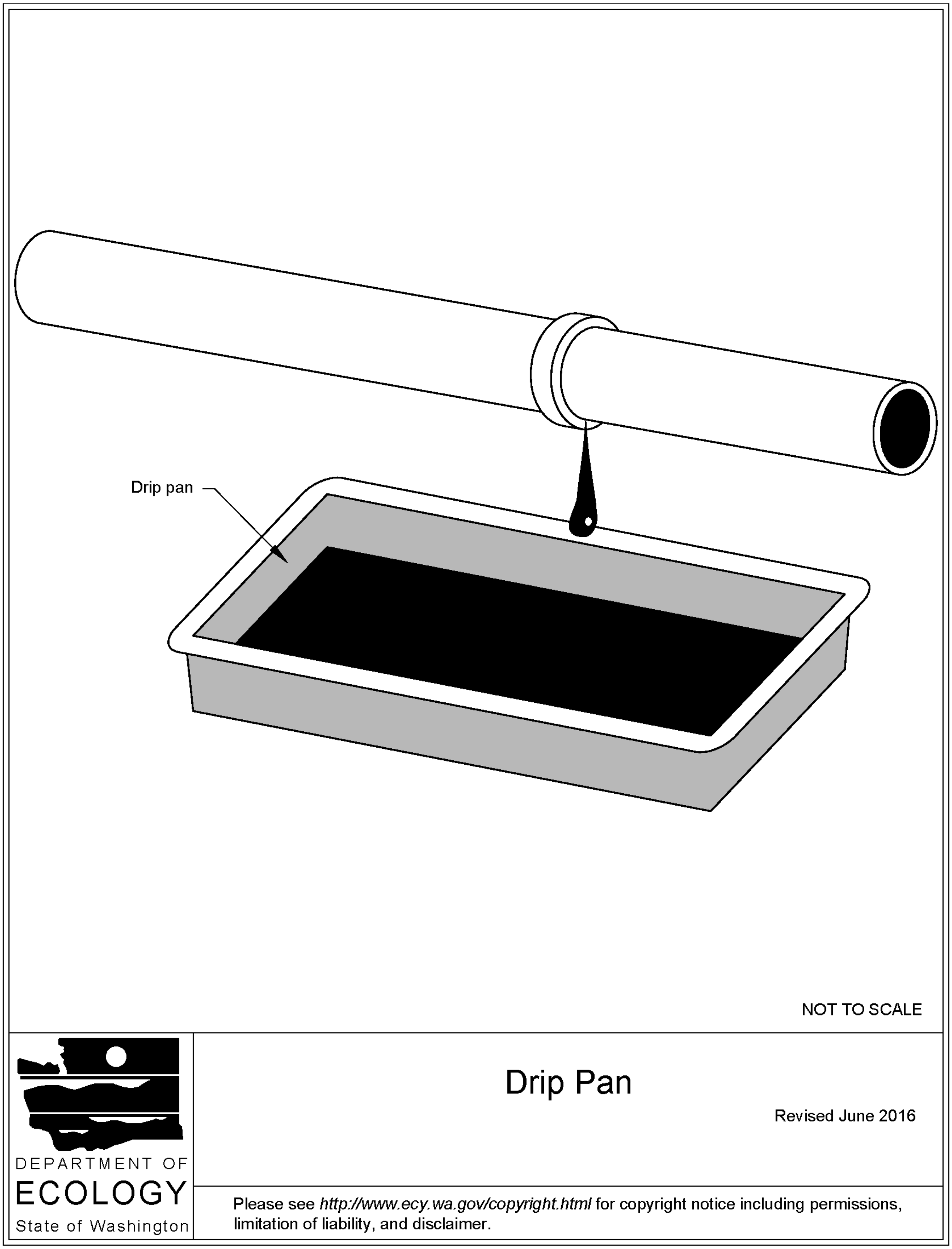
Pollutant Control Approach: Cover and contain the loading/unloading area where necessary to prevent run-on of stormwater and runoff of contaminated stormwater.

Applicable Operational BMPs:

At All Loading/ Unloading Areas

- A significant amount of debris can accumulate at outside, uncovered loading/unloading areas. Sweep these surfaces frequently to remove loose material that could contaminate stormwater. Sweep areas temporarily covered after removal of the containers, logs, or other material covering the ground.
- Place drip pans, or other appropriate temporary containment device, at locations where leaks or spills may occur such as hose connections, hose reels and filler nozzles. Always use drip pans when making and breaking connections (see Figure IV-6.2: Drip Pan). Check loading/unloading equipment such as valves, pumps, flanges, and connections regularly for leaks and repair as needed.

Figure IV-6.2: Drip Pan



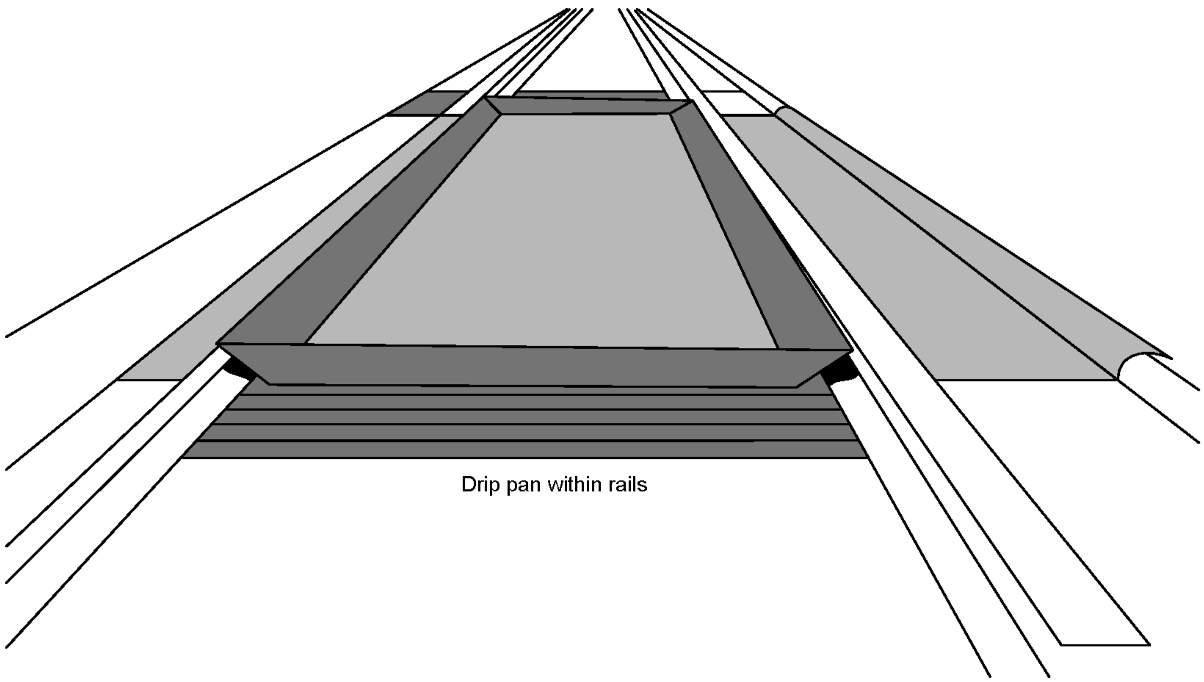
At Tanker Truck and Rail Transfer Areas to Above/Below-ground Storage Tanks

- To minimize the risk of accidental spillage, prepare an "Operations Plan" that describes procedures for loading/unloading. Train employees in its execution and post it or otherwise have it readily available to all employees.
- Report spills of reportable quantities to Ecology.
- Prepare and implement an Emergency Spill Cleanup Plan for the facility (See S426 BMPs for Spills of Oil and Hazardous Substances) which includes the following BMPs:
    - Ensure the cleanup of liquid/solid spills in the loading/unloading area immediately, if a significant spill occurs, and, 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. (See S426 BMPs for Spills of Oil and Hazardous Substances).
    - Ensure that an employee trained in spill containment and cleanup is present during loading/unloading.

At Rail Transfer Areas to Above/below-ground Storage Tanks

Install a drip pan system as illustrated (see Figure IV-6.3: Drip Pan Within Rails) within the rails to collect spills/leaks from tank cars and hose connections, hose reels, and filler nozzles.

Figure IV-6.3: Drip Pan Within Rails



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Drip Pan Within Rails

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Loading/Unloading from/to Marine Vessels

Facilities and procedures for the loading or unloading of petroleum products must comply with Coast Guard requirements specified in Coast Guard Requirements for Marine Transfer of Petroleum Products within I-2.15 Other Requirements.

Transfer of Small Quantities from Tanks and Containers

Refer to S428 BMPs for Storage of Liquids in Permanent Aboveground Tanks and S427 BMPs for Storage of Liquid, Food Waste, or Dangerous Waste Containers for requirements on the transfer of small quantities from tanks and containers, respectively.

Applicable Structural Source Control BMPs:

At All Loading/ Unloading Areas

- Consistent with Uniform Fire Code requirements (see Uniform Fire Code Requirements within I-2.15 Other Requirements) and to the extent practicable, conduct unloading or loading of solids and liquids in a manufactured building, under a roof, or lean-to, or other appropriate cover.
- 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 of the shoreline, or slope the edge such that the stormwater can flow to an internal storm sewer system that leads to an approved treatment BMP. Avoid draining directly to the surface water from loading areas.
- Pave and slope loading/unloading areas to prevent the pooling of water. Minimize the use of catch basins and drain lines within the interior of the paved area or place catch basins in designated “alleyways” that are not covered by material, containers, or equipment.
- Retain on-site the necessary materials for rapid cleanup of spills.

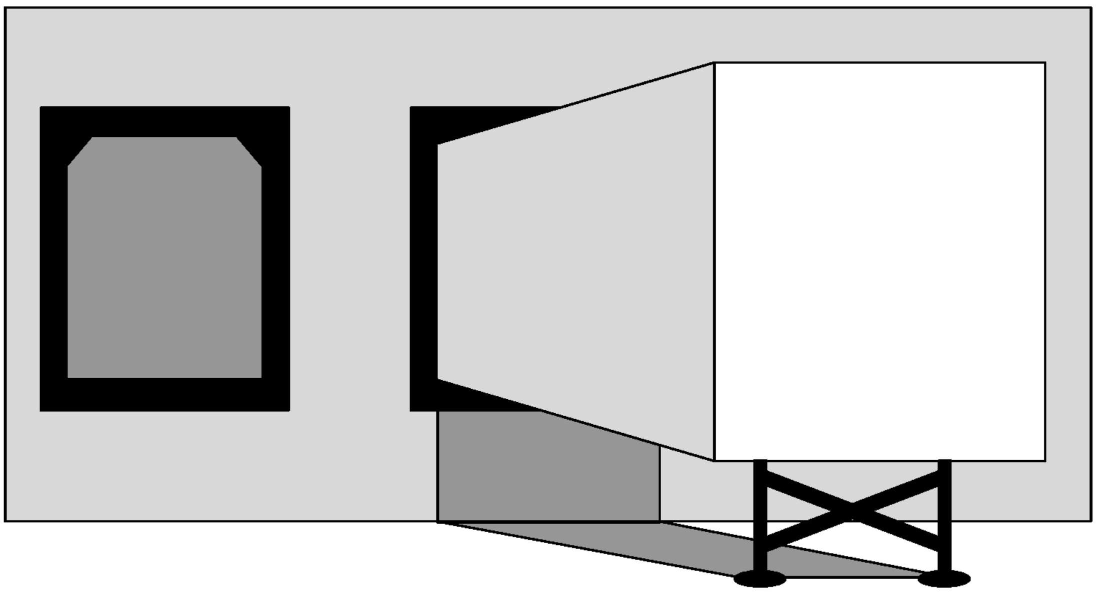
Recommended Structural Source Control BMPs:

For the transfer of pollutant liquids in areas that cannot contain a catastrophic spill, install an automatic shutoff system in case 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 IV-6.4: Loading Dock with Door Skirt and Figure IV-6.5: 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.

Figure IV-6.4: Loading Dock with Door Skirt



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Loading Dock with Door Skirt

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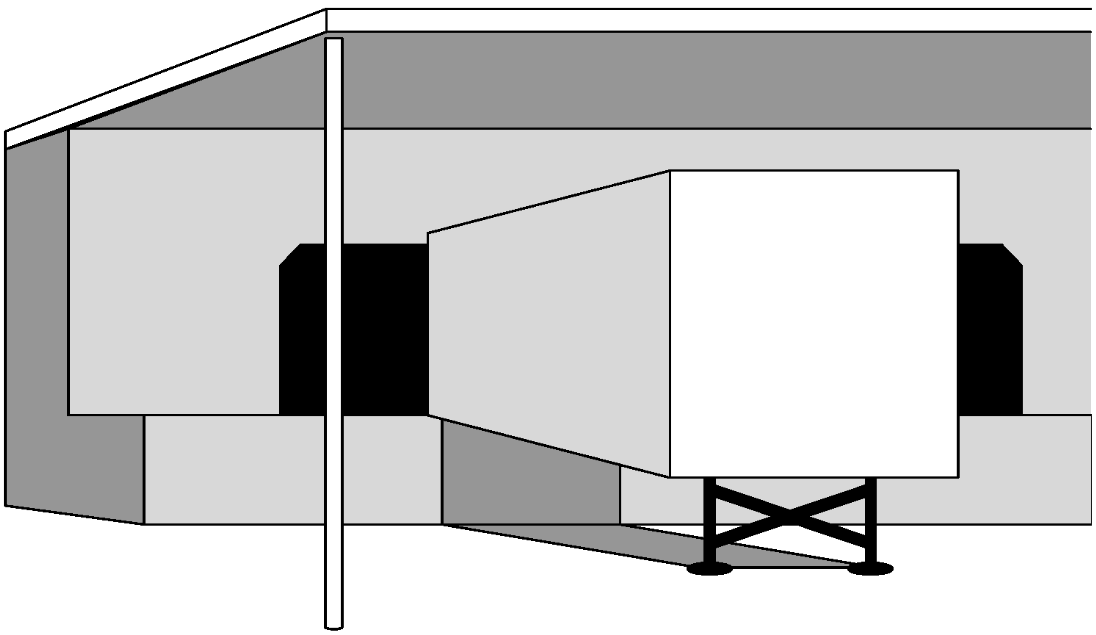
Figure IV-6.5: Loading Dock with Overhang



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Loading Dock with Overhang

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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, a spill control oil/water separator, or other spill control device. The minimum spill retention time should be 15 minutes at the greater flow rate of the highest fuel dispenser nozzle through-put rate, or the peak flow rate of the 6-month, 24-hour storm event over the surface of the containment pad, whichever is greater. The capacity of the spill containment sump should be a minimum of 50 gallons with adequate additional capacity provided for grit sedimentation.

S419 BMPs for Mobile Fueling of Vehicles and Heavy Equipment

Description of Pollutant Sources: 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. Diesel fuel is categorized as a Class II Combustible Liquid, whereas gasoline is categorized as a Flammable Liquid.

Note that some local fire departments may have restrictions on mobile fueling practices.

Historically organizations conducted mobile fueling for off-road vehicles operated for extended periods in remote areas. This includes construction sites, logging operations, and farms. Some organizations conduct mobile fueling of on-road vehicles commercially in the State of Washington.

Pollutant Control Approach: Fueling operators need proper training of fueling operations, the use of spill/drip control, and fuel transfer procedures.

Applicable Operational BMPs:

Organizations and individuals conducting mobile fueling operations must implement the BMPs in the following list. The operating procedures for the driver/operator should be simple, clear, effective, and their implementation verified by the organization liable for environmental and third party damage.

- Ensure that the local fire department approves all mobile fueling operations. Comply with local and Washington State fire codes.
- In fueling locations that are in close proximity to sensitive aquifers, designated wetlands, wetland buffers, or other waters of the State, approval by local jurisdictions is necessary to ensure compliance with additional local requirements.
- Ensure compliance with all 49 CFR 178 requirements for all fuel delivery vehicles or containers. Documentation from a Department of Transportation (DOT) Registered Inspector provides proof of compliance.
- Ensure the presence and the constant observation/monitoring of the driver/operator at the fuel transfer location at all times during fuel transfer and ensure implementation of the following procedures at the fuel transfer locations:

- Locate the point of fueling at least 25 feet from the nearest storm sewer or inside an impervious containment with a volumetric holding capacity equal to or greater than 110 percent of the fueling tank volume, or covering the storm sewer to ensure no inflow of spilled or leaked fuel. Covers are not required for storm sewers that convey the inflow to a spill control separator approved by the local jurisdiction and the fire department. Potential spill/leak conveyance surfaces must be impervious and in good repair. Do not remove the drain cover if sheen is present. Properly collect and dispose of any contaminated material.
- 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 at least 5 gallons. There is no need to report spills retained in the drip pan or the pad.
- Manage the handling and operation of fuel transfer hoses and nozzle, drip pan(s), and absorbent pads as needed to prevent spills/leaks of fuel from reaching the ground, storm sewer, and receiving waters.
- Avoid extending the fueling hoses across a traffic lane without fluorescent traffic cones, or equivalent devices, conspicuously placed to block all traffic from crossing the fuel hose.
- Remove the fill nozzle and cease filling the tank when the automatic shut-off valve engages. Do not lock automatic shutoff fueling nozzles in the open position.
- Do not “top off” the fuel receiving equipment.

- Provide the driver/operator of the fueling vehicle with:
  - Adequate flashlights or other mobile lighting to view fuel fill openings with poor accessibility. Consult with local fire department for additional lighting requirements.
  - Two-way communication with his/her home base.
- Train the driver/operator annually in spill prevention and cleanup measures and emergency procedures. Make all employees aware of the significant liability associated with fuel spills.
- The responsible manager shall properly sign and date the fueling operating procedures. Distribute procedures to the operators, retain them in the organization files, and make them available in the event an authorized government agency requests a review.
- Immediately notify the local fire department (911), the appropriate regional office of the Department of Ecology, and the local jurisdiction in the event of any spill entering surface or ground waters. Establish a “call down list” to ensure the rapid and proper notification of management and government officials should any significant amount of product be lost off-site. Keep the list in a protected but readily accessible location in the mobile fueling truck. The “call down list” should also identify spill response contractors available in the area to ensure the rapid removal of significant product spillage into the environment.
- In all fueling vehicles, maintain a minimum of the following spill cleanup materials and have them readily available for use:

- Non-water absorbents capable of absorbing at least 15 gallons of fuel.
- A storm drain plug or cover kit.
- A non-water absorbent containment boom of a minimum 10 feet in length with a 12-gallon minimum absorbent capacity.
- A non-spark generating shovel (a steel shovel could generate a spark and cause an explosion in the right environment around a spill).
- Two, five-gallon buckets with lids.

- 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.
- Immediately remove and properly dispose of soils with visible surface contamination to prevent the spread of chemicals to groundwater or receiving water via stormwater runoff.
- Do not use dispersants to clean up spills or sheens unless properly removed for disposal following application. Dispersants are prohibited from use for spills on water or where the dispersant may enter storm drains, surface waters, treatment systems, or sanitary sewers.

Applicable Structural Source Control BMPs:

Include the following fuel transfer site components:

- Automatic fuel transfer shut-off nozzles.
- An adequate lighting system at the filling point.

S426 BMPs for Spills of Oil and Hazardous Substances

Description of Pollutant Sources: Washington Administrative Code requires owners or operators of facilities engaged in drilling, producing, gathering, storing, processing, transferring, distributing, refining, or consuming oil and/or oil products to have a Spill Prevention and Emergency Cleanup Plan (SPECP). The SPECP is required if the above ground storage capacity of the facility is 1,320 gallons or more of oil. Additionally, the SPECP is required if the facility, due to its location, could reasonably be expected to discharge oil in harmful quantities, as defined in 40 CFR Part 110, into or upon the navigable waters of the United States or adjoining shorelines {40 CFR 112.1 (b)}. Onshore and offshore facilities, which, due to their location, could not reasonably be expected to discharge oil into or upon the navigable waters of the United States or adjoining shorelines are exempt from these regulations {40 CFR 112.1(d)(1)(i)}. State Law requires owners of businesses that produce dangerous wastes to have a SPECP. These businesses should refer to Washington State/Federal Emergency Spill Cleanup Requirements (see I-2.15 Other Requirements). The federal definition of oil is 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.

Pollutant Control Approach: Maintain, update, and implement a Spill Prevention and Emergency Cleanup Plan.

Applicable Operational BMPs:

The businesses and public agencies identified in Appendix IV-A: Urban Land Uses and Pollutant Generating Sources required to prepare and implement a Spill Prevention and Emergency Cleanup Plan shall implement the following:

- Prepare a Spill Prevention and Emergency Cleanup Plan (SPECP), which includes:
  - A description of the facility including the owner's name and address.
  - The nature of the activity at the facility.
  - The general types of chemicals used or stored at the facility.
  - A site plan showing the location of storage areas for chemicals, the locations of storm drains, the areas draining to them, and the location and description of any devices to stop spills from leaving the site such as positive control valves.
  - Cleanup procedures.
  - Notification procedures used in the event of a spill, such as notifying key personnel. Agencies such as Ecology, local fire department(s), Washington State Patrol, and the local Sewer Authority, shall be notified.
  - The name of the designated person with overall spill cleanup and notification responsibility.
- Train key personnel in the implementation of the SPECP. Prepare a summary of the plan and post it at appropriate points in the building, identifying the spill cleanup coordinators, location of cleanup kits, and phone numbers of regulatory agencies to contact in the event of a spill.
- Update the SPECP regularly.
- Immediately notify Ecology, the local jurisdiction, and the local Sewer Authority if a spill may reach sanitary or storm sewers, ground water, or surface water, in accordance with federal and Ecology spill reporting requirements.
- Immediately clean up spills. Do not use emulsifiers for cleanup unless there is an appropriate disposal method for the resulting oily wastewater. Do not wash absorbent material down a floor drain or into a storm sewer.
- Locate emergency spill containment and cleanup kit(s) in high-potential spill areas. The contents of the kit shall be appropriate for the type and quantities of chemical liquids stored at the facility.

Recommended Additional Operational BMP:

Spill kits should include appropriately lined drums, absorbent pads, and granular or powdered materials for neutralizing acids or alkaline liquids where applicable. In fueling areas: Package absorbent material in small bags for easy use and make available small drums for storage of absorbent and/or used absorbent. Deploy spill kits in a manner that allows rapid access and use by employees.

S439 BMPs for In-Water and Over-Water Fueling

Description of Pollutant Sources: 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.

Pollutant Control Approach: Provide employees with proper training and use spill control devices to prevent the discharge of pollutants in the receiving water or the drainage system.

Applicable Operational BMPs

Applicable Operational 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 S426 BMPs for Spills of Oil and Hazardous Substances.
- Manage petroleum-contaminated booms, pads, and absorbents in a designated collection container and properly dispose of these materials (see S427 BMPs for 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.

Applicable Operational 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.

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IV-7 Other Source Control BMPs

S401 BMPs for the Building, Repair, and Maintenance of Boats and Ships

Description of Pollutant Sources: Sources of pollutants for the building, repair, and maintenance of boats and ships 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, anti-corrosion compounds, paint chips, scrap metal, welding rods, resins, glass fibers, dust, and miscellaneous trash. Pollutant constituents include suspended solids, oil and grease, organics, copper, lead, tin, and zinc.

Pollutant Control Approach: Apply good housekeeping, conduct routine preventive maintenance, and cover and contain BMPs in and around work areas.

NPDES Permit Requirements: Ecology's statewide Boatyard General Permit applies to boatyards that discharge stormwater runoff from areas with industrial activity directly to the ground, to a surface waterbody, or to a storm sewer system that drains to a surface waterbody. This general permit also regulates wastewater from pressure washing in boatyards. All boatyards in the state must apply for coverage under this permit and must comply with all conditions specified in this permit, as applicable to their facility, unless exempted. Ecology may require coverage under an individual NPDES permit for large boatyards and shipyards in Washington State not covered by the Boatyard General Permit or Industrial Stormwater General Permit (ISGP).

Applicable Operational BMPs:

- Clean regularly all accessible work, service, and storage areas to remove debris, spent sandblasting material, and any other potential stormwater pollutants.
- Whenever the boat is in the water, avoid the use of soaps, detergents and other chemicals that need to be rinsed or hosed off. If necessary, consider applying sparingly so that a sponge, towel or rag can be used to remove residuals. Consider instead washing the boat in a suitable controlled area (see S431 BMPs for Washing and Steam Cleaning Vehicles / Equipment / Building Structures) while it is out of the water.
- Sweep rather than hose debris on the dock. Collect and convey hose water to treatment if hosing is unavoidable,
- Collect spent abrasives regularly and store them under cover to await proper disposal.
- Dispose of greasy rags, oil filters, air filters, batteries, spent coolant, and degreasers properly.
- Drain oil filters before disposal or recycling.
- Immediately repair or replace leaking connections, valves, pipes, hoses, and other equipment

that may cause the contamination of stormwater.

- Use drip pans, drop cloths, tarpaulins, or other protective devices in all paint mixing and solvent operations unless carried out in impervious contained and covered areas.
- Convey sanitary sewage to pump-out stations, portable on-site pump-outs, commercial mobile pump-out facilities, or other appropriate onshore facilities.
- Maintain automatic bilge pumps in a manner that will prevent automatic pumping of waste material into surface water.
- Prohibit uncontained spray painting, blasting or sanding activities over open water.
- Do not dump or pour waste materials down floor drains, sinks, or outdoor storm drain inlets that discharge to surface water. Plug floor drains connected to storm drains or to surface water. If necessary, install a regularly operated sump pump.
- Prohibit outside spray-painting, blasting, or sanding activities during windy conditions that render containment ineffective.
- Do not burn paint and/or use spray guns on topsides or above decks.
- Immediately clean up any spillage on the pier, wharf, boat, ship deck, or adjacent surface areas and dispose of the wastes properly.
- Apply source control BMPs for other activities conducted at the marina, boat yard, shipyard, or port facility (see S409 BMPs for Fueling At Dedicated Stations, S431 BMPs for Washing and Steam Cleaning Vehicles / Equipment / Building Structures, and S426 BMPs for Spills of Oil and Hazardous Substances).
- Locate spill kits so they are readily accessible on all piers and docks.

Applicable Structural Source Control BMPs:

- 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 the surface water. Keep the use of such platforms to a minimum, and do not perform extensive repair, modification, surface preparation, or coating while the boat is in the water (anything in excess of 25 percent of the surface area of the vessel above the waterline).
- 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 storm sewers or receiving waters. Use plywood and/or plastic sheeting to cover open areas between decks when sandblasting (scuppers, railings, freeing ports, ladders, and doorways).
- Direct deck drainage to a collection system sump for settling and/or additional treatment.
- Store cracked batteries in covered secondary containers.

Recommended Additional Operational BMPs:

- Consider recycling paint, paint thinner, solvents, used oils, oil filters, pressure wash wastewater and any other recyclable materials.
- Perform paint and solvent mixing, fuel mixing, etc., on shore.

S402 BMPs for Commercial Animal Handling Areas

Description of Pollutant Sources: Animals at racetracks, kennels, fenced pens, veterinarians, and businesses that provide boarding services for horses, dogs, cats, etc., can generate pollutants from the following activities: manure deposits, animal washing, grazing, and any other animal handling activity that could contaminate stormwater. Pollutants can include coliform bacteria, nutrients, and total suspended solids. Individual Stormwater Permits covering commercial animal handling facilities include additional applicable source controls.

Pollutant Control Approach: To prevent, to the maximum extent practicable, the discharge of contaminated stormwater from animal handling and keeping areas.

Applicable Operational BMPs

- Regularly sweep and clean animal keeping areas to collect and properly dispose of droppings, uneaten food, and other potential stormwater contaminants.
- Do not hose down areas that contain potential stormwater contaminants where they drain to storm drains or to receiving waters.
- Do not discharge any washwater to storm drains or to receiving waters without proper treatment.
- If the operator keeps animals in unpaved and uncovered areas, the ground must have either vegetative cover or some other type of ground cover such as mulch.
- Surround the area where animals are kept with a fence or other means to prevent animals from moving away from the controlled area where BMPs are used.
- For outside surface areas that must be disinfected, use an unsaturated mop to spot clean the area. Do not allow wastewater runoff to enter the drainage system.
- Do not stockpile manure in areas where runoff is allowed to flow into a storm drain or to nearby receiving waters or wetlands.

S403 BMPs for Commercial Composting

Description of Pollutant Sources: Commercial composting facilities, operating outside without cover, require large areas to decompose wastes and other feedstocks. Design these facilities to separate stormwater from leachate (i.e., industrial wastewater) to the greatest extent possible. When stormwater contacts 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 composting facilities include runoff from areas not associated with active processing and curing, such as product storage areas, vehicle maintenance areas, and access roads.

NPDES and State Solid Waste Permit Requirements: Composting facilities are regulated under WAC 173-350-220. Solid Waste Regulations require the collection and containment of all leachate produced from activities at commercial composting facilities. Composting facilities that propose to discharge to surface water, municipal sewer system, or ground water must obtain the appropriate permits. Zero discharge is possible by containing all leachate from the facility (in tanks or ponds) for use early in the composting process or preventing production of leachate (by composting under a roof or in an enclosed building).

Pollutant Control Approach: Consider zero leachate discharge.

Applicable Operational, Structural, and Treatment BMPs:

- See WAC 173-350-220, Composting Facilities
- See *Siting and Operating Composting Facilities in Washington State: Good Management Practices* (Ecology, 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. Contact your local permitting authority and jurisdictional health department or district for more information.
- Apply for coverage under the Industrial Stormwater General Permit (ISGP) if the facility discharges stormwater to surface water or a municipal stormwater system. If all stormwater from the facility properly infiltrates to ground water, the ISGP may not be required. There are some cases where an Individual State Waste Discharge permit is required. Check with your local Ecology office and jurisdictional health department or district to discuss your permitting options.
- 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 sanitary sewer, holding tank, or on-site treatment system. Leachate may not go to the storm drain or groundwater.
- Collect the leachate with a dike or berm, or with intercepting drains placed on the down slope side of the compost area.
- Direct outside runoff away from the composting areas.
- Clean up debris from yard areas as needed to prevent stormwater contamination.

Recommended 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.
- Locate stored residues in areas designed to collect leachate and limit storage time to prevent degradation and generation of leachate.

S404 BMPs for Commercial Printing Operations

Description of Pollutant Sources: 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. With indoor printing operations, the only likely points of potential contact with stormwater are the outside temporary storage of waste materials and offloading of chemicals at external unloading bays. Pollutants can include TSS, pH, heavy metals, oil and grease, and COD.

Pollutant Control Approach: Ensure appropriate disposal and NPDES permitting of process wastes. Cover and contain stored raw and waste materials.

Applicable Operational BMPs:

- Discharge process wastewaters to a sanitary sewer, if approved by the local sewer authority, or to an approved process wastewater treatment system.
- Do not discharge process wastes or wastewaters into storm sewers or surface water.
- 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, and environmentally acceptable materials handling procedures.
- Store materials in proper, appropriately labeled containers. Identify and label all chemical substances.
- Regularly inspect all stormwater management devices and maintain as necessary.
- Try to use press washes without listed solvents, and with the lowest volatile organic compound (VOC) content possible. Do not evaporate ink cleanup trays to the outside atmosphere.
- Place cleanup sludges into a container with a tight lid and dispose of as dangerous waste. Do not dispose of cleanup sludges in the garbage or in containers of soiled towels.

For additional information on pollution prevention, Ecology recommends *Environmental Management and Pollution Prevention: A Guide for Lithographic Printers* (Ecology, 2001).

S413 BMPs for Log Sorting and Handling

Description of Pollutant Sources: 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

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 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

Ecology's Baseline General 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 an Industrial Stormwater Pollution Prevention Plan (SWPPP). Required and recommended operational, structural source control, and treatment BMPs are presented in detail in *Industrial Stormwater General Permit Implementation Manual for Log Yards* (Ecology, 2016c). Ecology recommends that all log yard facilities obtain a copy of this document.

S414 BMPs for Maintenance and Repair of Vehicles and Equipment

Description of Pollutant Sources: Pollutant sources include parts/vehicle cleaning, spills/leaks of fuel and other liquids, replacement of liquids, outdoor storage of batteries/liquids/parts, and vehicle parking.

Pollutant Control Approach: Control of leaks and spills of fluids using good housekeeping and cover and containment BMPs.

Applicable Operational BMPs:

- Inspect all incoming vehicles, parts, and equipment stored temporarily outside for leaks.
- Use drip pans or containers under parts or vehicles that drip or that are likely to drip liquids, such as during dismantling of liquid containing parts or removal or transfer of liquids. Inspect drip pans regularly to prevent accumulation of stormwater or other liquids, and dispose of any accumulated liquid appropriately.
- 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.
- Remove liquids from vehicles retired for scrap.
- Empty oil and fuel filters before disposal. Provide for proper disposal of used oil and fuel.
- Do not pour/convey washwater, liquid waste, or other pollutants into storm drains or to surface water. Check with the local sanitary sewer authority for approval to convey water to a sanitary sewer.
- Do not connect maintenance and repair shop floor drains to storm drains or to surface water.
- To allow for snowmelt during the winter, install a drainage trench with a sump for particulate collection. Use the drainage trench for draining the snowmelt only. Do not discharge any vehicular or shop pollutants to the trench drain.

Applicable Structural Source Control BMPs:

- Conduct all maintenance and repair of vehicles and equipment in a building, or other covered impervious containment area that is sloped to prevent run-on of uncontaminated stormwater and runoff of contaminated water.
- Operators may conduct maintenance of refrigeration engines in refrigerated trailers in the parking area. Exercise due caution to avoid the release of engine or refrigeration fluids to storm drains or surface water.
- Park large mobile equipment, such as log stackers, in a designated contained area.

Applicable Treatment BMPs:

Convey contaminated stormwater runoff from vehicle staging and maintenance areas to a sanitary sewer, if allowed by the local sewer authority, or to an API or CP oil and water separator followed by a Basic Treatment BMP (See Volume V), applicable filter, or other equivalent oil treatment system.

Note this applicable treatment BMP for contaminated stormwater.

Recommended Additional Operational BMPs:

- Store damaged vehicles inside a building or other covered containment, until successfully removing all liquids.
- Clean parts with aqueous detergent based solutions or non-chlorinated solvents such as kerosene or high flash mineral spirits, and/or use wire brushing or sand blasting whenever practicable. Avoid using toxic liquid cleaners such as methylene chloride, 1,1,1-trichloroethane, trichloroethylene or similar chlorinated solvents. Choose cleaning agents that can be recycled.
- Inspect all BMPs regularly, particularly after a significant storm. Identify and correct deficiencies to ensure that the BMPs are functioning as intended.
- Avoid hosing down work areas. Use dry methods for cleaning leaked fluids.
- Recycle greases, used oil, oil filters, antifreeze, cleaning solutions, automotive batteries, hydraulic fluids, transmission fluids, and engine oils. Contact Ecology's Hazardous Waste & Toxics Reduction Program for recommendations on recycling or disposal of waste materials. (https://ecology.wa.gov/About-us/Get-to-know-us/Our-Programs/Hazardous-Waste-Toxics-Reduction)
- Do not mix dissimilar or incompatible waste liquids stored for recycling.

S418 BMPs for Manufacturing Activities - Outside

Description of Pollutant Sources: Manufacturing pollutant sources include outside process areas, stack emissions, and areas where manufacturing activity has taken place in the past and significant exposed pollutant materials remain.

Pollution Control Approach: Cover and contain outside manufacturing and prevent stormwater run-on and contamination, where feasible.

Applicable Operational BMP:

- Sweep paved areas regularly, as needed, to prevent contamination of stormwater.
- Alter the activity by eliminating or minimizing the contamination of stormwater.

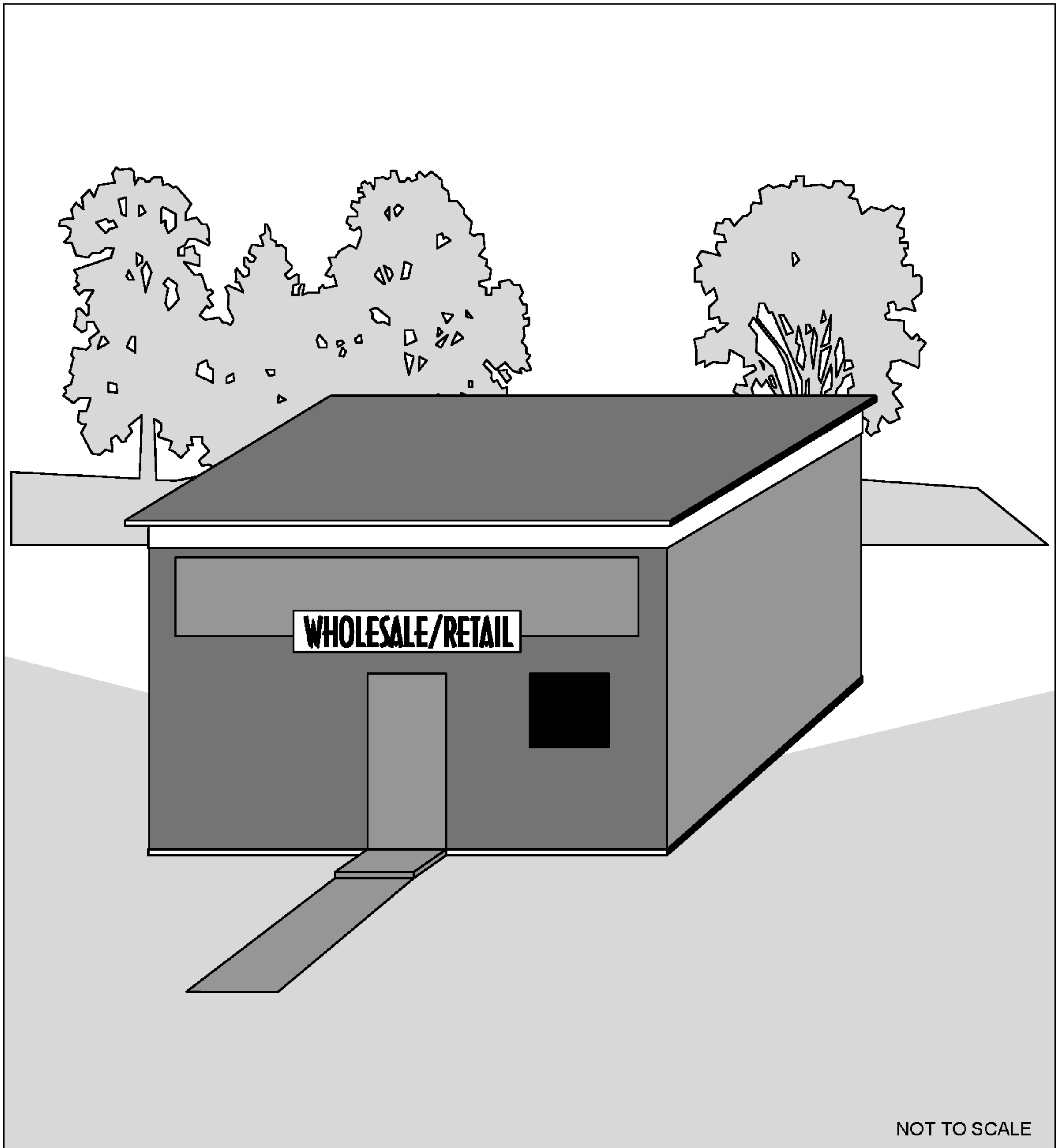
Applicable Structural Source Control BMPs:

- Enclose the activity (see Figure IV-7.1: Enclose the Activity). If possible, enclose the manufacturing activity in a building.
- Cover the activity and connect floor drains to a sanitary sewer, if approved by the local sewer

authority. Berm or slope the floor as needed to prevent drainage of pollutants to outside areas. (See Figure IV-7.2: Cover the Activity).

- Isolate and segregate pollutants as feasible. Convey the segregated pollutants to a sanitary sewer, process treatment, or a dead-end sump depending on available methods and applicable permit requirements.

Figure IV-7.1: Enclose the Activity



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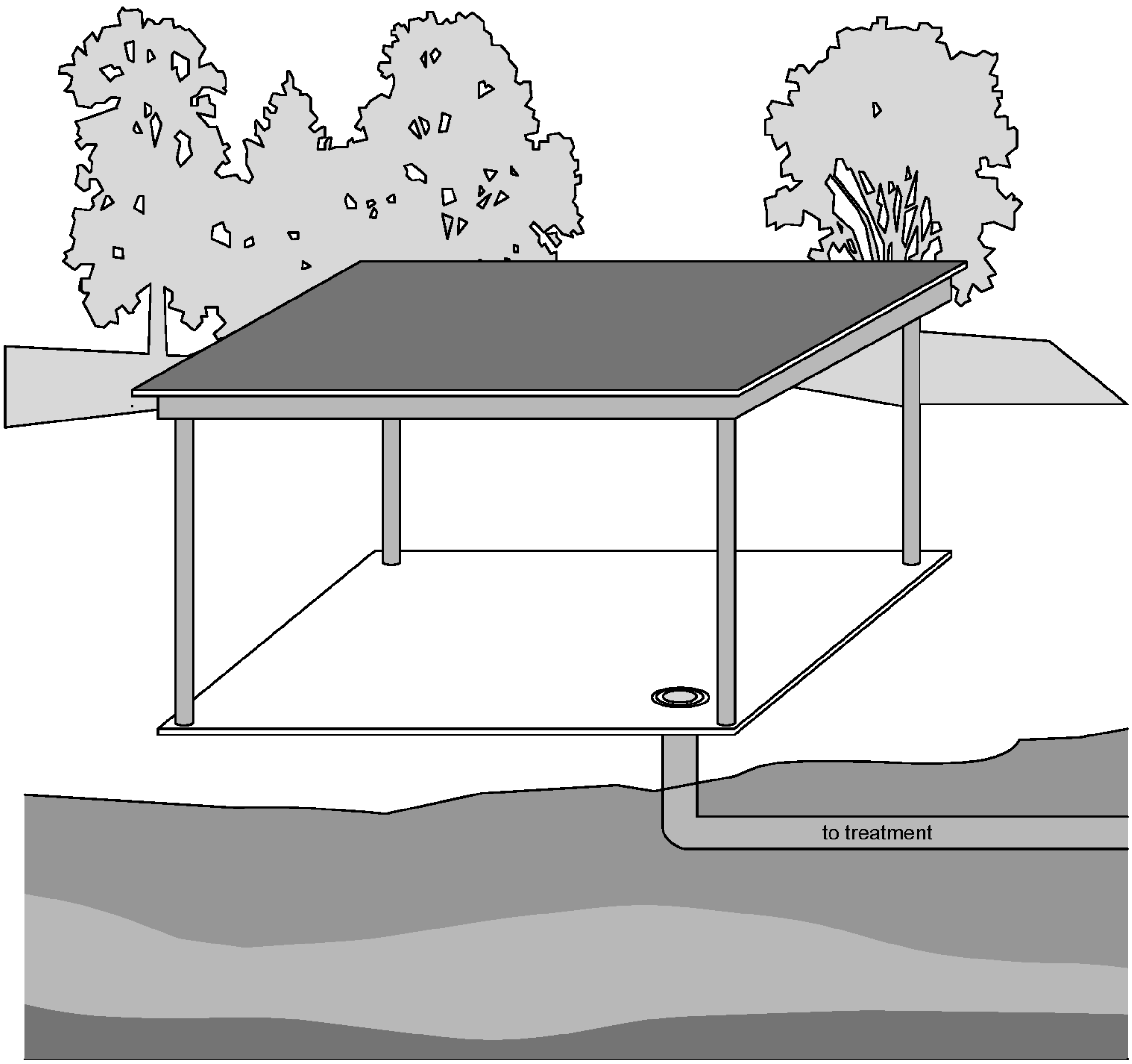
State of Washington

Enclose the Activity

Revised June 2016

Figure IV-7.2: Cover the Activity



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Cover the Activity

Revised June 2016

S420 BMPs for Painting/Finishing/Coating of Vehicles/Boats/Buildings/Equipment

Description of Pollutant Sources: 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.

Pollutant Control Approach: Cover and contain painting and sanding operations and apply good housekeeping and preventive maintenance practices to prevent the contamination of stormwater with painting over sprays and grit from sanding.

Applicable Operational BMPs:

- Train employees in the careful application of paints, finishes, and coatings to reduce misuse and over spray. Use drop cloths underneath outdoor painting, scraping, and 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 a storm sewer, receiving water, or conveyance ditch.
- On dock areas sweep rather than hose down debris. Collect any hose water generated and convey to appropriate treatment and disposal.
- Use a catch basin cover, filter sock, or other effective runoff control device if dust, grit, washwater, or other pollutants may escape the work area and enter a catch basin. 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 for activities such as outdoor paint mixing and tool cleaning, or where spills can contaminate stormwater.
- Properly dispose of all wastes and prevent all uncontrolled releases to the air, ground, or water.
- Clean paintbrushes and tools covered with water-based paints in sinks connected to sanitary sewers. Do not dump pollutants collected in portable containers into a stormwater drain.
- 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) 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.

Applicable Structural Source Control BMPs:

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 that render containment ineffective.

Recommended Operational BMPs:

- Recycle paint, paint thinner, solvents, pressure washwater, 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.

S422 BMPs for Railroad Yards

Description of Pollutant Sources:

Pollutant sources can include:

- Drips/leaks of vehicle fluids onto the railroad bed
- Human waste disposal
- Litter
- Locomotive/railcar/equipment cleaning areas
- Fueling areas
- Outside material storage areas
- Erosion and loss of soil particles from the railroad bed
- Maintenance and repair activities at railroad terminals
- Switching and maintenance yards
- Herbicides used for vegetation management

Waste materials can include used oil, solvents, degreasers, antifreeze solutions, chromate and other anti-rust compounds, dyes, radiator flush, acids, brake fluids, soiled rags, oil filters, sulfuric acid and battery sludges, and 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.

Pollutant Control Approach: Apply good housekeeping and preventive maintenance practices to control leaks and spills of liquids in railroad yard areas.

Applicable Operational and Structural Source Control BMPs:

- Implement the applicable BMPs in this volume depending on the pollutant generating activities/sources at a railroad yard facility.
- Do not allow discharge to outside areas from toilets while a train is in transit. Use pumpout facilities to service these units.
- Use drip pans at hose/pipe connections during liquid transfer and other leak-prone areas.
- 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. For larger metal scrap, see Applicable Treatment BMPs below.
- Do not dump, drain, or allow the discharge of any water-based coolant from multi-punch presses into storm drains.
- 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.

Figure IV-7.3: Installed Railroad Track Mats

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State of Washington

Installed Railroad Track Mats

Revised August 2017

- 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 runoff.

Recommended Operational and Structural Source Control 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.

Applicable Treatment BMPs:

In areas subjected to leaks/spills of oils or other chemicals, convey stormwater to appropriate treatment such as a sanitary sewer, if approved by the appropriate sewer authority, or, to BMP T11.10: API (Baffle type) Separator, BMP T11.11: Coalescing Plate (CP) Separator, or other treatment, as approved by the local jurisdiction.

Recommended Treatment BMPs:

Store large metal scrap and materials that cannot be stored in covered areas because of their size, volume, and/or weight (for example rail and tie plates) in locations where stormwater runoff is managed, controlled, and directed to a Runoff Treatment BMP the meets the Enhanced Treatment Performance Goal.

S423 BMPs for Recyclers and Scrap Yards

Description of Pollutant Sources: Includes businesses that reclaim various materials for resale or for scrap, such as vehicles and vehicle/equipment parts, construction materials, metals, beverage containers, and papers.

Potential sources of pollutants include paper, plastic, metal scrap debris, engines, transmissions, radiators, batteries, and other materials contaminated or that contain 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, PCBs, total suspended solids, BOD, heavy metals, and acidic pH.

Applicable 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, 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 runoff.
- 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.

Required Routine Maintenance:

- Inspect storage areas regularly and promptly clean up any leaks, spills, or contamination.
- Sweep scrap storage areas as needed. Do not hose down anything to a storm drain.
- 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.

Recommended 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.

S424 BMPs for Roof / Building Drains at Manufacturing and Commercial Buildings

Description of Pollutant Sources: 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. Research has identified vapors and entrained liquid and solid droplets/particles 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 performed a study on zinc in industrial stormwater. The study is presented in *Suggested Practices to Reduce Zinc Concentrations in Industrial Stormwater Discharges* (Ecology, 2008). The user should refer to this document for more details on addressing zinc in stormwater.

Pollutant Control Approach: Evaluate the potential sources of stormwater pollutants and apply source control BMPs where feasible.

Applicable Operational Source Control BMPs:

- If leachates and/or emissions from buildings are suspected sources of stormwater pollutants, then sample and analyze the stormwater draining from the building.
- Sweep the area routinely to remove any residual pollutants.
- 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, etc.

Applicable Structural Source Control BMPs:

- Paint/coat the galvanized surfaces as described in *Suggested Practices to Reduce Zinc Concentrations in Industrial Stormwater Discharges* (Ecology, 2008).

Applicable Treatment BMPs:

Treat runoff from roofs to the appropriate level. The facility may use Enhanced Treatment BMPs as described in III-1.2 Choosing Your Runoff Treatment BMPs. Some facilities regulated by the Industrial Stormwater General Permit, or local jurisdiction, may have requirements than cannot be achieved with Enhanced 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.

S432 BMPs for Wood Treatment Areas

Description of Pollutant Sources: Wood treatment includes both anti-staining and wood preserving using pressure processes or by dipping or spraying. Wood preservatives include creosote, creosote/coal tar, pentachlorophenol, copper naphthenate, arsenic trioxide, malathion, or inorganic arsenicals such as chromated copper arsenate, acid copper chromate, chromate zinc chloride, and fluor-chrome-arsenate-phenol. Anti-staining chemical additives include iodo-prophenyl-butyl carbamate, dimethyl sulfoxide, didecyl dimethyl ammonium chloride, sodium azide, 8 quinolinol; copper (II) chelate, sodium ortho-phenylphenate, 2 (thiocyanomethylthio)-benzothiazole (TCMTB) and methylene bis- (thiocyanate), and zinc naphthenate.

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.

Pollutant Control Approach: Cover and contain all wood treating facilities and prevent all leaching of and stormwater contamination by wood treating chemicals. Wood treating facilities may be covered by the Industrial Stormwater General Permit or by an individual permit. Individual permits covering wood treatment areas include applicable source control BMPs or require the development of BMPs or a SWPPP. Facilities covered under the Industrial Stormwater General Permit must prepare and implement a SWPPP. When developing a SWPPP or BMPs, wood treating facilities should include the applicable operational and structural source control BMPs listed below.

Applicable Operational BMPs:

- 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 ground water and/or surface water via stormwater runoff.
- If incidental drippage is discovered in the storage yard, relocate the wood to a concrete chemical containment structure until it is drip free.

Recommended Operational BMP:

Consider using preservative chemicals that do not adversely affect receiving surface water and ground water.

Applicable Structural Source Control BMPs:

- 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. Segregate clean stormwater 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 chemical 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.

S433 BMPs for Pools, Spas, Hot Tubs, and Fountains

Description of Pollutant Sources: This section includes BMPs for pools, spas, hot tubs, and fountains used for recreational and/or decorative purposes that may use chemicals and/or be heated. Industrial Stormwater Permittees that use pools, spas, hot tubs, and fountains as part of an industrial process should refer to their Industrial Stormwater Permit.

Discharge from pools, spas, hot tubs, and fountains can degrade ambient water quality. The waters from these sources typically contain bacteria that contaminate the receiving waters. Chemicals lethal to aquatic life such as chlorine, bromine and algaecides can be found in pools, spas, hot tubs, and fountains. These waters may be at an elevated temperature and can have negative effects on receiving waters and to aquatic life. Diatomaceous earth backwash from swimming pool filters can clog gills and suffocate fish.

Routine maintenance activities generate a variety of wastes. Chlorinated water, backwash residues, algaecides, and acid washes are a few examples. Direct disposal of these waters to drainage systems and waters of the State is not permitted without prior treatment and approval.

The quality of any discharge to the ground after proper treatment must comply with Ecology's Ground Water Quality Standards, Chapter 173-200 WAC.

The Washington State Department of Health and local health authorities regulate Water Recreation facilities which include pools, spas, and hot tubs. Owners and operators of those facilities must comply with those regulations, policies and procedures. Following the guidelines here does not exempt or supersede any requirements of the regulatory authorities.

Pollutant Control Approach: Many manufacturers do not recommend draining pools, spas, hot tubs or fountains; refer to the facility's operation and maintenance manual. If the water feature must be drained, convey discharges (within hoses or pipes) to a sanitary sewer if approved by the local sewer authority or to a storm sewer following the conditions outlined below. Do not discharge to a septic system, since it may cause the system to fail. No discharge to the ground or to surface water should occur, unless permitted by the proper regulatory authority.

Applicable Operational BMPs:

- Clean the pool, spa, hot tub, or fountain regularly. Maintain proper chlorine levels and maintain water filtration and circulation. Doing so will limit the need to drain the facility.
- Manage pH and water hardness to reduce copper pipe corrosion that can stain the facility and pollute receiving waters.
- Before using copper algaecides, try less toxic alternatives. Only use copper algaecides if the others alternative do not work. Ask a maintenance service or pool chemical supplier for help resolving persistent algae problems without using copper algaecides.
- Develop, implement, and regularly update a facility maintenance plan that follows all discharge requirements.
- Dispose of unwanted chemicals properly. Many of them are hazardous wastes when discarded.
- Discharge waters originating from a pool, spa, hot tub, or fountain to a sanitary sewer, if approved by the local sewer authority, local health authority, or both. Do not discharge waters containing copper-based algaecides to storm sewer systems.
- Do not discharge water directly from a pool, spa, hot tub, fountain, process wastes, or wastewaters into storm drains except if the discharge water is:
    - Dechlorinated/debrominated to 0.1 ppm or less. Some guidance on dechlorination is provided in the Washington State Department of Health's *Water System Design Manual* (WSDOH, 2009). The *Water System Design Manual* (WSDOH, 2009) further references *C651-99: AWWA Standard for Disinfecting Water Mains* (AWWA, 1999) and *C652-02: AWWA Standard for Disinfection of Water-Storage Facilities* (AWWA, 2002) for more details. Contact a pool chemical supplier to obtain the neutralizing chemicals needed.
    - Free from sodium chloride.
    - pH-adjusted.
    - Reoxygenated if necessary.
    - Free of any coloration, dirt, suds, or algae.
    - Free of any filter media.
    - Free of acid cleaning wastes.
    - At a temperature that will prevent an increase in temperature in the receiving water. Cool heated water prior to discharge.
    - Released at a rate that can be accommodated by the receiving body (i.e. can infiltrate or be safely conveyed).
- Swimming pool cleaning wastewater and filter backwash shall not be discharged to the storm

sewer.

- Bag diatomaceous earth (pool filtering agent) and dispose at a landfill.

Applicable Structural Source Control BMPs:

- Ensure that the pool, spa, hot tub, or fountain system is free of leaks and operates within the design parameters.
- Do not provide any permanent links to drainage systems. All connections should be visible and carefully controlled.
- If the dechlorination or cooling process selected requires the water to be stored for a time, it should be contained within the pool or appropriate temporary storage container.

S436 BMPs for Color Events

Description of Pollutant Sources: 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 drainage systems 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 storm drains 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 storm drains. Dye material and any wash water are prohibited discharges.

Pollutant Control Approach: Plan for the event. Control the application areas for the powder or liquid dyes. Block off storm drain inlets prior to the event. Clean up the areas immediately after the event.

Figure IV-7.4: Powdered Dyes at Color Events

Color events typically involve the use of powdered dyes such as those pictured.

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State of Washington

Powdered Dyes at Color Events

Revised June 2017

Applicable Operational 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.
  - Storm drain 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 drainage 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).
  - Emergency numbers for the local city or county in case dye material does enter the storm drain or water body.
- 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 storm drains 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 local jurisdiction event permit requirements that contain stormwater pollution prevention BMPs. If no local event permit is required, provide to the local jurisdiction in charge of stormwater drainage and/or surface water management, in plenty of time (two weeks or more) prior to the event:
  - 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 Runoff from Entering Drainage Systems and Water Bodies

- Protect storm drains by using berms, covering the drains, and using catch basin covers.
- Use care when removing berms, covers, and tarps to ensure no dye enters the storm drains.
- 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 Clean-Up

- 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 to the sanitary sewer system, with approval from the local sewer agency.
- Call the local spill response hotline immediately (24/7) if any colored water enters a storm drain or water body.
- 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.

S438 BMPs for Construction Demolition

Description of Pollutant Sources: This activity applies to removal of existing buildings and other structures by controlled explosions, wrecking balls, or manual methods, and subsequent clearing of the rubble. The loose debris may contaminate stormwater.

Pollutants of concern include toxic organic compounds, hazardous wastes, high pH, heavy metals, and suspended solids.

Pollutant Control Approach: Do not expose hazardous materials to stormwater. Regularly clean up debris that can contaminate stormwater. Protect the drainage system from dirty runoff and loose particles. Sweep paved surfaces daily. Educate employees about the need to control site activities.

Applicable Operational BMPs:

- Identify, remove, and properly dispose of hazardous substances from the building before beginning construction demolition activities that could expose them to stormwater. Such substances could include PCBs, asbestos, lead paint, mercury switches, and electronic waste.
- Educate employees about the need to control site activities to prevent stormwater pollution, and also train them in spill cleanup procedures.
- Keep debris containers, dumpsters, and debris piles covered.
- Place storm drain covers, or a similarly effective containment device, on all nearby drains to prevent dirty runoff and loose particles from entering the drainage system.
    - Place the covers (or devices) at the beginning of the workday.
    - Collect and properly dispose of the accumulated materials before removing the covers (or devices) at the end of the workday.
    - Use dikes, berms, or other methods to protect overland discharge paths from runoff if stormwater drains are not present.
- Sweep street gutters, sidewalks, driveways, and other paved surfaces in the immediate area of the demolition at the end of each workday. Collect and properly dispose of loose debris and garbage.
- Lightly spray water (such as from a hydrant or water truck) throughout the site to help control windblown fine materials such as soil, concrete dust, and paint chips. Control the amount of dust control water so that runoff from the site does not occur, yet dust control is achieved. Do not use oils for dust control.

Suggested Operational BMPs:

- Construct a screen to prevent stray building materials and dust from escaping the area during demolition. Size and orient the screen to capture wind-blown materials and contain them onsite.
- Schedule demolition to take place at a dry time of the year to prevent stormwater runoff from the demolition site.

S440 BMPs for Pet Waste

Description of Pollutant Sources: 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.

Pollutant Control Approach: Use a plastic bag or pooper scooper to clean up after pets. Properly dispose of pet waste.

Recommended Operational 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.
- 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 a storm drain, in a toilet, or down a sink. Check with your local refuse collector for proper disposal locations of pet medications.
- When cleaning out cages and kennels, dispose of wash water down the toilet or a mop sink. Otherwise, wash directly over lawn areas or make sure the wash water drains to a vegetated area.
- Bathe pets indoors or in a manner that wash water won’t be discharged to storm drains, ditches, or surface waters of the state.

Rcommended Operational 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.
- At multi-family properties with roof-top dog runs, ensure that stormwater from the dog run is

not discharged to the stormwater system. Check with the local jurisdiction regarding roof-top dog run connections to sanitary sewer.

Figure IV-7.5: Example of a Pet Waste Station

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Example of a Pet Waste Station

Revised May 2019

S442 BMPs for Labeling Storm Drain Inlets On Your Property

Description of Pollutant Sources: Waste materials dumped into storm drain inlets can have severe impacts on receiving waters. Posting notices regarding discharge prohibitions at storm drain inlets can prevent waste dumping. Storm drain signs and stencils are highly visible source controls that are typically placed directly adjacent to storm drain inlets.

Pollutant Control Approach: The stencil, affixed sign, or metal grate contains a brief statement that prohibits dumping of improper materials into the urban runoff conveyance system. Storm drain messages have become a popular method of alerting the public about the effects of and the prohibitions against waste disposal.

Applicable Operational BMPs:

- Label storm drain inlets in residential, commercial, industrial areas, and any other areas where contributions or dumping to storm drains is likely.
- Stencil or apply storm drain markers adjacent to storm drain inlets to help prevent the improper disposal of pollutants. Or, use a storm drain grate stamped with warnings against polluting.
- 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. 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”
- Check with your local government agency to find out if they have approved specific signage and / or storm drain message placards for use. Consult the local agency stormwater staff to determine specific requirements for placard types and methods of application.
- Maintain the legibility of markers and signs. 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 painting stencils or installing markers, temporarily block the storm drain inlet so that no pollutants are discharged from the labeling activities.

Optional Operational BMPs:

Use a stencil in addition to a storm drain marker or grate to increase visibility of the message.

Reference for this BMP: (CASQA, 2003)

Figure IV-7.6: Storm Drain Inlet Labels

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Storm Drain Inlet Labels

Revised October 2017

S443 BMPs for Fertilizer Application

Description of Pollutant Sources: 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.

Pollutant Control Approach: Minimize the amount of fertilizer necessary to maintain vegetation. Control the application of fertilizer to prevent the discharge of stormwater pollution.

Applicable Operational 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 fertilizer runoff occurs.
- 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 hose down to a storm drain, conveyance ditch, or water body.
- 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 drainage systems.
- In areas that drain to sensitive water bodies, apply no fertilizer at commercial and industrial facilities, to grass swales, filter strips, or buffer areas unless approved by the local jurisdiction.
- 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 and ground waters.
- 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

Recommended Operational 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.

S446 BMPs for Well, Utility, Directional and Geotechnical Drilling

Description of Pollutant Sources: This activity 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.

Pollutant Control Approach: Reduce sediment runoff from drilling operations.

Applicable Operational 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 drainage 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 storm drains and surface waters. 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 storm sewer system or surface waters.
- 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 S429 BMPs for Storage or Transfer (Outside) of Solid Raw Materials, Byproducts, or Finished Products.
- Stabilize exposed soils at the end of the job, using mulch or other erosion control measures. See S425 BMPs for Soil Erosion and Sediment Control at 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).

S447 BMPs for Roof Vents

Description of Pollutant Sources: 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 roof runoff.

Pollutant Control Approach: Evaluate the potential sources of stormwater pollutants and apply source control BMPs where feasible.

Applicable 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 pipefittings 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 approved water quality 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 sanitary sewer after approval by the local sewer authority, or have a waste disposal company remove it.

S451 BMPs for Building, Repair, Remodeling, Painting, and Construction

Description of Pollutant Sources: This activity refers to:

- The construction of buildings and other structures.
- Remodeling of existing buildings and houses.
- General exterior building repair work.

Pollutants of concern include toxic hydrocarbons, hazardous wastes, toxic organics, suspended solids, heavy metals, pH, oils, and greases.

Pollutant Control Approach: Educate employees about the need to control site activities. Control leaks, spills, and loose material. Utilize good housekeeping practices. Regularly clean up debris that can contaminate stormwater. Protect the drainage system from dirty runoff and loose particles.

Applicable Operational BMPs:

- Identify, remove, and properly dispose of hazardous substances from the building before beginning repairing or remodeling activities that could expose them to stormwater. Such substances could include PCBs, asbestos, lead paint, mercury switches, and electronic waste.
- Educate employees about the need to control site activities to prevent stormwater pollution, and also train them in spill cleanup procedures.
- At all times, have available at the work site spill cleanup materials appropriate to the chemicals used on site.
- Clean up the work site at the end of each work day. Put away materials (such as solvents) indoors or cover and secure them, so that unauthorized personnal will not have access to them.
- Sweep the area daily to collect loose litter, paint chips, grit, and dirt.
- Do not dump any substance on pavement, on the ground, in the storm drain, or toward the storm drain, regardless of its content, unless it is clean water only.
- Place a drop cloth, 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.
- Use ground or drop cloths underneath scraping and sandblasting work. Use ground cloths, buckets, or tubs anywhere that work materials are laid down.
- Clean paint brushes and other tools covered with water-based paints in sinks connected to sanitary sewers or in portable containers that can subsequently be dumped into a sanitary sewer drain.
- Clean brushes and tools covered with non-water-based finishes or other materials in a manner that enables collection of used solvents for recycling or proper disposal. Do not discharge non-water-based finishes or paints or used solvents into the sanitary sewer, or any other drain.
- Use storm drain covers, or similarly effective devices, to prevent dust, grit, washwater, or other pollutants from escaping the work area. Place the cover or containment device over the storm drain at the beginning of the work day. Collect and properly dispose of accumulated dirty runoff and solids before removing the cover or device at the end of each work day.
- Refer to S431 BMPs for Washing and Steam Cleaning Vehicles / Equipment / Building Structures for best management practices associated with power washing buildings.

Suggested Operational BMPs:

- Lightly spray water on the work site to control dust and grit that could blow away. Do not use oils for dust control. Never spray to the point of water runoff from the site.
- Clean tools over a ground cloth or within a containment device such as a tub.
- Consider using filtered vacuuming to collect waste that may be hard to sweep, such as dust on a drop cloth.
- If conducting work in wet weather conditions, consider setting up temporary cover when scraping or pressure-washing lead-based paint.

S452 BMPs for Goose Waste

Description of Pollutant Sources: 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.

Pollutant Control Approach: To help decrease geese pollution to water sources, remove waste periodically and use deterrent management practices.

Applicable Operational BMPs:

This BMP is for areas of chronic accumulation of goose waste that impact stormwater systems.

- 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 storm sewer systems.
- 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.

Optional Operational 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:** When directed by a handler, dogs are the method of choice for large open areas. 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. A dog can be tethered to a long lead (which may require relocating the dog and tether frequently to cover more area), be allowed to chase and retrieve a decoy thrown over a large flock of geese, or be periodically released to chase the birds (if this is not against leash laws).
    - **Eyespot Balloons:** Large, helium-filled balloons with large eye-like images. 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:** Simple flags from plastic 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/species-habitats/species/branta-canadensis for additional information.

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Appendix IV-A: Urban Land Uses and Pollutant Generating Sources

Use this appendix to identify pollutant-generating sources at various land uses (manufacturing, transportation, communication, wholesale, retail, service - based on the *North American Industry Classification System* (United States Census Bureau, 2017), and public agencies). Applicable operational and structural source control and treatment BMPs for each pollutant source may then be selected by referring to Volume IV. Other land uses not included in this appendix should also consider implementing applicable (mandatory) BMPs for their pollutant sources. Note that potentially polluting operations may not be limited to those examples identified with NAICS codes.

1. Manufacturing Businesses

Cement

NAICS 3273XX:*Cement and Concrete Product Manufacturing*

Description: These businesses primarily produce Portland cement, the binder used in concrete for paving, buildings, pipe, and other structural products. The three basic steps in cement manufacturing are: 1) proportioning, grinding, and blending raw materials; 2) heating raw materials to produce a hard, stony substance known as clinker; and 3) combining the clinker with other materials and grinding the mixture into a fine powdery form. The raw materials include limestone, silica, alumina, iron, chalk, oyster shell marl, or shale. Waste materials from other industries are often used such as slag, fly ash and spent blasting sand. Raw materials are crushed, mixed and heated in a kiln to produce the correct chemical composition. Kilns typically are coal, gas, or oil fired. The output of the kiln is a clinker that is ground to produce the final product.

The basic process may be wet or dry. In the wet process water is mixed with the raw ingredients in the initial crushing operation and in some cases is used to wash the material prior to use. Water may also be used in the air pollution control scrubber. The most significant waste material from cement production is the kiln dust. Concrete products may also be produced at ready-mix concrete facilities. Refer to Concrete Products for a description of the BMPs appropriate to these activities.

Potential Pollutant Generating Sources: Stormwater contamination may occur during the crushing, grinding, storage, and handling of kiln dust, limestone, shale, clay, coal, clinker, gypsum, anhydrite, slag, sand, and product and at the vehicle and equipment maintenance, fueling, and cleaning areas. Aluminum, iron, heavy metals, chemical oxygen demand (COD), pH, potassium, sulfate, oil & grease, and total suspended solids (TSS) are some of the potential pollutants.

Chemical Manufacturing

NAICS 325XXX:*Chemical Manufacturing*

Description: This group is engaged in the manufacture of chemicals, or products based on chemicals such as acids, alkalis, inks , chlorine, industrial gases, pigments, chemicals used in the production of synthetic resins, fibers and plastics, synthetic rubber, soaps and cleaners, pharmaceuticals, cosmetics, paints, varnishes, resins, photographic materials, chemicals, organic chemicals, agricultural chemicals, adhesives, and sealants .

Potential Pollutant Generating Sources: Activities that can contaminate stormwater include bagging, blending, packaging, crushing, milling, shredding, granulation, grinding, storage, distribution, loading/unloading, and processing of materials; equipment storage; application of fertilizers; foundries; lime application; use of machinery; material handling and warehousing; cooling towers; fueling; boilers; dangerous waste treatment, storage and disposal; wastewater treatment; areas of past industrial activity; access roads and tracks; drum washing, and maintenance and repair.

Chemical businesses in the Seattle area surveyed for dangerous wastes were found to produce waste caustic solutions, soaps, heavy metal solutions, inorganic and organic chemicals, solvents, acids, alkalis, paints, varnishes, pharmaceuticals, and inks. The potential pollutants include biological oxygen demand (BOD), COD, oil & grease, pH, total phosphorus, ammonia,nitrates, nitrites, total Kjeldahl nitrogen (TKN), TSS, specific organics, and heavy metals.

Concrete Products

NAICS 3273XX: *Cement and Concrete Product Manufacturing*

NAICS 3274XX: *Lime and Gypsum Product Manufacturing*

Description: Businesses that manufacture ready-mix concrete, gypsum products, concrete blocks and bricks, concrete sewer or drainage pipe, septic tanks, and prestressed concrete building components. Concrete is prepared on-site and poured into molds or forms to produce the desired product. The basic ingredients of concrete are sand, gravel, Portland cement, crushed stone, clay, and reinforcing steel for some products. Admixtures including fly ash, calcium chloride, triethanolamine, lignosulfonic acid, sulfonated hydrocarbon, fatty acid glyceride, or vinyl acetate, may be added to obtain desired characteristics such as slower or more rapid curing times.

The first stage in the manufacturing process is proportioning cement, aggregate, admixtures and water, and then transporting the product to a rotary drum, or pan mixer. The mixture is then fed into an automatic block-molding machine that rams, presses, or vibrates the mixture into its final form. The final product is then stacked on iron framework cars where it cures in four hours. After being mixed in a central mixer, concrete is molded in the same manner as concrete block. The concrete cures in the forms for a number of hours. Forms are washed for reuse, and the concrete products are stored until they can be shipped.

Potential Pollutant Generating Sources: Pollutant generating activities/sources include stockpiles of raw materials; washing of waste concrete from trucks, forms, equipment, and the general work area; and water from the curing of concrete products. Besides the basic ingredients for making concrete products, chemicals used in the curing of concrete and the removal of forms may end up in stormwater. These chemicals can include latex sealants, bitumastic coatings and release agents. Trucks and equipment maintained on-site may generate waste oil and solvents, and other waste materials. Potential pollutants include COD, BOD, TSS, total dissolved solids (TDS), pH, iron, lead, zinc, and oil & grease.

Electrical Products

NAICS 33324x: *Industrial Machinery Manufacturing*

NAICS 33331x: *Commercial and Service Industry Machinery Manufacturing*

NAICS 33341x: *Ventilation, Heating, Air Conditioning, and Commercial Refrigeration Equipment Manufacturing*

NAICS 3339xx: *Other General Purpose Machinery Manufacturing*

NAICS 334xxx: *Computer and Electronic Product Manufacturing*

NAICS 335xxx: *Electrical Equipment, Appliance, And component Manufacturing*

NAICS 336xxx: *Transportation Equipment Manufacturing*

NAICS 339xxx: *Miscellaneous Manufacturing*

Description: A variety of products are produced including electrical transformers and switchgear, motors, generators, relays, and industrial controls; communications equipment for radio and TV stations and systems; electronic components and accessories including semiconductors; printed board circuits; electromedical and electrotherapeutic apparatus; and electrical instrumentation. Manufacturing processes include electroplating, machining, fabricating, etching, sawing, grinding, welding, and parts cleaning. Materials used include metals, ceramics, quartz, silicon, inorganic oxides, acids, alkaline solutions, arsenides, phosphides, cyanides, oils, fuels, solvents, and other chemicals.

Potential Pollutant Generating Sources: Most of the actual manufacturing and processing activity at the types of facilities discussed here normally occur indoors and will not be exposed to stormwater. The types of activities where exposure to stormwater may occur consist primarily of loading/ and unloading activities, and the storage and handling of raw materials, by-products, final products, or waste products. A wide variety of materials are used at these facilities, including metals, acids used for chemical etching, alkaline solutions, solvents, various oils and fuels, and miscellaneous chemicals. Tanks or drums of these materials may be exposed to stormwater during loading/ and un-loading operations, or through outdoor storage or handling.

Liquid wastes which may be exposed at least temporarily include spent solvents and acids, miscellaneous chemicals, and oily wastes. These wastes may be contaminated with a variety of heavy metals and chlorinated hydrocarbons. Used equipment, scrap metal and wire, soiled rags, and sanding materials may also be exposed to stormwater and constitute a potential source of pollutants. In addition, some facilities may have dumpsters containing nonhazardous wastes or manufacturing debris that may be exposed to stormwater.

Wastewater consists of solutions and rinses from electroplating operations and the wastewaters from cleaning operations. Water may also be used to cool saws and grinding machines. Sludges are produced by the wastewater treatment process. Potential pollutants include BOD, COD, oil & grease, organics, pH, TSS, TKN, nitrate and nitrite nitrogen, copper, lead, silver, and zinc.

Food and Kindred Products

NAICS 115114: *Postharvest Crop Activities (except Cotton Ginning)*

NAICS 311xxx: *Food Manufacturing*

NAICS 312xxx: *Beverage and Tobacco Product Manufacturing*

Description: Businesses in this category include facilities manufacturing or processing foods, beverages, and related products for human consumption, and prepared feeds for animals and fowls. Facilities engaged in manufacturing cigarettes, cigars, and other tobacco products are also included. Food processing typically occurs inside buildings. Exceptions are meat packing plants where live animals may be kept outside, and fruit and vegetable plants where the raw material may be temporarily stored outside. Meat production facilities include stockyards, slaughtering, cutting and deboning, meat processing, rendering, and materials recovery. Dairy production facilities include receiving stations, clarification, separation, and pasteurization followed by culturing, churning, pressing, curing, blending, condensing, sweetening, drying, milling, and packaging. Canned frozen and preserved fruits and vegetables are typically produced by washing, cutting, blanching, and cooking followed by drying, dehydrating, and freezing.

Grain mill products are processed during washing, milling, debranning, heat treatment, screening, shaping, and vitamin and mineral supplementing. Bakery products processing includes mixing, shaping, of dough, cooling, and decorating. Operations at an edible oil manufacturer include refining, bleaching, hydrogenation, fractionation, emulsification, deodorization, filtration, and blending. Beverage production includes brewing, distilling, fermentation, blending, and packaging. Wine processors often crush grapes outside the process building and/or store equipment outside when not in use. Some wine producers use juice from grapes crushed elsewhere. Some vegetable and fruit processing plants use caustic solutions.

Potential Pollutant Generating Sources: The nature of the business, and the required sanitary conditions, require that raw and processed materials be protected from stormwater. As such, the contamination of stormwater from these activities is primarily from the loading and unloading of products and raw materials; spillage and leaks from tanks and containers stored outdoors; waste management practices; pest control; and improper connections to the storm sewer.. The following are the pollutants typically expected from this industry segment: BOD, fecal coliform, oil & grease, pH, TKN, TSS, copper, manganese, and pesticides.

Glass Products

NAICS 32721x: *Glass and Glass Product Manufacturing*

Description: The produced glass form may be flat or window glass, safety glass, container glass, tubing, glass wool, or fibers. The raw materials are sand mixed with a variety of oxides such as aluminum, antimony, arsenic, copper, cobalt oxide, barium, and lead. The raw materials are mixed and heated in a furnace. Processes that vary with the intended product shape the resulting molten material. The cooled glass may be edged, ground, polished, annealed and/or heat-treated to produce the final product. Air emissions from the manufacturing buildings are scrubbed to remove particulates.

Potential Pollutant Generating Sources: Raw materials are generally stored in silos except for crushed recycled glass and materials washed off recycled glass. Contamination of stormwater and/or ground water can be caused by raw materials lost during unloading operations, errant flue dust, equipment/vehicle maintenance and engine fluids from mobile lifting equipment that is stored outside. The maintenance of the manufacturing equipment will produce waste lubricants and cleaning solvents. The flue dust is likely to contain heavy metals such as arsenic, cadmium, chromium, mercury, and lead. Potential pollutants include oil & grease, high/low pH, lead, and heavy metals such as arsenic, cadmium, chromium, mercury, and lead.

Industrial Machinery & Equipment, Trucks & Trailers, Aircraft, Aerospace, & Railroad

NAICS 333xxx: *Machinery Manufacturing*

NAICS 336xxx: *Transportation Equipment Manufacturing*

Description: This category includes the manufacture of a variety of equipment including engines and turbines, farm and garden equipment, construction and mining machinery, metal working machinery, pumps, computers and office equipment, automatic vending machines, refrigeration and heating equipment, and equipment for the manufacturing industries. This group also includes many small machine shops, and the manufacturing of trucks, trailers and parts, airplanes and parts, missiles, spacecraft, and railroad equipment and instruments.

Manufacturing processes include various forms of metal working and finishing, such as electroplating, anodizing, chemical conversion coating, etching, chemical milling, cleaning, machining, grinding, polishing, sand blasting, laminating, hot dip coating, descaling, degreasing, paint stripping, painting, and the production of plastic and fiberglass parts. Raw materials include ferrous and non-ferrous metals, such as aluminum, copper, iron, steel, and their alloys, paints, solvents, acids, alkalis, fuels, lubricating and cutting oils, and plastics.

Potential Pollutant Generating Sources: Potential pollutant sources include spills and leaks from fueling, maintenance shops, loading/unloading of materials, and outside storage of gasoline, diesel, cleaning fluids, equipment, solvents, paints, wastes, detergents, acids, other chemicals, oils, metals, and scrap materials. Air emissions from stacks and ventilation systems are potential areas for exposure of materials to rainwater.

Metal Products

NAICS 331xxx: *Primary Metal Manufacturing*

NAICS 332xxx: *Fabricated Metal Product Manufacturing*

NAICS 337124: *Metal Household Furniture Manufacturing*

NAICS 337214: *Office Furniture (except Wood) Manufacturing*

NAICS 339xxx: *Miscellaneous Manufacturing*

Description: This group includes mills that produce basic metals and primary products, as well as foundries, electroplaters, and fabricators of final metal products. Basic metal production includes aluminum, copper, and steel. Mills that transform metal billets, either ferrous or nonferrous such as aluminum, to primary metal products are included. Primary metal forms include sheets, flat bar, building components such as columns, beams and concrete reinforcing bar, and large pipe.

Steel mills in the Pacific Northwest primarily use recycled metal and electric furnaces. The molten steel is cast into billets or ingots that may be reformed on site or taken to rolling mills that produce primary products. As iron and steel billets may sit outside before reforming, surface treatment to remove scale may occur prior to reforming. Foundries pour or inject molten metal into a mold to produce a shape that cannot be readily formed by other processes. The metal is first melted in a furnace. The mold is made of sand or metal die blocks that are locked together to make a complete cavity. The molten metal is ladled in and the mold is cooled. The rough product is finished by quenching, cleaning and chemical treatment. Quenching involves immersion in a plain water bath or water with an additive.

Businesses that fabricate metal products from metal stock provide a wide range of products. The raw stock is manipulated in a variety of ways including machining of various types, grinding, heating, shearing, deformation, cutting and welding, soldering, sand blasting, brazing, and laminating. Fabricators may first clean the metal by sand blasting, descaling, or solvent degreasing. Final finishing may involve electroplating, painting, or direct plating by fusing or vacuum metalizing. Raw materials, in particular recycled metal, are stored outside prior to use, as are billets before reforming. The descaling process may use salt baths, sodium hydroxide, or acid (pickling).

Primary products often receive a surface coating treatment. Prior to the coating the product surface may be prepared by acid pickling to remove scale or byalkaline cleaning to remove oils and greases. The two major classes of metallic coating operations are hot and cold coating. Aluminum, tin, and zinc coatings are applied in molten metal baths. Chromium and tin are usually applied electrolytically from plating solutions.

Potential Pollutant Generating Sources: Potential pollutant generating sources include outside storage of chemicals, metal feedstock, byproducts (fluxes), finished products, fuels, lubricants, waste oil, sludge, waste solvents, dangerous wastes, piles of coal, coke, dusts, fly ash, baghouse waste, slag, dross, sludges, sand refractory rubble, and machining waste; unloading of chemical feedstock and loading of waste liquids such as spent pickle liquor by truck or rail; material handling equipment such as cranes, conveyors, trucks, and forklifts; particulate emissions from scrubbers, baghouses or electrostatic precipitators; fugitive emissions; maintenance shops; erosion of soil from plant yards; and floor, sink, and process wastewater drains.

Paper, Pulp, and Paperboard Mills

NAICS 3221xx:*Pulp, Paper, and Paperboard Mills*

Description: Large industrial complexes in which pulp and/or paper, and/or paperboard are produced. Products also include newsprint, bleached paper, glassine, tissue paper, vegetable parchment, and industrial papers. Raw materials include wood logs, chips, wastepaper, jute, hemp, rags, cotton linters, bagasse, and esparto. The chips for pulping may be produced on-site from logs, and/or imported.

The following manufacturing processes are typically used: raw material preparation, pulping, bleaching, and papermaking. All of these operations use a wide variety of chemicals including caustic soda, sodium and ammonium sulfites, chlorine, titanium oxide, starches, solvents, adhesives, biocides, hydraulic oils, lubricants, dyes, and many chemical additives.

Potential Pollutant Generating Sources: The large process equipment used for pulping is not enclosed. Thus, precipitation falling over these areas may become contaminated. Maintenance of the process equipment produces waste products similar to that produced from vehicle and mobile equipment maintenance. Logs may be stored, debarked and chipped on site. Large quantities of chips are stored outside. Although this can be a source of pollution, the volume of stormwater flow is relatively small because the chip pile retains the majority of the precipitation. Mobile equipment such as forklifts, log stackers, and chip dozers are sources of leaks/spills of hydraulic fluids. Vehicles and equipment are fueled and maintained on-site.

Paper Products

NAICS 3222xx:*Converted Paper Product Manufacturing*

Description: Included are businesses that take paper stock and produce basic paper products such as cardboard boxes and other containers, and stationery products such as envelopes and bond paper. Wood chips, pulp, and paper can be used as feedstock.

Potential Pollutant Generating Sources: Potential pollutant generating sources include outside loading and unloading orf solid and/or liquid materials; outside storage and handling of dangerous wastes, liquid, and/or solid materials; maintenance and fueling activities for forklifts and other vehicles and equipment; and outside processing activities related to paper production.

Petroleum Products

NAICS 3241xx: *Petroleum and Coal Products Manufacturing*

Description: The petroleum refining industry manufactures gasoline, kerosene, distillate and residual oils, lubricants, and related products from crude petroleum, and asphalt paving and roofing materials. Although petroleum is the primary raw material, petroleum refineries also use other materials such as natural gas, benzene, toluene, chemical catalysts, caustic soda, and sulfuric acid. Wastes may include filter clays, spent catalysts, sludges, and oily water.

Asphalt paving products consist of sand, gravel and petroleum-based asphalt that serves as the binder. Raw materials include stockpiles of sand and gravel and asphalt emulsions stored in aboveground tanks.

Potential Pollutant Generating Sources: Potential pollutant generating sources include outside processing such as distillation, fractionation, catalytic cracking, solvent extraction, coking, desulfuring, reforming, and desalting; petrochemical and fuel storage and handling; outside liquid chemical piping and tankage; mobile liquid handling equipment such, as tank trucks, forklifts, etc.; maintenance and parking of trucks and other equipment; waste piles, and handling and storage of asphalt emulsions, cleaning chemicals, and solvents; and waste treatment and conveyance systems.

The following are potential pollutants at oil refineries: oil & grease, BOD, COD, total organic carbon (TOC), phenolic compounds, polyaromatic hydrocarbons (PAH), ammonia nitrogen, TKN, sulfides, TSS, low and high pH, and chromium (total and hexavalent).

Printing

NAICS 323xxx: *Printing and Related Support Activities*

Description: This industrial category includes the production of newspapers, periodicals, commercial printing materials and bybusinesses that do their own printing and those that perform services for the printing industry, for example bookbinding. Processes include typesetting, engraving, photoengraving, and electrotyping.

Potential Pollutant Generating Sources: Various materials used in modifying the paper stock include inorganic and organic acids, resins, solvents, polyester film, developers, alcohol, vinyl lacquer, dyes, acetates, and polymers. Waste products may include waste inks, ink sludge, resins, photographic chemicals, solvents, acid and alkaline solutions, chlorides, chromium, lead, silver, zinc, spent formaldehyde, plasticizers, and used lubricating oils. As the printing operations occur indoors, the only likely points of potential contact with stormwater are the outside temporary storage of waste materials, offloading of chemicals at external unloading bays, and vehicle/equipment repair and maintenance. Pollutants of concern include COD, heavy metals, oil & grease, pH, and TSS.

Rubber and Plastic Products

NAICS 3252xx: *Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing*

NAICS 326xxx: *Plastics and Rubber Products Manufacturing*

Description: Products in this category include rubber tires, hoses, belts, gaskets, seals, plastic sheet, film, tubes, pipes, bottles, cups, ice chests, packaging materials, and plumbing fixtures. The rubber and plastics industries use a variety of processes ranging from polymerization to extrusion using natural or synthetic raw materials. These industries use natural or synthetic rubber, plastics components, pigments, adhesives, resins, acids, caustic soda, zinc, paints, fillers, and curing agents.

Potential Pollutant Generating Sources: Pollutant generating sources/activities include storage of liquids, other raw materials or by-products, scrap materials, oils, solvents, inks and paints; unloading of liquid materials from trucks or rail cars; washing of equipment; waste oil and solvents produced by cleaning manufacturing equipment; used equipment that could drip oil and residual process materials; and maintenance shops.

Potential pollutants are BOD, COD, nitrate and nitrite nitrogen, TKN, total phosphorus, TSS, pH, trichloroethane, methylene chloride, toluene, zinc, and oil & grease.

Ship and Boat Building and Repair Yards

NAICS 3366xx: *Ship and Boat Building*

Description: Businesses that build or repair ships and boats. Typical activities include hull scraping, sandblasting, finishing, metal fabrication, electrical repairs, engine overhaul, welding, fiberglass repairs, hydroblasting, and steam cleaning.

Potential Pollutant Generating Sources: Outside boatyard activities that can be sources of stormwater pollution include pressure washing, surface preparation, paint removal, sanding, painting, engine/vessel maintenance and repairs, and material handling and storage.

Secondary sources of stormwater contaminants are cooling water, pump testing, gray water, sanitary waste, washing down the work area, and engine bilge water. Engine room bilge water and oily wastes are typically collected and disposed of through a licensed contracted disposal company. Two prime sources of copper are leaching of copper from anti-fouling paint and wastes from hull maintenance. Wastes generated by boatyard activities include spent abrasive grits, spent solvent, spent oils, fuel, ethylene glycol, washwater, paint overspray, various cleaners/detergents and anti-corrosive compounds, paint chips, scrap metal, welding rods, wood, plastic, resins, glass fibers, dust, and miscellaneous trash such as paper and glass.

Ecology, local shipyards, and METRO have sampled pressure-wash wastewater. The effluent quality has been variable and frequently exceeded water quality criteria for copper, lead, tin, and zinc. From monitoring results received to date, metal concentrations typically range from 5 to 10 mg/L, but have gone as high as 190 mg/L copper with an average 55 mg/L copper.

Wood

NAICS 321xxx (except 321114): *Wood Product Manufacturing (except Wood Preservation)*

Description: This group includes sawmills, and all businesses that make wood products using cut wood, with the exception of wood treatment businesses. Wood treatment as well as log storage and sorting yards are covered in other sections of this appendix. Included in this group are planing mills, millworks, and businesses that make wooden containers and prefab building components, mobile homes, and glued-wood products like laminated beams, office and home furniture, partitions, and cabinets. All businesses employ cutting equipment whose by-products are chips and sawdust. Finishing is conducted in many operations.

Potential Pollutant Generating Sources: Businesses may have operations that use paints, solvents, wax emulsions, melamine formaldehyde, and other thermosetting resins, and produce waste paints, paint thinners, turpentine, shellac, varnishes and other waste liquids. Outside storage, trucking, and handling of these materials can also be pollutant sources.

Potential pollutants are BOD, COD, nitrate and nitrite nitrogen, TKN, total phosphorus, TSS, arsenic, copper, total phenols, oil & grease, and pH.

Wood Treatment

NAICS 321114: *Wood Preservation*

Description: This group includes both anti-staining and wood preserving. Some wood trimming may occur. After treatment, the lumber is typically stored outside. Forklifts are used to move both the raw and finished product. Wood treatment consists of a pressure process using the chemicals described below. Anti-staining treatment is conducted using dip tanks or by spraying. Wood preservatives may include creosote, creosote/coal tar, pentachlorophenol, copper naphthenate or inorganic arsenicals such as chromated copper arsenate dissolved in water. The use of pentachlorophenol is declining in the Puget Sound region.

Potential Pollutant Generating Sources: Potential pollutant generating sources/activities include the retort area, handling of the treated wood, outside storage of treated materials and products, equipment/vehicle storage and maintenance, and the unloading, handling, and use of the preservative chemicals. Based on (USEPA, 1995) the following stormwater contaminants have been reported: BOD, COD, TSS, and the specific pesticide(s) used for the wood preservation.

Other Manufacturing Businesses

NAICS 313xxx: *Textile Mills*

NAICS 314xxx: *Textile Product Mills*

NAICS 315xxx: *Apparel Manufacturing*

NAICS 316xxx: *Leather and Allied Product Manufacturing*

NAICS 3253xx: *Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing*

NAICS 327xxx: *Nonmetallic Mineral Product Manufacturing*

Description: Includes manufacturing of textiles and apparel, agricultural fertilizers, leather products, clay products such as bricks, pottery, bathroom fixtures; and nonmetallic mineral products.

Potential Pollutant Generating Sources: Pollutant generating sources at facilities in these categories include fueling, loading & unloading, material storage and handling (especially fertilizers), and vehicle and equipment cleaning and maintenance. Potential pollutants include BOD, COD, oil & grease, TSS, heavy metals and fertilizer components including nitrates, nitrites, ammonia nitrogen, TKN, and phosphorous compounds.

2. Transportation and Communication

Airfields and Aircraft Maintenance

NAICS 481xxx:*Air Transportation*

NAICS 4881xx:*Support Activities for Air Transportation*

Description: Industrial activities include vehicle and equipment fueling, maintenance and cleaning, and aircraft/runway deicing.

Potential Pollutant Generating Sources: Fueling is accomplished by tank trucks at the aircraft and is a source of spills. Dripping of fuel and engine fluids from the aircraft and at vehicle and equipment maintenance/ cleaning areas, and application of deicing materials to the aircraft and the runways are potential sources of stormwater contamination. Aircraft maintenance and cleaning produces a wide variety of waste products, similar to those found with any vehicle or equipment maintenance, including: used oil and cleaning solvents, paints, oil filters, soiled rags, and soapy wastewater. Deicing materials used on aircraft and/or runways include ethylene and propylene glycol, and urea. Other chemicals currently considered for ice control are sodium and potassium acetates, isopropyl alcohol, and sodium fluoride. Pollutant constituents include BOD, COD, oil & grease, pH, TSS, TKN, and specific deicing components such as glycol and urea.

Fleet Vehicle Yards

NAICS 484xxx:*Truck Transportation*

NAICS 485xxx:*Transit and Ground Passenger Transportation*

NAICS 4871xx:*Scenic and Sightseeing Transportation, Land*

NAICS 4884xx:*Support Activities for Road Transportation*

NAICS 492xxx:*Couriers and Messengers*

NAICS 5321xx:*Automotive Equipment Rental and Leasing*

NAICS 621910:*Ambulance Services*

Description: Includes all businesses that own, operate and maintain or repair large vehicle fleets, including cars, buses, trucks and taxis, as well as the renting or leasing of cars, trucks, and trailers.

Potential Pollutant Generating Sources: Potential pollutant generating sources include spills/leaks of fuels, used oils, oil filters, antifreeze, solvents, brake fluid, and batteries, sulfuric acid, battery acid sludge, and leaching from empty contaminated containers and soiled rags; leaking underground storage tanks that can cause ground water and/or soil contamination; dirt, oils, and greases from outside steam cleaning and vehicle washing; dripping of liquids from parked vehicles; solid and liquid wastes that are not properly stored outside; and loading and unloading areas.

Potential pollutants from this section may include BOD, heavy metals, oil & grease, TSS, organics, and pH.

Railroads

NAICS 482xxx:*Rail Transportation*

NAICS 4882xx:*Support Activities for Rail Transportation*

Description: Railroad activities are spread over a large geographic area: along railroad lines, in switching yards, and in maintenance yards. Railroad activity occurs on both property owned or leased by the railroad and at the loading or unloading facilities of its customers. Employing BMPs at commercial or public loading and unloading areas is the responsibility of the particular property owner.

Potential Pollutant Generating Sources: The following are potential sources of pollutants: dripping of vehicle fluids onto the road bed, leaching of wood preservatives from the railroad ties, human waste disposal, litter, locomotive sanding areas, locomotive/railcar/equipment cleaning areas, fueling areas, outside material storage areas, the erosion and loss of soil particles from the bed, and herbicides used for vegetation management.

Maintenance activities include maintenance shops for vehicles and equipment, track maintenance, and ditch cleaning. In addition to the railroad stock, the maintenance shops service highway vehicles and other types of equipment. Waste materials can include waste oil, solvents, degreasers, antifreeze, radiator flush, acid solutions, brake fluids, soiled rags, oil filters, sulfuric acid and battery sludge, and machine chips with residual machining oil and any toxic fluids or solids lost during transit. The following are potential pollutants at railyards: BOD, heavy metals, oil & grease, TSS, organics, and pesticides.

Warehouses and Mini-Warehouses

NAICS 493xxx: *Warehousing and Storage*

Description: Businesses that store goods in buildings and other structures.

Potential Pollutant Generating Sources: The following are potential pollutant sources from warehousing operations: Loading and unloading areas, outside storage of materials and equipment, and fueling and maintenance areas. Potential pollutants include oil & grease and TSS.

Other Transportation and Communication

NAICS 2211xx: *Electric Power Generation, Transmission, and Distribution*

NAICS 515xxx: *Broadcasting (except Internet)*

NAICS 517xxx: *Telecommunications*

NAICS 518xxx: *Data Processing, Hosting, and Related Services*

NAICS 519xxx: *Other Information Services*

NAICS 5615xx: *Travel Arrangement and Reservation Services*

Description: This group includes travel agencies, communication services such as TV and radio stations, cable companies, and electric and gas services. It does not include railroads, airplane transport services, airlines, pipeline companies, and airfields.

Potential Pollutant Generating Sources: Gas and electric services are likely to own vehicles that are washed, fueled and maintained on site. Communication service companies can generate used oils and dangerous wastes. The following are the potential pollutants: BOD, heavy metals, oil & grease, and TSS.

3. Retail and Wholesale Businesses

Gas Stations

NAICS 447xxx: *Gasoline Stations*

Refer to S409 BMPs for Fueling At Dedicated Stations to select applicable BMPs.

Recyclers and Scrap Yards

NAICS 423140: *Motor Vehicle Parts (Used) Merchant Wholesalers*

NAICS 423930: *Recyclable Material Merchant Wholesalers*

Refer to S423 BMPs for Recyclers and Scrap Yards

Commercial Composting

NAICS 325314: *Fertilizer (Mixing Only) Manufacturing*

Description: This typically applies to businesses that have numerous compost piles that require large open areas to break down the wastes. Composting can contribute nutrients, organics, coliform bacteria, low pH, color, and suspended solids to stormwater runoff.

Potential Pollutant Generating Sources: The compost must be contained, but may be a cause for concern during loading and unloading. Compost can have high levels of nutrients, organics, coliform bacteria, low pH, color concerns and suspended solids. Composting requires heavy equipment such as trucks and loaders. The equipment can generate oil & grease.

Restaurants/Fast Food

NAICS 711110: *Theater Companies and Dinner Theaters*

NAICS 722xxx: *Food Services and Drinking Places*

Description: Businesses that provide food service to the general public, including drive through facilities.

Potential Pollutant Generating Sources: Potential pollutant sources include high-use customer parking lots, outdoor used grease storage, and garbage dumpsters. The cleaning of roofs and other outside areas of restaurant and cooking vent filters into the parking lot can cause cooking grease to be discharged to the storm drains. The discharge of washwater or grease to storm drains or surface water is not allowed.

Retail/General Merchandise

NAICS 442xxx: *Furniture and Home Furnishings Stores*

NAICS 443xxx: *Electronics and Appliance Stores*

NAICS 444xxx: *Building Material and Garden Equipment And Supplies Dealers*

NAICS 445xxx: *Food and Beverage Stores*

NAICS 446xxx: *Health and Personal Care Stores*

NAICS 447xxx: *Gasoline Stations*

NAICS 448xxx: *Clothing and Clothing Accessories Stores*

NAICS 451xxx: *Sporting Goods, Hobby, Musical Instrument, and Book Stores*

NAICS 452xxx: *General Merchandise Stores*

NAICS 453xxx: *Miscellaneous Store Retailers*

NAICS 454xxx: *Nonstore Retailers*

Description: This group includes general merchandising stores such as department stores, shopping malls, variety stores, 24-hour convenience stores, and general retail stores that focus on a few product types such as clothing and shoes. It also includes furniture and appliance stores.

Potential Pollutant Generating Sources: Of particular concern are the high-use parking lots of shopping malls and 24-hour convenience stores. Furniture and appliance stores may provide repair services in which dangerous wastes may be produced.

Retail/Wholesale Vehicle and Equipment Dealers

NAICS 423110: *Automobile and Other Motor Vehicle Merchant Wholesalers*

NAICS 4238xx: *Machinery, Equipment, and Supplies Merchant Wholesalers*

NAICS 441xxx: *Motor Vehicle and Parts Dealers*

NAICS 453930: *Manufactured (Mobile) Home Dealers*

NAICS 5321xx: *Automotive Equipment Rental and Leasing*

NAICS 5324xx: *Commercial & Industrial Machinery & Equipment Rental & Leasing*

Description: This group includes all retail and wholesale businesses that sell, rent, or lease cars, trucks, boats, trailers, mobile homes, motorcycles and recreational vehicles. It includes both new and used vehicle dealers. It also includes sellers of heavy equipment for construction, farming, and industry. These businesses generally have large parking lots. Most retail dealers that sell new vehicles and large equipment also provide repair and maintenance services.

Potential Pollutant Generating Sources: Oil and other materials that have dripped from parked vehicles can contaminate stormwater at high-use parking areas. Vehicles are washed regularly generating vehicle grime and detergent pollutants. The storm or washwater runoff will contain oils and various organics, metals, and phosphorus. Repair and maintenance services generate a variety of waste liquids and solids including used oils and engine fluids, solvents, waste paint, soiled rags, and dirty used engine parts. Many of these materials are dangerous wastes.

Retail/Wholesale Nurseries and Building Materials

NAICS 4233xx: *Lumber and Other Construction Materials Merchant Wholesalers*

NAICS 4237xx: *Hardware and Plumbing and Heating Equipment and Supplies Merchant Wholesalers*

NAICS 4238xx: *Machinery, Equipment, and Supplies Merchant Wholesalers*

NAICS 424930: *Flower, Nursery Stock, & Florists' Supplies Merchant Wholesalers*

NAICS 444xxx: *Building Equipment and Garden Equipment and Supplies Dealers*

Description: These businesses are in a separate group because they are likely to store much of their merchandise outside of the main building. They include nurseries, and businesses that sell building and construction materials and equipment, paint, and hardware.

Potential Pollutant Generating Sources: Some businesses may have small fueling capabilities for forklifts and may also maintain and repair their vehicles and equipment. Some businesses may have unpaved areas, with the potential to contaminate stormwater by leaching of nutrients, pesticides, and herbicides. Businesses in this group surveyed in the Puget Sound area for dangerous wastes were found to produce waste solvents, paints and used oil. Storm runoff from exposed storage areas can contain suspended solids, and oil & grease from vehicles, forklifts, and high-use customer parking lots. Runoff from nurseries may contain nutrients, pesticides and/or herbicides.

Retail/Wholesale Chemicals and Petroleum

NAICS 4246xx: *Chemical and Allied Products Merchant Wholesalers*

NAICS 4247xx: *Petroleum and Petroleum Products Merchant Wholesalers*

NAICS 447xxx: *Gasoline Stations*

NAICS 454310: *Fuel Dealers*

Description: These businesses sell plastic materials, chemicals and related products. This group also includes the bulk storage and selling of petroleum products such as diesel oil, automotive fuels, etc.

Potential Pollutant Generating Sources: The general areas of concern are the spillage of chemicals or petroleum during loading and unloading, and the washing and maintenance of tanker trucks and other vehicles. Also the fire code requires that vegetation be controlled within a tank farm to avoid a fire hazard. Herbicides are typically used. The concentration of oil in untreated stormwater has been known to exceed the water quality effluent guideline for oil and grease. Runoff is also likely to contain significant concentrations of benzene, chloroform, phenol, lead, and zinc.

Retail/Wholesale Foods and Beverages

NAICS 4244xx: *Grocery and Related Product Merchant Wholesalers*

NAICS 4248xx: *Beer, Wine, & Distilled Alcoholic Beverage Merchant Wholesalers*

NAICS 445xxx: *Food and Beverage Stores*

NAICS 447110: *Gasoline Stations with Convenience Stores*

NAICS 4523xx: *General Merchandise Stores, including Warehouse Clubs and Supercenters*

NAICS 4542xx: *Vending Machine Operators*

NAICS 454390: *Other Direct Selling Establishments*

Description: Included are businesses that provide retail food including general groceries, fish and seafood, meats and meat products, dairy products, poultry, soft drinks, and alcoholic beverages.

Potential Pollutant Generating Sources: Vehicles may be fueled, washed and maintained at the business. Spillage of food and beverages may occur. Waste food and broken contaminated glass may be temporarily stored in containers located outside. High-use customer parking lots may be sources of oil and other contaminants

Other Retail/Wholesale Businesses

NAICS 423xxx: *Merchant Wholesalers, Durable Goods*

NAICS 424xxx: *Merchant Wholesalers, Nondurable Goods*

NAICS 425xxx: *Wholesale Electronic Markets and Agents and Brokers*

NAICS 441xxx: *Motor Vehicle and Parts Dealers*

NAICS 442xxx: *Furniture and Home Furnishing Stores*

NAICS 443xxx: *Electronic and Appliance Stores*

NAICS 444xxx: *Building Material and Garden Equipment and Supplies Dealers*

NAICS 446xxx: *Health and Personal Care Stores*

NAICS 448xxx: *Clothing and Clothing Accessories Stores*

NAICS 451xxx: *Sporting Goods, Hobby, Musical Instrument, and Book Stores*

NAICS 452xxx: *General Merchandise Stores*

NAICS 453xxx: *Miscellaneous Store Retailers*

Description: Businesses in this group include sellers of vehicle parts, tires, farm supplies, hand and garden tools, furniture and home furnishings, photographic and office equipment, electrical goods, sporting goods and toys, paper products, drugs, and apparel.

Potential Pollutant Generating Sources: Pollutant sources include loading/unloading areas, high-use parking lots, and delivery vehicles that may be fueled, washed, and maintained on premises.

4. Service Businesses

Animal Care Services

NAICS 1152xx: *Support Activities for Animal Production*

NAICS 45391x: *Pet and Pet Supplies Stores*

NAICS 54194x: *Veterinary Services*

NAICS 711212: *Racetracks*

NAICS 71329x: *Other Gambling Industries*

NAICS 81291x: *Pet care (except Veterinary) Services*

Description: This group includes racetracks, kennels, fenced pens, veterinarians and businesses that provide boarding services for animals including horses, dogs, and cats.

Potential Pollutant Generating Sources: The primary sources of pollution include animal manure, washwaters, waste products from animal treatment, runoff from pastures where larger livestock may roam, and vehicle maintenance and repair shops. Pastures may border streams and direct access to the stream may occur. Both surface water and ground water may be contaminated. Potential stormwater contaminants include BOD, fecal coliform, nutrients, oil & grease, and TSS.

Commercial Car and Truck Washes

NAICS 48849x: *Other Support Activities for Road Transportation*

NAICS 488999: *All Other support Activities for Transportation*

NAICS 811192: *Car Washes*

Description: Facilities include automatic systems found at individual businesses or at gas stations and 24-hour convenience stores, as well as self-service. There are three main types: tunnels, rollovers and hand-held wands. The tunnel wash, the largest, is housed in a long building through which the vehicle is pulled. At a rollover wash the vehicle remains stationary while the equipment passes over. Wands are used at self-serve car washes. Some car washing businesses also sell gasoline.

Potential Pollutant Generating Sources: Wash wastewater may contain detergents and waxes. Wastewater should be discharged to sanitary sewers. In self-service operations a drain is located inside each car bay. Although these businesses discharge the wastewater to the sanitary sewer, some washwater can find its way to the storm drain, particularly with the rollover and wand systems. Rollover systems often do not have air-drying. Consequently, as it leaves the enclosure the car sheds water to the pavement. With the self-service system, washwater with detergents can spray outside the building and drain to storm sewer. Users of self-serve operations may also clean engines and change oil, dumping the used oil into the storm drain. Potential pollutants include BOD, detergents, oil & grease, soaps, and TSS.

Equipment Repair

NAICS 532xxx: *Rental and Leasing Services*

NAICS 8112xx: *Electronic and Precision Equipment Repair and Maintenance*

NAICS 8113xx: *Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance*

NAICS 8114xx: *Personal and Household Goods Repair and Maintenance*

Description: This group includes several businesses that specialize in repairing different equipment including communications equipment, radio, TV, household appliances, and refrigeration systems. Also included are businesses that rent or lease heavy construction equipment as miscellaneous repair and maintenance may occur on site.

Potential Pollutant Generating Sources: Potential pollutant sources include storage and handling of fuels, waste oils and solvents, and loading/unloading areas. Potential pollutants include oil & grease, low/high pH, and TSS.

Laundries and Other Cleaning Services

NAICS 5612xx: *Facilities Support Services*

NAICS 56174x: *Carpet and Upholstery Cleaning Services*

NAICS 8123xx: *Drycleaning and Laundry Services*

Description: This category includes all types of cleaning services such as laundries, linen suppliers, diaper services, coin-operated laundries, dry cleaners, and carpet and upholstery services. Wet washing may involve the use of acids, bleaches and/or multiple organic solvents. Dry cleaners use an organic-based solvent, although small amounts of water and detergent are sometimes used. Solvents may be recovered and filtered for further use. Carpets and upholstery may be cleaned with dry materials, hot water extraction process, or in-plant processes using solvents followed by a detergent wash.

Potential Pollutant Generating Sources: Wash liquids are discharged to sanitary sewers. Stormwater pollutant sources include: loading and unloading of liquid materials, particularly at large commercial operations, disposal of spent solvents and solvent cans, high-use customer parking lots, and outside storage and handling of solvents and waste materials. Potential stormwater contaminants include chlorinated and other solvents, oil & grease, soaps and detergents, low/high pH, and TSS.

Marinas and Boat Clubs

NAICS 713930: *Marinas*

Description: Marinas and yacht clubs provide moorage for recreational boats. Marinas may also provide fueling and maintenance services. Other activities include cleaning and painting of boat surfaces, minor boat repair, and pumping of bilges and sanitary holding tanks. Not all marinas have a system to receive pumped bilge water.

Potential Pollutant Generating Sources: Both solid and liquid wastes are produced as well as stormwater runoff from high-use customer parking lots. Waste materials include sewage and bilge water. Maintenance by the tenants will produce used oils, oil filters, solvents, waste paints and varnishes, used batteries, and empty contaminated containers and soiled rags. Potential stormwater contaminants include heavy metals, oil & grease, low/high pH, and TSS.

Golf and Country Clubs

NAICS 713910: *Golf Courses and Country Clubs*

Description: Public and private golf courses and parks are included.

Potential Pollutant Generating Sources: Maintenance of grassed areas and landscaped vegetation has historically required the use of fertilizers and pesticides. Golf courses contain small lakes that are sometimes treated with algaecides and/or mosquito larvicides. The fertilizer and pesticide application process can lead to inadvertent contamination of nearby surface waters by overuse, misapplication, or the occurrence of storms shortly after application. Heavy watering of surface greens in golf courses may cause pesticides or fertilizers to migrate to surface and shallow ground water resources. The use of pesticides and fertilizers generates waste containers. Equipment must be cleaned and maintained.

Miscellaneous Services

NAICS 54192x: *Photographic Services*

NAICS 5617xx:*Services to Buildings and Dwellings*

NAICS 562xxx:*Waste Management and Remediation Services*

NAICS 712xxx:*Museums, Historical Sites, And Similar Institutions*

NAICS 713xxx:*Amusement, Gambling, and Recreation Industries*

NAICS 8122xx:*Death Care Servies*

NAICS 8129xx:*Other Personal Services*

Description: This group includes photographic studios, commercial photography, funeral services, amusement parks, furniture and upholstery repair, pest control services, and other professional offices. Pollutants from these activities can include pesticides, waste solvents, heavy metals, pH, suspended solids, soaps and detergents, and oil & grease.

Potential Pollutant Generating Sources: Leaks and spills of materials from the following businesses can be sources of stormwater pollutants:

1. Building maintenance produces wash and rinse solutions, oils, and solvents.
2. Pest control produces rinsewater with residual pesticides from washing application equipment and empty containers.
3. Outdoor advertising produces photographic chemicals, inks, waste paints, and organic paint sludges containing metals.
4. Funeral services produce formalin, formaldehyde, and ammonia.
5. Upholstery and furniture repair businesses produce oil, stripping compounds, wood preservatives and solvents.

Professional Services

NAICS 52xxxx:*Finance and Insurance*

NAICS 54xxxx:*Professional, Scientific, and Technical Services*

NAICS 55xxxx:*Management of Companies and Enterprises*

NAICS 561xxx:*Administrative and Support Services*

NAICS 61xxxx:*Education Services*

NAICS 62xxxx:*Health Care and Social Assistance*

NAICS 71xxxx:*Arts, Entertainment, And Recreation*

NAICS 72xxxx:*Accommodation and Food Services*

NAICS 8121xx:*Personal Care Services*

NAICS 8129xx:*Other Personal Services*

NAICS 813xxx:*Religious, Grantmaking, Civic, Professional, & Similar Organization*

Description: The remaining service businesses include theaters, hotels/motels, finance, banking, hospitals, medical/dental laboratories, medical services, nursing homes, schools/universities, and legal, financial and engineering services. Stormwater from parking lots will contain undesirable concentrations of oil & grease, suspended particulates, and metals such as lead, cadmium and zinc. Dangerous wastes might be generated at hospitals, nursing homes and other medical services.

Potential Pollutant Generating Sources: The primary concern is runoff from high use parking areas, spills from vehicle or equipment fueling or repair at maintenance shops, loading/unloading areas, and storage and handling of dangerous wastes.

Vehicle Maintenance and Repair

NAICS 8111xx: *Automotive Repair and Maintenance*

NAICS 8113xx: *Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance*

Description: This category includes businesses that paint, repair and maintain automobiles, motorcycles, trucks, and buses and battery, radiator, muffler, lube, tune-up and tire shops, excluding those businesses listed elsewhere in this manual.

Potential Pollutant Generating Sources: Pollutant sources include storage and handling of vehicles, solvents, cleaning chemicals, waste materials, vehicle liquids, batteries, and washing and steam cleaning of vehicles, parts, and equipment. Potential pollutants include waste oil, solvents, degreasers, antifreeze, radiator flush, acid solutions with cadmium, chromium, copper, lead, and zinc, brake fluid, soiled rags, oil filters, sulfuric acid and battery sludge, and machine chips in residual machining oil.

Multifamily Residences

NAICS 53111x: *Lessors of Residential Buildings and Dwellings*

NAICS 531311: *Residential Property Managers*

NAICS 7213xx: *Rooming and Boarding Houses, Dormitories, and Workers' Camps*

Description: Multifamily residential buildings such as apartments and condominiums. The activities of concern are vehicle parking, vehicle washing, oil changing, minor repairs, and temporary storage of garbage.

Potential Pollutant Generating Sources: Stormwater contamination can occur at vehicle parking lots and from washing of vehicles. Runoff from parking lots may contain undesirable concentrations of oil & grease, TSS, and metals such as cadmium, lead, and zinc.

Construction Businesses

NAICS 23xxxx: *Construction*

NAICS 5617xx: *Services to Buildings and Dwellings*

NAICS 562xxx: *Waste Management and Remediation Services*

Description: This category includes builders of homes, commercial and industrial buildings, and heavy equipment as well as plumbing, painting, paper hanging, carpentry, electrical, roofing and sheet metal, wrecking and demolition, stonework, drywall, and masonry contractors. It does not include construction sites.

Potential Pollutant Generating Sources: Potential pollutant sources include leaks/spills of used oils, solvents, paints, batteries, acids, strong acid/alkaline wastes, paint/varnish removers, tars, soaps, coatings, asbestos, lubricants, anti-freeze compounds, litter, and fuels at the headquarters, operation, staging, and maintenance/repair locations of the businesses.

Demolition contractors may store reclaimed material before resale. Roofing contractors generate residual tars and sealing compounds, spent solvents, kerosene, and soap cleaners, as well as non-dangerous waste roofing materials. Sheet metal contractors produce small quantities of acids and solvent cleaners such as kerosene, metal shavings, adhesive residues, enamel coatings, and asbestos residues that have been removed from buildings. Asphalt paving contractors are likely to store application equipment such as dump trucks, pavers, tack coat tankers and pavement rollers at their businesses. Stormwater passing through this equipment may be contaminated by the petroleum residuals. Potential pollutants include BOD, COD, heavy metals, oil & grease, organic compounds, pH, TSS, etc.

5. Public Agency Activities

Introduction

Local, state, and federal governments conduct many of the pollutant generating activities conducted at business facilities. Local governments include cities and counties, also single-purpose entities such as fire, sewer and water districts.

Public Facilities and Streets

Description: Included in this group are public buildings. Also included are maintenance (deicing), and repair of streets and roads.

Potential Pollutant Generating Sources: Wastes generated include deicing and anti-icing compounds, solvents, paint, acid and alkaline wastes, paint and varnish removers, and debris. Large amounts of scrap materials are also produced throughout the course of construction and street repair. Potential pollutants include suspended solids, oil & grease, and low/high pH.

Maintenance of Open Public Space Areas

Description: The maintenance of large open spaces covered by expanses of grass and landscaped vegetation. Examples are zoos and public cemeteries. Golf courses and parks are covered in S411 BMPs for Landscaping and Lawn / Vegetation Management.

Potential Pollutant Generating Sources: Maintenance of grassed areas and landscaped vegetation has historically required the use of fertilizers and pesticides. Golf courses contain small lakes that are sometimes treated with algaecides and/or mosquito larvicides. The application of pesticides can lead to inadvertent contamination of nearby surface waters by overuse, misapplication, or the occurrence of storms shortly after application. Heavy watering of surface greens in golf courses may cause pesticides or fertilizers to migrate to surface and shallow ground water resources. The application of pesticides and fertilizers generates waste containers. Equipment must be cleaned and maintained. Maintenance shops where the equipment is maintained must comply with the BMPs specified under S414 BMPs for Maintenance and Repair of Vehicles and Equipment.

Maintenance of Public Stormwater Pollutant Control Facilities

Description: Facilities include roadside catch basins on arterials and within residential areas, conveyance pipes, detention facilities such as ponds and vaults, oil and water separators, biofilters, settling basins, infiltration systems, and all other types of stormwater Runoff Treatment BMPs presented in Volume V.

Potential Pollutant Generating Sources: Research has shown that roadside catch basins can remove from 5 to 15 percent of the pollutants present in stormwater. However, to be effective they must be cleaned. Research has indicated that once catch basins are about 60 percent full of sediment, they cease removing sediments. Generally in urban areas, catch basins become 60 percent full within 6 to 12 months.

Water and solids produced during the cleaning of stormwater treatment systems, including oil/water separators, can adversely affect both surface and ground water quality if disposed improperly. Ecology has documented water quality violations and fish kills due to improper disposal of decant water (water that is removed) and catch basin sediments from maintenance activities. Disposal of decant water and solids shall be conducted in accordance with local, state, and federal requirements.

Historically, decant water from trucks has been placed back in the storm drain. Solids have been disposed in permitted landfills and in unpermitted vacant land including wetlands. Research has shown that these residuals contain pollutants at concentrations that exceed water quality criteria. For example, limited sampling by King County and the Washington State Department of Transportation of sediments removed from catch basins in residential and commercial areas has found the petroleum hydrocarbons to frequently exceed 200 mg/gram. Above this concentration, regulations require disposal at a lined landfill.

Water and Sewer Districts and Departments

Description: The maintenance of water and sewer systems can produce residual materials that, if not properly handled, can cause short-term environmental impacts in adjacent surface and/or ground waters. With the exception of a few simple processes, both water and sewage treatment produce residual sludge that must be disposed properly. However, this activity is controlled by other Ecology regulatory programs and is not discussed in this manual. Larger water and sewer districts or departments may service their own vehicles.

Potential Pollutant Generating Sources: Maintenance operations of concern include the cleaning of sewer, water lines, and water reservoirs, general activities around treatment plants, disposal of sludge, and the temporary shutdown of pump stations for either normal maintenance or emergencies. During the maintenance of water transmission lines and reservoirs, water district/departments must dispose of wastewater, both when the line or reservoir is initially emptied, as well as when it is cleaned and then sanitized. Sanitation requires chlorine concentrations of 25 to 100 ppm, considerably above the normal concentration used to chlorinate drinking water. These waters are discharged to sanitary sewers where available.

However, transmission lines from remote water supply sources often pass through both rural and urban-fringe areas where sanitary sewers are not available. In these areas, chlorinated water may need to be discharged to a nearby stream or storm drain, particularly since the emptying of a pipe section occurs at low points that frequently exist at stream crossings. Although prior to disposal the water is dechlorinated using sodium thiosulfate or a comparable chemical, malfunctioning of the dechlorination system can kill fish and other aquatic life. The drainage from reservoirs located in unsewered areas is conveyed to storm drains. The cleaning of sewer lines and manholes generates sediments. These sediments contain both inorganic and organic materials and may be contaminated with microorganisms and heavy metals. Activities around sewage treatment plants can be a source of non-point pollution. Besides the normal runoff of stormwater from paved surfaces, grit removed from the headworks of the plant is stored temporarily in dumpsters that may be exposed to the elements. Maintenance and repair shops may produce waste paints, used oil, cleaning solvents, and soiled rags.

Port Districts

Description: The port districts considered here include the following business activities: recreational boat marinas and launch ramps, airfields, container trans-shipment, bulk material import/-export including farm products, lumber, logs, alumina, cement; and break-bulk (piece) material such as machinery, equipment, and scrap metals. Port districts frequently have tenants whose activities are not marine-dependent.

Potential Pollutant Generating Sources: Marine terminals require extensive use of mobile equipment that may drip liquids. Waste materials associated with containers/vehicle/equipment washing/steam cleaning, maintenance and repair may be generated at a marine terminal. Debris can accumulate in loading/unloading or open storage areas, providing a source of stormwater contamination. Wooden debris from the crating of piece cargo crushed by passing mobile loading equipment leaches soluble pollutants when in contact with pooled stormwater. Log sorting yards produce large quantities of bark that can be a source of suspended solids and leached pollutants. Potential pollutants include oil & grease, heavy metals, organics, and TSS.

Appendix IV-B: Management of Street Waste Solids and Liquids

Introduction

This appendix addresses street waste as defined in chapter 173-350 WAC, Solid waste handling standards. WAC 173-350 is the governing rule for management of typical street waste solids. Ecology adopted revisions to this rule that became effective September 1, 2018, in part to provide clarity on managing soils impacted by release of contaminants, such as street waste. Ecology has solid waste guidance to help ensure handlers of street waste manage it in accordance with WAC 173-350. End users and other authorities may have their own requirements for street waste reuse and handling.

- Per WAC 173-350:
  - **"Street waste"** means solids or dewatered materials collected from stormwater catch basins and similar stormwater treatment and conveyance structures, and materials collected during street and parking lot sweeping.

"Street waste," as defined here, does not include solids and liquids from street washing using detergents, cleaning of electrical vaults, vehicle wash sediment traps, restaurant grease traps, industrial process waste, sanitary sewage, mixed process, or combined sewage/stormwater wastes. Wastes from oil/water separators at sites that load fuel are not included as street waste. Street waste also does not include flood debris, landslide debris, and chip seal gravel.

Regulations for Street Waste Management

Street waste is solid waste. While street waste from routine road maintenance is likely not dangerous waste, it is presumed to be solid waste under WAC 173-350. This Rule classifies Street Waste as a likely “contaminated soil," which is included in the definition of “solid waste.” Since stormwater conveyance structures are places where contaminants from streets can accumulate at concentrations that could be harmful for indiscriminant placement, material from such structures is presumed to be “contaminated soil.”

- Per WAC 173-350:
  - **"Contaminated soil"** means soil containing one or more contaminants from a release and when moved from one location to another for placement on or into the ground:
    a. Contains contaminants at concentrations that exceed a cleanup level under chapter 173-340 WAC, Model Toxics Control Act—Cleanup, that would be established for existing land use at the location where soil is placed; or
    b. Contains contaminants that affect pH, and pH of the soil is below 4.5 or above 9.5 or is not within natural background pH limits that exist at the location where soil is placed.

Unless excluded in WAC 173-350-020, contaminated soil is solid waste and must be managed at a solid waste handling facility in conformance with this chapter or chapter 173-351 WAC, Criteria for municipal solid waste landfills. Characterization of material may be required based on solid waste facility acceptance standards. Examples of potentially contaminated soil may include, but are not limited to, street waste, petroleum contaminated soil, engineered soil, and soil likely to have contaminants from a release associated with industrial or historical activities.

Based on test results, street waste to contain contaminants at concentrations that would require either disposal at a permitted solid waste disposal facility, or treatment at a permitted solid waste handling facility for use.

Owners/operators storing or treating street waste prior to disposal or use are typically subject to permitting under the section in WAC 173-350 dealing with “piles used for storage and treatment,” since most storage and treatment takes place in outdoor piles. Indoor or other storage or treatment is subject to permitting under the section dealing with “transfer stations and drop boxes.” To obtain a permit, an owner/operator will need to meet design standards, operating requirements, including characterization procedures and concentration limits if propose to use materials, and record keeping and reporting.

Note: Decant facilities are not subject to solid waste permitting if they will not have intermediate storage or treatment of decanted solids between the decant part of a facility operating in conformance with water quality rules and placement into transfer vehicles going to permitted solid waste facilities.

Street waste solids may contain contaminants at levels too high to allow unrestricted use. Street waste will need to meet the definition in WAC 173-350 for “clean soil” in order for its management or use outside of permitted solid waste handling facilities. “Clean soil” is tied to meeting contaminant concentrations so as not to create a cleanup site where placement of materials would occur.

- Per WAC 173-350:
    - **"Clean soil"** means soil that does not contain contaminants from a release. It also includes soil that contains one or more contaminants from a release and when moved from one location to another for placement on or into the ground:
        a. Does not contain contaminants at concentrations that exceed a cleanup level under chapter 173-340 WAC, Model Toxics Control Act—Cleanup, that would be established for existing land use at the location where soil is placed; or
        b. Contains contaminants that affect pH, but pH of the soil is between 4.5 and 9.5 or within natural background pH limits that exist at the location where soil is placed.

        Examples of potentially clean soil may include, but are not limited to, soil from undeveloped lands unlikely to have impacts from release of contaminants associated with area-wide or local industrial or historical activities. This includes similar soils over which development may have occurred but land use is unlikely to have led to a release, such as use for residential housing, or over which development provided protection from impacts from a release, such as coverage by pavement. Soil with substances from natural background conditions, as natural background is defined in WAC 173-350-100, is clean soil under this section.

Street waste that will go directly to a permitted landfill or transfer station is not subject to the standards of WAC 173-350, though operators will need to adhere to receiving facility acceptance criteria. For street waste that will not go directly to a permitted landfill or transfer station, an operator needs to consult with their jurisdictional health department to see what solid waste regulations apply to street waste management. In Washington, chapter 70.95 RCW, Solid waste management – Reduction and recycling, gives jurisdictional health departments primary authority over solid waste handling and permitting.

As stated earlier, guidance will be available soon with more specificity on how to manage “contaminated soil” under the recently revised WAC 173-350.

Contaminants in Street Waste Solids

Street waste does not typically classify as dangerous waste. The owner of the stormwater facility and/or collector of street waste is considered the waste generator and responsible for deciding whether the waste designates as dangerous waste. However, sampling has historically shown that material from routine maintenance of roads and stormwater facilities does not classify as dangerous waste.

It is possible that street waste from spill sites has high enough concentration of contaminants to classify it as dangerous waste. Street waste suspected to be dangerous waste should not be collected with other street waste to avoid creating a larger volume of dangerous waste. Street waste with obvious contamination (unusual color, staining, corrosion, unusual odors, fumes, and oily sheen) should be left in place or segregated until tested. Base testing activities on probable contaminants. If collecting potentially dangerous waste because of emergency conditions, or if the waste becomes suspect after it is collected, an owner/operator should handle and store it separately until a determination as to proper disposal is made. Dangerous waste must be handled following chapter 173-303 WAC, Dangerous waste regulations.

Test results from sampling street waste show that it contains contaminants including total petroleum hydrocarbons (TPH), carcinogenic polycyclic aromatic hydrocarbons (c-PAHs), and several metals. These contaminants can be at concentrations high enough to be harmful to human health and the environment unless managed appropriately. The following tables provide a summary of some past test results.

Table IV-B.1: Typical TPH Levels in Street Sweeping and Catch Basin Solids

Reference	Street Sweeping (mg/kg)	Catch Basin Solid (mg/kg)
Snohomish County (1) (Landau, 1995)	390 - 4300	
King County (1) (Herrera, 1995)		123 - 11049 (Median 1036)
Snohomish County & Selected Cities (1) (W&H Pacific, 1994)	163 - 1500 (Median 760)	163 -1562 (Median 760)

Table IV-B.1: Typical TPH Levels in Street Sweeping and Catch Basin Solids (continued)

Reference	Street Sweeping (mg/kg)	Catch Basin Solid (mg/kg)
City of Portland (2) (Bretsch, 2000)		MDL - 1830 (Median 208)
City of Seattle - Diesel Range (2) (Seattle Public Utilities and Herrera, 2009)	330 - 520	780 - 1700
City of Seattle - Motor Oil (2) (Seattle Public Utilities and Herrera, 2009)	2000 - 2800	3500 - 7000
Oregon (1) (Collins, 1998)	1600 - 2380	
Oregon (3) (Collins, 1998)	98 - 125	
(1) Method WTPH 418.1; does not incorporate new methods to reduce background interference due to vegetative material (2) Method NWTPH-Dx (3) Method WTPH - HCID		

Table IV-B.2: Typical c-PAH Values in Street Waste Solids and Related Materials

Sample Source	City of Everett					WSDOT	
Analyte	Street Sweepings	Soil	3-Way Topsoil	Vactor Solids	Leaf & Sand	Sweepings - Fresh	Sweepings - Weathered
Benzo(a)anthracene	0.1U	0.076U	0.074U	0.21	0.45	0.56	0.40
Chrysene	0.14	0.09	0.074U	0.32	0.53	0.35	0.35
Benzo(b)fluoranthene	0.11	0.076U	0.074U	0.27	0.52	0.43	0.51
Benzo(k)fluoranthene	0.13	0.076U	0.074U	0.25	0.38	0.39	0.40
Benzo (a)pyrene	0.13	0.076U	0.074U	0.26	0.5	0.41	0.33U
Indeno(1,2,3-cd)pyrene	0.1U	0.076U	0.074U	0.19	0.39	NR	NR

Table IV-B.2: Typical c-PAH Values in Street Waste Solids and Related Materials (continued)

Sample Source	City of Everett					WSDOT	
Analyte	Street Sweepings	Soil	3-Way Topsoil	Vactor Solids	Leaf & Sand	Sweepings - Fresh	Sweepings - Weathered
Dibenzo(a,h)-anthracene	0.1U	0.076U	0.074U	0.081	0.12	0.39	0.33U
Revised MTCA Benzo (a)pyrene [ND=PQL]	0.215	0.134	0.134	0.388	0.727	0.708	0.597
Benzo (a)pyrene [ND = 1/2 PQL]	0.185	0.069	0.067	0.388	0.727	0.708	0.366
Benzo (a)pyrene [See * below]	0.185	0.069	0	0.388	0.727	0.708	0.366
Benzo (a)pyrene [ND = 0]	0.155	0.001	0	0.388	0.727	0.708	0.135
* If the analyte was not detected for any PAH, then ND=0; If analyte was detected in at least 1 PAH, then ND=1/2PQL; If the average concentration (using ND=1/2 PQL) is greater than the maximum detected value, then ND=Maximum value.							

Table IV-B.3: Typical Metals Concentrations in Catch Basin Sediments

PARAMETER	Ecology 1993	Thurston 1993	King County 1995	King county 1995	City of Seattle 2003 through 2011
Metals: Total (mg/kg)	(Min - Max)	(Min - Max)	(Min - Max)	Mean	Min - Max (Mean)
As	< 3 - 24	.39 - 5.4	4 -56	0.250	<5 - 50 (9.3)
Cd	0.5 - 2.0	< 0.22 - 4.9	0.2 - 5.0	0.5	
Cr	19 - 241	5.9 - 71	13 - 100	25.8	
Cu	18 - 560	25 - 110	12 - 730	29	9.1 - 3,280 (166)
Pb	24 - 194	42 - 640	4 - 850	80	3 - 3,690 (154)
Ni	33 - 86	23 - 51	14 - 41	23	

Table IV-B.3: Typical Metals Concentrations in Catch Basin Sediments (continued)

PARAMETER	Ecology 1993	Thurston 1993	King County 1995	King county 1995	City of Seattle 2003 through 2011
Metals: Total (mg/kg)	(Min - Max)	(Min - Max)	(Min - Max)	Mean	Min - Max (Mean)
Zn	90 - 558	97 - 580	50 - 2000	130	44 - 4170 (479)
Hg	0.04 - 0.16	0.24 - 0.193			<0.03 - 3.8 (0.16)

Table IV-B.4: Pollutants in Catch Basin Solids - Comparison to Dangerous Waste Criteria

PARAMETER	Range of Values in Catch Basin Waste	Range of Values in Catch Basin Waste	Dangerous Waste Criteria
METALS	Total Metals (mg/kg)	TCLP Metals (mg/kg)	TCLP values (mg/l)
As	<3 - 56	< 0.02 - 0.5	5.0
Cd	< 0.22 - 5	0.0002 - 0.03	1.0
Cr	5.9 - 241	0.0025 - 0.1	5.0
Cu	12 - 730	0.002 - 0.88	none
Pb	4 - 850	0.015 - 3.8	5.0
Ni	23 - 86	< 0.01 - 0.36	none
Zn	50 - 2,000	0.04 - 6.7	none
Hg	0.02 - 0.19	0.0001 - 0.0002	0.2
Data from (Thurston County, 1993), (Herrera, 1995) and (Serdar, 1993)			

Street Waste Liquids

General Procedures:

Street waste collection should emphasize retention of solids in preference to liquids. Street waste solids are the principal objective in street waste collection and are substantially easier to store and treat than liquids.

Street waste liquids require treatment before their discharge. Street waste liquids, which include eductor and street sweeping truck decant and drainage from piles and containers, usually contain high amounts of suspended and total solids and adsorbed metals. Treatment requirements depend on the discharge location.

The entity responsible for operation and maintenance of the system must approve discharges to sanitary sewer and storm sewer systems. Ecology will not generally require waste discharge permits for discharge of stormwater decant to sanitary sewers or to stormwater treatment BMPs constructed and maintained in accordance with this manual.

Listed below is the required order of preference for disposal of liquid from collection of Street Wastes.

1. **Discharge of Street Waste liquids to a municipal sanitary sewer connected to a Public Owned Treatment Works (POTW).** Discharge to a municipal sanitary sewer requires the approval of the sewer authority. Approvals for discharge to a POTW will likely contain pretreatment, quantity, and location conditions to protect the POTW. Following the local sewer authority's conditions is a permit requirement.

2. **Discharge of Street Waste liquids may be allowed into a Basic or Enhanced Runoff Treatment BMP, if option 1 is not available.** Only discharge street waste liquid into the storm sewer system under the following conditions:

   - The preferred disposal option of discharge to sanitary sewer is not reasonably available.
   - The discharge is to a Basic or Enhanced Runoff Treatment BMP. If pretreatment does not remove visible sheen from oils, the Runoff Treatment BMP must be able to prevent the discharge of oils causing a visible sheen.
   - The discharge from the eductor truck is as near to the inlet of the Runoff Treatment BMP as practical, to minimize contamination or recontamination of the collection system.
   - The storm sewer system owner/operator has granted approval and has determined that the Runoff Treatment BMP will accommodate the increased loading. Part of the approval process may include pretreatment conditions to protect the Runoff Treatment BMP. Following local pretreatment conditions is a requirement of this permit.
   - Ecology must approve in advance flocculants for the pretreatment of street waste liquids. The liquids must be non-toxic under the circumstances of use.

   The discharger shall determine if reasonable availability of sanitary sewer discharge exists, by evaluating such factors as distance, time of travel, load restrictions, and capacity of the Runoff Treatment BMP.

3. **Operators may return water removed from stormwater ponds, vaults, and oversized catch basins to the storm sewer system.** Stormwater ponds, vaults, and oversized catch basins contain substantial amounts of liquid, which hampers the collection of solids and poses problems in hauling the removed waste away from the site. Water removed from these facilities may be discharged back into the pond, vault, or catch basin provided:

   - Operators may discharge clear water removed from a stormwater treatment structure directly to a down gradient cell of a treatment pond or into the storm sewer system.
   - Turbid water may be discharged back into the structure it was removed from if the removed water has been stored in a clean container (eductor truck, Baker tank, or other appropriate container used specifically for handling stormwater or clean water); and

there will be no discharge from the treatment structure for at least 24 hours.

- The storm sewer system owner/operator must approve the discharge.

Table IV-B.5: Typical Street Waste Decant Values Compared to Surface Water Quality Criteria

PARAMETER	State Surface Water Quality Criteria		Range of Values Reported	
METALS	Freshwater Acute (ug/l - dissolved metals)	Freshwater Chronic (ug/l - dissolved metals)	Total Metals (ug/l)	Dissolved Metals (ug/l)
Arsenic	360	190	100 - 43,000	60 - 100
Cadmium*	2.73	0.84	64 - 2,400	2 - 5
Chromium (total)			13 - 90,000	3 - 6
Chromium (III)*	435	141		
Chromium (VI)	0.5	10		
Copper*	13.04	8.92	81 - 200,000	3 - 66
Lead*	47.3	1.85	255 - 230,000	1 - 50
Nickel*	1114	124	40 - 330	20 - 80
Zinc*	90.1	82.3	401 - 440,000	1,900 - 61,000
Mercury	2.10	0.012	0.5 - 21.9	
Hardness dependent; hardness assumed to be 75 mg/L				

Table IV-B.6: Typical Values for Conventional Pollutants in Street Waste Decant

PARAMETER	Ecology 1993	(Min - Max)	King County 1995	(Min - Max)
Values as mg/l; except where stated	Mean		Mean	
pH	6.94	6.18 - 7.98	8	6.18 - 11.25
Conductivity (umhos/cm)	364	184 - 1,110	480	129 - 10,100
Hardness (mg/l CaCO3)	234	73 - 762		
Fecal Coliform (MPN/100 ml)	3,000			
BOD	151	28 - 1,250		

Table IV-B.6: Typical Values for Conventional Pollutants in Street Waste Decant (continued)

PARAMETER	Ecology 1993	(Min - Max)	King County 1995	(Min - Max)
Values as mg/l; except where stated	Mean		Mean	
COD	900	120 - 26,900		
Oil & Grease	11	7.0 - 40	471	15 - 6,242
TOC	136	49 - 7,880	3,670	203 - 30,185
Total Solids	1,930	586 - 70,400		
Total Dissolved Solids	212	95 - 550		
Total Suspended Solids	2,960	265 - 111,000		
Settleable Solids (ml/l/hr)	27	2 - 234	57	1 - 740
Turbidity (ntu)	1,000	55 - 52,000	4,673	43 - 78,000

Table IV-B.7: Street Waste Decant Values Following Settling

PARAMETER; Total Metals in mg/l	Portland - Inverness Site Min - Max	King County - Renton Min - Max	METRO Pretreatment Discharge Limits
Arsenic	0.0027 - 0.015	< MDL - 0.12	4
Cadmium	0.0009 - 0.0150	< MDL - 0.11	0.6
Chromium	0.0046 - 0.0980	0.017 - 0.189	5
Copper	0.015 - 0.8600	0.0501 - 0.408	8
Lead	0.050 - 6.60	0.152 - 2.83	4
Nickel	0.0052 - 0.10	0.056 - 0.187	5
Silver	0.0003 - 0.010	< MDL	3
Zinc	0.130 - 1.90	0.152 - 3.10	10
Settleable Solids; ml/L	No Data	0.02 - 2.0	7
Nonpolar FOG	5.7 - 25	5 - 22	100
Ph (std)	6.1 - 7.2	6.74 - 8.26	5.0 - 12.0
TSS	2.8 - 1310		
Recorded Total Monthly Flow; Gallons	Data not available	31,850 - 111,050	
Recorded Max. Daily	Data not available	4,500 - 18,600	25,000 GPD

Table IV-B.7: Street Waste Decant Values Following Settling (continued)

PARAMETER; Total Metals in mg/l	Portland - Inverness Site Min - Max	King County - Renton Min - Max	METRO Pretreatment Discharge Limits
Flow; Gallons			
Calculated Average Daily Flow; GPD	Data not available	1,517 - 5,428	
1) Data from King County's Renton Facility (data from 1998 - 1999) and the City of Portland's Inverness Site (data from 1999 - 2001); detention times not provided			

Collection Site Assessment

Ecology suggests a collection site assessment to identify spills or locations that potentially contain dangerous wastes.

The collection site assessment will aid in determining if waste is a dangerous waste and in deciding what to test for if dangerous waste is suspected. The collection site assessment will also help determine if the waste meets the requirements of the receiving facility.

There are three steps to a collection site assessment:

1. A **historical review** of the site for spills, previous contamination and nearby cleanup sites or dangerous waste facilities.

   The historical review will be easier if done on an area wide basis prior to scheduling any waste collection. The historical review should be more thorough for operators who have never collected waste at the site before. At a minimum, the historical review should include operator knowledge of the area's collection history or records from previous waste collections.

   Private operators should ask the owner of the site for records of previous contamination and the timing of the most recent cleaning. Ecology’s Hazardous Substance Information Office maintains a Toxic Release Inventory and a Facility/Site Database, tracking more than 15,000 sites.

   Ecology's online Facility/Site Database is available at www.ecy.wa.gov/fs/.

   The database allows anyone with web-access to search for facility information by address, facility name, town, zip code, and SIC code, etc. It lists why Ecology is tracking each one (NPDES, TSCA, RCRA, Clean Air Act, etc.), as well as who to call within Ecology to find out more about the given facility. EPA’s toxic release website is http://iaspub.epa.gov/triexplorer/tri_release.chemical

2. A **visual inspection** for potential contaminant sources such as a past fire, leaking tanks and electrical transformers, and surface stains.

Take a look at the area for contaminant sources prior to collection of the waste. If the inspection finds a potential contaminant source, delay the waste collection until the potential contaminant is assessed.

A second portion of the visual inspection is a good housekeeping assessment of the area. Locations with poor housekeeping commonly cut corners in less obvious places. Inspect these sites in greater detail for illegal dumping and other contamination spreading practices.

3. **Sweeping route, catch basin, waste, and container inspection** before and during collection.

   The inspection of the waste and catch basin or vault is the last and perhaps most critical step in the collection site assessment.

   For example, if the stormwater facility has an unusual color in or around it, then it is possible someone dumped something near it or into it. Some colors to be particularly wary of are yellow/green from antifreeze dumping and black and rainbow sheen from oil and/or grease dumping. In addition, if the inspector observes any staining or corrosion, then a solvent may have been dumped.

   Fumes are also good indicators of potential contamination. Avoid deliberate smelling of catch basins for worker safety, but suspicious odors may be encountered from catch basins thought to be safe. Some suspicious odors are rotten eggs (hydrogen sulfide is present), gasoline or diesel fumes, or solvent odors. If unusual odors are noted, contact a dangerous waste inspector before cleaning the basin.

   Finally, operator experience is the best guide to avoid collection of contaminated waste.

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Volume V

Runoff Treatment, Flow Control, and LID BMP Library

Stormwater Management Manual for Western Washington

Prepared by:

Washington State Department of Ecology
Water Quality Program

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Executive Summary of Volume V

Welcome to Volume V of Ecology's 2019 Stormwater Management Manual for Western Washington. Volume V provides guidance for the design and maintenance of BMPs used to meet I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.6 MR6: Runoff Treatment, and/or I-3.4.7 MR7: Flow Control. In this Volume you will find the following:

V-1 General BMP Design provides design guidance that may be applicable to multiple BMP types.

V-2 Site Design BMPs provides BMPs for consideration while designing the site layout.

V-3 Dispersion BMPs includes BMPs that provide Runoff Treatment and/or Flow Control by dispersing stormwater through vegetation.

V-4 Roof Downspout BMPs provides BMPs for use at the end of roof downspouts.

V-5 Infiltration BMPs includes BMPs that provide Runoff Treatment and/or Flow Control by infiltrating stormwater runoff into the native soils.

V-6 Filtration BMPs includes BMPs that provide Runoff Treatment by filtering stormwater through a sand layer or other media.

V-7 Biofiltration BMPs includes BMPs that provide Runoff Treatment by filtering stormwater through an engineered vegetation strip.

V-8 Wetpool BMPs include BMPs that provide Runoff Treatment by allowing suspended pollutants to settle as stormwater passes through a permanent pool of water.

V-9 Pretreatment BMPs includes BMPs that may be used as pretreatment prior to an infiltration BMP, or as part of a larger BMP Runoff Treatment train.

V-10 Manufactured Treatment Devices as BMPs describes how a manufactured treatment device can get Ecology Approval, a description of the different levels of approval, and a link to Ecology's website with a list of the manufactured treatment devices that have Ecology approval.

V-11 Miscellaneous LID BMPs includes LID BMPs that may not be used to meet I-3.4.6 MR6: Runoff Treatment or I-3.4.7 MR7: Flow Control, and do not fit into any of the other categories presented by the other chapters within this volume.

V-12 Detention BMPs includes BMPs that provide Flow Control by detaining stormwater in ponds, tanks, or vaults, and releasing the stormwater at a slower rate through an engineered control structure.

V-13 Oil and Water Separator BMPs includes BMPs that may be used to provide Runoff Treatment that meets the Oil Control Performance Goal.

Appendix V-A: BMP Maintenance Tables is a centralized location for maintenance activities recommended by Ecology for BMPs within Volume V.

Refer to Volumes I through IV for information on the following:

Volume I introduces the measures necessary to control the quantity and quality of stormwater produced by new development and redevelopment. It includes an introduction to stormwater management, guidance on regulatory requirements for stormwater management, and details the minimum requirements for new development and redevelopment sites.

Volume II focuses on managing stormwater impacts associated with construction activities. It discusses the need for pollution prevention for construction stormwater, details how to document construction BMPs in a construction stormwater pollution prevention plan, and includes information on how to implement construction stormwater BMPs.

Volume III provides guidance on how to choose, hydrologically model, and document stormwater BMPs in a stormwater site plan.

Volume IV contains a library of source control BMPs, categorized by types of activities.

V-1 General BMP Design

V-1.1 Sequence of Runoff Treatment and Detention BMPs

In general, Runoff Treatment BMPs may be installed upstream of detention facilities, although pre-settling basins are needed for sand filters and infiltration basins. However, not all Runoff Treatment BMPs can function effectively if located downstream of detention BMPs. Those Runoff Treatment BMPs that treat unconcentrated flows, such as filter strips, are usually not practical downstream of detention BMPs. Other types of Runoff Treatment BMPs present special problems that must be considered before placement downstream of detention BMPs is advisable.

For instance, prolonged flows discharged by a detention BMP that is designed to meet the flow duration standard of I-3.4.7 MR7: Flow Control may interfere with proper functioning of basic biofiltration swales and sand filters. Grasses typically specified in the basic biofiltration swale design may not survive. A wet biofiltration design would be a better choice.

For sand filters, the prolonged flows may cause extended saturation periods within the filter. Saturated sand can lose all oxygen and become anoxic. If that occurs, some amount of phosphorus captured within the filter may become soluble and released. To prevent long periods of saturation, adjustments may be necessary after the sand filter is in operation to bypass some areas of the filter. This bypassing will allow them to drain completely. It may also be possible to use a different type of BMP that is less sensitive to prolonged flows.

Oil control BMPs must be located upstream of Runoff Treatment BMPs and as close to the source of oil-generating activity as possible. They should also be located upstream of detention facilities, if possible.

Manufactured Treatment Devices may be installed either upstream or downstream of detention BMPs. The location depends on the type of technology and the level of treatment desired.

Table V-1.1: Runoff Treatment BMP Placement in Relation to Detention summarizes placement considerations of Runoff Treatment BMPs in relation to detention.

Table V-1.1: Runoff Treatment BMP Placement in Relation to Detention

Runoff Treatment BMP	Preceding Detention	Following Detention
BMP T9.10: Basic Biofiltration Swale	OK	OK. Prolonged flows may reduce grass survival. Consider wet biofiltration swale
BMP T9.20: Wet Biofiltration Swale	OK	OK
BMP T9.40: Vegetated Filter Strip	OK	No - must be installed before flows concentrate.
BMP T10.10: Wet-	OK	OK - less water level fluctuation in ponds downstream of

Table V-1.1: Runoff Treatment BMP Placement in Relation to Detention (continued)

Runoff Treatment BMP	Preceding Detention	Following Detention
ponds - Basic and Large		detention may improve aesthetic qualities and performance.
BMP T10.40: Combined Detention and Wetpool Facilities	Not applicable	Not applicable
BMP T10.20: Wetvaults	OK	OK
BMP T8.10: Basic Sand Filter Basin BMP T8.11: Large Sand Filter Basin BMP T8.20: Sand Filter Vault	OK, but pre-settling and control of floatables needed	OK - sand filters downstream of detention facilities may require field adjustments if prolonged flows cause sand saturation and interfere with phosphorus removal.
BMP T10.30: Stormwater Treatment Wetlands	OK	OK - less water level fluctuation and better plant diversity are possible if the stormwater wetland is located downstream of the detention facility.

V-1.2 Setbacks, Slopes, and Embankments

The following guidelines for setbacks, slopes, and embankments are intended to provide for adequate maintenance accessibility to Runoff Treatment BMPs. Setback requirements are generally required by local regulations, International building code requirements, or other state regulations. Local governments should require specific setback, slope and embankment limitations to address public health and safety concerns.

Setbacks

Local governments may require specific setbacks in sites with steep slopes, land-slide areas, open water features, springs, wells, and septic tank drain fields. Setbacks from tract lines are necessary for maintenance access and equipment maneuverability. Adequate room for maintenance equipment should be considered during site design.

Examples of text describing commonly used setbacks include the following:

- Stormwater infiltration BMPs shall be set back at least 100 feet from open water features and designated landslide hazard areas; stormwater infiltration BMPs shall be set back 200 feet from springs and flowing artesian wells used for drinking water supply. Infiltration BMPs upgradient of drinking water supplies must comply with Health Department requirements.
- Stormwater infiltration BMPs, and unlined wetponds and detention ponds shall be located at least 100 feet from drinking water wells and septic tanks and drainfields.

- Wetvaults and tanks may be required to be set back from building foundations, structures, property lines, and vegetative buffers. A typical setback requirement is 20 feet, for maintenance access.
- Stormwater infiltration BMPs shall be set back 100-feet from retaining walls to prevent "short circuiting" of stormwater by free-draining rock behind the retaining walls, unless the bottom of the infiltration BMP is greater than 2-feet below the lowest point on the retaining wall.
- All facilities shall be a minimum of 50 feet from any steep (greater than 15%) slope. A geotechnical report must address the potential impact of a wetpond on a steep slope.

Side Slopes and Embankments

Side slopes should preferably not be steeper than a slope of 3H:1V. Moderately undulating slopes are acceptable and can provide a more natural setting for the BMP. In general, gentle side slopes improve the aesthetic attributes of the BMP and enhance safety.

Interior side slopes may be retaining walls, if the design is prepared and stamped by a licensed engineer in the state of Washington. A fence should be provided along the top of the wall for safety for any retaining wall exceeding 4-feet in height or any pond with a design depth greater than 2-feet.

Embankments that impound water must comply with the Washington State Dam Safety Regulations (Chapter 173-175 WAC). If the impoundment has a storage capacity (including both water and sediment storage volumes) greater than 10 acre-feet (435,600 cubic feet or 3.26 million gallons) above natural ground level, or has an embankment height of > 6 feet at the downstream toe, then dam safety design and review are required by Ecology.

V-1.3 Liners and Geotextiles

V-1.3.1 General Liner Design

Liners are intended to reduce the likelihood that pollutants in stormwater will reach ground water when Runoff Treatment BMPs are constructed. In addition to ground water protection considerations, some BMP types require permanent pools of water for proper functioning. An example is the first cell of a wetpond.

Treatment liners amend the soil with materials that treat stormwater before it reaches more freely draining soils. Treatment liners have slow rates of infiltration, generally less than 2.4 inches per hour (1.7 x 10 -3 cm/s), but not as slow as low permeability liners. Treatment liners may use in-place native soils or imported soils.

Low permeability liners reduce infiltration to a very slow rate, generally less than 0.02 inches per hour (1.4 x 10 -5 cm/s). These types of liners should be used for industrial or commercial sites with a potential for high pollutant loading in the stormwater runoff. Low permeability liners may be fashioned from compacted till, clay, geomembrane, or concrete. Till liners are preferred because of their general resilience and ease of maintenance.

The following should be considered when a liner is part of your design:

- Table V-1.2: Liner Types Recommended for Runoff Treatment BMPs shows recommendations for the type of liner (either treatment or low permeability) generally best suited for use with various Runoff Treatment BMPs.
- Liners shall be evenly placed over the bottom and/or sides of the treatment area of the BMP as indicated in Table V-1.2: Liner Types Recommended for Runoff Treatment BMPs. Areas above the treatment volume required to pass flows greater than the water quality treatment flow (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:
    1. Where the seasonal high ground water elevation is likely to contact a low permeability liner, liner buoyancy may be a concern. A low permeability liner shall not be used in this situation unless evaluated and recommended by a geotechnical engineer.
    2. Where grass must be planted over a low permeability liner per the BMP design, a minimum of 6 inches of 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.
- 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 ground water specialist and found to be as protective as if the liner were above the level of the ground water.

See V-1.3.2 Treatment Liners and V-1.3.3 Low Permeability Liners for more specific design criteria for treatment liners and low permeability liners.

Table V-1.2: Liner Types Recommended for Runoff Treatment BMPs

Runoff Treatment BMP	Area to be Lined	Type of Liner Recommended
BMP T6.10: Presettling Basin	Bottom and sides	Low permeability liner or Treatment liner (If the basin will intercept the seasonal high ground water table, a treatment liner is recommended.)
BMP T10.10: 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 ground water table, a treatment liner is recommended.)
BMP T10.10: Wetponds - Basic and Large (second cell)	bottom and sides to WQ design water surface	Treatment liner
BMP T10.40: 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 ground water table a treatment liner is recommended.)
BMP T10.40: Combined Deten-	bottom and sides to	Treatment liner

Table V-1.2: Liner Types Recommended for Runoff Treatment BMPs (continued)

Runoff Treatment BMP	Area to be Lined	Type of Liner Recommended
tion and Wetpool Facilities (second cell)	WQ design water surface	
BMP T10.30: Stormwater Treatment Wetlands	Bottom and sides, both cells	Low permeability liner (If the facility will intercept the seasonal high ground water table, a treatment liner is recommended.)
BMP T8.10: Basic Sand Filter Basin or BMP T8.11: Large Sand Filter Basin	Basin sides only	Treatment liner
BMP T8.20: Sand Filter Vault	Not applicable	No liner needed
BMP T8.30: Linear Sand Filter (in vault)	Not applicable if in vault	No liner needed
BMP T8.30: Linear Sand Filter (not in vault)	Bottom and sides of presettling cell if not in vault	Low permeability or treatment liner
BMP T10.20: Wetvaults	Not applicable	No liner needed

V-1.3.2 Treatment Liners

Listed below is Ecology's design criteria for treatment liners:

- A two foot thick layer of soil with a minimum organic content of 1.0% AND a minimum cation exchange capacity (CEC) of 5 milliequivalents/100 grams can be used as a treatment liner beneath a Runoff Treatment or Flow Control BMP.
- To demonstrate that in place soils meet the above criteria, one sample per 1,000 square feet of BMP area shall be tested. Each sample shall be a composite of subsamples taken throughout the depth of the treatment liner (usually two to six feet below the expected BMP invert).
- Typically, side wall seepage is not a concern if the seepage flows through the same stratum as the bottom of the Runoff Treatment BMP. However, if the treatment liner is an engineered soil or has very low permeability, the potential to bypass the treatment liner through the side walls may be significant. In those cases, the Runoff Treatment BMP side walls must be lined with at least 18 inches of treatment soil, as described above, to prevent untreated seepage. This lesser soil thickness is based on unsaturated flow as a result of alternating wet-dry periods.

  Ecology approved continuous simulation models must be run using the “No Infiltration” option through the sidewalls if one sidewall is impervious.

- Organic content shall be measured on a dry weight basis using ASTM D2974.
- Cation exchange capacity (CEC) shall be tested using EPA laboratory method 9081.
- Certification by a soils testing laboratory that imported soil meets the organic content and CEC criteria above shall be provided to the local approval authority.

V-1.3.3 Low Permeability Liners

This section contains Ecology's design criteria for the following low permeability liner options:

- compacted till liners,
- clay liners,
- geomembrane liners, and
- concrete liners.

Compacted Till Liners

- Liner thickness shall be 18 inches after compaction.
- Soil shall be compacted to 95% minimum dry density, modified proctor method (ASTM D 1557).
- A different depth and density sufficient to retard the infiltration rate to 2.4 x 10^{-5} inches per minute (1 x 10^{-6} cm/s) may also be used instead of bullets 1 and 2 above.
- Soil should be placed in 6-inch lifts.
- Soils may be used that meet the following gradation:

Table V-1.3: Soil Gradation for Compacted Till Liners

Sieve Size	Percent Passing
6-inch	100
4-inch	90
#4	70 - 100
#200	20

Clay Liners

- Liner thickness shall be 12 inches.
- Clay shall be compacted to 95% minimum dry density, modified proctor method (ASTM D 1557).
- A different depth and density sufficient to retard the infiltration rate to 2.4 x 10^{-5} inches per minute (1 x 10^{-6} cm/s) may also be used instead of bullets 1 and 2 above.
- The slope of clay liners must be no steeper than 3H:1V for all areas requiring soil cover; otherwise, the soil layer must be stabilized by another method so that soil slippage into the BMP does not occur. Any alternative soil stabilization method must take maintenance access into consideration.
- Where clay liners form the sides of ponds, the interior side slope should not be steeper than 3H:1V, irrespective of fencing. This restriction is to ensure that anyone falling into the pond may safely climb out.

Geomembrane Liners

- Geomembrane liners shall be ultraviolet (UV) light resistant and have a minimum thickness of 30 mils. A thickness of 40 mils shall be used in areas of maintenance access or where heavy machinery may be operated over the geomembrane liner.
- Geomembrane liners shall be bedded according to the manufacturer's recommendations.
- Geomembrane liners shall be installed so that they can be covered with 12 inches of top dressing forming the bottom and sides of the Runoff Treatment BMP, except for BMP T8.20: Sand Filter Vault, BMP T8.30: Linear Sand Filter if located in a vault, or BMP T10.20: Wetvaults. 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 geomembrane liner.
- If possible, geomembrane 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 BMP.
- 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 geotechnical engineer that the top dressing will be stable for all site conditions, including maintenance.

Concrete Liners

- Portland cement liners are allowed irrespective of BMP size, and shotcrete may be used on slopes. However, specifications must be developed by a licensed engineer in the state of Washington who certifies the liner against cracking or losing water retention ability under expected conditions of operation, including BMP 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.

V-1.3.4 Geotextile Specifications

Table V-1.4: Geotextile Properties for Underground Drainage

Geotextile Property Requirements[1]			
		Low Survivability	Moderate Survivability
Geotextile Property	Test Method	Woven / Nonwoven	Woven / Nonwoven
Grab Tensile Strength, 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) with seam located in the center of 8-inch-long specimen oriented parallel to grip faces	ASTM D4632	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, 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

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 V-1.5: Geotextile for Underground Drainage Filtration Properties

Geotextile Property Requirements[1]				
Geotextile Property	Test Method	Class A	Class B	Class C
AOS[2]	ASTM D4751	No. 40 max.	No. 60 max.	No. 80 max.
Water Permittivity	ASTM D4491	0.5/sec min.	0.4/sec min.	0.3/sec min.

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 V-1.6: Geotextile Strength Properties for Impermeable Liner Protection

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 xenon arc device
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).		

Applications

1. For sand filter drain strip between the sand and the drain rock or gravel layers specify Geotextile Properties for Underground Drainage, moderate survivability, Class A, from Table V-1.4: Geotextile Properties for Underground Drainage and Table V-1.5: Geotextile for Underground Drainage Filtration Properties.

2. For sand filter matting located immediately above the impermeable liner and below the drains, the function of the geotextile is to protect the impermeable liner by acting as a cushion. The specification provided in Table V-1.6: Geotextile Strength Properties for Impermeable Liner Protection should be used to specify survivability properties for the liner protection application. Table V-1.5: Geotextile for Underground Drainage Filtration Properties, Class C should be used for filtration properties. Only nonwoven geotextiles are appropriate for the liner protection application.

3. For an infiltration drain specify Geotextile for Underground Drainage, low survivability, Class C, from Table V-1.4: Geotextile Properties for Underground Drainage and Table V-1.5: Geotextile for Underground Drainage Filtration Properties.

4. For a sand bed cover a geotextile fabric is placed exposed on top of the sand layer to trap debris brought in by the storm water and to protect the sand, facilitating easy cleaning of the surface of the sand layer. However, a geotextile is not the best product for this application. A polyethylene or polypropylene geonet would be better. The geonet material 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. -1 or more) and percent open area

(CWO-22125, 10% or more). Tensile strength should be on the order of 200 lbs grab (ASTM D4632) or more.

Courtesy of Tony Allen (Allen, 1999).

Reference for Table V-1.4: Geotextile Properties for Underground Drainage and Table V-1.5: Geotextile for Underground Drainage Filtration Properties: Section 9-33.2 “Geotextile Properties” from WSDOT's 2012 *Standard Specifications for Road, Bridge, and Municipal Construction* (WSDOT, 2012).

V-1.4 Hydraulic Structures

V-1.4.1 Flow Splitters

Many Runoff Treatment BMPs can be designed as on-line systems with flows above the Water Quality design flow rate or Water Quality design storm volume simply passing through the BMP at a lower pollutant removal efficiency. However, it is sometimes desirable to restrict flows to Runoff Treatment BMPs and bypass the remaining higher flows around them. This turns the BMP into an off-line facility. This can be accomplished by splitting flows in excess of the Water Quality design flow rate upstream of the Runoff Treatment BMP and diverting higher flows to a bypass pipe or channel. The bypass typically enters a detention pond or the downstream receiving drainage system, depending on Flow Control requirements. In most cases, it is the designer’s choice whether Runoff Treatment BMPs are designed as on-line or off-line; an exception is oil/water separators, which must be designed off-line.

A crucial factor in designing flow splitters is to ensure that low flows are delivered to the Runoff Treatment BMP up to the Water Quality design flow rate. Above this rate, additional flows are diverted to the bypass system with minimal increase in head at the flow splitter structure to avoid surcharging the Runoff Treatment BMP under high flow conditions.

Flow splitters are typically manholes or vaults with concrete baffles. In place of baffles, the splitter mechanism may be a half tee section with a solid top and an orifice in the bottom of the tee section. A full tee option may also be used as described below in the “General Design Criteria.” We show two possible design options for flow splitters in Figure V-1.1: Flow Splitter, Option A and Figure V-1.2: Flow Splitter, Option B. Other equivalent designs that achieve the result of splitting low flows and diverting higher flows around the facility are also acceptable.

General Design Criteria

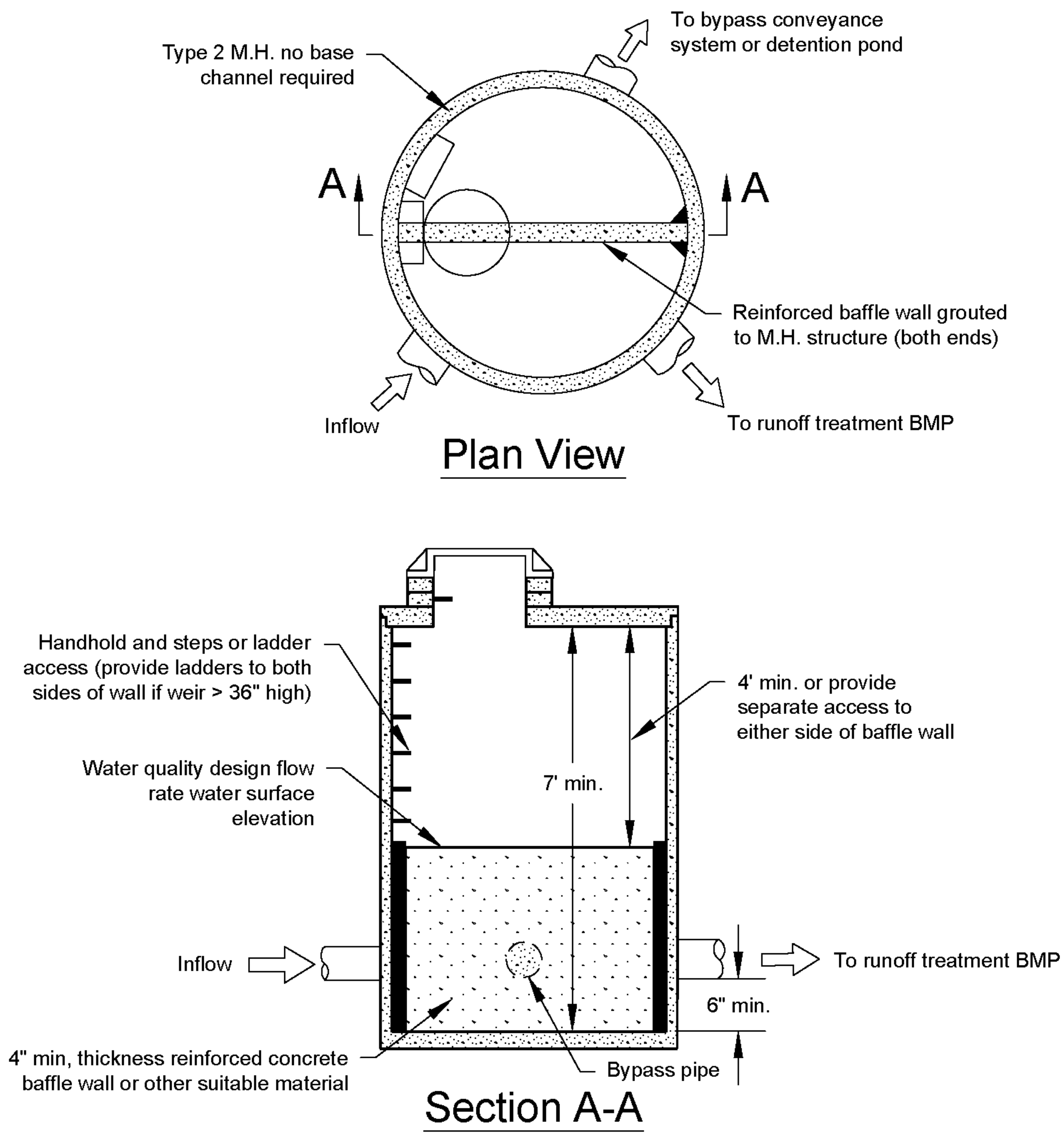
- A flow splitter must be designed to deliver the Water Quality design flow rate to the Runoff Treatment BMP.
    - For BMP T8.10: Basic Sand Filter Basin, which is sized based on the Water Quality design storm volume, use the Water Quality design flow rate to design the splitter.
    - For BMP T8.11: Large Sand Filter Basin, use either the 2-year flow rate or the flow rate that corresponds with treating 95 percent of the runoff volume of a long-term time series predicted by an approved continuous runoff model.

- Locate the top of the bypass weir at the water surface for the design flow. Remaining flows enter the bypass line.
- Flows modeled using a continuous simulation model should use 15-minute time steps.
- The maximum head must be minimized for flows in excess of the Water Quality design flow rate. Specifically, flow to the Runoff Treatment BMP at the 100-year water surface must not be more than 110% of the Water Quality design flow rate.
- Designers may use either design shown in Figure V-1.1: Flow Splitter, Option A or Figure V-1.2: Flow Splitter, Option B or an equivalent design.
- When using the design shown in Figure V-1.1: Flow Splitter, Option A, the designer must consider the headwater depth under both inlet and outlet control on the pipe to the BMP.
- As an alternative to using a solid top plate in Figure V-1.2: Flow Splitter, Option B, a full tee section may be used with the top of the tee slightly above the 100-year water surface. This alternative would route emergency overflows (if the overflow pipe were plugged) through the Runoff Treatment BMP rather than back up from the flow splitter.
- Special applications may require 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 BMPs, designers must include back water effects in designing the height of the standpipe in the flow splitter.
- Designers must provide ladder or step and handhold access. If the weir wall is higher than 36 inches, two ladders, one to either side of the wall, must be used.

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 should be provided.
- All metal parts must be corrosion resistant. Examples of preferred materials include aluminum, stainless steel, and plastic. Zinc and galvanized materials are discouraged because of aquatic toxicity. Painted metal parts should not be used because of poor longevity.

Figure V-1.1: Flow Splitter, Option A



Note: The outlet pipe to the Runoff Treatment BMP may require an orifice plate installed on the outlet to control the water quality design flow rate water surface elevation (weir height). The water quality design flow rate water surface elevation should be set to provide a minimum headwater/diameter ratio of 2.0 on the outlet pipe.

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Flow Splitter, Option A

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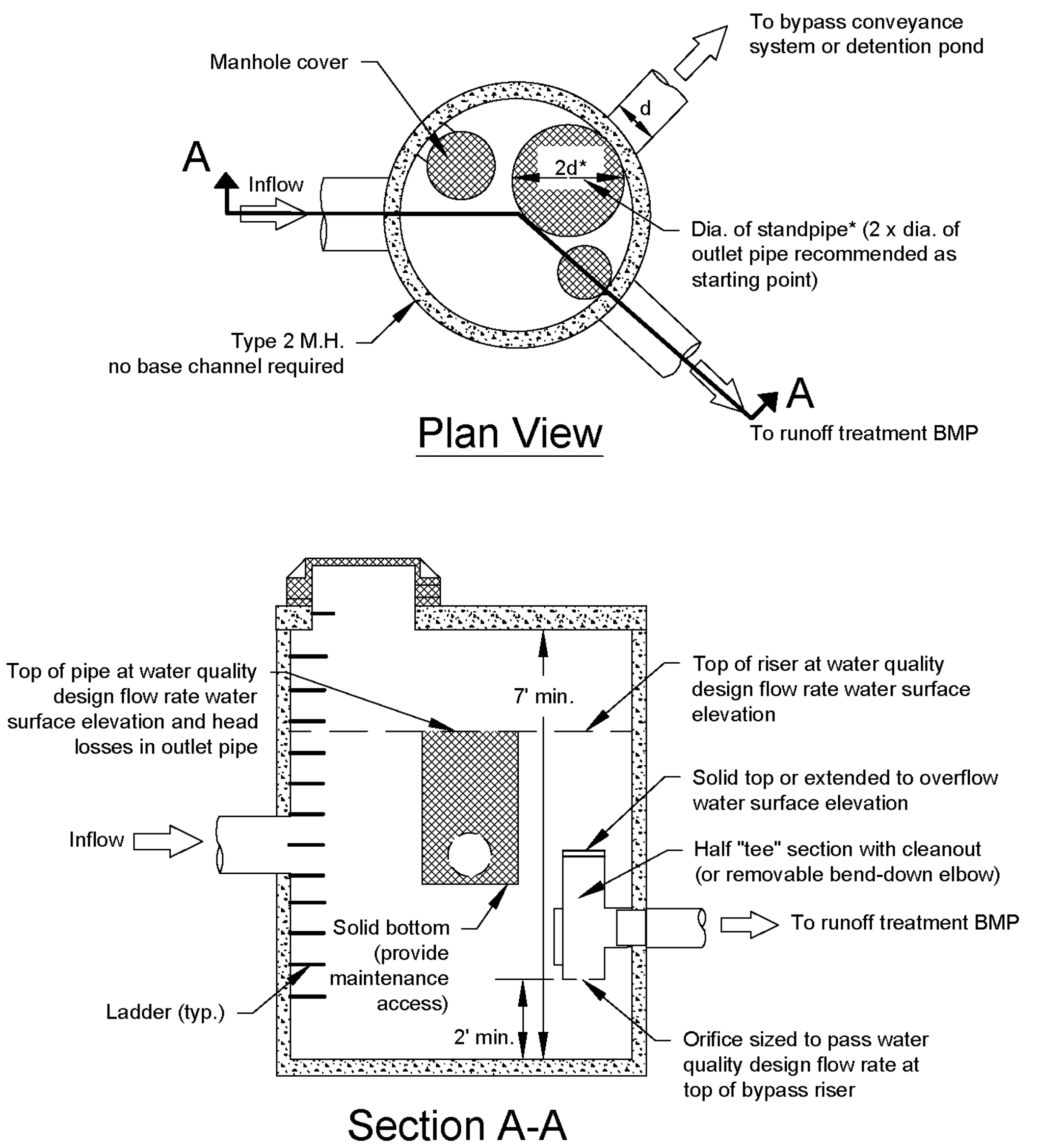
Figure V-1.2: Flow Splitter, Option B



*Note: Diameter of standpipe (2d) should be large enough to minimize head above water quality design water surface and to keep water quality design flows from increasing more than 10% during 100-year flows.

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Flow Splitter, Option B

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V-1.4.2 Flow Spreaders

A flow spreader functions to uniformly spread flows across the inlet of a Runoff Treatment BMP (e.g., sand filter, biofiltration swale, or filter strip). There are five flow spreader options presented here:

- Option A - Anchored Plate
- Option B - Concrete Sump Box
- Option C - Notched Curb Spreader
- Option D - Through-Curb Ports
- 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 BMP design criteria. Options A through C can also be used for unconcentrated flows, and in some cases must be used, for example to correct for moderate grade changes along BMP T9.40: Vegetated Filter Strip.

Options D and E are only for flows that are already unconcentrated and enter BMP T9.40: Vegetated Filter Strip or BMP T9.30: Continuous Inflow Biofiltration Swale. Other flow spreader options are possible with approval from the reviewing authority.

General Design Criteria

- Where flow enters the flow spreader through a pipe, it is recommended that the pipe be submerged to the extent practical to dissipate energy as much as possible.
- Flow spreaders are difficult to maintain and continue to evenly distribute flow and should not be used on slopes greater than five percent to prevent recombining of downstream flow that can create rills and gullies. Flow spreaders are not to be used in areas accessible by the public as walking on them can alter their flow characteristics.
- For higher inflows (greater than 5 cfs for the 100-yr storm), a Type 1 catch basin should be positioned in the spreader and the inflow pipe should enter the catch basin with flows exiting through the top grate of the catch basin. The top of the grate should be lower than the flow spreader plate, or if a notched spreader is used, lower than the bottom of the v-notches.

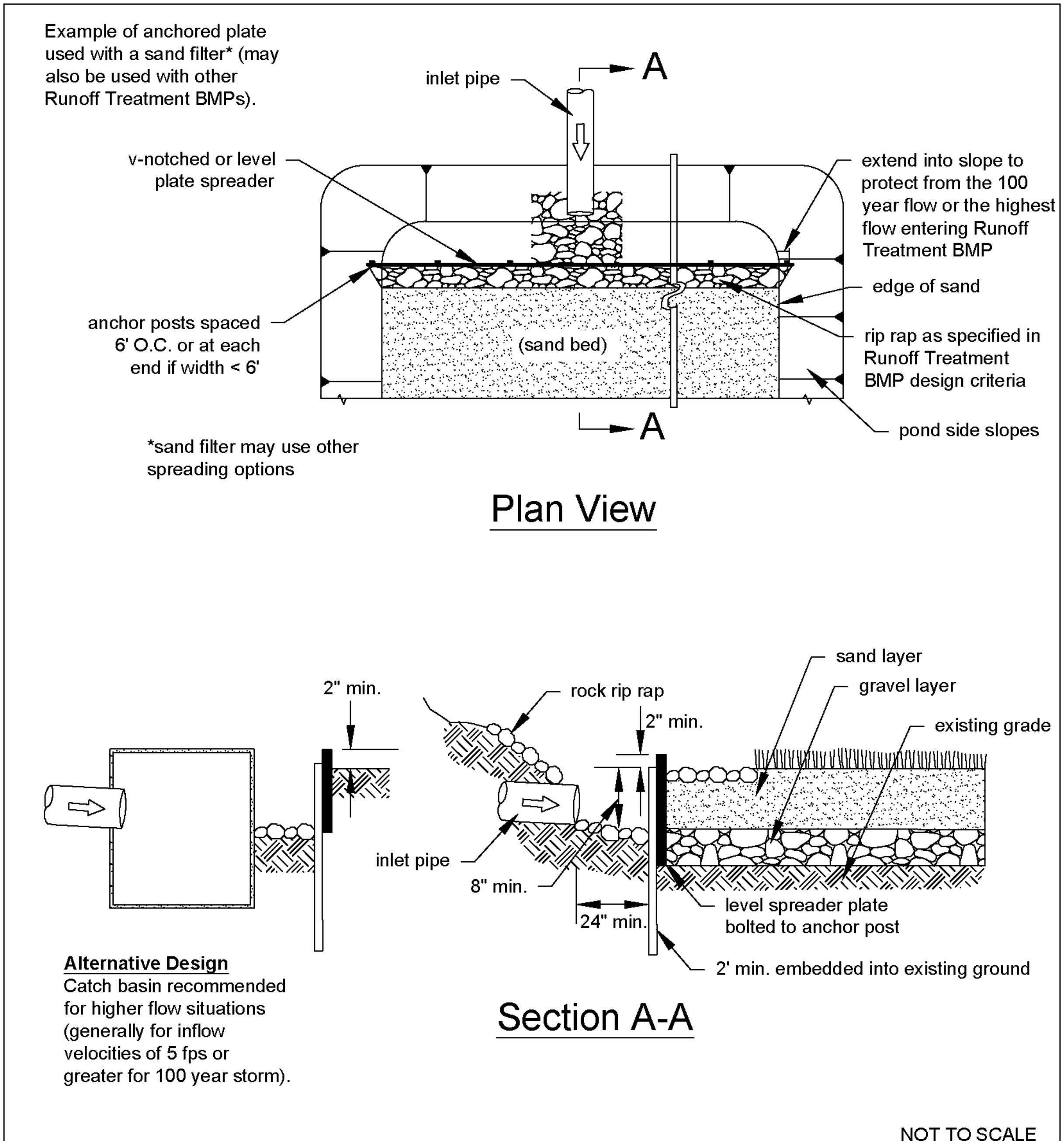
Option A - Anchored Plate

- 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 Runoff Treatment BMP, 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.
- A flow spreader plate must extend horizontally beyond the bottom width of the Runoff

Treatment BMP to prevent water from eroding the side slope. The horizontal extent should be such that the bank is protected for all flows up to the 100-year flow or the maximum flow that will enter the Runoff Treatment BMP.

- 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 V-1.3: Flow Spreader Option A: Anchored Plate



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Flow Spreader Option A: Anchored Plate

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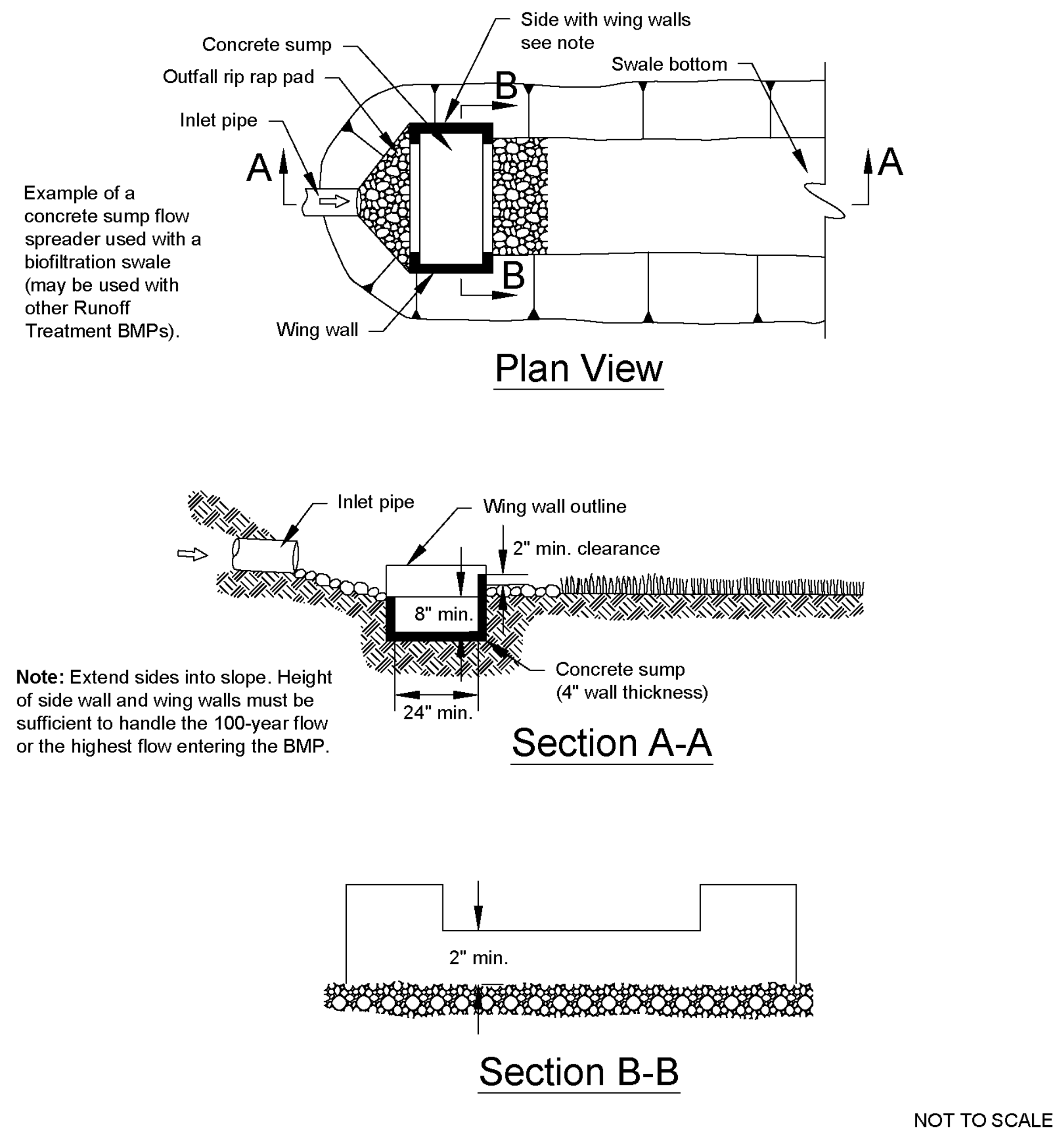
Option B - Concrete Sump Box

- The wall of the downstream side of a rectangular concrete sump box must extend a minimum of 2 inches above the inlet to the Runoff Treatment BMP. This serves as a weir to spread the flows uniformly across the BMP inlet.
- 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 sump boxes.
- Sump boxes must be placed over bases that consists of 4 inches of crushed rock, 5/8-inch minus to help assure the sump box remains level.

Figure V-1.4: Flow Spreader Option B: Concrete Sump Box



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Flow Spreader Option B: Concrete Sump Box

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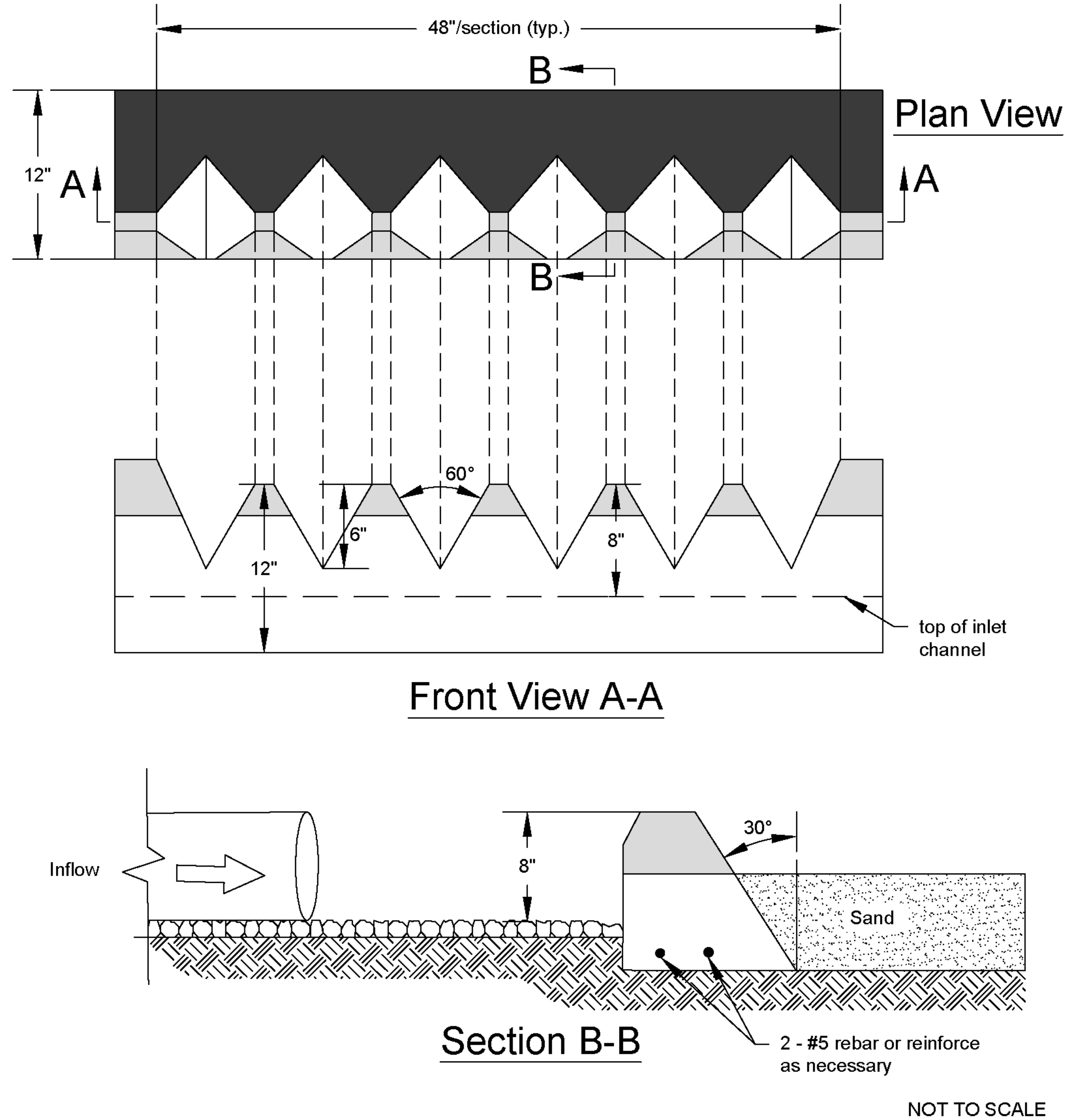
Option C - Notched Curb Spreader

Notched curb spreader sections must be made of extruded concrete laid side-by-side and level. Typically five “teeth” per four-foot section provides good spacing. The space between adjacent “teeth” forms a v-notch.

Figure V-1.5: Flow Spreader Option C: Notched Curb Spreader



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Flow Spreader Option C: Notched Curb Spreader

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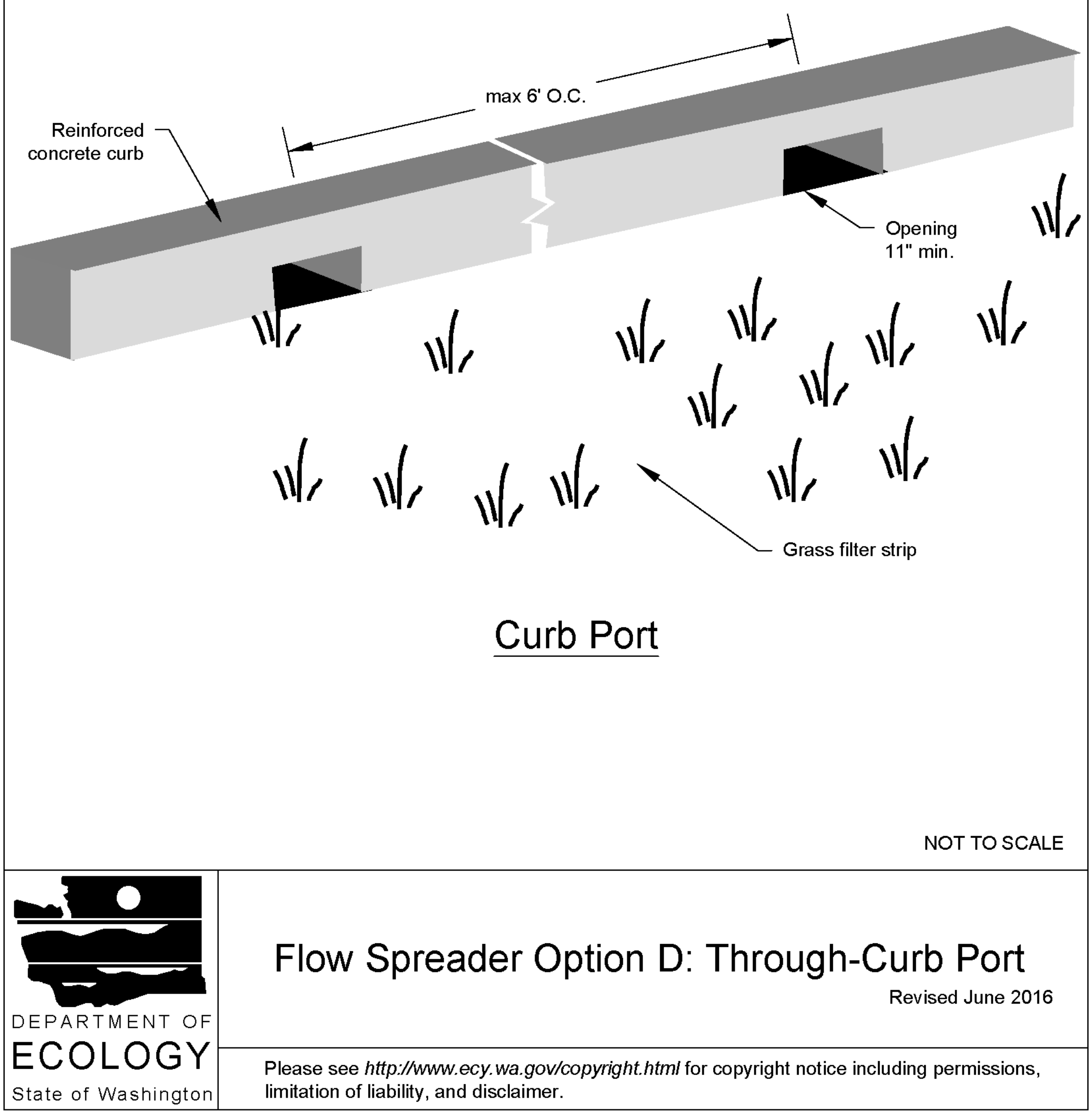
Option D - Through-Curb Ports

Unconcentrated flows from paved areas entering BMP T9.40: Vegetated Filter Strip or BMP T9.30: Continuous Inflow Biofiltration Swale can use through-curb ports (this option) or interrupted curbs (Option E) to allow flows from the pavement to enter the BMP. Through-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 Runoff Treatment BMP.

Openings in the curb must be at regular intervals and at least every 6 feet. The width of each opening must be at least 11 inches. Approximately 15 percent or more of the curb section length should be in open ports, and no port should discharge more than about 10 percent of the flow.

Figure V-1.6: Flow Spreader Option D: Through-Curb Port



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 the Runoff Treatment BMP it serves) of the treatment area. At a minimum, gaps must be every 6 feet to allow distribution of flows into the Runoff Treatment BMP before they become too concentrated. The gaps must be a minimum of 11 inches. As a general rule, no opening should discharge more than 10 percent of the overall flow entering the BMP.

V-1.4.3 Outfall Systems

Properly designed outfalls are critical to reducing adverse impacts that may result from concentrated discharges from pipe systems and culverts. Outfall systems include rock splash pads, flow dispersal trenches, gabion or other energy dissipators, and tightline systems. A tightline system is typically a continuous length of pipe used to convey flows down a steep or sensitive slope with appropriate energy dissipation at the discharge end.

Provided below are general design criteria for both Outfall Features and Tightline Systems.

Outfall Features

At a minimum, all outfalls must be provided with a rock splash pad (see Figure V-1.7: Pipe/Culvert Outfall Discharge Protection), unless the site requires a more rubust energy dissipator. See the bullets below for guidance on outfall features, including other types of energy dissipation and appropriate uses for each. Also refer to Appendix V-A: BMP Maintenance Tables for outfall protection needs based on maintenance observations.

- The flow dispersal trenches shown in Figure V-1.8: Flow Dispersal Trench and Figure V-1.9: Alternative Flow Dispersal Trench should only be used when both criteria below are met:
    1. An outfall is necessary to disperse concentrated flows across uplands where no conveyance system exists and the natural (existing) discharge is unconcentrated; and
    2. The 100-year peak discharge rate is less than or equal to 0.5 cfs.
- For freshwater outfalls with a design velocity greater than 10 fps, a gabion dissipator or engineered energy dissipator may be required. There are many possible designs.

  Note The gabion outfall detail shown in Figure Figure V-1.10: Gabion Outfall Detail is illustrative only. A design engineered to specific site conditions must be developed. This type of outfall should not be installed in fish bearing streams.
- Tightline systems may be needed to prevent aggravation or creation of a downstream erosion problem.
- Energy dissipators shall be located above the Ordinary High Water Mark on fish bearing streams. Stormwater outfalls not intended for fish passage shall have an invert elevation a minimum of 1' above the Ordinary High Water Mark.
- In marine waters, 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 that depicted in Figure V-1.11: Diffuser TEE (an example of energy dissipating end feature), are also not generally recommended in or above the intertidal zone. They may be acceptable in low bank or rock shoreline locations. Stilling basins or bubble-up structures are acceptable. Generally, tightlines trenched to extreme low water or dissipation of the discharge energy above the ordinary high water line are preferred. Outfalls below extreme low water may still need an energy dissipation device (e.g., a tee structure) to prevent nearby erosion.

- Engineered energy dissipators, including stilling basins, drop pools, hydraulic jump basins, baffled aprons, and bucket aprons, are required for outfalls with design velocity greater than 20 fps. These should be designed using published or commonly known techniques found in such references as *Hydraulic Design of Energy Dissipators for Culverts and Channels* (FHWA, 2006), *Open-Channel Hydraulics* (Chow, 1959), *Hydraulic Design of Stilling Basins and Energy Dissipators* (Peterka, 1984), and other publications, such as those prepared by the Natural Resource Conservation Service (NRCS).

- Alternate mechanisms may be used, such as bubble-up structures that eventually drain and structures fitted with reinforced concrete posts. If alternate mechanisms are considered, they should be designed using sound hydraulic principles and consideration of ease of construction and maintenance.

- Mechanisms that reduce velocity prior to discharge from an outfall 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 such an end feature is a Diffuser Tee with holes in the front half, as shown in Figure V-1.11: Diffuser TEE (an example of energy dissipating end feature).

  Note: stormwater outfalls submerged in a marine environment can be subject to plugging due to biological growth and shifting debris and sediments. Therefore, unless intensive maintenance is regularly performed, they may not meet their long-term designed function.

- New pipe outfalls can provide an opportunity for low-cost fish habitat improvements. For example, an alcove of low-velocity water can be created by constructing the pipe outfall and associated energy dissipator back from the stream edge and digging a channel, over widened to the upstream side, from the outfall to the stream (as shown in Figure V-1.12: Fish Habitat Improvement at New Outfalls). Overwintering juvenile and migrating adult salmonids may use the alcove as shelter during high flows. Potential habitat improvements should be discussed with the Washington Department of Fish and Wildlife biologist prior to inclusion in design.

- Bank stabilization, bioengineering and habitat features may be required for disturbed areas.

- Outfall structures should be located where they minimize impacts to fish, shellfish, and their habitats.

- One caution to note is that the in-stream sample gabion mattress energy dissipator 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 gabion basket located outside the ordinary high water mark should be considered for these applications.

Note: A Hydraulic Project Approval (Chapter 77.55 RCW) and an Army Corps of Engineers permit may be required for any work within the ordinary high water mark. Other provisions of the RCW or the Hydraulic Code Rules (Chapter 220-660 WAC) may also apply. Contact the appropriate regional office of the State Department of Fish and Wildlife.

Table V-1.7: Rock Protection at Outfalls

Discharge Velocity at Design Flow in feet per second (fps)	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 required				

Footnotes:

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:
   - Maximum stone size: 24 inches (nominal diameter)
   - Median stone size: 16 inches
   - Minimum stone size: 4 inches

Note: Riprap sizing governed by side slopes on outlet channel, assumed to be approximately 3H:1V.

Figure V-1.7: Pipe/Culvert Outfall Discharge Protection

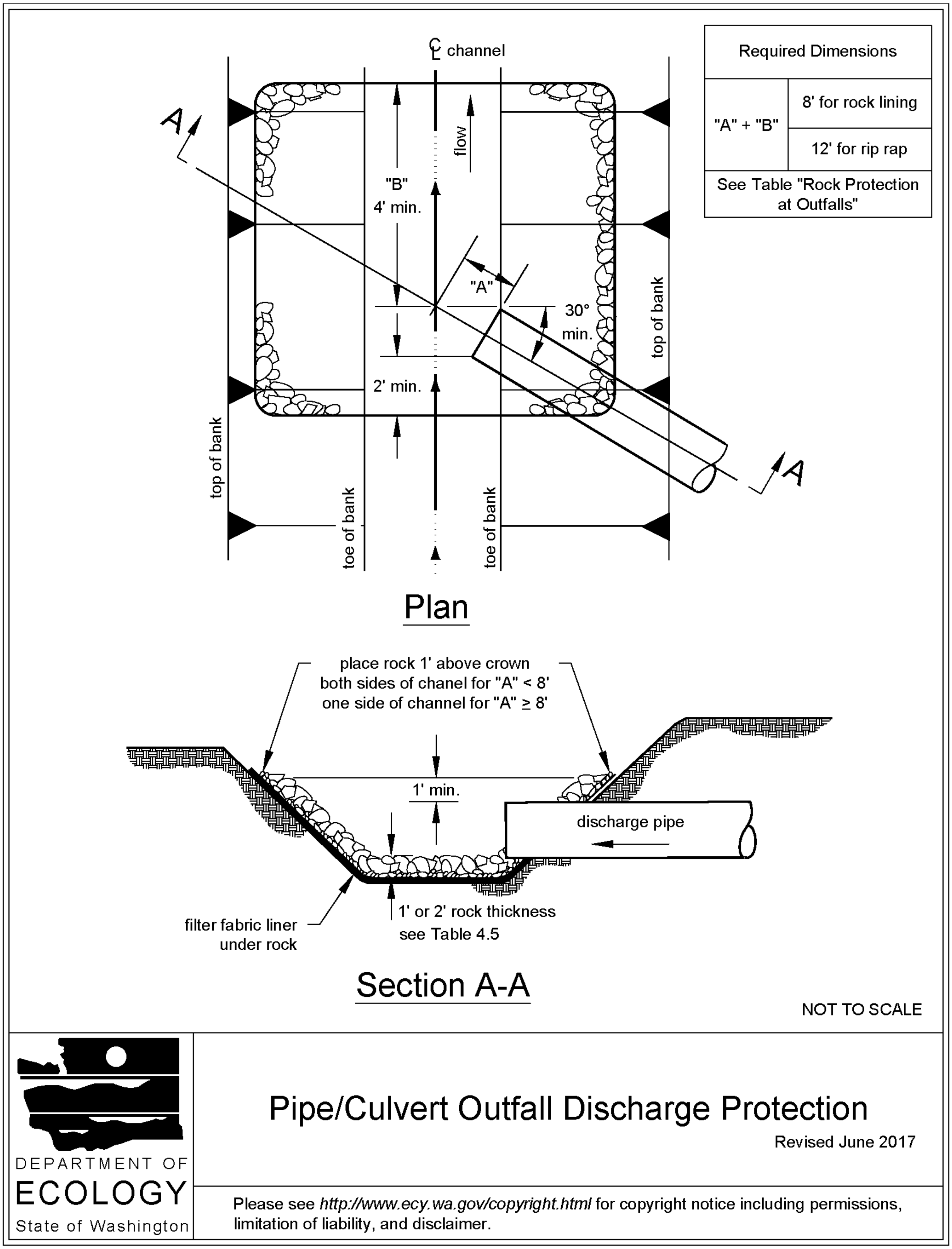
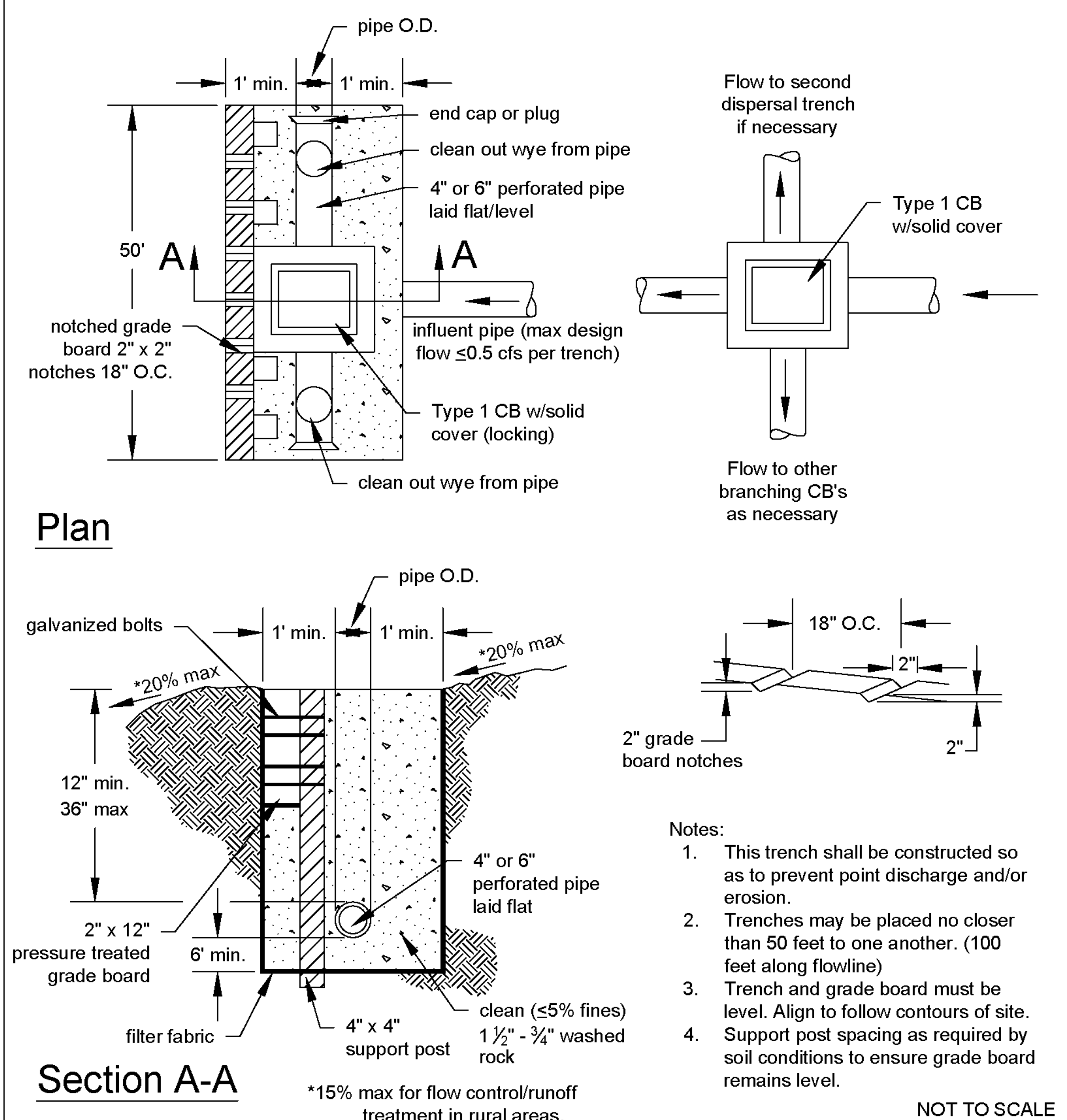


Figure V-1.8: Flow Dispersal Trench



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Flow Dispersal Trench

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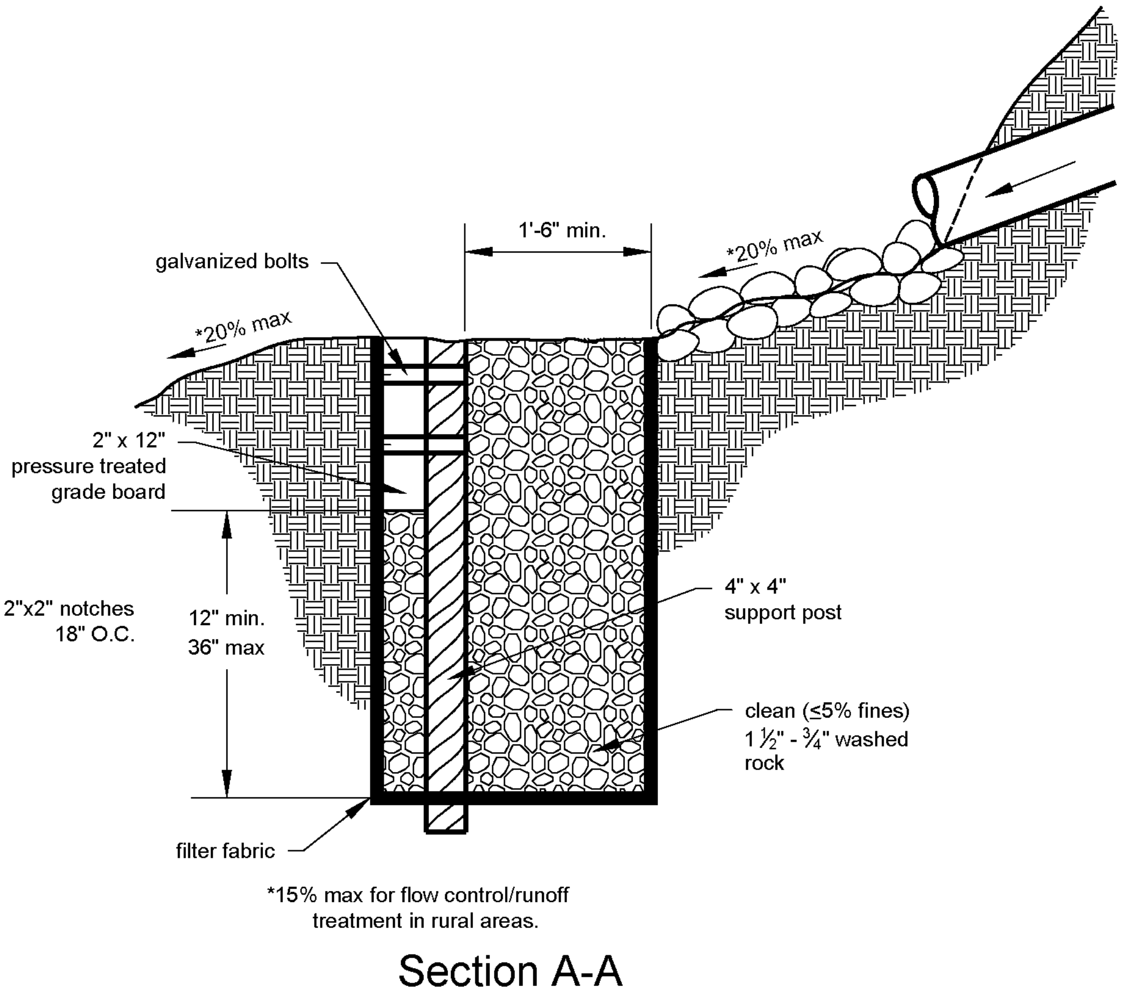
Figure V-1.9: Alternative Flow Dispersal Trench



Notes:

1. This trench shall be constructed so as to prevent point discharge and/or erosion.
2. Trenches may be placed no closer than 50 feet to one another. (100 feet along flowline)
3. Trench and grade board must be level. Align to follow contours of site.
4. Support post spacing as required by soil conditions to ensure grade board remains level.

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Alternative Flow Dispersal Trench

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Figure V-1.10: Gabion Outfall Detail

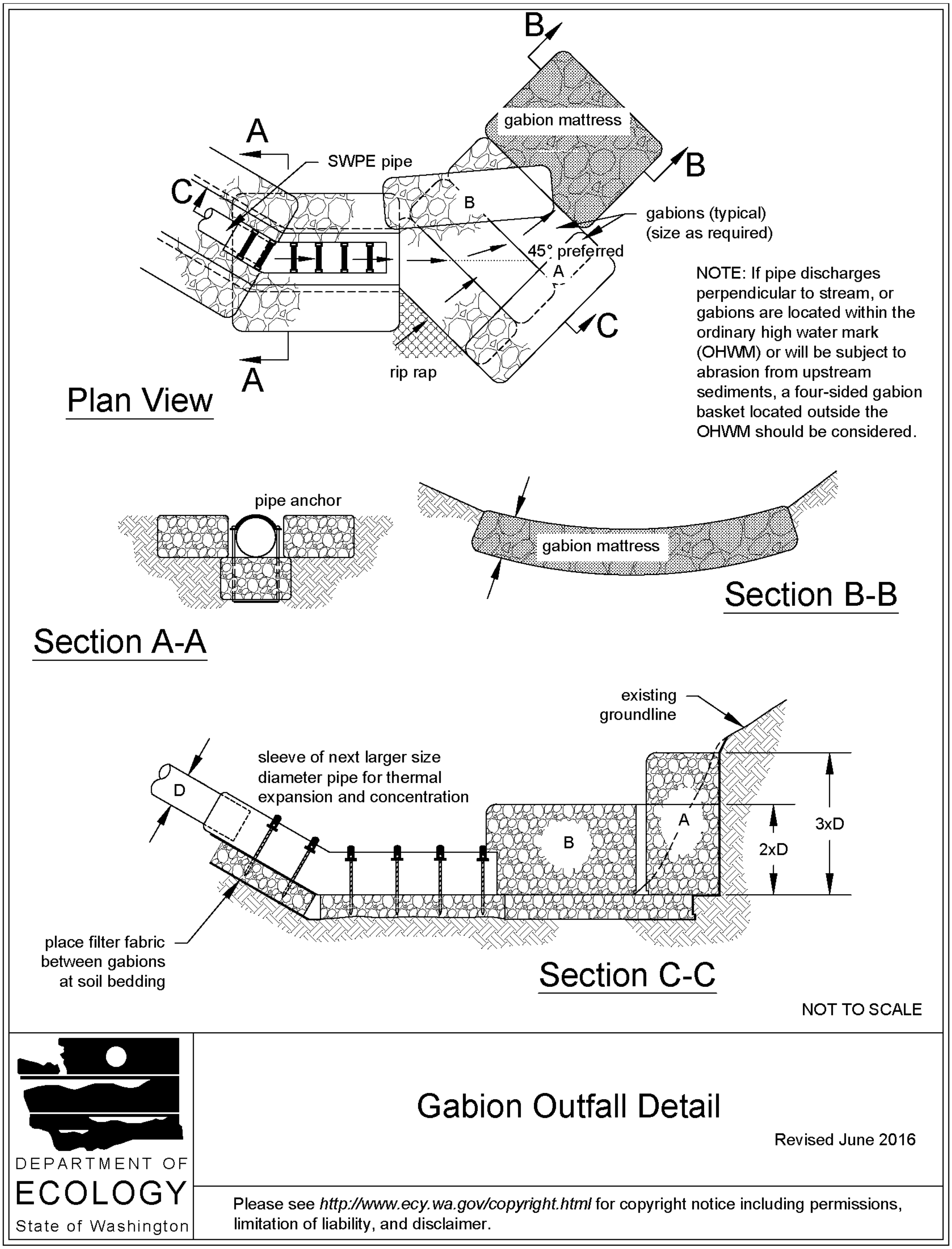
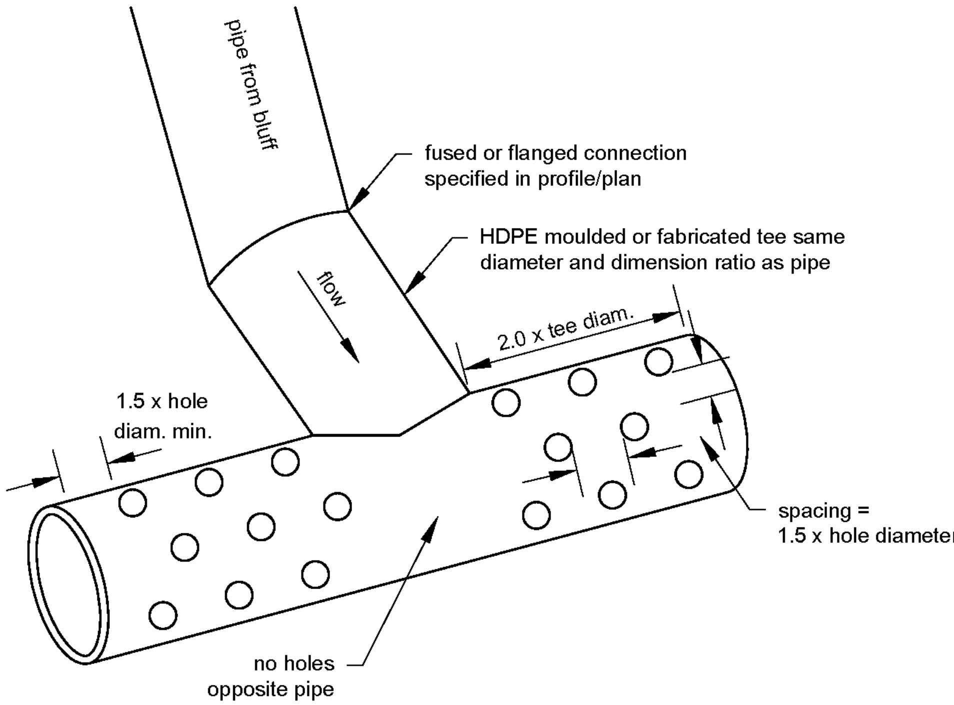


Figure V-1.11: Diffuser TEE (an example of energy dissipating end feature)



Drill holes in front half of tee only.
Hole diameter (inches) = tee diameter (inches) divided by 6
(ex. 6 inch tee = 1 inch holes
18 inch tee = 3 inch holes)

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Diffuser TEE
(an example of energy dissipating end feature)

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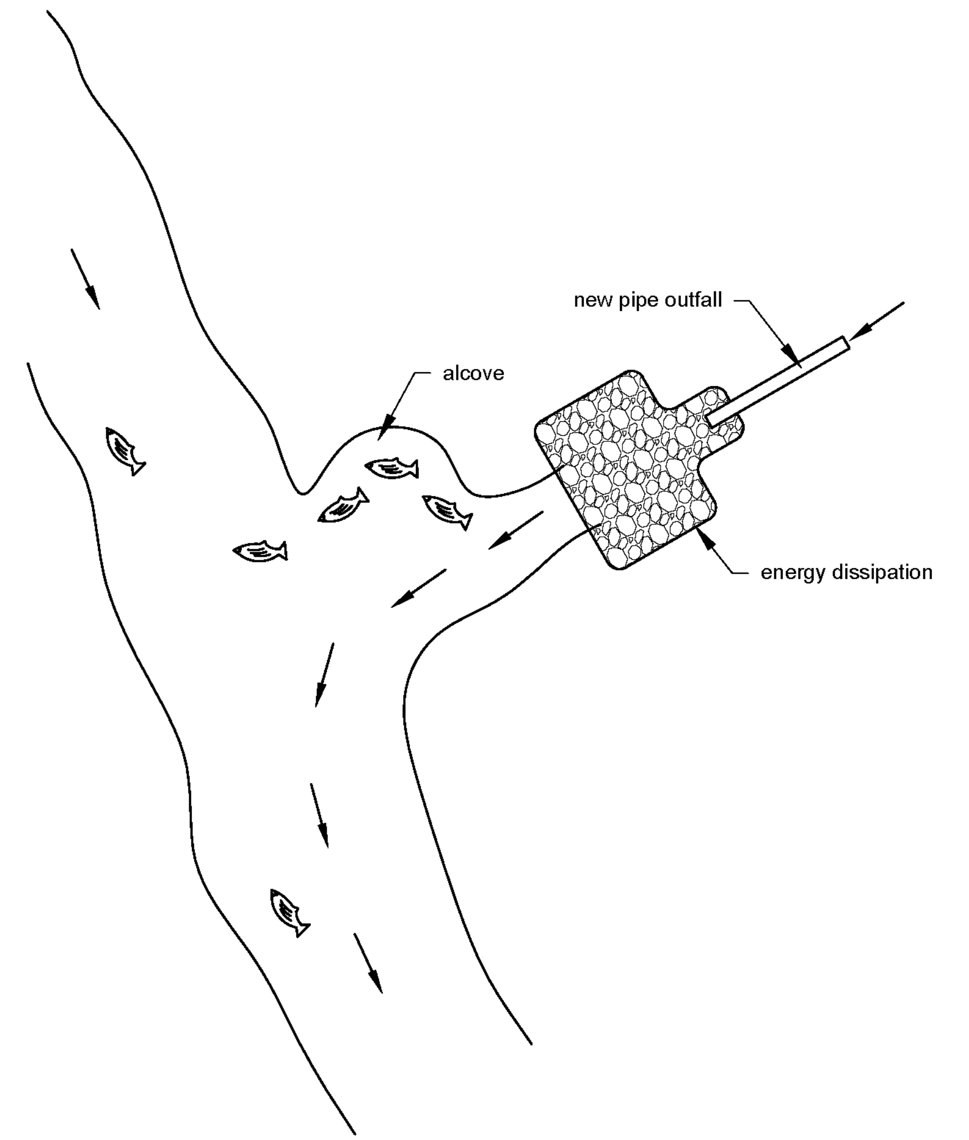
Figure V-1.12: Fish Habitat Improvement at New Outfalls



Fish Habitat Improvement at New Outfalls

Revised June 2016

Tightline Systems

- Outfall tightlines may be installed in trenches with standard bedding on slopes up to 20%. In order to minimize disturbance to steep slopes, it is recommended that tightlines be welded HDPE or restrained joint ductile iron pipe placed at grade with proper pipe anchorage and support.
- Except as indicated above, tightlines or conveyances that traverse the marine intertidal zone and connect to outfalls must be buried to a depth sufficient to avoid exposure of the line during storm events or future changes in beach elevation. If non-native material is used to bed the tightline, such material shall be covered with at least 3 feet of native bed material or equivalent.
- High density polyethylene pipe (HDPE) tightlines must be designed to address the material limitations, particularly thermal expansion and contraction and pressure design, as specified by the manufacturer. The coefficient of thermal expansion and contraction for solid wall polyethylene pipe (SWPE) is on the order of 0.001 inch per foot per Fahrenheit degree. Sliding sleeve connections must be used to address this thermal expansion and contraction. These sleeve connections consist of a section of the appropriate length of the next larger size diameter of pipe into which the outfall pipe is fitted. These sleeve connections must be located as close to the discharge end of the outfall system as is practical.
- Due to the ability of HDPE tightlines to transmit flows of very high energy, special consideration for energy dissipation must be made. Details of a sample gabion mattress energy dissipator have been provided as Figure V-1.10: Gabion Outfall Detail. Flows of very high energy will require a specifically engineered energy dissipator structure.

V-2 Site Design BMPs

V-2.1 Introduction to Site Design BMPs

Site Design BMPs are general practices for site design to minimize the impacts of development on stormwater runoff. They are provided here as an encouragement to project designers. The extent to which these BMPs must be followed depends upon the site development codes, rules, and standards adopted by the local government.

BMP T5.40: Preserving Native Vegetation

Purpose and Definition

Preserving native vegetation on-site to the maximum extent practicable will minimize the impacts of development on stormwater runoff. Preferably 65 percent or more of the development site should be protected for the purposes of retaining or enhancing existing forest cover and preserving wetlands and stream corridors. Maintain tree canopy on the project site to the greatest extent feasible and in accordance with the requirements of the local jurisdiction.

Applications and Limitations

New development often takes place on tracts of forested land. In fact, building sites are often selected because of the presence of mature trees. However, unless sufficient care is taken and planning done, in the interval between buying the property and completing construction much of this resource is likely to be destroyed. The property owner is ultimately responsible for protecting as many trees as possible, with their understory and groundcover. This responsibility is usually exercised by agents, the planners, designers and contractors. It takes 20 to 30 years for newly planted trees to provide the benefits for which trees are so highly valued.

Forest and native growth areas allow rainwater to naturally percolate into the soil, recharging ground water for summer stream flows and reducing surface water runoff that creates erosion and flooding. Conifers can hold up to about 50 percent of all rain that falls during a storm. Twenty to 30 percent of this rain may never reach the ground but evaporates or is taken up by the tree. Forested and native growth areas also may be effective as stormwater buffers around smaller developments.

Preservation of 65 percent or more of the site in native vegetation will allow the use of full dispersion techniques presented in BMP T5.30: Full Dispersion. Sites that can fully disperse per BMP T5.30: Full Dispersion have met the requirements of I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.6 MR6: Runoff Treatment, and I-3.4.7 MR7: Flow Control.

Design Guidelines

- The preserved area should be situated to minimize the clearing of existing forest cover, to maximize the preservation of wetlands, and to buffer stream corridors.
- The preserved area should be placed in a separate tract or protected through recorded

easements for individual lots.

- If feasible, the preserved area should be located downslope from the building sites, since flow control and runoff treatment are enhanced by flow dispersion through duff, undisturbed soils, and native vegetation.
- The preserved area should be shown on all property maps and should be clearly marked during clearing and construction on the site.

Maintenance

Vegetation and trees should not be removed from the natural growth retention area, except for approved timber harvest activities and the removal of dangerous and diseased trees.

BMP T5.41: Better Site Design

Purpose and Definition

Fundamental hydrological and stormwater management concepts can be applied at the site design phase that are:

- more integrated with natural topography,
- reinforcing the hydrologic cycle,
- more aesthetically pleasing, and
- often less expensive to build.

A few site planning principles help to:

- locate development on the least sensitive areas of a site;
- accommodate residential land use; and
- mitigate the impact on stormwater quality.

Design Guidelines

- **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, or 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 drainage system are the greatest contributors to urban nonpoint source pollution. Any impervious surface that drains into a catch basin or other conveyance structure is a “directly connected impervious surface.” As stormwater runoff flows across parking lots, roadways, and other paved areas, the oil, sediment, metals, and other pollutants are collected and concentrated. If this runoff is collected by a drainage structure and carried directly along impervious gutters or in sealed underground pipes, it has no opportunity for filtering by plant material or infiltration into the soil. It also increases in velocity and amount, causing increased peak-flows in the winter and decreased base-flows in the summer.

A basic site design principle for stormwater management is to minimize these directly connected impervious areas. This can be done by limiting overall impervious land coverage or by infiltrating and/or dispersing runoff within 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.

  Clustered driveways, small visitor parking bays and other strategies can also minimize the impact of transportation-related surfaces while still providing adequate access.

  Once site coverage is minimized through clustering and careful planning, pavement surfaces can be selected for permeability. A patio of brick-on-sand, for example, is more permeable than a large concrete slab. Engineered soil/landscape systems are permeable ground covers suitable for a wide variety of uses. Permeable/porous pavements can be used in place of traditional concrete or asphalt pavements in many low traffic applications.

  Maximizing permeability at every possible opportunity requires the integration of many small strategies. These strategies will be reflected at all levels of a project, from site planning to materials selection. In addition to the environmental and aesthetic benefits, a high-permeability site plan may allow the reduction or elimination of expensive underground conveyance systems, Flow Control BMPs, and/or Runoff Treatment BMPs, yielding significant savings in development costs.

- **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 drainage system.

  The combination of large, directly connected impervious areas, together with the pollutants generated by automobiles, makes the street network a principal contributor to stormwater pollution in residential areas.

  Street design is usually mandated by local municipal standards. These standards have been developed to facilitate efficient automobile traffic, maximize parking, and allow for emergency vehicle access. Most require large impervious land coverage. In recent years, new street standards have been gaining acceptance that meet the access requirements of local residential streets while reducing impervious land coverage. These standards generally create a new class of street that is narrower than the current local street standard, called an “access” street. An access street is intended only to provide access to a limited number of residences.

Because street design is the greatest factor in a residential development’s impact on stormwater quality, it is important that designers, municipalities and developers employ street standards that reduce impervious land coverage.

- **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.

  Bicycle lanes and paths, secure bicycle parking at community centers and shops, direct, safe pedestrian connections, and transit facilities are all site-planning elements that maximize choices for mobility.

- **Use Drainage as a Design Element** - Unlike conveyance drainage systems that hide water beneath the surface and work independently of surface topography, a drainage 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.

  By applying stormwater management techniques early in the site plan development, the drainage system can suggest pathway alignments, optimum locations for parks and play areas, and potential building sites. In this way, the drainage system helps to generate urban form, giving the development an integral, more aesthetically pleasing relationship to the natural features of the site. Not only does the integrated site plan complement the land, it can also save on development costs by minimizing earthwork and expensive drainage features.

V-3 Dispersion BMPs

V-3.1 Introduction to Dispersion BMPs

The BMPs in this chapter are grouped together because they all operate by dispersing runoff through vegetation, which provides varying levels of attenuation and treatment.

BMP T5.11: Concentrated Flow Dispersion

Purpose and Definition

Dispersion of concentrated flows from driveways or other pavement through a vegetated pervious area attenuates peak flows by slowing entry of the runoff into the conveyance system, allowing for some infiltration, and providing some water quality benefits.

Applications and Limitations

- Use this BMP in any situation where concentrated flow can be dispersed through vegetation.
- Figure V-3.1: Typical Concentrated Flow Dispersion for Steep Driveways shows two possible ways of spreading flows from steep driveways.

Design Guidelines

- Maintain a vegetated flow path of at least 25 feet between the discharge point and any property line, structure, steep slope, stream, wetland, lake, or other impervious surface.
    - If the vegetated flow path is 25 - 50 ft, the design must include a dispersion trench prior to discharge over the vegetated flow path.
    - If the vegetated flow path is 50 ft or more, the design may use either a dispersion trench or a pad of crushed rock (as described below) prior to discharge over the vegetated flow path.
- A maximum of 700 square feet of impervious area may drain to each concentrated flow dispersion BMP.
- Provide a pad of crushed rock (a minimum of 2 feet wide by 3 feet long by 6 inches deep) at each discharge point.
- See BMP T5.10B: Downspout Dispersion Systems for dispersion trench design criteria.
- No erosion or flooding of downstream properties may result.
- Runoff discharged towards landslide hazard areas must be evaluated by a geotechnical engineer or qualified geologist. Do not place the discharge point on or above slopes greater than 20%, or above erosion hazard areas, without assessment by a geotechnical engineer or qualified geologist and approval by the Local Plan Approval Authority.

- For sites with septic systems, the discharge point must be ten feet downgradient of the drainfield primary and reserve areas (WAC 246-272A-0210). A Local Plan Approval Authority may waive this requirement if site topography clearly prohibits flows from intersecting the drainfield.

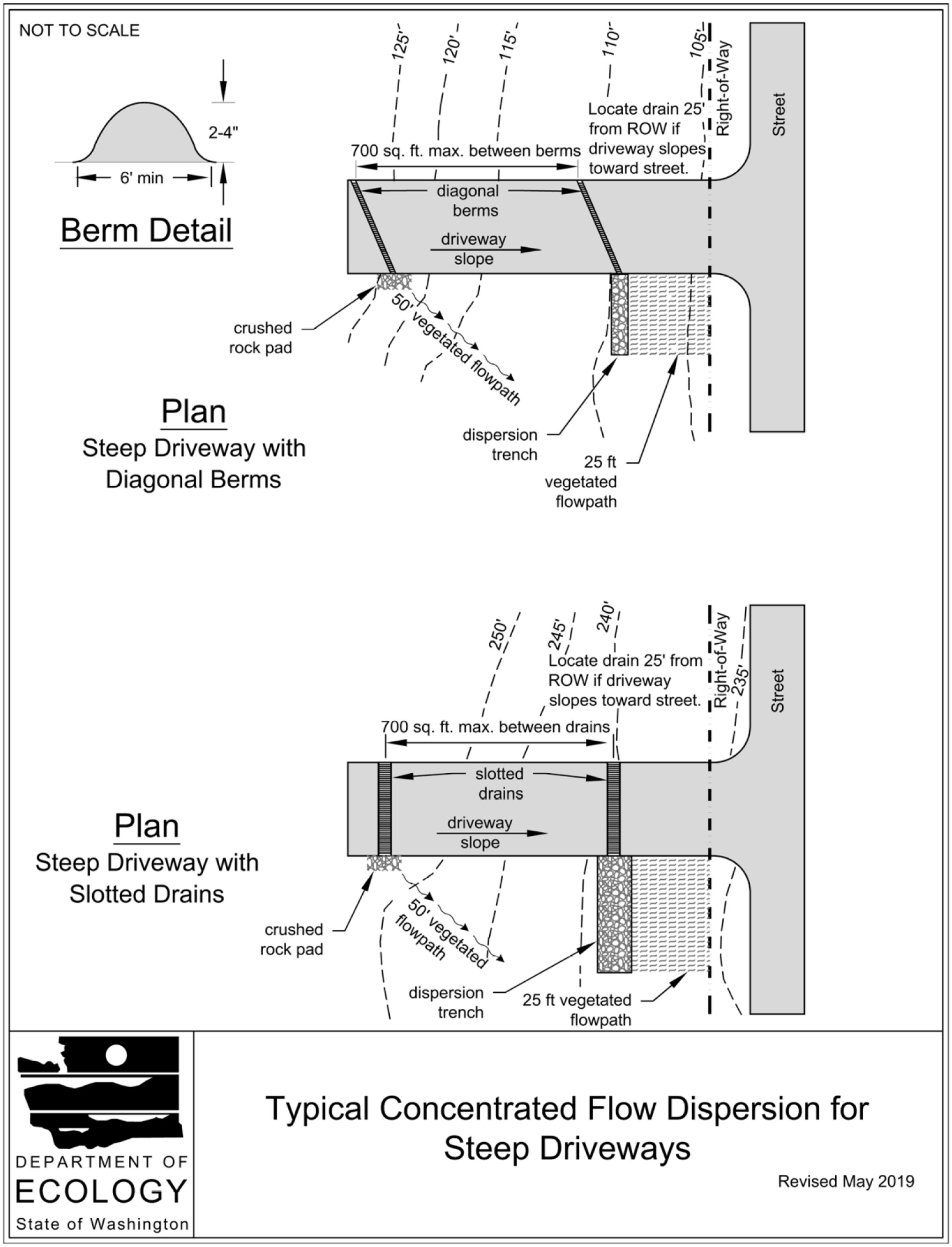
Runoff Model Representation

Where this BMP is used to disperse impervious area runoff into an undisturbed native landscape area or an area that meets BMP T5.13: Post-Construction Soil Quality and Depth, the impervious area should be modeled as a lateral flow impervious area. Do this in WWHM on the Mitigated Scenario screen by connecting the lateral flow impervious area element (representing the area that is dispersed) to the lawn/landscape lateral flow soil basin element (representing the area that will be used for dispersion). The design must adhere to the flow path lengths and dispersion trench/rock pad options described above as a prerequisite to using the lateral flow elements.

In situations where multiple instances of concentrated flow dispersion will occur, Ecology allows the following options:

- When a pad of crushed rock or dispersion trenches are used per the guidance above, and the length of the vegetated flow path is at least 50 feet, the impervious area may be modeled as a landscaped area (grass) so that the project schematic in the approved continuous runoff model becomes manageable.
- When dispersion trenches are used per the guidance above, and the length of the vegetated flow path is 25 - 50 feet, the impervious area may be modeled as 50%landscaped / 50%impervious so that the project schematic in the approved continuous runoff model becomes manageable.

Figure V-3.1: Typical Concentrated Flow Dispersion for Steep Driveways



BMP T5.12: Sheet Flow Dispersion

Purpose and Definition

Sheet flow dispersion is the simplest method of runoff control. This BMP can be used for any impervious or pervious surface that is graded 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 on-site stormwater management.

Applications and Limitations

Use this BMP for flat or moderately sloping (< 15% slope) surfaces such as driveways, sports courts, patios, roofs without gutters, lawns, pastures; or any situation where concentration of flows can be avoided.

Design Guidelines

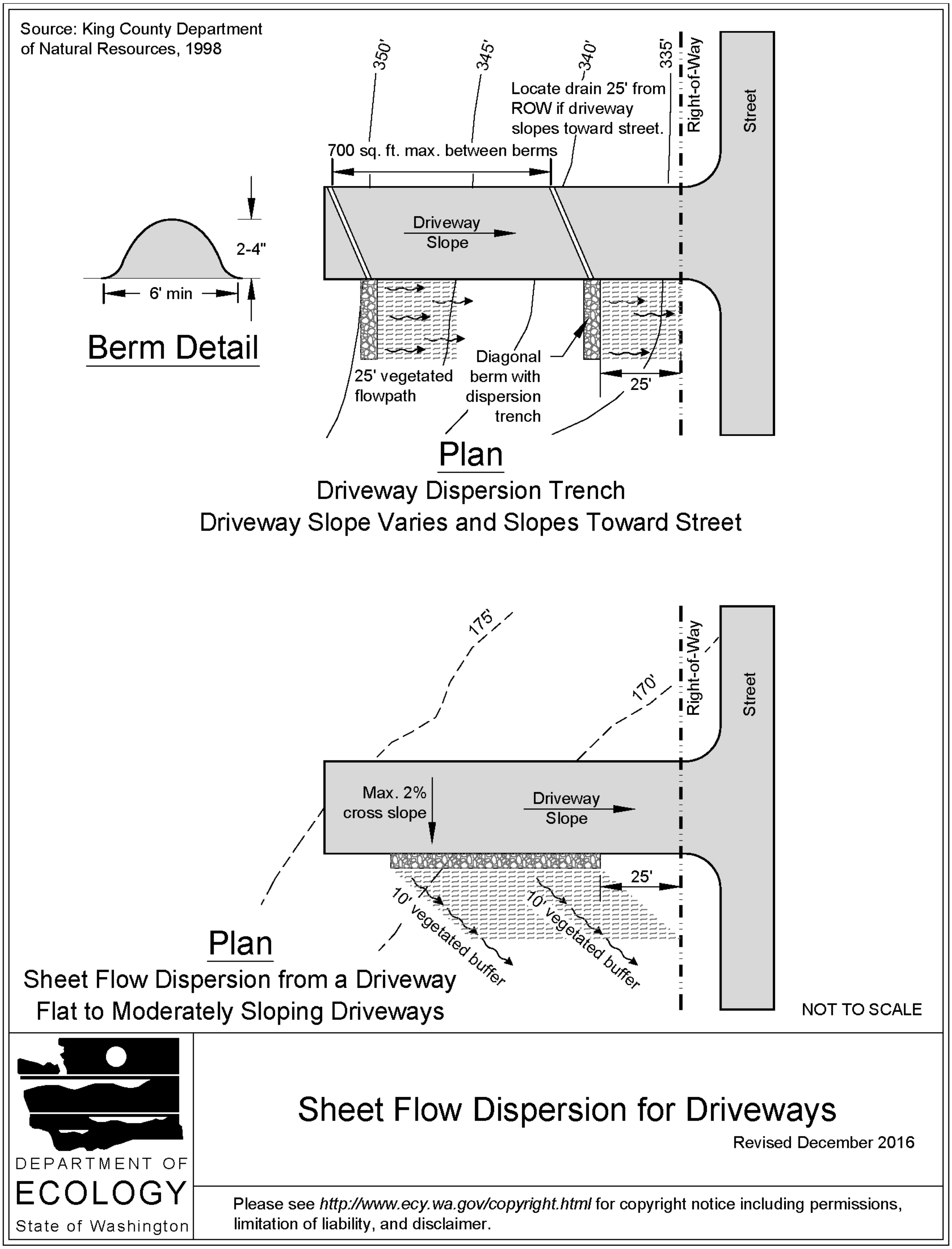
- See Figure V-3.2: Sheet Flow Dispersion for Driveways for details for driveways.
- See BMP T5.10B: Downspout Dispersion Systems for dispersion trench design criteria.
- Provide a 2-foot-wide transition zone to discourage channeling between the edge of the impervious surface (or building eaves) and the downslope vegetation. This transition zone may consist of an extension of subgrade material (crushed rock), modular pavement, drain rock, or other material acceptable to the Local Plan Approval Authority.
- Provide a 10-foot-wide vegetated buffer for up to 20 feet of width of paved or impervious surface. Provide an additional 10 feet of vegetated buffer width 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 vegetated buffer, with a 2-foot by 60-foot transition zone.
- The design must not result in erosion or flooding of downstream properties.
- Runoff discharge toward landslide hazard areas must be evaluated by a geotechnical engineer or a qualified geologist. Do not allow sheet flow on or above slopes greater than 20%, or above erosion hazard areas, without evaluation by a geotechnical engineer or qualified geologist and approval by the Local Plan Approval Authority.
- For sites with septic systems, the discharge area must be ten feet downgradient of the drainfield primary and reserve areas (WAC 246-272A-0210). A Local Plan Approval Authority may waive this requirement if site topography clearly prohibits flows from intersecting the drainfield.

Runoff Model Representation

Where this BMP is used to disperse impervious area runoff into an undisturbed native landscape area or an area that meets BMP T5.13: Post-Construction Soil Quality and Depth, the impervious area should be modeled as a lateral flow impervious area. Do this in WWHM on the Mitigated

Scenario screen by connecting the lateral flow impervious area element (representing the area that is dispersed) to the lawn/landscape lateral flow soil basin element (representing the area that will be used for dispersion).

Figure V-3.2: Sheet Flow Dispersion for Driveways



BMP T5.30: Full Dispersion

Purpose and Definition

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.

Ecology accepts Full Dispersion as meeting I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.6 MR6: Runoff Treatment, and I-3.4.7 MR7: Flow Control. Sites that can fully disperse are not required to provide additional Runoff Treatment or Flow Control BMPs. Hard surfaces that are not fully dispersed should be partially dispersed to the maximum extent practicable.

Applications and Limitations

The site (or area of the site) that is applying full dispersion per this BMP must be laid out to allow the runoff from the impervious (or cleared) surface to fully disperse into the preserved dispersion area. (i.e. Have full access to and not be intercepted by pipe(s), ditch(es), stream(s), river(s), pond(s), lake (s), or wetland(s)).

Projects that successfully apply this BMP on all or a portion of their site will decrease effective impervious surfaces, and may avoid triggering the TDA Thresholds in I-3.4.7 MR7: Flow Control.

A site (or an area of a site) that applies full dispersion per this BMP consists of the following elements:

- **An impervious (or cleared) area**. The impervious (or cleared) area is the area that the design is mitigating for by using this BMP.
- **A flow spreader.** Runoff from the impervious (or cleared) area may need to be routed through a flow spreader (see V-1.4.2 Flow Spreaders), depending on the site 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 depending on the site type. Details are provided below for what amount of vegetation the dispersion area must contain based on site type.
  - If the dispersion area must be preserved as forest or native vegetation, it may be a previously cleared area that has been replanted in accordance with Native Vegetation Landscape Specifications (below).
  - The dispersion area should be situated to minimize the clearing of existing forest cover, to maximize the preservation of wetlands (though the wetland area and any streams and lakes do not count as part of the dispersion area), and to buffer stream corridors.
  - The dispersion area should be placed in a separate tract or protected through recorded easements for individual lots.
  - The dispersion area should be shown on all property maps and should be clearly

marked during clearing and construction on the site.

  - All trees within the dispersion area at the time of permit application shall be retained, aside from:
    - dangerous or diseased trees, and
    - approved timber harvest activities regulated under WAC Title 222. Class IV General Forest Practices that are conversions from timberland to other uses are not acceptable for the preserved area.
  - The dispersion area may be used for passive recreation and related facilities, including pedestrian and bicycle trails, nature viewing areas, fishing and camping areas, and other similar activities that do not require permanent structures. Cleared areas and areas of compacted soil associated with these areas and facilities must not exceed eight percent of the dispersion area.
  - The dispersion area may contain utilities and utility easements, but not septic systems. For the purpose of this BMP, utilities are defined as potable and wastewater underground piping, underground wiring, and power and telephone poles.
  - The dispersion area is not allowed in critical area buffers or on slopes steeper than 20%. Dispersion areas proposed on slopes steeper than 15% or within 50 feet of a geologically hazardous area (RCW 36.70A.030(5)) must be approved by a geotechnical engineer or engineering geologist.
  - For sites with on-site sewage disposal systems, the discharge of runoff from the dispersion area must be located downslope of the primary and reserve drainfield areas. This requirement may be waived by the permitting jurisdiction if site topography clearly prevents discharged flows from intersecting the drainfield.
- **A flow path through the dispersion area.** The length of the flow path from the impervious (or cleared) area through the dispersion area varies based on the site layout and type of impervious surface, as further described below. Regardless of the site layout and type of impervious surface, the flow path must meet the following criteria:
  - The slope of the flow path must be no steeper than 15% for any 20-foot reach of the flow path. 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 flow paths from adjacent flow spreaders must be sufficiently spaced to prevent overlap of flows in the flow path areas.

The dispersion of runoff must not create flooding or erosion impacts.

Minimum Design Requirements for Residential Projects

Rural single family residential developments should use this BMP wherever possible to minimize effective impervious surfaces.

Full Dispersion from 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 areas that are beyond the 10% cannot drain to the dispersion area, and are subject to the thresholds in I-3.4.6 MR6: Runoff Treatment and I-3.4.7 MR7: Flow Control.

The lawn and landscaping areas associated with the impervious area being mitigated may be dispersed into the dispersion area. The lawn and landscaped area must comply with BMP T5.13: 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 flow path from the impervious surface through the area preserved as forest or native vegetation must be at least 100 feet in length, or 25 feet for sheet flow from lawn and landscaping areas associated with the impervious area being mitigated.

The following additional guidelines must be followed for the following types of impervious surfaces within residential projects:

- **Full dispersion from roof surfaces:** Runoff from roof surfaces must either:
    - Provide dispersion BMPs as described in BMP T5.10B: Downspout Dispersion Systems prior to the runoff entering the dispersion area. The dispersion area and flow path must meet the criteria described in this BMP.

      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:** Runoff from driveway surfaces must either:
    - Provide dispersion BMPs as described in BMP T5.11: Concentrated Flow Dispersion and BMP T5.12: Sheet Flow Dispersion prior to the runoff entering the dispersion area. The dispersion area and flow path must meet the criteria described in this BMP.

      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:** Runoff from roadway surfaces comply with all of the following requirements:
    - The road section shall be designed to minimize collection and concentration of roadway runoff. Sheet flow over roadway fill slopes (i.e., where roadway subgrade is above adjacent right-of-way) should be used 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 point from a ditch for the 100-year runoff event. Where flows at a particular ditch discharge point 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 points with up to 0.2 cfs discharge for the peak 100-year flow shall use rock pads or dispersion trenches to disperse flows into the dispersion area. Ditch discharge points with between 0.2 and 0.5 cfs discharge for the 100-year peak flow shall use dispersion trenches to disperse flows into the dispersion area. See V-1.4.3 Outfall Systems for details on rock pads and dispersion trenches.
  - Dispersion trenches shall be designed to accept surface flows (free discharge) from a pipe, culvert, or ditch end, shall be aligned perpendicular to the flowpath, and shall have a minimum 2 feet by 2 cross section, 50 feet in length, filled with 3/4-inch to 1 1/2-inch washed rock, and provided with a level notched grade board. Manifolds may be used to split flows up to 2 cfs discharge for the 100-year peak flow between up to 4 trenches. Dispersion trenches shall have a minimum spacing of 50 feet between centerlines.
- Where the Local Plan Approval Authority determines there is a potential for significant adverse impacts downstream (e.g., erosive steep slopes or existing downstream drainage problems), dispersion of runoff from roadway surfaces may not be allowed, or other measures may be required.

Full Dispersion from Cleared Areas in Residential Projects

The runoff 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 T5.13: Post-Construction Soil Quality and Depth.
- The dispersion area must be preserved as forest or native vegetation.
- The flow path through the cleared area (and leading to the dispersion area) must not be greater than 25 feet.
- If the cleared area has a width of up to 25 feet:
  - The minimum flow path length from the cleared area through the dispersion area must be at least 25 feet.
- If the cleared area has a width of 25 to 250 feet:
  - The minimum flow path length from the cleared area through the dispersion area must be 25 feet, plus an additional 1 foot for every 3 feet of width of the cleared area (beyond the initial 25 feet) up to a maximum width of 250 feet.

- The topography of the cleared area must be such that runoff will not concentrate prior to discharge to the dispersion area.
- The width of the dispersion area must equal the width of the cleared area.

Minimum Design Requirements for Public Road Projects

These criteria apply to the construction of public roads not within the context of residential, commercial, or industrial site development. They will likely only be implementable on roads outside of the urban growth areas where roadside areas are not planned for urban density development.

Full dispersion can be applied to public road projects that meet the following requirements:

- The dispersion area must be outside of the urban growth area; or if inside the urban growth area, in legally protected areas (easements, conservation tracts, public parks).
- If the dispersion area is outside urban growth areas, legal agreements should be reached with the owner(s) of the property(ies) that contain the dispersion area.
- An agreement with the property owner(s) is advised for any dispersion areas that represent a continuation of past practice. If not a continuation of past practice, an agreement should be reached with the property owner.

Full Dispersion by Sheet Flow from Uncollected, Unconcentrated Runoff into the Dispersion Area

The runoff from public road projects that sheet flow into the dispersion area is "fully dispersed" if it meets all of the following criteria:

- The dispersion area must be preserved as forest or native vegetation.
- Depth to the average annual maximum ground water elevation should be at least 3 feet.
- The flow path through any impervious area leading to the dispersion area must not be greater than 75 feet.
- The flow path through any pervious area leading to the dispersion area must not be greater than 150 feet. Pervious flow paths include up-gradient road side slopes that run onto the road and down-gradient road side slopes that precede the dispersion area.
- The width of the dispersion area should be equivalent to the width of impervious surface sheet flowing into it.
- Flow path length through the dispersion area:
    - For outwash soils: The following criteria apply to sites (or areas of sites) with outwash soils (Type A – sands and sandy gravels, possibly some Type B – loamy sands). The outwash soils must have an initial saturated hydraulic conductivity rate of 4 inches per hour or greater. The saturated hydraulic conductivity must be based on a Pilot Infiltration Test or the Soil Grain Size Analysis method as identified in V-5.4 Determining the Design Infiltration Rate of the Native Soils, or another method as allowed by the local government.

        - If the impervious area has a flow path length of up to 20 feet, the flow path length through the dispersion area must be at least 10 feet.
        - If the impervious area has a flow path length greater than 20 feet, the flow path length through the dispersion area must be 10 feet, plus an additional 0.25 feet for every 1 foot of impervious flow path length beyond the initial 20 feet.
    - For other soils: The following criteria apply to sites (or areas of sites) with soils other than those described in the bullet above (Types C and D and some Type B not meeting the criterion described in the bullet above).
        - For every 1 foot of flow path length across the impervious surface, the flow path length through the dispersion area must be 6.5 feet.
        - The minimum flow path length through the dispersion area is 100 feet.
- The lateral slope of the impervious area should be less than 8%.
- Road side slopes must be less than 25%. Road side slopes do not count as part of the dispersion area unless native vegetation is re-established and slopes are less than 15%. Road shoulders that are paved or graveled to withstand occasional vehicle loading count as impervious surface.
- Longitudinal slope of road should be ≤ 5%.
- The average longitudinal (parallel to road) slope of dispersion area should be less than or equal to 15%.
- The average lateral slope of dispersion area should be less than or equal to 15%.

Full Dispersion of Channelized (Collected and Re-dispersed) Stormwater into the Dispersion Area

The runoff from public road projects that is collected and re-dispersed is "fully dispersed" if it meets all of the following criteria:

- The dispersion area may be either:
    - preserved as forest or native vegetation, or
    - cleared land. This cleared land option may only be used if the site is outside of the Urban Growth Area and does not have a natural or man-made drainage system.
- Depth to the average annual maximum ground water elevation should be at least three feet.
- Channelized flow must be re-dispersed to produce the longest possible flow path.
- Flows must be evenly dispersed across the dispersion area.
- Ditch discharge points with up to 0.2 cfs discharge for the peak 100-year flow shall use rock pads or dispersion trenches to disperse flows into the dispersion area. Ditch discharge points with between 0.2 and 0.5 cfs discharge for the 100-year peak flow shall use dispersion trenches to disperse flows into the dispersion area. See V-1.4.3 Outfall Systems for details on

rock pads and dispersion trenches.

  - Dispersion trenches shall be designed to accept surface flows (free discharge) from a pipe, culvert, or ditch end, shall be aligned perpendicular to the flowpath, and shall have a minimum 2 feet by 2 cross section, 50 feet in length, filled with 3/4-inch to 1 1/2-inch washed rock, and provided with a level notched grade board. Manifolds may be used to split flows up to 2 cfs discharge for the 100-year peak flow between up to 4 trenches. Dispersion trenches shall have a minimum spacing of 50 feet between centerlines.

- Approved energy dissipation techniques may be used.
- Limited to on-site (associated with the road) flows.
- The width of the dispersion area should be equivalent to length of the road from which runoff is collected.
- The average longitudinal and lateral slopes of the dispersion area should be ≤ 8%.
- The slope of any flowpath segment within the dispersion area must be no steeper than 15% for any 20-foot reach of the flowpath segment.
- Flow path length through the dispersion area:
  - For outwash soils: The following criteria apply to sites (or areas of sites) with outwash soils (Type A – sands and sandy gravels, possibly some Type B – loamy sands) that have an initial saturated hydraulic conductivity rate of 4 inches per hour or greater. The saturated hydraulic conductivity must be based on field results using procedures (Pilot Infiltration Test or Soil Grain Size Analysis Method) identified in V-5.4 Determining the Design Infiltration Rate of the Native Soils, or another method as allowed by the local government.
    - The dispersion area should be at least ½ of the impervious drainage area.
  - For other soils: The following criteria apply to sites (or areas of sites) with soils other than those described in the bullet above (Types C and D and some Type B not meeting the criterion in the bullet above).
    - For every 1 foot of flow path length across the impervious surface, the flow path length through the dispersion area must be 6.5 feet.
    - The minimum flow path length through the dispersion area is 100 feet.

Full Dispersion by Engineered Dispersion

The runoff from public road projects is "fully dispersed" if it meets all of the following criteria:

- Stormwater can be dispersed via sheet flow or via collection and re-dispersion in accordance with the techniques for Full Dispersion of Channelized (Collected and Re-dispersed) Stormwater into the Dispersion Area (above).
- The dispersion area should be planted with native trees and shrubs.
- For outwash soils: The following criteria apply to sites (or areas of sites) with outwash soils

(Type A – sands and sandy gravels, possibly some Type B – loamy sands) that have an initial saturated hydraulic conductivity rate of 4 inches per hour or greater. The saturated hydraulic conductivity must be based on field results using procedures (Pilot Infiltration Test or Soil Grain Size Analysis Method) identified in V-5.4 Determining the Design Infiltration Rate of the Native Soils, or another method as allowed by the local government.

  - The dispersion area must be compost amended in accordance with guidelines in BMP T5.13: Post-Construction Soil Quality and Depth. The guidance document *Building Soil: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13 in WDOE Stormwater Management Manual for Western Washington* (Stenn et al., 2016) can be used, or an approved equivalent soil quality and depth specification approved by Ecology.
  - If the impervious area has a flow path length of up to 20 feet, the flow path length through the dispersion area must be at least 10 feet.
  - If the impervious area has a flow path length greater than 20 feet, the flow path length through the dispersion area must be 10 feet, plus an additional 0.25 feet for every 1 foot of impervious flow path length beyond the initial 20 feet.

- For other soils: The following criteria apply to sites (or areas of sites) with soils other than those described in the bullet above (Types C and D and some Type B not meeting the criterion in the bullet above).
- If the dispersion area has Type C or D soils, it
  - The dispersion area must be compost-amended following guidelines in BMP T5.13: Post-Construction Soil Quality and Depth. The guidance document *Building Soil: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13 in WDOE Stormwater Management Manual for Western Washington* (Stenn et al., 2016) can be used, or an approved equivalent soil quality and depth specification approved by Ecology.
  - The dispersion area must have be 6.5 times the area of the surface(s) draining to it.
- The average longitudinal (parallel to road) slope of the dispersion area should be ≤ 15%.
- The average lateral slope of the dispersion area should be ≤ 15%.
- The depth to the average annual maximum ground water elevation should be at least three feet.

Native Vegetation Landscape Specifications

These specifications may be used in situations where an applicant wishes to convert a previously developed surface to a native vegetation landscape for purposes of meeting full dispersion requirements or code requirements for forest retention. Native vegetation landscape is intended to have the soil, vegetation, and runoff characteristics approaching that of natural forestland.

Conversion of a developed surface to native vegetation landscape requires the removal of impervious surface, de-compaction of soils, and the planting of native trees, shrubs, and ground cover in compost-amended soil according to all of the following specifications:

1. Existing impervious surface and any underlying base course (e.g., crushed rock, gravel) must be completely removed from the conversion area(s).
2. Underlying soils must be broken up to a depth of 18 inches. This can be accomplished by excavation or ripping with either a backhoe equipped with a bucket with teeth, or a ripper towed behind a tractor.
3. At least 4 inches of well-decomposed compost must be tilled into the broken up soil as deeply as possible. The finished surface should be gently undulating and must be only lightly compacted.
4. The area of native vegetated landscape must be planted with native species trees, shrubs, and ground cover. Species must be selected as appropriate for site shade and moisture conditions, and in accordance with the following requirements:
   a. Trees: a minimum of two species of trees must be planted, one of which is a conifer. Conifer and other tree species must cover the entire landscape area at a spacing recommended by a professional landscaper or in accordance with local requirements.
   b. Shrubs: a minimum of two species of shrubs should be planted. Space plants to cover the entire landscape area, excluding points where trees are planted.
   c. Groundcover: a minimum of two species of ground cover should be planted. Space plants so as to cover the entire landscape area, excluding points where trees or shrubs are planted.

   For landscape areas larger than 10,000 square feet, planting a greater variety of species than the minimum suggested above is strongly encouraged. For example, an acre could easily accommodate three tree species, three species of shrubs, and two or three species of groundcover.
5. At least 4 inches of hog fuel or other suitable mulch must be placed between plants as mulch for weed control. It is also possible to mulch the entire area before planting; however, an 18-inch diameter circle must be cleared for each plant when it is planted in the underlying amended soil. *Note: Plants and their root systems that come in contact with hog fuel or raw bark have a poor chance of survival.*
6. Plantings must be watered consistently once per week during the dry season for the first two years.
7. The plantings must be well established on at least 90% of the converted area. A minimum of 90% plant survival is required after 3 years.

Conversion of an area that was under cultivation to native vegetation landscape requires a different treatment. Elimination of cultivated plants, grasses and weeds is required before planting and will be required on an on-going basis until native plants are well-established. The soil should be tilled to a depth of 18 inches. A minimum of 8 inches of soil having an organic content of 6 to 12 percent is required, or a four inch layer of compost may be placed on the surface before planting, or 4 inches of clean wood chips may be tilled into the soil, as recommended by a landscape architect or forester. After soil preparation is complete, continue with steps 4 through 7 above. Placing 4 inches of compost on the surface may be substituted for the hog fuel or mulch. For large areas where frequent watering is not practical, bare-root stock may be substituted at a variable spacing from 10 to 12 feet o.c. (with an average of 360 trees per acre) to allow for natural groupings and 4 to 6 feet o.c. for shrubs. Allowable bare-root stock types are 1-1, 2-1, P-1 and P-2. Live stakes at 4 feet o.c. may be substituted for willow and red-osier dogwood in wet areas.

Runoff Model Representation

Areas that are fully dispersed do not have to use approved runoff models to demonstrate compliance. They are presumed to fully meet the Runoff Treatment and Flow Control requirements in I-3.4.6 MR6: Runoff Treatment and I-3.4.7 MR7: Flow Control.

V-4 Roof Downspout BMPs

V-4.1 Introduction to Roof Downspout BMPs

Roof downspout BMPs are simple pre-engineered designs for infiltrating and/or dispersing runoff from roof areas for the purposes of increasing opportunities for ground water recharge and reduction of runoff volumes from development.

Roof downspout BMPs include infiltration trenches, dry wells, and partial dispersion systems for use in individual lots, proposed plats, and short plats. Roof downspout BMPs are used in conjunction with, and in addition to, any Flow Control BMPs that may be necessary. They are included in the list of BMPs to consider if using the List Approach for compliance with I-3.4.5 MR5: On-Site Stormwater Management.

How to Select Roof Downspout BMPs

Large lots in rural areas (5 acres or greater) typically have enough area to disperse or infiltrate roof runoff. Lots created in urban areas will typically be smaller (about 8,000 square feet) and have a limited amount of area in which to site infiltration or dispersion trenches. BMP T5.10A: Downspout Full Infiltration should be used in those soils that readily infiltrate. BMP T5.10B: Downspout Dispersion Systems should be used for urban lots located in less permeable soils, where infiltration is not feasible. Where BMP T5.10B: Downspout Dispersion Systems is not feasible because of very small lot size, or where there is a potential for creating drainage problems on adjacent lots, use BMP T5.10C: Perforated Stub-out Connections to connect downspouts with perforated stub-out connections to the street drainage system, which directs the runoff to a stormwater management facility.

Where supported by appropriate soil infiltration tests, downspout full infiltration in finer soils may be practical using a larger infiltration system.

Roof downspout BMPs can be applied to individual commercial lot developments when the percent impervious area and pollutant characteristics are comparable to those from residential lots.

Note: Other innovative downspout control BMPs such as rain barrels, ornamental ponds, downspout cisterns, or other downspout water storage devices may be used to supplement any of the BMPs in this chapter if approved by the reviewing authority.

BMP T5.10A: Downspout Full Infiltration

Downspout full infiltration systems are trench or drywell designs intended only for use in infiltrating runoff from roof downspout drains. They are not designed to directly infiltrate runoff from pollutant-generating impervious surfaces.

Roof surfaces that comply with this BMP are considered to be "fully infiltrated" (i.e., zero percent effective imperviousness).

Procedure for Evaluating Feasibility

1. Have one of the following prepare a soils report to determine if soils suitable for infiltration are present on the site:
   - A professional soil scientist certified by the Soil Science Society of America (or an equivalent national program)
   - A locally licensed on-site sewage designer
   - A suitably trained person working under the supervision of a professional engineer, geologist, hydrogeologist, or engineering geologist registered in the State of Washington.

   The report shall reference a sufficient number of soils logs to establish the type and limits of soils on the project site. The report should at a minimum identify the limits of any outwash type soils (i.e., those meeting USDA soil texture classes ranging from coarse sand and cobbles to medium sand) versus other soil types and include an inventory of topsoil depth.

2. Complete additional site-specific testing on lots or sites containing outwash (coarse sand and cobbles to medium sand) and loam type soils.

   Individual lot or site tests must consist of at least one soils log at the location of the infiltration system, a minimum of 4 feet in depth from the proposed grade and at least 1 foot below the expected bottom elevation of the infiltration trench or dry well.

   Identify the NRCS series of the soil and the USDA textural class of the soil horizon through the depth of the log, and note any evidence of high ground water level, such as mottling.

3. Downspout full infiltration is considered feasible on lots or sites that meet all of the following:
   - 3 feet or more of permeable soil from the proposed final grade to the seasonal high ground water table.
   - At least 1-foot of clearance from the expected bottom elevation of the infiltration trench or dry well to the seasonal high ground water table.
   - The downspout full infiltration system can be designed to meet the minimum design criteria specified below.

Setbacks

Local governments may require specific setbacks in sites with slopes over 40%, land slide areas, open water features, springs, wells, and septic tank drain fields. Adequate room for maintenance access and equipment should also be considered. Examples of setbacks commonly used include the following:

1. All infiltration systems should be at least 10 feet from any structure, property line, or sensitive area (except slopes over 40%).
2. All infiltration systems must be at least 50 feet from the top of any slope over 40%. This setback may be reduced to 15 feet based on a geotechnical evaluation, but in no instances may it

be less than the buffer width.

3. For sites with septic systems, infiltration systems must be downgradient of the drainfield unless the site topography clearly prohibits subsurface flows from intersecting the drainfield.

Design Criteria

Infiltration Trenches

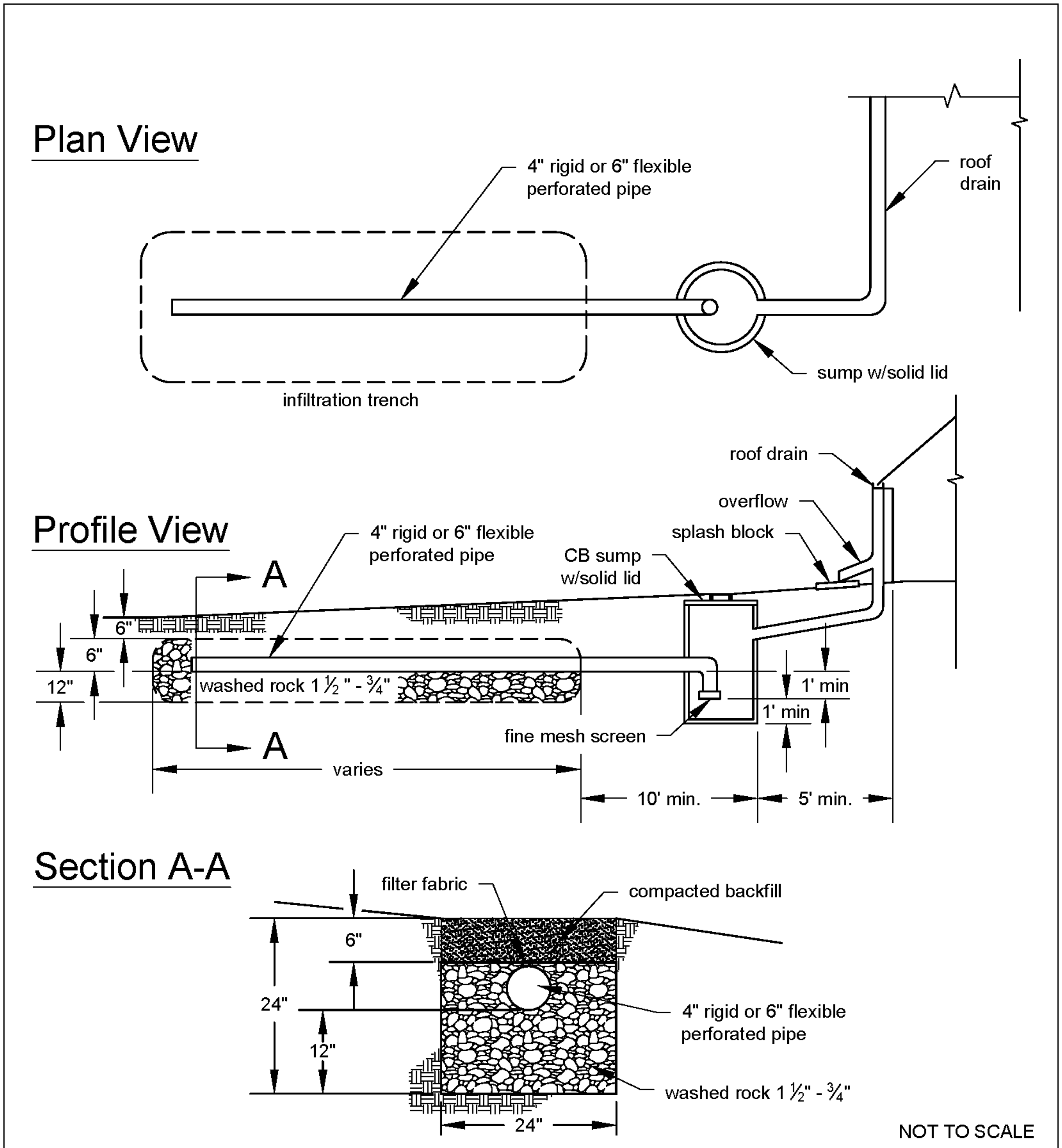
Figure V-4.1: Typical Downspout Infiltration Trench shows a typical downspout infiltration trench system, and Figure V-4.2: Alternative Downspout Infiltration Trench System for Coarse Sand and Gravel presents an alternative infiltration trench system for sites with coarse sand and cobble soils. These systems are designed as specified below.

1. The following minimum lengths (linear feet) per 1,000 square feet of roof area based on soil type may be used for sizing downspout infiltration trenches:
   - Coarse sands and cobbles: 20 LF
   - Medium sand: 30 LF
   - Fine sand, loamy sand: 75 LF
   - Sandy loam: 125 LF
   - Loam: 190 LF
2. Silt and clay type soils have a saturated hydraulic conductivity that is too small for adequate infiltration and are infeasible for downspout infiltration trenches.
3. The maximum length of the trench shall not exceed 100 feet from the inlet sump.
4. The minimum spacing between trench centerlines shall be 6 feet.
5. Filter fabric shall be placed over the drain rock as shown on Figure V-4.1: Typical Downspout Infiltration Trench prior to backfilling.
6. Infiltration trenches may be placed in fill material if:
   - the fill is placed and compacted under the direct supervision of a geotechnical engineer or professional civil engineer with geotechnical expertise, and
   - the measured infiltration rate is at least 8 inches per hour.

   Trench length in fill must be 60 linear feet per 1,000 square feet of roof area. Infiltration rates can be tested using the methods described in V-5.4 Determining the Design Infiltration Rate of the Native Soils.
7. Infiltration trenches should not be built on slopes steeper than 25% (4:1). A geotechnical analysis and report may be required on slopes over 15%, or if the proposed trench is located within 200 feet of the top of a slope steeper than 40%, or in a landslide hazard area.
8. Infiltration 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 down-hill properties or drainage systems. This is intended to prevent saturation of the pavement in the event of system failure.

Figure V-4.1: Typical Downspout Infiltration Trench



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Typical Downspout Infiltration Trench

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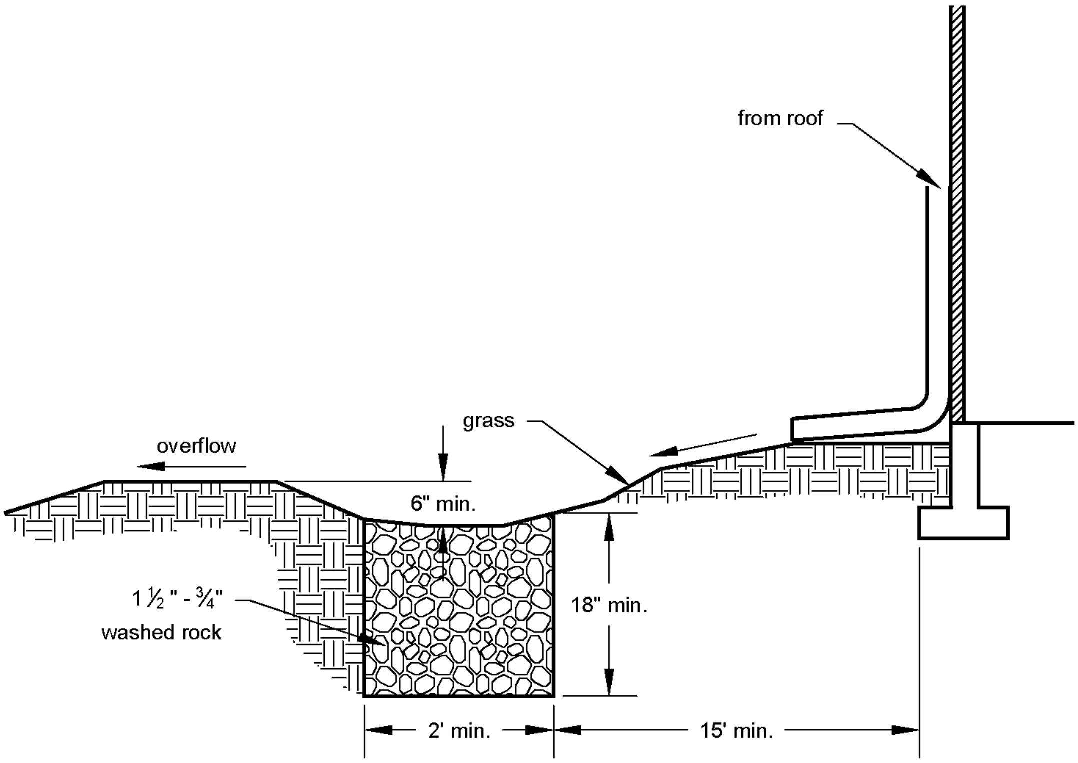
Figure V-4.2: Alternative Downspout Infiltration Trench System for Coarse Sand and Gravel



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Alternative Downspout Infiltration Trench System for Coarse Sand and Gravel

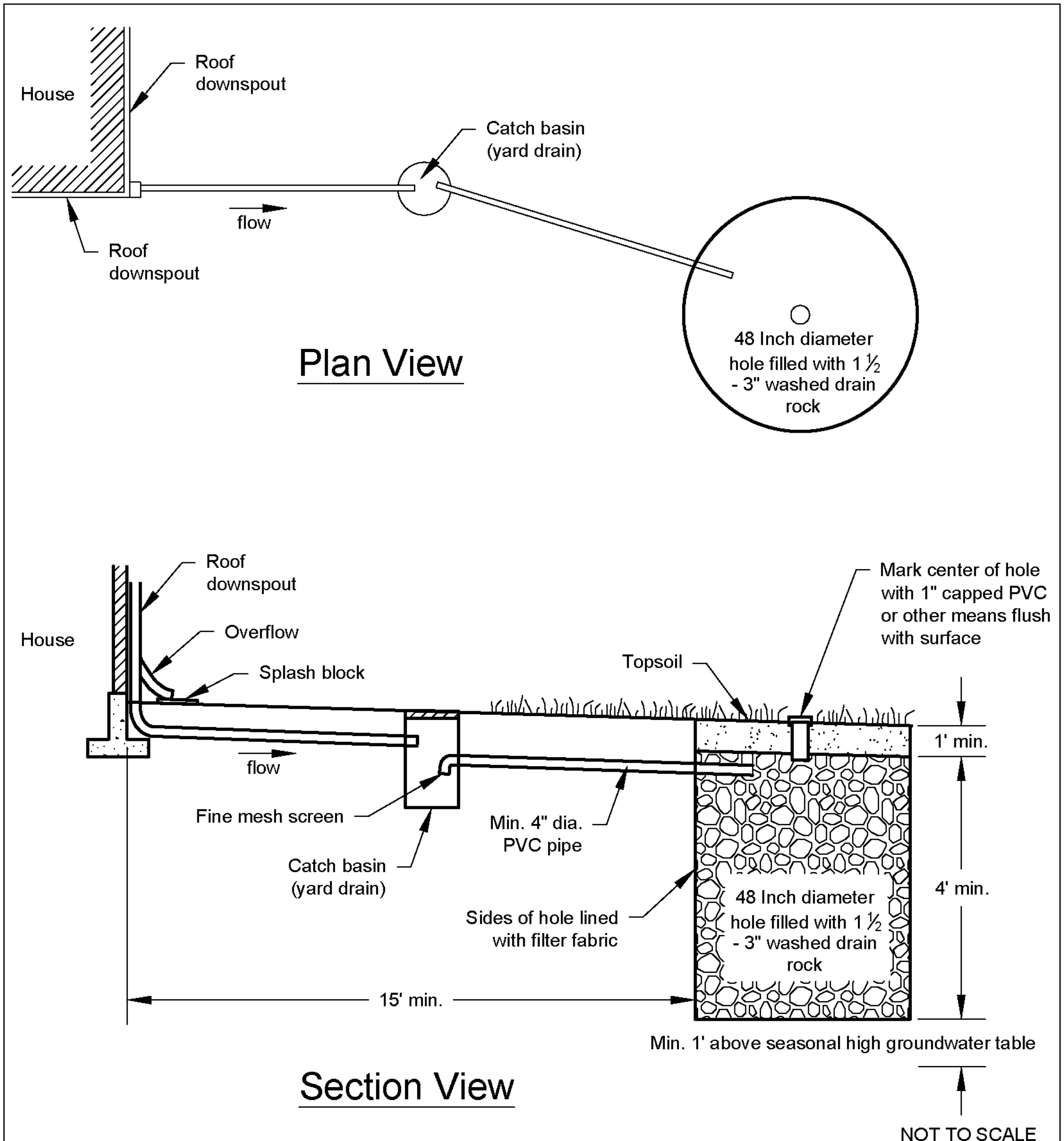
Revised June 2016

Infiltration Drywells

Figure V-4.3: Typical Downspout Infiltration Drywell shows a typical downspout infiltration drywell system. These systems are designed as specified below.

1. Drywell bottoms must be a minimum of 1 foot above the seasonal high ground water level or impermeable soil layers.
2. When located in course sands and cobbles, drywells must contain a volume of gravel equal to or greater than 60 cubic feet per 1000 square feet of impervious surface served. When located in medium sands, drywells must contain at least 90 cubic feet of gravel per 1,000 square feet of impervious surface served.
3. Drywells must be at least 48 inches in diameter (minimum) and deep enough to contain the gravel amounts specified above for the soil type and impervious surface served.
4. Filter fabric (geotextile) must be placed on top of the drain rock and on drywell sides prior to backfilling.
5. Spacing between drywells must be a minimum of 10 feet.
6. Downspout infiltration drywells must not be built on slopes greater than 25% (4:1). Drywells may not be placed on or above a landslide hazard area or on slopes greater than 15% without evaluation by a licensed engineer in the state of Washington with geotechnical expertise or a licensed geologist, hydrogeologist, or engineering geologist, and with jurisdiction approval.

Figure V-4.3: Typical Downspout Infiltration Drywell



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Typical Downspout Infiltration Drywell

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Runoff Model Representation

Roof areas served by downspouts that drain to infiltration dry wells or infiltration trenches that are sized in accordance with the guidance in this BMP do not have to be entered into the runoff model. They are presumed to fully infiltrate the roof runoff.

BMP T5.10B: Downspout Dispersion Systems

Downspout dispersion systems are splash blocks or gravel filled trenches, which serve to spread roof runoff over vegetated pervious areas. Dispersion attenuates peak flows by slowing the runoff entering into the conveyance system, allowing some infiltration, and providing some water quality benefits.

Design Criteria

1. Use downspout trenches designed as shown in Figure V-4.4: Typical Downspout Dispersion Trench and Figure V-4.5: Standard Dispersion Trench with Notched Grade Board for all downspout dispersion applications except where splash blocks are allowed below.

2. Splash blocks shown in Figure V-4.6: Typical Downspout Splashblock Dispersion may be used for downspouts discharging to a vegetated flow path at least 50 feet in length as measured from the downspout to the downstream property line, structure, slope over 15%, stream, wetland, or other impervious surface. Sensitive area buffers may count toward flow path lengths.

3. The vegetated flow path must consist of well-established lawn or pasture, landscaping with well-established groundcover , native vegetation with natural groundcover, or an area that meets BMP T5.13: Post-Construction Soil Quality and Depth. The groundcover shall be dense enough to help disperse and infiltrate flows and to prevent erosion.

4. If the vegetated flow path (measured as defined above) is less than 25 feet, BMP T5.10C: Perforated Stub-out Connections may be used in lieu of downspout dispersion. BMP T5.10C: Perforated Stub-out Connections may also be used where implementation of downspout dispersion might cause erosion or flooding problems, either on site or on adjacent lots. For example, this provision might be appropriate for lots constructed on steep hills where downspout discharge could culminate and might pose a potential hazard for lower lying lots, or where dispersed flows could create problems for adjacent off-site lots. This provision does not apply to situations where lots are flat and on-site downspout dispersal would result in saturated yards.

   Note: For all other types of projects, the use of a perforated stub-out in lieu of downspout dispersion shall be as determined by the Local Plan Approval Authority.

5. For sites with septic systems, the discharge point of all dispersion systems must be downslope of the primary and reserve drainfield areas. This requirement may be waived if site topography clearly prohibits flows from intersecting the drainfield or where site conditions (soil permeability, distance between systems, etc.) indicate that this is unnecessary.

6. No erosion or flooding of downstream properties may result.

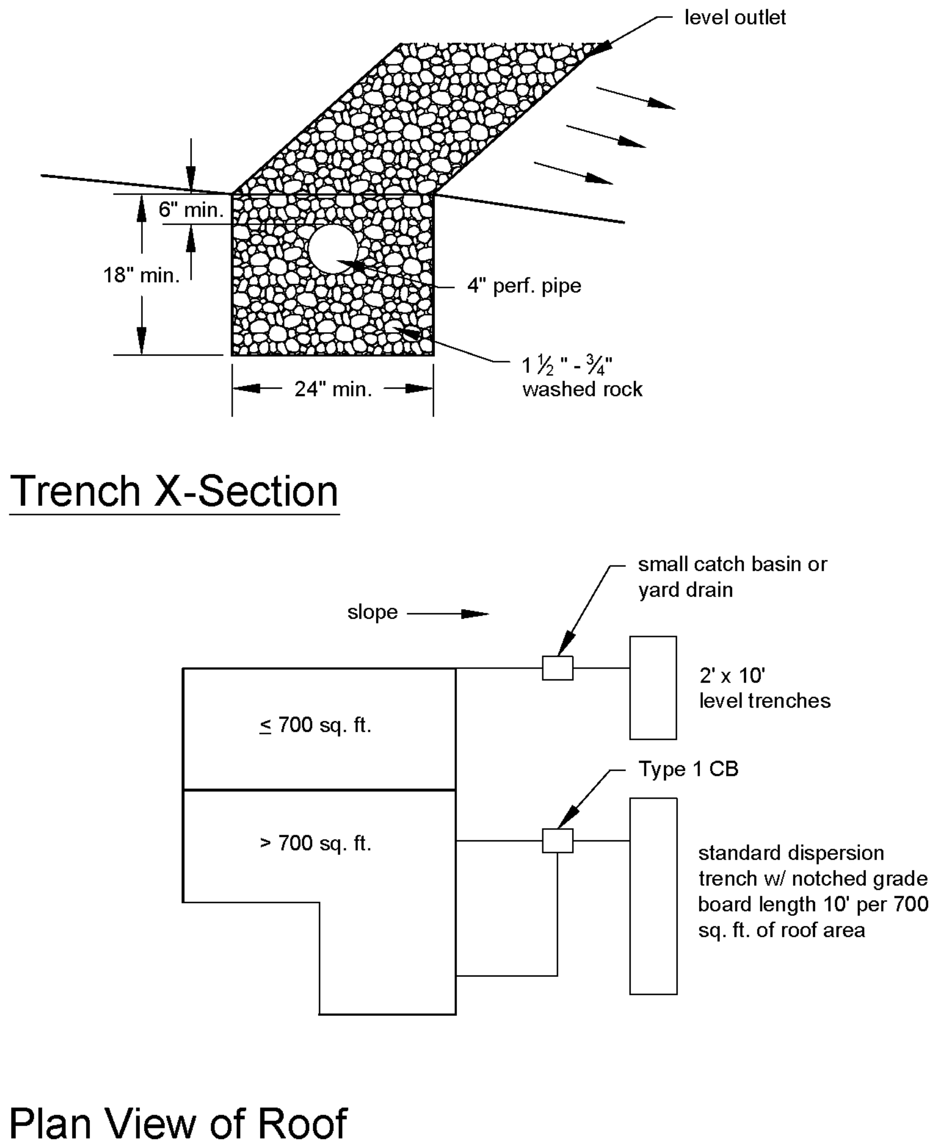
7. For purposes of maintaining adequate separation of flows discharged from adjacent dispersion devices, the vegetated flowpath segment for the splashblock (or the outer edge of the vegetated flowpath segment for the dispersion trench) must not overlap with other flowpath segments, except those associated with sheet flow from a non-native pervious surface.
8. Have a geotechnical engineer or a licensed geologist, hydrogeologist, or engineering geologist evaluate runoff discharged towards landslide hazard areas. Do not place the discharge point from splashblocks or dispersion trenches on or above slopes greater than 15% or above erosion hazard areas without evaluation by a licensed engineer in the state of Washington with geotechnical expertise or a licensed geologist, hydrogeologist, or engineering geologist, and approval by the Local Plan Approval Authority.

Design Criteria for Dispersion Trenches

1. A vegetated flow path of at least 25 feet in length must be maintained between the outlet of the dispersion trench and any property line, structure, stream, wetland, or impervious surface. A vegetated flow path of at least 50 feet in length must be maintained between the outlet of the trench and any slope steeper than 15%. Sensitive area buffers may count towards flow path lengths.
2. Trenches serving up to 700 square feet of roof area may be 10-foot-long by 2-foot wide gravel filled trenches as shown in Figure V-4.4: Typical Downspout Dispersion Trench.

   For roof areas larger than 700 square feet, a dispersion trench with notched grade board as shown in Figure V-4.5: Standard Dispersion Trench with Notched Grade Board or alternative material approved by the Local Plan Approval Authority may be used. The total trench length must not exceed 50 feet and must provide at least 10 feet of trench length per 700 square feet of roof area.
3. Maintain a setback of at least 5 feet between any edge of the trench and any structure or property line.

Figure V-4.4: Typical Downspout Dispersion Trench



Source: King County Department of Natural Resources, 1998

NOT TO SCALE

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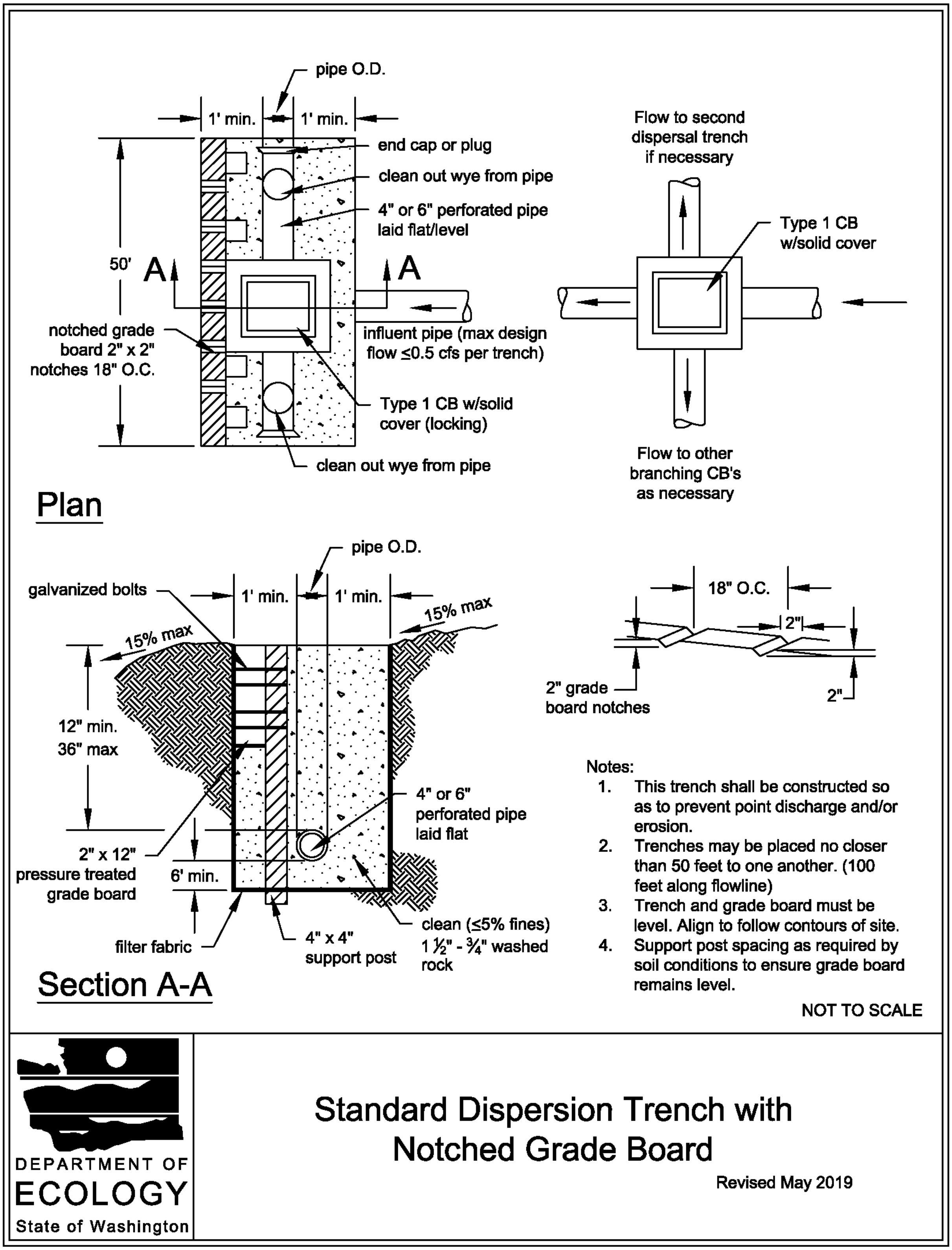
Typical Downspout Dispersion Trench

Revised December 2016

Figure V-4.5: Standard Dispersion Trench with Notched Grade Board



Design Criteria for Splashblocks

A typical downspout splashblock is shown in Figure V-4.6: Typical Downspout Splashblock Dispersion. 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 storm runoff. If the ground is fairly level, if the structure includes a basement, or if foundation drains are proposed, splashblocks with downspout extensions may be a better choice because the discharge point is moved away from the foundation. Downspout extensions can include piping to a splashblock/discharge point a considerable distance from the downspout, as long as the runoff can travel through a well-vegetated area as described below.

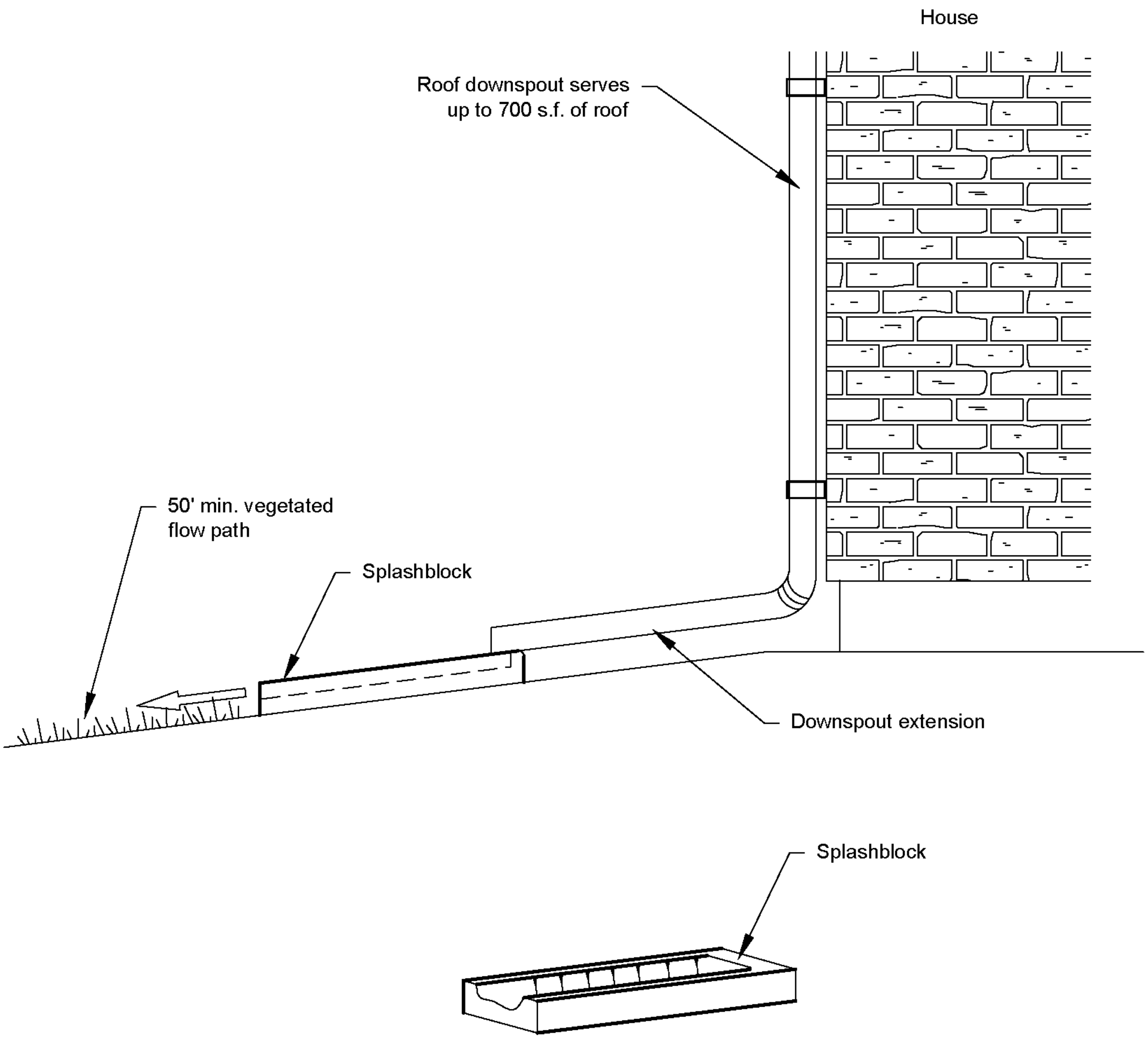
The following apply to the use of splashblocks:

1. Maintain a vegetated flow path of at least 50 feet between the discharge point and any property line, structure, slope steeper than 15%, stream, wetland, lake, or other impervious surface. Sensitive area buffers may count toward flow path lengths.

2. A maximum of 700 square feet of roof area may drain to each splashblock.

3. Place a splashblock or a pad of crushed rock (2 feet wide by 3 feet long by 6 inches deep) at each downspout discharge point.

Figure V-4.6: Typical Downspout Splashblock Dispersion



Source: King County Department of Natural Resources, 1998

NOT TO SCALE

DEPARTMENT OF
ECOLOGY
State of Washington

Typical Downspout Splashblock Dispersion

Revised December 2016

Runoff Model Representation

The designer has the following options to model the amount of Flow Control presumed to be provided by this BMP:

- When splashblocks or dispersion trenches are used per the guidance above, and the length of the vegetated flow path is at least 50 feet:
  - When modeling in an approved continuous runoff model, the connected roof area should be modeled as a lateral flow impervious area. Do this in WWHM on the Mitigated Scenario screen by connecting the dispersed impervious area (the roof area) to the lawn/landscape lateral flow soil basin element representing the area that will be used for dispersion (the vegetated flow path).

    In situations where multiple downspout dispersions will occur, Ecology allows the roof area to be modeled as a landscaped area (grass) so that the project schematic in the approved continuous runoff model becomes manageable.
  - When calculating the runoff curve number to include in calculations described in III-2.3 Single Event Hydrograph Method, the curve number may be determined by considering the roof area as landscaped area (grass).
- When dispersion trenches are used per the guidance above, and the length of the vegetated flow path is 25 - 50 feet:
  - When modeling in an approved continuous runoff model, the connected roof area should be modeled as a lateral flow impervious area. Do this in WWHM on the Mitigated Scenario screen by connecting the dispersed impervious area (the roof area) to the lawn/landscape lateral flow soil basin element representing the area that will be used for dispersion (the vegetated flow path).

    In situations where multiple downspout dispersions will occur, Ecology allows the roof area to be modeled as 50%landscaped / 50%impervious so that the project schematic in the approved continuous runoff model becomes manageable.
  - When calculating the runoff curve number to include in calculations described in III-2.3 Single Event Hydrograph Method, the curve number may be determined by considering the roof area as 50%landscaped / 50%impervious.

BMP T5.10C: Perforated Stub-out Connections

A perforated stub out connection is a length of perforated pipe within a gravel filled trench that is placed between roof downspouts and a stub out to the local drainage system. Figure V-4.7: Perforated Stub-Out Connection illustrates a perforated stub out connection. These systems are intended to provide some infiltration during drier months. During the wet winter months, they may provide little or no Flow Control.

Applications & Limitations

Perforated stub-outs are not appropriate when the seasonal water table is less than one foot below the trench bottom.

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. Use the same setbacks as for infiltration trenches in BMP T5.10A: Downspout Full Infiltration.

Have a licensed geologist, hydrogeologist, or engineering geologist evaluate potential runoff discharges towards landslide hazard areas. Do not place the perforated portion of the pipe on or above slopes greater than 20% or above erosion hazard areas without evaluation by a licensed engineer in the state of Washington with geotechnical expertise or qualified geologist and jurisdiction approval.

For sites with septic systems, the perforated portion of the pipe must be downgradient of the drainfield primary and reserve areas. This requirement can be waived if site topography will clearly prohibit flows from intersecting the drainfield or where site conditions (soil permeability, distance between systems, etc.) indicate that this is unnecessary.

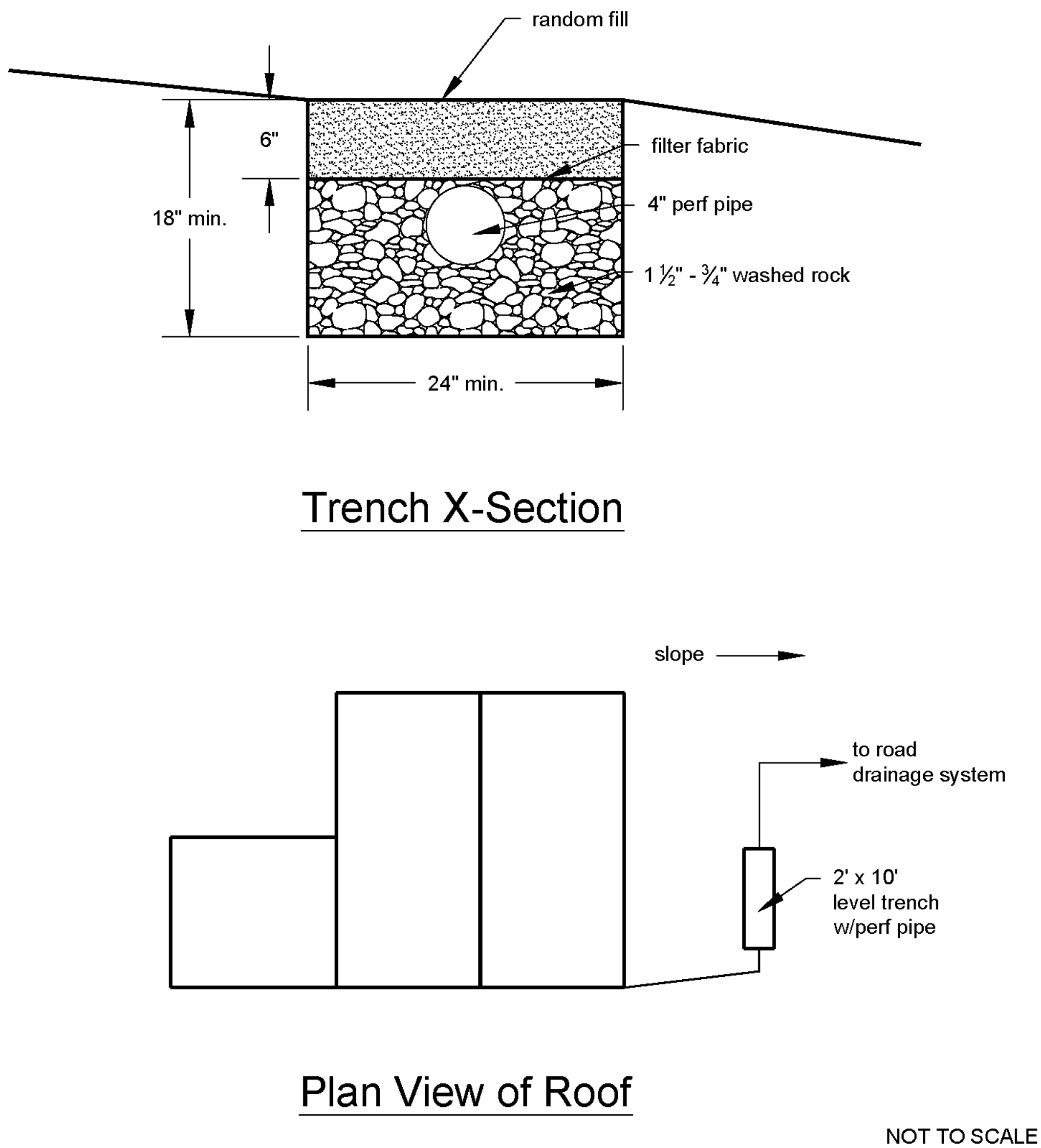
Design Criteria

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 fill (see Figure V-4.7: Perforated Stub-Out Connection).

Runoff Model Representation

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 V-4.7: Perforated Stub-Out Connection



DEPARTMENT OF ECOLOGY
State of Washington

Perforated Stub-Out Connection

Revised June 2016

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V-5 Infiltration BMPs

V-5.1 Introduction to Infiltration BMPs

An infiltration BMP is typically an impoundment; such as a basin, trench, or bioretention swale whose soil may remove pollutants from stormwater. Permeable pavement is a non-impoundment type of infiltration BMP. Stormwater dry-wells receiving uncontaminated or properly treated stormwater can also be considered an infiltration BMP. (See Underground Injection Control Program, Chapter 173-218 WAC).

Infiltration BMPs are used as Flow Control BMPs, and in some cases can also be used as Runoff Treatment BMPs. Infiltration BMPs used as Flow Control BMPs convey stormwater runoff from new development or redevelopment to the ground and ground water after appropriate Runoff Treatment. Infiltration BMPs used as Runoff Treatment BMPs rely either on the soil profile or on a treatment layer within the BMP to provide Runoff Treatment.

Infiltration BMPs can help accomplish the following:

- Ground water recharge.
- Discharge of uncontaminated or properly treated stormwater to dry-wells in compliance with Ecology's UIC regulations (Chapter 173-218 WAC).
- Retrofits in limited land areas: BMP T7.20: Infiltration Trenches can be considered for residential lots, commercial areas, parking lots, and open space areas.
- Flood control.
- Streambank erosion control.

Infiltration refers to the use of the filtration, adsorption, and biological properties of native soils, with or without amendments, to remove pollutants as stormwater soaks into the ground. Infiltration can provide multiple benefits including pollutant removal, peak flow control, ground water recharge, and flood control. One condition that can limit the use of infiltration is the potential adverse impact on ground water quality. You must understand the difference between infiltrating in soils that are suitable for Runoff Treatment and soils only suitable for Flow Control to protect ground water. Sufficient organic content and sorption capacity to remove pollutants must be present for soils to provide Runoff Treatment. See V-5.6 Site Suitability Criteria (SSC) for details. Examples of suitable soils are silty and sandy loams. Coarser soils, such as gravelly sands, can provide flow control but are not suitable for providing runoff treatment. The use of coarser soils to provide Flow Control for runoff from pollutant generating surfaces must always be preceded by Runoff Treatment to protect ground water quality. Thus, there will be instances when soils are suitable for Runoff Treatment but not Flow Control, and vice versa.

Due to the multiple hydrologic benefits of infiltration, Ecology encourages infiltration to the maximum extent practicable. Sites that can fully infiltrate are not required to provide additional Runoff Treatment or Flow Control BMPs. Hard surfaces that are not fully infiltrated should be partially infiltrated to the maximum extent practicable.

Infiltration BMPs used for Runoff Treatment are typically installed:

- Where the native soils meet the criteria for Runoff Treatment as described in V-5.6 Site Suitability Criteria (SSC)
- As off-line systems, or on-line for small contributing areas
- As a polishing treatment for street/highway runoff after pretreatment for TSS and oil
- As part of a treatment train
- As retrofits at sites with limited land areas, such as residential lots, commercial areas, parking lots, and open space areas.
- With appropriate pretreatment for oil and silt control to prevent clogging. Appropriate pretreatment devices are described in V-9 Pretreatment BMPs.

V-5.2 Infiltration BMP Design Steps

Designers should follow the steps below if an infiltration BMP is proposed for the project site.

1. Select A Location for the Infiltration BMP

Base the location on the ability to convey flow to the location and the expected soil conditions of the location. Conduct a preliminary surface and sub-surface characterization study (V-5.5 Site Characterization Criteria for Infiltration). Do a preliminary check of Site Suitability Criteria (V-5.6 Site Suitability Criteria (SSC)) to initially estimate feasibility of locating an infiltration BMP on the site.

2. Estimate the Volume of Stormwater Runoff, Vdesign

Estimate the volume of stormwater runoff by using an approved continuous runoff model. The runoff file developed for the project site serves as input to the infiltration BMP.

For infiltration BMPs sized simply to meet Runoff Treatment requirements, the BMP must successfully infiltrate 91% of the influent runoff file. The remaining 9% of the influent file can bypass the infiltration BMP. Note that infiltration BMPs used to provide Runoff Treatment must either have a treatment layer as part of the BMP (such as BMP T7.30: Bioretention), or the native soils must meet the criteria for Runoff Treatment per V-5.6 Site Suitability Criteria (SSC).

For infiltration BMPs sized to meet the LID Performance Standard and/or the Flow Control Performance Standard, the BMP must infiltrate either all of the influent file, or a sufficient amount of the influent file such that any overflow/bypass meets the standard.

3. Develop Trial Infiltration BMP Geometry

To develop the trial BMP geometry, assume a design infiltration rate based on previously available data, or a default design infiltration rate of 0.3 inches/hour. Use this trial BMP geometry to help locate the BMP and for planning purposes in developing the geotechnical subsurface investigation plan.

4. Complete a More Detailed Site Characterization Study and Consider the Site Suitability Criteria

Information gathered during initial geotechnical and surface investigations is necessary to know whether infiltration is feasible. The geotechnical investigation evaluates the suitability of the site for infiltration, establishes the infiltration rate for design, and evaluates slope stability, foundation capacity, and other geotechnical design information needed to design and assess constructability of the BMP.

See V-5.5 Site Characterization Criteria for Infiltration and V-5.6 Site Suitability Criteria (SSC) for details.

5. Determine the Design Infiltration Rate

Refer to V-5.4 Determining the Design Infiltration Rate of the Native Soils.

6. Size the Infiltration BMP

The maximum ponded water depth should be between 2 and 6 feet with at least one foot of freeboard.

If sizing an infiltration BMP as a Runoff Treatment BMP, use the output files from an approved continuous runoff model to document:

1. That the BMP can infiltrate 91 percent of the influent runoff file; and
2. That the Water Quality Design Volume (as described in III-2.6 Sizing Your Runoff Treatment BMPs) can infiltrate through the infiltration BMP surface within 48 hours. This can be calculated by multiplying a horizontal projection of the infiltration BMP mid-depth dimensions by the estimated long-term infiltration rate; and multiplying the result by 48 hours.

If sizing an infiltration BMP to meet the LID Performance Standard or the Flow Control Performance Standard, use the output files of an approved continuous runoff model to document that the total of any bypass and overflow meets the applicable performance standard.

7. Ground Water Mounding Analysis

On projects where an infiltration BMP has a contributing drainage area exceeding 1 acre and has less than fifteen feet depth to seasonal high ground water (as measured from the elevation at which infiltration into the native soil begins) or other low permeability stratum, determine the final design infiltration rate using an analytical ground water model to investigate the effects of the local hydrologic conditions on BMP performance.

These larger projects can use the design infiltration rate determined in V-5.4 Determining the Design Infiltration Rate of the Native Soils as input into an approved continuous runoff model to do an initial sizing of the infiltration BMP. Then complete the ground water modeling (mounding analysis) of the proposed infiltration BMP. Use MODRET or an equivalent model unless the local government approves an alternative analytic technique.

Export the full output hydrograph of the developed condition and use it as input to MODRET. Note that an iterative process may be required beginning with an estimated design rate, sizing of the BMP using the continuous runoff model, then ground water model testing.

8. Construct the Infiltration BMP & Conduct Performance Testing

Test and monitor the constructed BMP to demonstrate that the BMP performs as designed. Use the same test method for saturated hydraulic conductivity as used in the planning stages so that results are comparable. Perform the testing after stabilizing the construction site.

Submit the results and comparisons to the pre-project measured (initial) and design infiltration rates to the local stormwater authority that approved the project design. If the post project measured rates are lower than the design saturated hydraulic conductivity, the applicant shall implement measures to improve infiltration capability within the footprint of the constructed BMP and re-test.

If less intensive measures prove unsuccessful, replacement of the top foot of soil – or more if visual observation indicates deeper fouling of the bed with fine sediment – with a soil meeting the design needs (i.e., Runoff Treatment, Flow Control, or both) shall be provided. Longer-term monitoring of drawdown times and periodic testing of the BMP should provide an indication of when the BMP needs maintenance to restore infiltration rates.

V-5.3 General Design Criteria for Infiltration BMPs

This section provides design, construction and maintenance criteria that apply to all types of infiltration BMPs. The designer should refer to this section, as well as the design criteria provided for the individual BMP when designing the infiltration BMP.

Sizing Infiltration BMPs

The size of the infiltration BMP can be determined by routing the influent runoff file generated by the continuous runoff model through it.

To prevent the onset of anaerobic conditions, an infiltration BMP designed for Runoff Treatment purposes (either by a layer within the infiltration BMP, as in BMP T7.30: Bioretention, or by treatment through native soils that meet the criteria for Runoff Treatment per V-5.6 Site Suitability Criteria (SSC)) must be designed to drain the Water Quality Design Volume within 48 hours (see explanation under SSC-4 Soil Infiltration Rate/Drawdown Time).

In general, an infiltration BMP would have 2 discharge modes. The primary mode of discharge from an infiltration BMP is infiltration into the ground. However, when the infiltration capacity of the BMP is reached, additional runoff to the BMP will cause the BMP to overflow. Overflows from an infiltration BMP must comply with the performance standard they are designed to meet - typically either the LID Performance Standard within I-3.4.5 MR5: On-Site Stormwater Management and/or the Flow Control Performance Standard within I-3.4.7 MR7: Flow Control. Infiltration BMPs used for Runoff Treatment must not overflow more than 9% of the influent runoff file.

In order to determine compliance with the LID Performance Standard and/or the Flow Control Performance Standard , use an approved continuous runoff model (see III-2.2 Continuous Simulation Models). When using the continuous runoff model for simulating flow through an infiltrating BMP, represent the BMP by using the appropriate element within the software (pond, trench, permeable pavement, or bioretention), and entering the pre-determined infiltration rates. Below are the procedures for sizing an infiltration BMP to:

A. Completely infiltrate 100% of the runoff;

B. Treat 91% of runoff to meet the Runoff Treatment requirements, and

C. Partially infiltrate runoff to meet the LID Performance Standard and/or the Flow Control Performance Standard.

(A) Sizing an Infiltration BMP To Infiltrate 100% of the Runoff

1. Input dimensions of your infiltration BMP,
2. Input the infiltration rate and safety (rate reduction) factor.
    - When the native soil infiltration rate was calculated using the Simplified Approach (as described in V-5.4 Determining the Design Infiltration Rate of the Native Soils), you may enter the measured (initial) saturated hydraulic conductivity (K_{sat}) as the infiltration rate and the Total Correction Factor as the safety factor; OR,

      Enter the estimated final design infiltration rate after application of the Total Correction Factor, and a safety factor of 1.
    - When the native soil infiltration rate was calculated using the Detailed Approach (as described in V-5.4 Determining the Design Infiltration Rate of the Native Soils), you should enter your preliminary design infiltration rate calculated in step 3. Then enter the aspect ratio for the pond, as calculated in step 4, as the safety factor in the model input.
3. Input a riser height and diameter (any flow through the riser indicates that you have less than 100% infiltration and must increase your infiltration BMP dimensions).
4. Run the model for only the Developed Mitigated Scenario (if that is where you put the infiltration BMP).
5. After running the model, go back to the infiltration BMP element and look at the Percentage Infiltrated (this is at the bottom right if using WWHM). If less than 100% is infiltrated, increase the BMP dimension until you get 100% infiltrated.

(B) Sizing an Infiltration BMP to Infiltrate 91% of the Runoff (The Water Quality Design Volume)

The procedure is the same as above, except that your target is 91%.

Infiltration BMPs for Runoff Treatment can be located upstream or downstream of detention, and can be off-line or on-line.

Refer to III-2.6 Sizing Your Runoff Treatment BMPs for more information about the flows that must be treated for on-line and off-line Runoff Treatment BMPs. For infiltration BMPs serving as Runoff Treatment BMPs, the designer must use continuous runoff modeling software to show that all of the applicable flow is treated by passing through the infiltration BMP.

(C) Sizing an Infiltration BMP to Meet LID and/or Flow Control Performance Standards

This design will allow something less than 100% infiltration as long as any overflows will meet the applicable performance standard. Use a discharge structure with orifices and risers similar to a detention BMP, and include infiltration occurring from the infiltration BMP.

Treatment Prior to Infiltration BMPs

Pretreatment Prior to Infiltration BMPs

A pretreatment BMP to remove a portion of the influent suspended solids should precede all infiltration BMPs. This is to reduce potential plugging of the soils and prolong the life of the infiltration BMP. Use either a basic treatment BMP, as described in III-1.2 Choosing Your Runoff Treatment BMPs, or a pretreatment BMP as described in V-9 Pretreatment BMPs. The lower the influent suspended solids loading to the infiltration BMP, the longer the infiltration BMP can infiltrate the desired amount of water, and the longer interval between maintenance activity.

In BMPs such as BMP T7.20: Infiltration Trenches where a reduction in infiltration capability can have significant maintenance or replacement costs, selection of a reliable pretreatment or basic treatment BMP prior to the infiltration BMP with high solids removal capability is preferred. For infiltration BMPs that allow easier access for maintenance and less costly maintenance activity (e.g., BMP T7.10: Infiltration Basins with gentle side slopes), there is a trade-off between using a pretreatment or basic treatment BMP with a higher solids removal capability and a device with a lower capability. Generally, basic treatment BMPs are more capable at solids removal than pretreatment BMPs. Though basic treatment BMPs may be higher in initial cost and space demands, the infiltration BMP should have lower maintenance costs.

Runoff Treatment Prior to Infiltration BMPs

In an effort to protect ground water, projects must apply the appropriate level of Runoff Treatment whenever infiltration is proposed. The appropriate level of Runoff Treatment varies by land use and project type, and is determined by one of the following methods:

- If the project is required to meet I-3.4.6 MR6: Runoff Treatment, use the guidance in III-1.2 Choosing Your Runoff Treatment BMPs to determine the appropriate level of Runoff Treatment prior to infiltration.
- If the project is installing a UIC well as defined in I-2.14 Underground Injection Control (UIC) Program, use the guidance in I-4 UIC Program to determine the appropriate level of Runoff Treatment prior to infiltration.
- If the conditions below the infiltration BMP meet the criteria for Runoff Treatment per V-5.6 Site Suitability Criteria (SSC), this will satisfy the Runoff Treatment requirements for both I-3.4.6 MR6: Runoff Treatment and I-4 UIC Program.
- If the project is proposing infiltration, but is not required to meet I-3.4.6 MR6: Runoff Treatment or follow the guidance in I-4 UIC Program, the designer has the following options to determine the appropriate level of Runoff Treatment:

- Follow the guidance in III-1.2 Choosing Your Runoff Treatment BMPs
- Follow the guidance in I-4 UIC Program
- Provide another protective measure consistent with all applicable regulations. See I-2 Relationship of This Manual to Permits, Requirements, and Programs for some of the regulations and standards that may apply to the project.

- Infiltration or dispersion BMPs that are only used to meet The List Approach in I-3.4.5 MR5: On-Site Stormwater Management do not require additional Runoff Treatment prior to infiltration.

Additional Design Criteria

- The slope of the base of the infiltration BMP should be < 3 percent.
- Construct a nonerodible 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 proving Runoff Treatment, side-wall seepage is not a concern if seepage occurs through the same stratum as the bottom of the BMP. However, for 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 at least 18 inches of treatment soil to prevent seepage of untreated flows through the side walls.

Construction Criteria

- Conduct initial excavation for the infiltration BMP to within 1-foot of the final elevation of the BMP floor. Excavate to final grade only after all disturbed areas in the upgradient project drainage area have been permanently stabilized. The final phase of excavation should remove all accumulation of silt in the infiltration BMP before putting it in service. After construction completion, prevent sediment from entering the infiltration BMP by first conveying the runoff water through an appropriate pretreatment BMP.
- Generally, do not use infiltration BMPs as temporary sediment traps during construction. If an infiltration BMP will be used as a sediment trap, do not excavated to final grade until after stabilizing the upgradient drainage area. Remove any accumulation of silt in the BMP prior to putting it in service.
- Traffic Control – Relatively light-tracked equipment is recommended for this operation to avoid compaction of the infiltration BMP floor. Consider the use of draglines and trackhoes for constructing infiltration BMPs. Flag or mark the infiltration area to keep heavy equipment away.

Maintenance Criteria

Make provisions for regular and perpetual maintenance of the infiltration BMP, including replacement and/or reconstruction of any media relied upon for Runoff Treatment purposes.

An Operation and Maintenance Plan, approved by the local jurisdiction, should ensure maintaining the desired infiltration rate.

Include adequate access for operation and maintenance in the design of infiltration BMPs.

Conduct removal of accumulated debris/sediment in the infiltration BMP every 6 months or as needed to prevent clogging. Indications that the BMP is not infiltrating adequately include:

- Overflows occur more frequently than planned. For example, off-line infiltration BMPs should not have any overflows. Infiltration BMPs designed to completely infiltrate all flows should not overflow.
- The Water Quality Design Volume does not infiltrate within 48 hours.
- Water remains in the BMP for greater than 24 hours after the end of most moderate rainfall events.

For more detailed information on maintenance, see Appendix V-A: BMP Maintenance Tables.

Verification of Performance

During the first 1-2 years of operation, verification testing is strongly recommended, along with a maintenance program that results in achieving expected performance levels. Operating and maintaining ground water monitoring wells is also strongly encouraged.

V-5.4 Determining the Design Infiltration Rate of the Native Soils

A crucial element to infiltration BMP design is the long term (design) infiltration rate of the native soils. In order to determine the design infiltration rate, the designer must first determine the measured (initial) saturated hydraulic conductivity (K_{sat}) of the native soils. Detailed below are three methods for determining initial K_{sat}. Ecology then offers a simplified approach and a detailed approach to use the initial K_{sat} to determine the design infiltration rate of the native soils. The design infiltration rate is used to size the infiltration BMP, including verifying compliance with the maximum drawdown time of 48 hours.

Determining the Measured (Initial) K_{sat}

Initial K_{sat} rates can be determined using in-situ field measurements (PIT test options detailed below), or, if the site has soils unconsolidated by glacial advance, by a correlation to grain size distribution from soil samples (soil grain size analysis option detailed below). The latter method uses the ASTM soil size distribution test procedure (ASTM D422), which considers the full range of soil particle sizes, to develop soil size distribution curves.

K_{sat} Determination Option 1: Large Scale Pilot Infiltration Test (PIT)

The large scale Pilot Infiltration Test (PIT) is a large-scale in-situ infiltration measurement, and is the preferred method for estimating the initial K_{sat} of the soil profile beneath the proposed infiltration BMP. 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.

Infiltration Test

- Testing should occur between December 1 and April 1.
- The horizontal and vertical locations of the PIT shall be surveyed by a licensed land surveyor and accurately shown on the design drawings.
- Excavate the test pit to the estimated elevation of the proposed infiltration into the native soil. Note that for some proposed BMPs, such as BMP T7.30: Bioretention and BMP T5.15: Permeable Pavements, this will be below the proposed finished grade. If the native soils will have to meet a minimum subgrade compaction requirement (for example, the road subgrade if using BMP T5.15: Permeable Pavements), compact the native soil to that requirement 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.
- The horizontal surface area of the bottom of the test pit should be approximately 100 square feet. Document the size and geometry of the test pit.
- Install a vertical measuring rod (long enough to measure the ponded water depth, minimum 5-ft. long) marked in half-inch increments in the center of the pit bottom.
- Use a rigid 6-inch diameter pipe with a splash plate on the bottom to convey water to the test pit and reduce side-wall erosion or excessive disturbance of the test pit bottom. Excessive erosion and bottom disturbance will result in clogging of the infiltration receptor and yield lower than actual infiltration rates.
- 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 flow rate into the pit.

  Note: The depth should not exceed the proposed maximum depth of water expected in the completed BMP. For infiltration BMPs serving large drainage areas, designs with multiple feet of standing water can have infiltration tests with greater than 1 foot of standing water.
- Every 15-30 min, record the cumulative volume and instantaneous flow rate in gallons per minute necessary to maintain the water level at the same point on the measuring rod.
- Keep adding water to the pit until one hour after the flow rate into the pit has stabilized (constant flow rate; a goal of 5% 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 flow rate has stabilized should be no less than 6 hours.
- After the flow rate 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 the infiltration rate with head.
- 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 the hydraulic restricting layer, and is determined by the engineer or certified soils professional. Mounding is an indication that a mounding analysis is necessary.

Data Analysis

Calculate and record the initial K_{sat} rate in inches per hour in 30 minutes or one-hour increments until one hour after the flow has stabilized.

Use statistical/trend analysis to obtain the hourly flow rate when the flow stabilizes. This would be the lowest hourly flow rate.

Example

The area of the bottom of the test pit is 8.5-ft. by 11.5-ft. (97.75 sq. ft.).

Water flow rate was measured and recorded at intervals ranging from 15 to 30 minutes throughout the test. Between 400 minutes and 1,000 minutes the flow rate stabilized between 10 and 12.5 gallons per minute or 600 to 750 gallons per hour, or 80.2 to 100 ft^3 per hour. Dividing this rate by the surface area gives an initial K_{sat} of 9.8 to 12.3 inches per hour.

K_{sat} Determination Option 2: Small Scale Pilot Infiltration Test (PIT)

A small-scale PIT can be substituted for Ksat Determination Option 1: Large Scale Pilot Infiltration Test (PIT) in any of the following instances:

- The drainage area to the infiltration BMP is less than 1 acre.
- The testing is for BMP T7.30: Bioretention or BMP T5.15: Permeable Pavements that either serve small drainage areas and/or are widely dispersed throughout a project site.
- The site has a high infiltration rate (>4 in/hr), making a large scale PIT difficult, and the site geotechnical investigation suggests uniform subsurface characteristics.

Infiltration Test

Use the same procedures described above in Ksat Determination Option 1: Large Scale Pilot Infiltration Test (PIT), with the following changes:

- The horizontal surface area of the bottom of the test pit should be 12 to 32 square feet. It may be circular or rectangular. Document the size and geometry of the test pit.
- The rigid pipe with a splash plate used to convey water to the pit may be a 3-inch diameter pipe for pits on the smaller end of the recommended surface area, or 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.
- 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 flow rate 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 the hydraulic restricting layer, and is determined by the engineer or certified soils professional. The soils professional should judge whether a mounding analysis is necessary.

Data Analysis

See the explanation under the guidance for Ksat Determination Option 1: Large Scale Pilot Infiltration Test (PIT).

K_{sat} Determination Option 3: Soil Grain Size Analysis

The following grain size analysis may be used to determine initial K_{sat} if the site has soils unconsolidated by glacial advance. This method uses the ASTM soil size distribution test procedure (ASTM D422), which considers the full range of soil particle sizes, to develop soil size distribution curves.

For each defined layer below an infiltration pond to a depth below the pond bottom of 2.5 times the maximum depth of water in the pond, but not less than 10 feet, estimate the initial K_{sat} in cm/sec using the following relationship (see (Massman, 2003) and Massmann et al., 2003). For large infiltration BMPs serving drainage areas of 10 acres or more, soil grain size analyses should be performed on layers up to 50 feet deep (or no more than 10 feet below the water table).

$$\log_{10}(K_{sat}) = -1.57 + 1.90D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08f_{fines}$$

Where, D_{10}, D_{60} and D_{90} are the grain sizes in mm for which 10 percent, 60 percent and 90 percent of the sample is more fine and f_{fines} is the fraction of the soil (by weight) that passes the number-200 sieve (K_{sat} is in cm/s). (1 cm/sec = 1417 in/hr)

For BMP T7.30: Bioretention, analyze each defined layer below the top of the final bioretention area subgrade to a depth of at least 3 times the maximum ponding depth, but not less than 3 feet (1 meter).

For BMP T5.15: Permeable Pavements, analyze for each defined layer below the top of the final subgrade to a depth of at least 3 times the maximum ponding depth within the base course, but not less than 3 feet (1 meter).

If the licensed professional conducting the investigation determines that deeper layers will influence the rate of infiltration for the facility, soil layers at greater depths must be considered when assessing the site's initial K_{sat}. (Massman, 2003) indicates that where the water table is deep, soil or rock strata up to 100 feet below an infiltration BMP can influence the rate of infiltration. Note that only the layers near and above the water table or low permeability zone (e.g., a clay, dense glacial till, or rock layer) need to be considered, as the layers below the ground water table or low permeability zone do not significantly influence the rate of infiltration. Also note that this equation for estimating K_{sat} assumes minimal compaction consistent with the use of tracked (i.e., low to moderate ground pressure) excavation equipment.

If the soil layer being characterized has been exposed to heavy compaction (e.g., due to heavy equipment with narrow tracks, narrow tires, or large lugged, high pressure tires) the K_{sat} for the layer could be approximately an order of magnitude less than what would be estimated based on grain size characteristics alone (Pitt, 2003). In such cases, compaction effects must be taken into account when estimating K_{sat}.

For clean, uniformly graded sands and gravels, the reduction in K_{sat} due to compaction will be much less than an order of magnitude. For well graded sands and gravels with moderate to high silt content, the reduction in K_{sat} will be close to an order of magnitude. For soils that contain clay, the reduction in K_{sat} could be greater than an order of magnitude.

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.

Once the K_{sat} for each layer has been identified, determine the effective average K_{sat} of the native soils. K_{sat} estimates from different layers can be combined using the harmonic mean:

(equation 2):

$$K_{equiv} = \frac{d}{\Sigma \frac{d_i}{K_i}}$$

Where:

d is the total depth of the soil column,

d_i is the thickness of layer “i” in the soil column, and

K_i is the saturated hydraulic conductivity of layer “i” in the soil column.

The depth of the soil column, d, typically would include all layers between the infiltration pond bottom and the water table. However, for sites with very deep water tables (>100 feet) where ground water mounding to the base of the infiltration pond is not likely to occur, it is recommended that the total depth of the soil column in Equation 2 be limited to approximately 20 times the depth of infiltration pond, but not more than 50 feet. This is to ensure that the most important and relevant layers are included in the hydraulic conductivity calculations. Deep layers that are not likely to affect the infiltration rate near the infiltration pond bottom should not be included in Equation 2.

Equation 2 may over-estimate the effective K_{sat} value at sites with low conductivity layers immediately beneath the infiltration BMP. For sites where the lowest conductivity layer is within five feet of the base of the BMP, it is suggested that this lowest K_{sat} value be used as the equivalent hydraulic conductivity rather than the value from Equation 2. Using the layer with the lowest K_{sat} is advised for designing BMP T7.30: Bioretention and BMP T5.15: Permeable Pavements. The harmonic mean given by Equation 2 is the appropriate effective hydraulic conductivity for flow that is perpendicular to stratigraphic layers, and will produce conservative results when flow has a significant horizontal component such as could occur due to ground water mounding.

How to Calculate the Design Infiltration Rate of the Native Soils

Once the initial K_{sat} for a site has been determined using one of the methods above, use one of the methods below to determine the design infiltration rate.

The Simplified Approach to Calculating the Design Infiltration Rate of the Native Soils

The simplified approach was derived from high ground water and shallow pond sites in western Washington, and in general will produce conservative designs. This approach can be used when determining the trial geometry of the infiltration BMP and for small BMPs serving short plats or commercial developments less than 1 acre of contributing area. Designs of infiltration BMPs for larger projects should use the detailed approach (as described below) and may have to incorporate the results of a ground water mounding analysis as described in V-5.2 Infiltration BMP Design Steps. Note: A ground water mounding analysis is advisable for BMPs with drainage areas smaller than 1 acre if the depth to a low permeability layer (e.g., less than 0.1 inches per hour) is less than 10 feet.

Using the simplified approach, estimate the design (long-term) infiltration rate as follows:

- 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}.
- Assume that the K_{sat} is the measured (initial) infiltration rate for the native soils.
- Determine the design infiltration rate by adjusting the initial infiltration rate using the appropriate correction factors, as detailed below.

  Correction factors account for site variability, number of tests conducted, uncertainty of the test method, and the potential for long-term clogging due to siltation and bio-buildup. Table V-5.1: Correction Factors to be Used With In-Situ Saturated Hydraulic Conductivity Measurements to Estimate Design Rates summarizes the typical range of correction factors to account for these issues. The specific correction factors used shall be determined based on the professional judgment of the licensed engineer in the state of Washington or other site professional, considering all issues that may affect the infiltration rate over the long term, subject to the approval of the local jurisdictional authority.

  - **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 proposed location of the infiltration BMP. 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.

- **Uncertainty of test method (CF_t)** accounts for uncertainties in the testing methods. For the full scale PIT method, CF_t = 0.75; for the small-scale PIT method, CF_t = 0.50; for smaller-scale infiltration tests such as the double-ring infiltrometer test, CF_t = 0.40; for grain size analysis, CF_t = 0.40. 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.
- **Degree of influent control to prevent siltation and bio-buildup (CF_m)** Even with a pre-settling basin or a basic treatment BMP for pre-treatment, 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 BMP is infiltrating at only 90% of its design capacity. Therefore, a correction factor, CF_m, of 0.9 is called for.

Table V-5.1: Correction Factors to be Used With In-Situ Saturated Hydraulic Conductivity Measurements to Estimate Design Rates

Issue	Partial Correction Factor
Site variability and number of locations tested	CF_v = 0.33 to 1.0
Test Method	
• Large-scale PIT • Small-scale PIT • Other small-scale (e.g. Double ring, falling head) • Grain Size Method	• CF_t = 0.75 • = 0.50 • = 0.40 • = 0.40
Degree of influent control to prevent siltation and bio-buildup	CF_m = 0.9

Total Correction Factor, $CF_T = CF_v \times CF_t \times CF_m$

- The design infiltration rate (K_{sat}design) is calculated by multiplying the initial K_{sat} by the total correction factor:

$$K_{sat}\text{ design} = K_{sat}\text{ initial X } CF_T$$

The Detailed Approach to Calculating the Design Infiltration Rate of the Native Soils

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 as follows:

$$gradient = i \approx \frac{D_{wt}+D_{pond}}{138.62(K^{0.1})} CF_{size}$$

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 the development of this equation), and

CF_{size}, is the correction for 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 ground water depths (or to a low permeability layer) below the BMP, and conservatively accounts for the development of a ground water mound. A more detailed ground water mounding analysis using a program such as 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 gradient 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 ground water 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. Calculate the preliminary design infiltration rate using Darcy's law as follows:

$$f = K\left(\frac{dh}{dz}\right) = Ki$$

Where:

f is the preliminary design infiltration rate of water through a unit cross-section of the infiltration BMP (L/t),

K is the initial saturated hydraulic conductivity (L/t),

dh/dz is the hydraulic gradient (L/L), and

“i” is the gradient (as calcualted in Step 2 above).

4. Adjust the preliminary design infiltration rate to determine the design (long term) infiltration rate:

   This step adjusts the preliminary design infiltration rate (as determined in Step 3 above) for the effect of pond aspect ratio by multiplying the preliminary design infiltration rate by the aspect ratio correction factor F_{aspect} as shown in the following equation:

$$CF_{aspect} = 0.02A_r + 0.98$$

   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.

   The final design (long-term) infiltration rate will therefore be as follows:

$$\text{final design (long-term) infiltration rate} = K_{sat} \times i \times CF_{aspect}$$

V-5.5 Site Characterization Criteria for Infiltration

One of the first steps in siting and designing infiltration BMPs is to conduct a characterization study that includes surface and subsurface features characterization, as described below.

Information gathered during initial geotechnical investigations can be used for the site characterization.

Surface Features Characterization

The characterization study should document the following surface features:

1. Topography within 500 feet of the proposed infiltration BMP.
2. Anticipated site use (street/highway, residential, commercial, high-use site).
3. Location of water supply wells within 500 feet of the proposed infiltration BMP.
4. Location of ground water protection areas and/or 1, 5 and 10 year time of travel zones for municipal well protection areas (if available).
5. Location of areas known to have contaminated soils.

6. A description of local site geology, including soil or rock units likely to be encountered, the ground water regime, and geologic history of the site.

Subsurface Characterization

The characterization study should document the following subsurface data:

1. Subsurface explorations (test holes or test pits) to a depth below the base of the infiltration BMP of at least 5 times the maximum design depth of ponded water proposed for the infiltration BMP, but not less than 10 feet below the base of the BMP. However, at sites with shallow ground water (less than 15 feet from the estimated base of the infiltration BMP), if a ground water mounding analysis is necessary, determine the thickness of the saturated zone.

   Continuous sampling (representative samples from each soil type and/or unit within the infiltration receptor) to a depth below the base of the infiltration BMP of 2.5 times the maximum design ponded water depth, but not less than 10 feet. For large infiltration BMPs serving drainage areas of 10 acres or more, perform soil grain size analyses on layers up to 50 feet deep (or no more than 10 feet below the water table). These samples provide information on the treatment capabilities of the soils.

   The depth and number of test holes or test pits, and samples should be increased, if in the judgment of a licensed engineer in the state of Washington with geotechnical expertise (P.E.), a licensed geologist, engineering geologist, hydrogeologist, or other licensed professional acceptable to the local jurisdiction, the conditions are highly variable and such increases are necessary to accurately estimate the performance of the infiltration BMP.

2. If proposing to estimate the infiltration rate using the soil grain size analysis method (see V-5.4 Determining the Design Infiltration Rate of the Native Soils), obtain samples adequate for the purposes of that gradation/classification testing.

   - For BMP T7.10: Infiltration Basins, at least one test pit or test hole per 5,000 ft^2 of BMP infiltrating surface (in no case less than two per BMP).
   - For BMP T7.20: Infiltration Trenches, at least one test pit or test hole per 200 feet of trench length (in no case less than two per trench).

   The depth and number of test holes or test pits, and samples should be increased, if in the judgment of a licensed engineer in the state of Washington with geotechnical expertise (P.E.), a licensed geologist, engineering geologist, hydrogeologist, or other licensed professional acceptable to the local jurisdiction, the conditions are highly variable and such increases are necessary to accurately estimate the performance of the infiltration BMP.

   The exploration program may be decreased if, in the opinion of the licensed engineer in the state of Washington or other professional, the conditions are relatively uniform and the borings/test pits omitted will not influence the design or successful operation of the BMP.

   In high water table sites, the subsurface exploration sampling need not be conducted lower than two (2) feet below the ground water table.

3. Prepare detailed logs for each test pit or test hole and a map showing the location of the test pits or test holes. Logs must include at a minimum, depth of pit or hole, soil descriptions, depth

to water, presence of stratification.

Logs must substantiate whether stratification does or does not exist. The licensed professional may consider additional methods of analysis to substantiate the presence of stratification that will significantly impact the design of the infiltration BMP.

4. Provide ground water monitoring wells (or driven well points if there is shallow depth to ground water) to locate the ground water table and establish its gradient, direction of flow, and seasonal variations, considering both confined and unconfined aquifers. For infiltration BMPs with a contributing basin that is less than an acre, establish that the depth to ground water or other hydraulic restriction layer will be at least 10 feet below the base of the BMP. Use subsurface explorations or information from nearby wells.

   In general, a minimum of three wells per infiltration BMP, or three hydraulically connected surface or ground water 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 ground water levels may also be considered. If the ground water in the area is known to be greater than 50 feet below the proposed infiltration BMP, detailed investigation of the ground water regime is not necessary.

   Monitoring through at least one wet season is required, unless substantially equivalent site historical data regarding ground water levels is available.

5. If using the soil Grain Size Analysis Method for estimating infiltration rates: Complete laboratory testing as necessary to establish the soil gradation characteristics and other properties, to complete the infiltration facility design. At a minimum, conduct one-grain size analysis per soil stratum in each test hole within 2.5 times the maximum design water depth, but not less than 10 feet. When assessing the hydraulic conductivity characteristics of the site, soil layers at greater depths must be considered if the licensed professional conducting the investigation determines that deeper layers will influence the rate of infiltration for the BMP, requiring soil gradation/classification testing for layers deeper than indicated above.

Soil Testing Data

Soil characterization for each soil unit (soils of the same texture, color, density, compaction, consolidation and permeability) encountered should include:

- Grain-size distribution (ASTM D422 or equivalent AASHTO specification), if using the grain size analysis method to estimate infiltration rates
- Visual grain size classification
- Percent clay content (include type of clay, if known)
- Color/mottling
- Variations and nature of stratification

If the infiltration BMP will provide Runoff Treatment as well as Flow Control, the soil characterization should also include:

- Cation exchange capacity (CEC) and organic matter content for each soil type and strata where distinct changes in soil properties occur, to a depth below the base of the BMP of at least 2.5 times the maximum design water depth, but not less than 6 feet.
- For soils with low CEC and organic content, deeper characterization of soils may be warranted (refer to V-5.6 Site Suitability Criteria (SSC)).

Infiltration Receptor Data

Infiltration receptor (unsaturated and saturated soil receiving the stormwater) characterization should include:

1. The information obtained from ground water monitoring in #4 of the Subsurface Characterization above.
2. An assessment of the ambient ground water quality, if that is a concern.
3. An estimate of the volumetric water holding capacity of the infiltration receptor soil. This is the soil layer below the infiltration BMP and above the seasonal high-water mark, bedrock, hardpan, or other low permeability layer. Conduct this analysis at a conservatively high infiltration rate based on vadose zone porosity, and the Water Quality Design Volume to be infiltrated. This, along with an analysis of ground water movement, will be useful in determining if there are volumetric limitations that would adversely affect drawdown, and if a ground water mounding analysis should be conducted.
4. Determination of:
    - Depth to ground water table and to bedrock/impermeable layers.
    - Seasonal variation of ground water table based on well water levels and observed mottling.
    - Existing ground water 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 ground water mounding, flow direction, and water table; and the discharge point or area of the infiltrating water. Conduct a ground water mounding analysis at all sites where the depth to seasonal ground water 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.

V-5.6 Site Suitability Criteria (SSC)

This section provides criteria that must be considered for siting infiltration BMPs. When a site investigation reveals that any of the applicable site suitability criteria cannot be met, appropriate mitigation measures must be implemented so that the infiltration BMP will not pose a threat to safety, health, and the environment.

For site selection and design decisions, a geotechnical and hydrogeologic report should be prepared by a licensed engineer in the state of Washington with geotechnical and hydrogeologic experience, or a licensed geologist, hydrogeologist, or engineering geologist. The designer may utilize a team of certified or registered professionals in soil science, hydrogeology, geology, and other related fields.

SSC-1 Setback Criteria

Setback requirements are generally required by local regulations, uniform building code requirements, or other state regulations.

These setback criteria are provided as guidance.

- Stormwater infiltration BMPs should be set back at least 100 feet from drinking water wells, septic tanks or drainfields, and springs used for public drinking water supplies. Infiltration BMPs upgradient of drinking water supplies and within 1, 5, and 10-year time of travel zones must comply with Health Department requirements (WSDOH, 2010). Infiltration BMPs that qualify as Underground Injection Control Wells must comply with Chapter 173-218 WAC and the guidance in I-4 UIC Program.
- Additional setbacks must be considered if roadway deicers or herbicides are likely to be present in the influent to the infiltration BMP.
- From building foundations: ≥ 20 feet downslope and ≥ 100 feet upslope
- From a Native Growth Protection Easement (NGPE): ≥ 20 feet
- From the top of slopes >15%: ≥ 50 feet.
- Evaluate 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.

SSC-2 Ground Water Protection Areas

A site is not suitable for an infiltration BMP if the infiltration BMP will cause a violation of Ecology's Ground Water Quality Standards (Chapter 173-200 WAC). See SSC-3 High Vehicle Traffic Areas through SSC-6 Soil Physical and Chemical Suitability for Treatment, and SSC-8 Cold Climate and Impact of Roadway Deicers for measures to protect ground water quality. Local jurisdiction staff and local ordinances should be consulted for applicable pretreatment requirements if the project site is located in an aquifer sensitive area, sole source aquifer, wellhead protection area, or critical aquifer recharge area.

SSC-3 High Vehicle Traffic Areas

An infiltration BMP may be considered for runoff from areas that require an oil control BMP per III-1.2 Choosing Your Runoff Treatment BMPs. For such applications, provide the oil control BMP upstream of the infiltration BMP to ensure that ground water quality standards will not be violated and that the infiltration BMP is not adversely affected.

SSC-4 Soil Infiltration Rate/Drawdown Time

Infiltration Rates: measured (initial) and design (long-term)

For infiltration BMPs used for Runoff Treatment purposes, the measured (initial) soil infiltration rate should be 9 in/hr or less (For BMP T5.15: Permeable Pavements, this rate can be 12 in/hr or less). Design (long-term) infiltration rates up to 3.0 inches/hour can also be considered, if the infiltration receptor is not a sole-source aquifer, and in the judgment of the site professional, the treatment soil has characteristics comparable to those specified in SSC-6 Soil Physical and Chemical Suitability for Treatment to adequately control the target pollutants. Project sites with infiltration rates lower than those identified in the infeasibility criteria may be used for infiltration of stormwater, if the local jurisdiction approves the design.

The design infiltration rate should also be used for maximum drawdown time and routing calculations.

Drawdown Time

For infiltration BMPs designed strictly for Flow Control purposes, there isn't a maximum drawdown time.

For infiltration BMPs designed to provide Runoff Treatment, , document that the Water Quality Design Volume (as described in III-2.6 Sizing Your Runoff Treatment BMPs) can infiltrate through the infiltration BMP surface within 48 hours. This can be calculated by multiplying the horizontal projection of the infiltration BMP mid-depth dimensions by the estimated design infiltration rate, and multiplying the result by 48 hours.

This drawdown restriction is intended to meet the following objectives:

- Aerate vegetation and soil to keep the vegetation healthy.
- Enhance the biodegradation of pollutants and organics in the soil.

Note: This is a check procedure, not a method for determining infiltration BMP size. If the design fails the check procedure, redesign the infiltration BMP.

SSC-5 Depth to Bedrock, Water Table, or Impermeable Layer

The base of BMP T7.10: Infiltration Basins or BMP T7.20: Infiltration Trenches shall be ≥ 5 feet above the seasonal high-water mark, bedrock (or hardpan) or other low permeability layer. A separation down to 3 feet may be considered if the ground water mounding analysis, volumetric receptor capacity, and the design of the overflow and/or bypass structures are judged by the site professional to be adequate to prevent overtopping and meet the other site suitability criteria specified in this section.

SSC-6 Soil Physical and Chemical Suitability for Treatment

This SSC applies to infiltration BMPs that intend to use the native soil to provide Runoff Treatment. If the native soils do not meet the criteria below, Runoff Treatment must be provided prior to infiltration either by a layer within the infiltration BMP (such as is the case for BMP T7.30: Bioretention), a Runoff Treatment BMP upstream of the infiltration BMP, or by a layer of engineered soil that meets the criteria below. Refer to V-5.3 General Design Criteria for Infiltration BMPs for guidance to determine the appropriate level of Runoff Treatment, based on land use and project type, that is necessary to precede the infiltration BMP.

Consider the soil texture and design infiltration rates along with the physical and chemical characteristics specified below to determine if the 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, 1986). 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 (Buckman and Brady, 1969). Lower CEC content may be considered if it is based on a soil loading capacity determination for the target pollutants that is accepted by the local jurisdiction.
- Depth of soil used for infiltration Runoff Treatment must be a minimum of 18 inches. Depth of soil used for infiltration Runoff Treatment below BMP T5.15: Permeable Pavements that is a pollution-generating hard surface may be reduced to one foot if the permeable pavement does not accept run-on from other surfaces.
- Organic Content of the treatment soil (ASTM D 2974): Organic matter can increase the sorptive capacity of the soil for some pollutants. A minimum of 1.0 percent organic content is necessary.
- Waste fill materials shall not be used as infiltration soil media nor shall such media be placed over uncontrolled or non-engineered fill soils.

Engineered soils may be used to meet these design criteria. Field performance evaluation(s), using protocols cited in this manual, would be needed to determine feasibility and acceptability by the local jurisdiction.

SSC-7 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.

SSC-8 Cold Climate and Impact of Roadway Deicers

Consider the potential impact of roadway deicers on potable water wells in the siting determination. Implement mitigation measures if the infiltration of roadway deicers could cause a violation of ground water quality standards.

BMP T5.15: Permeable Pavements

Purpose and Definition

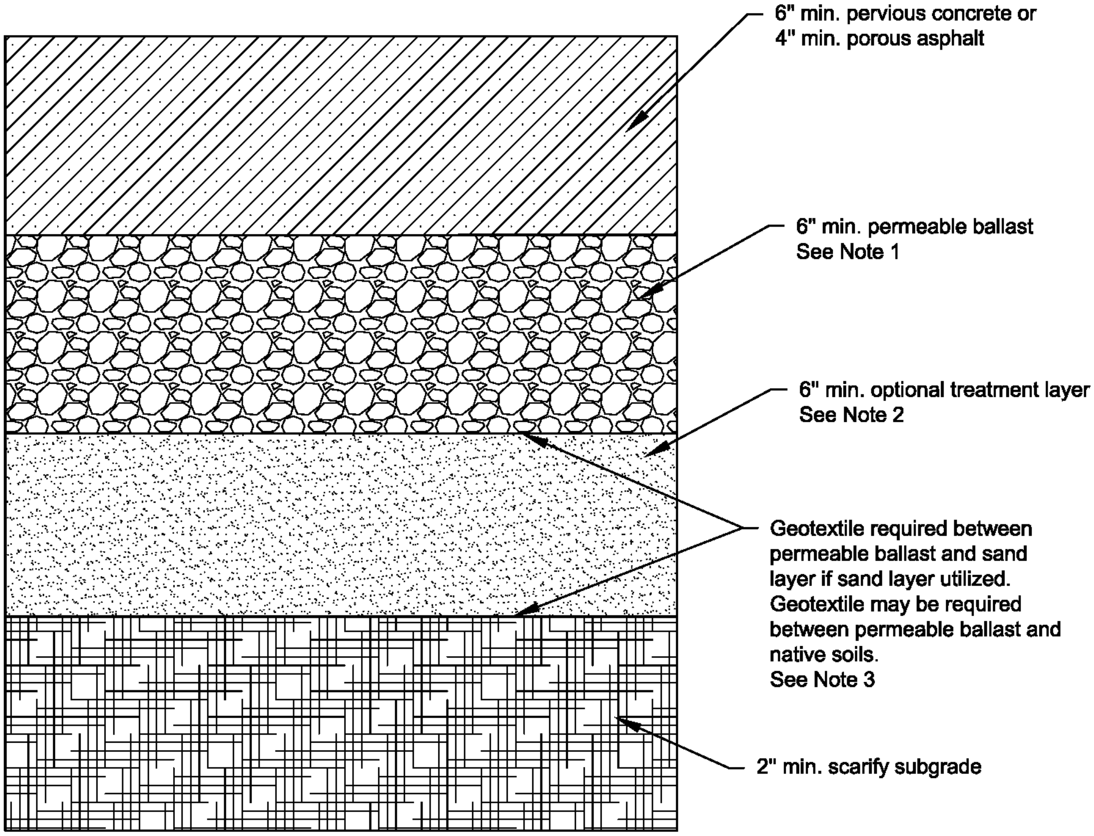
Ecology accepts Permeable Pavement as having the potential to meet I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.6 MR6: Runoff Treatment and I-3.4.7 MR7: Flow Control for the tributary drainage areas depending upon site conditions, configuration, and sizing.

Pavement for vehicular and pedestrian travel occupies roughly twice the space of buildings. Stormwater from vehicular pavement can contain significant levels of solids, heavy metals, and hydrocarbon pollutants. Both pedestrian and vehicular pavements also contribute to increased peak flow durations and associated physical habitat degradation of streams and wetlands. Optimum management of stormwater quality and quantity from paved surfaces is, therefore, critical for improving fresh and marine water conditions in Puget Sound.

The general categories of permeable paving systems include:

- ***Porous hot or warm-mix asphalt pavement*** (see Figure V-5.1: Example of a Permeable Pavement (Concrete or Asphalt) Section) 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*** (see Figure V-5.1: Example of a Permeable Pavement (Concrete or Asphalt) Section) 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.*** (see Figure V-5.2: Example of a Permeable Paver Section) 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.

Figure V-5.1: Example of a Permeable Pavement (Concrete or Asphalt) Section



Notes:

1. Thicker section of ballast may be required to establish sufficient reservoir capacity. Engineer to provide calculations.
2. 6" minimum treatment layer of sand or media if required.
3. Geotextile may be required between native soils and permeable pavement section, per soils professional recommendation. Geotextile will be required between permeable ballast and sand layer. Geotextile shall be geotextile for seperation per WSDOT 9.33.2(1), woven, Table 3, and installed per WSDOT 2-12.3(1).

NOT TO SCALE

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Example of a Permeable Pavement (Concrete or Asphalt) Section

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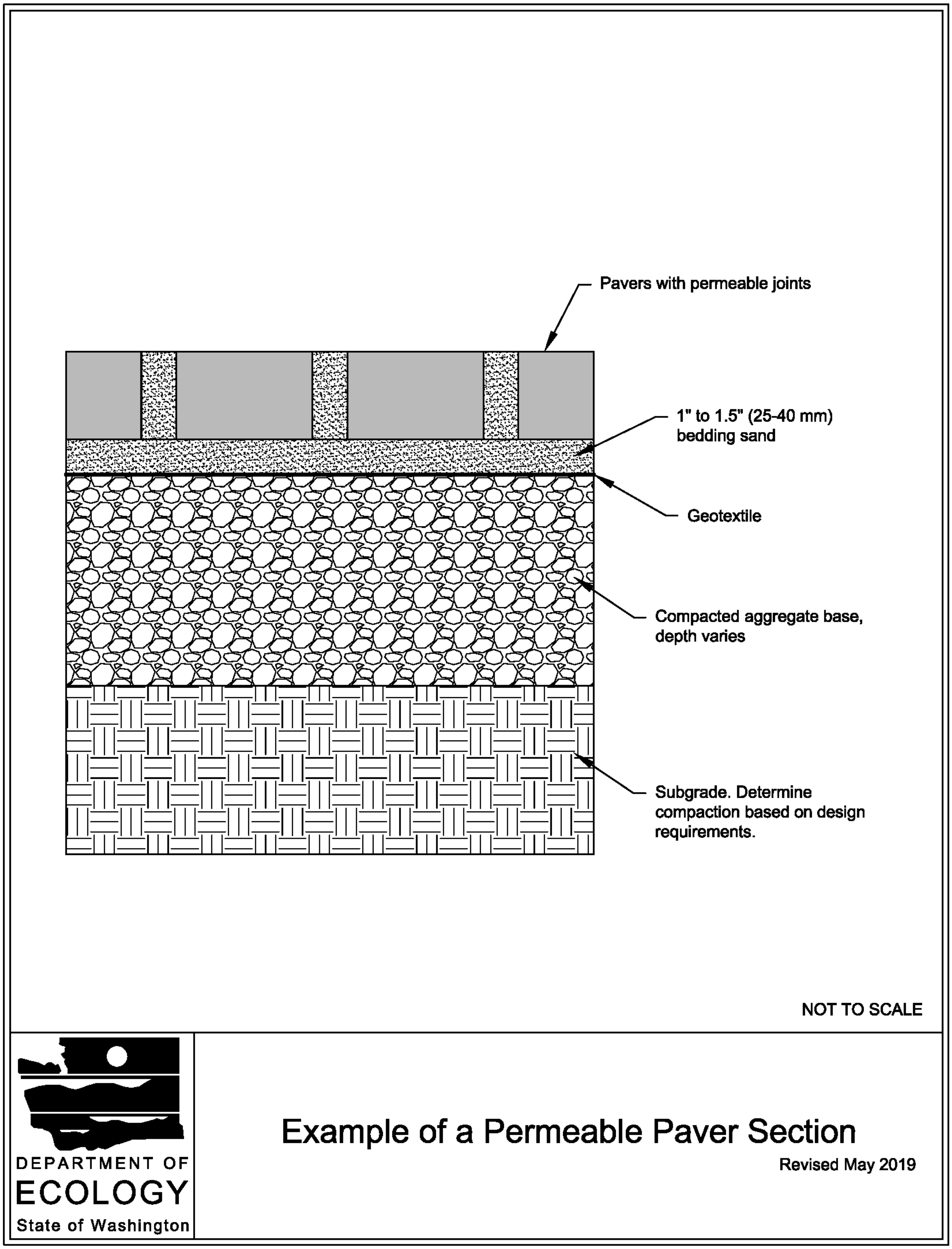
Figure V-5.2: Example of a Permeable Paver Section



Applications and Limitations

Permeable pavements are an important integrated management practice within the LID approach and can be designed to accommodate pedestrian, bicycle and auto traffic while allowing Runoff Treatment and Flow Control of stormwater.

Permeable pavements are appropriate in many applications where traditionally impermeable pavements have been used. Typical applications for permeable pavements include parking lots, sidewalks, pedestrian and bike trails, driveways, residential access roads, and emergency and facility maintenance roads.

Limitations to permeable pavements include:

- No run-on from pervious surfaces is preferred. If runoff comes from minor or incidental pervious areas, those areas must be fully stabilized.
- 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 > the impervious pavement area.
- Soils must not be tracked onto the wear layer or the base course during construction.

Infeasibility Criteria

The following infeasibility criteria describe conditions that make permeable pavement infeasible when applying The List Approach within I-3.4.5 MR5: On-Site Stormwater Management. If a project proponent wishes to use a permeable pavement BMP even though one of the infeasibility criteria within this section are met, they may propose a functional design to the local government.

These criteria also apply to impervious pavements that would employ stormwater collection from the surface of impervious pavement with redistribution below the pavement.

Any of the following circumstances allow the designer to determine permeable pavement as "infeasible" when applying the The List Approach within I-3.4.5 MR5: On-Site Stormwater Management:

- Citation of any of the following infeasibility criteria must be based on an evaluation of site-specific conditions and a written recommendation from an appropriate licensed professional (e.g, engineer, geologist, 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 ground water drains into an erosion hazard, or landslide hazard area.
    - Where infiltrating and ponded water below new permeable pavement area would compromise adjacent impervious pavements.
    - Where infiltrating water below a new permeable pavement area would threaten existing below grade basements.

- Where infiltrating water would threaten shoreline structures such as bulkheads.
- Down slope of steep, erosion prone areas that are likely to deliver sediment.
- Where fill soils are used that can become unstable when saturated.
- On excessively steep slopes where water within the aggregate base layer or at the sub-grade 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 can not provide sufficient strength to support heavy loads at industrial facilities such as ports.
- Where installation of permeable pavement would threaten the safety or reliability of pre-existing underground utilities, pre-existing underground storage tanks, or pre-existing road sub-grades.

- The following infeasibility criteria are based on conditions such as topography and distances to predetermined boundaries. Citation of the following criteria do not need site-specific written recommendations from a licensed professional, although some may require professional services to determine:
    - Within an area designated as an erosion hazard, or landslide hazard.
    - Within 50 feet from the top of slopes that are greater than 20%.
    - For properties with known soil or ground water 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 ground water modeling indicates infiltration will likely increase or change the direction of the migration of pollutants in the ground water;
        - 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 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 a small on-site sewage disposal drainfield, 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 any underground storage tank and connecting underground pipes, regardless of tank size. 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.

- At multi-level parking garages, and over culverts and bridges.
- Where the site design cannot avoid putting pavement in areas likely to have long-term excessive sediment deposition after construction (e.g., construction and landscaping material yards).
- Where the subgrade slope exceeds 6 percent after reasonable efforts to grade. Where the permeable pavement wearing course slope exceeds 6 percent after reasonable efforts to design grade.
- Where the native soils below a pollution-generating permeable pavement (e.g., road or parking lot) do not meet the criteria for Runoff Treatment in V-5.6 Site Suitability Criteria (SSC), or do not have adequate separation to ground water (or other impermeable surface). If the local jurisdiction wishes to allow permeable pavement in areas where the native soils do not meet the site suitability criteria, installation of a 6" layer of sand that meets the size gradation (by weight) given in Table V-6.1: Sand Medium Specification can be used to provide treatment.
- Where seasonal high ground water or an underlying impermeable/low permeable layer would create saturated conditions within one foot of the bottom of the permeable pavement BMP. The bottom of the permable pavement BMP is the bottom of the lowest layer that has been designed to be part of the BMP, such as the lowest gravel base course or a sand layer used for treatment below the permeable pavement.
- Where underlying soils are unsuitable for supporting traffic loads when saturated. Soils meeting a California Bearing Ratio of 5% are considered suitable for residential access roads.
- Where appropriate field testing indicates soils have a measured (a.k.a., initial) native soil saturated hydraulic conductivity (K_{sat}) less than 0.3 inches per hour. See V-5.4 Determining the Design Infiltration Rate of the Native Soils. (Note: In these instances, unless other infeasibility restrictions apply, roads and parking lots may be built with an underdrain, preferably elevated within the base course, if Flow Control benefits are desired.)
- Roads that receive 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). Note: This infeasibility criterion does not extend to sidewalks and other non-traffic bearing surfaces.
- Areas having more than very low truck traffic. Areas with very low truck traffic volumes are roads and 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. Note: This infeasibility criterion does not extend to sidewalks and other non-traffic bearing surfaces.
- Where replacing existing impervious surfaces, unless the existing surface is a non-

pollution generating surface over an outwash soil with a measured (initial) saturated hydraulic conductivity (K_{sat}) of four inches per hour or greater.

  - At sites that whose land use requires oil control BMPs per III-1.2 Choosing Your Runoff Treatment BMPs.
  - 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.

- A local government may designate geographic areas within which permeable pavement, or certain types of permeable pavement, may be designated as infeasible due to year-round, seasonal or periodic high groundwater conditions, or due to inadequate infiltration rates. Designations must be based upon a preponderance of field data, collected within the area of concern, that indicate a high likelihood of failure to achieve the minimum groundwater clearance or infiltration rates identified in the above infeasibility criteria. The local government must develop a technical report, and make it available upon request to Ecology. The technical report must be authored by (a) professional(s) with appropriate expertise (e.g., registered engineer, geologist, hydrogeologist, or certified soil scientist), and document the location and pertinent values/observations of data that were used to recommend the designation and boundaries for the geographic area. The types of pertinent data include, but are not limited to:
  - Standing water heights or evidence of recent saturated conditions in observation wells, test pits, test holes, and well logs.
  - Observations of areal extent and time of surface ponding, including local government or professional observations of high water tables, frequent or long durations of standing water, springs, wetlands, and/or frequent flooding.
  - Results of infiltration tests
- In addition, a local government can map areas that meet a specific infeasibility criterion listed above provided they have an adequate data basis. Criteria that are most amenable to mapping are:
  - Where land for permeable pavement is within an area designated by the local government as an erosion hazard, or landslide hazard
  - Within 50 feet from the top of slopes that are greater than 20% and over 10 feet vertical relief
  - Within 100 feet of a closed or active landfill

Design Criteria

General Design Criteria

- Ecology has listed below the critical design criteria you must consider when designing permeable pavement. Local governments can adopt alternative design criteria, as long as it does not conflict with the criteria listed below.
- You can find additional guidance for permeable pavement design in the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012).

  Note that the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012) is for additional informational purposes only. You must follow the guidance within this manual if there are any discrepancies between this manual and the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012).
- Project submission requirements: Submit results of infiltration (K_{sat}) testing, ground water elevation testing (or other documentation and justification for the rates and hydraulic restriction layer clearances) with the Stormwater Site Plan as justification for the feasibility decision regarding permeable pavement, and as justification for assumptions made in the runoff modeling. If necessary, also submit documentation of meeting the criteria for Runoff Treatment in V-5.6 Site Suitability Criteria (SSC).
- Legal documentation to track permeable pavement obligations: Where drainage plan submittals include assumptions in regard to size and location of permeable pavement, approval of the plat or short-plat should identify the permeable pavement obligation of each lot; and the appropriate lots should have deed requirements for construction and maintenance of those BMPs.

Permeable Pavement as Runoff Treatment

Ecology recognizes the permeable pavement BMP as a basic treatment BMP (as further described in III-1.2 Choosing Your Runoff Treatment BMPs) if it meets either of the following criteria:

- The native soils below the permeable pavement meet the criteria for Runoff Treatment per V-5.6 Site Suitability Criteria (SSC).

  OR
- The permeable pavement design includes a 6" layer of sand that meets the size gradation (by weight) given in Table V-6.1: Sand Medium Specification.

Subgrade

- Compact the subgrade to the minimum compaction necessary for structural stability. Two guidelines currently used to specify subgrade compaction are “firm and unyielding” (qualitative), and 90- 92% Standard Proctor (quantitative). Subgrade should not be subject to compaction beyond the qualitative and quantitative levels identified herein. Do not allow construction traffic and equipment onto the subgrade except when construction access on subgrade is required for the pavement section installation. Follow back dumping approach as noted below.

- To prevent compaction when installing the aggregate base, the following steps (back-dumping) should be followed: 1) the aggregate base is dumped onto the subgrade from the edge of the installation and aggregate is then pushed out onto the subgrade; 2) trucks then dump subsequent loads from on top of the aggregate base as the installation progresses.
- Use on soil types A through C.

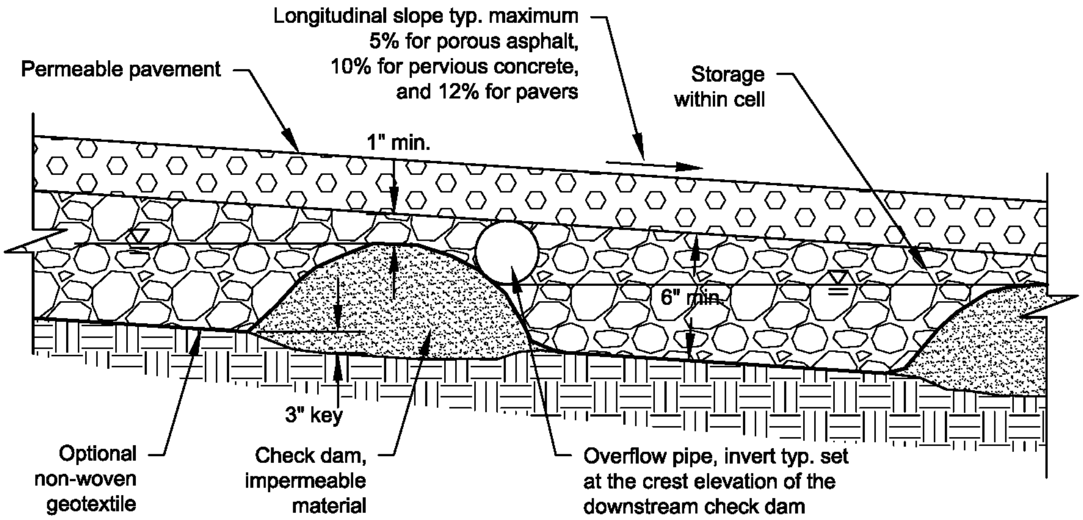
Separation or Bottom Filter Layer (recommended but optional)

- A layer of sand or crushed stone (0.5 inch or smaller) graded flat is recommended to promote infiltration across the surface, stabilize the base layer, protect underlying soil from compaction, and serve as a transition between the base course and the underlying geotextile material.

Base Material

- Local governments should adopt their own minimum base material requirements as they see necessary for support of flexible pavements. Many design combinations are possible. The material must be free draining. The municipality should determine and publish estimates of the void space for each standard base material allowed in their jurisdiction.
- To increase infiltration, improve flow attenuation and reduce structural problems associated with subgrade erosion on slopes, impermeable check dams may be placed on the subgrade and below the permeable pavement surface (See Figure V-5.3: Example of a Check Dam Along a Sloped Section of Permeable Pavement). Check dams should have an overflow drain invert placed at the maximum ponding depth. The distance between berms will vary depending on slope, Flow Control goals and cost.

Figure V-5.3: Example of a Check Dam Along a Sloped Section of Permeable Pavement



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Example of a Check Dam Along a Sloped Section of Permeable Pavement

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Wearing Layer

- For all surface types, a minimum initial infiltration rate of 20 inches per hour is necessary. To improve the probability of long-term performance, significantly higher initial infiltration rates are desirable.
- ***Porous Asphalt:*** Products must have adequate void spaces through which water can infiltrate. A void space within the range of 16 – 25% is typical.
- ***Pervious Concrete:*** Products must have adequate void spaces through which water can infiltrate. A void space within the range of 15 – 35% is typical..
- ***Grid/lattice systems filled with gravel, sand, or a soil of finer particles with or without grass:*** The fill material must be at least a minimum of 2 inches of sand, gravel, or soil.
- ***Permeable Interlocking Concrete Pavement and Aggregate Pavers:*** Pavement joints should be filled with No. 8, 89 or 9 stone. Consult with paver manufacturer specifications to determine the appropriate material type and size.

Drainage Conveyance

Roads should still be designed with adequate drainage conveyance facilities as if the road surface was impermeable. Roads with base courses that extend below the surrounding grade should have a designed drainage flow path to safely move water away from the road prism and into the roadside drainage facilities. Use of perforated storm drains to collect and transport infiltrated water from under the road surface will result in less effective designs and less Flow Control benefit.

Underdrains

Note that if an underdrain is placed at or near the bottom of the aggregate base in a permeable pavement BMP, the permeable pavement is no longer considered an LID BMP and cannot be used to satisfy The List Approach within I-3.4.5 MR5: On-Site Stormwater Management. However, designs utilizing an underdrain that is elevated within the aggregate base course to protect the pavement wearing course from saturation is considered an LID BMP and can be used to satisfy The List Approach within I-3.4.5 MR5: On-Site Stormwater Management.

Infiltration Test for Permeable Pavement Surface

- Permeable pavement driveways can be tested by simply throwing a bucket of water on the surface. If anything other than a scant amount puddles or runs off the surface, additional testing is necessary prior to accepting the construction.
- Permeable pavement roads may be initially tested with the bucket test described above. In addition, test the initial infiltration with a 6-inch ring, sealed at the base to the road surface, or with a sprinkler infiltrometer. Wet the road surface continuously for 10 minutes. Begin test to determine compliance with 20 inches per hour minimum rate. Use of ASTM C1701 or ASTM C1781, as appropriate, is also recommended.

Determining the Native Soil Infiltration Rates

Determining infiltration rates of the site soils is necessary to determine feasibility of designs that intend to infiltrate stormwater on-site. It is also necessary to estimate flow reduction benefits of such designs when using a continuous runoff model

The certified soils professional or engineer can exercise discretion concerning the need for and extent of infiltration rate (saturated hydraulic conductivity, K_{sat}) testing. The professional can consider a reduction in the extent of infiltration (K_{sat}) testing if, in their judgment, information exists confirming that the site is unconsolidated outwash material with high infiltration rates, and there is adequate separation from ground water.

Refer to V-5.4 Determining the Design Infiltration Rate of the Native Soils for further guidance on the methods to determine the infiltration rate of the native soils.

Field Testing Requirements Based Upon Project Size

- Projects subject to Minimum Requirements #1 - #5:
  - A small-scale Pilot Infiltration Test (PIT) – or other small-scale tests as allowed by the local jurisdiction - should be performed for every 5,000 sq. ft. of permeable pavement, but not less than 1 test per site. Submit results as part of the Stormwater Site Plan to establish a basis for a feasibility decision.
- Projects subject to Minimum Requirements #1 - #9:
  - A small-scale Pilot Infiltration Tests (PIT) - or other small-scale tests as allowed by the local jurisdiction - should be performed for every 5,000 sq. ft. of permeable pavement, but not less than 1 test per site.

On residential developments, small-scale infiltration tests should be performed at every proposed lot, at least every 200 feet of roadway and within each length of road with significant differences in subsurface characteristics. However, if the site subsurface characterization - including soil borings across the development site - indicate consistent soil characteristics and depths to seasonal high ground water conditions, the number of test locations may be reduced to a frequency recommended by a geotechnical professional.

Unless seasonal high ground water elevations across the site have already been determined, upon conclusion of the infiltration testing, infiltration sites should be over-excavated 1 foot to see any restrictive layers or ground water. Observations through a wet season can identify a seasonal ground water restriction.

Perform infiltration testing in the soil profile at the estimated bottom elevation of base materials for the permeable pavement. If no base materials, (e.g., a pervious concrete sidewalk), perform the testing at the estimated bottom elevation of the pavement.

Assignment of Appropriate Correction Factors

If the design requires determination of a long-term (design) infiltration rate of the native soils (for example, to demonstrate compliance with the LID Performance Standard and/or the Flow Control

Performance Standard), refer to V-5.4 Determining the Design Infiltration Rate of the Native Soils and the following additional guidance specific to permeable pavement BMPs:

- The overlying permeable pavement provides excellent protection for the underlying native soil from sedimentation. Accordingly, when using The Simplified Approach to Calculating the Design Infiltration Rate of the Native Soils as described in V-5.4 Determining the Design Infiltration Rate of the Native Soils, the correction factor for the sub-grade soil does not have to take into consideration the extent of influent control and clogging over time. The correction factor to be applied to in-situ, small-scale infiltration test results for permeable pavement sites is determined by the site variability and number of locations tested, the quality of the aggregate base material, and the method used to determine the initial K_{sat}. Using Table V-5.1: Correction Factors to be Used With In-Situ Saturated Hydraulic Conductivity Measurements to Estimate Design Rates, the correction factor for permeable pavement design is revised based on this guidance as:

  $$\text{Total Correction Factor, } CF_T = CF_V \times CF_t \times CF_a$$

  where CF_a is the partial correction factor determined by the quality of the pavement aggregate base material. CF_a ranges from 0.9 to 1.0.

- Tests should be located and be at adequate frequency capable of producing a soil profile characterization that fully represents the infiltration capability where the permeable pavement is located. The partial correction factor CF_V depends on the level of uncertainty that variable subsurface conditions justify. If enough pilot infiltration tests are conducted across the permeable pavement subgrade to provide an accurate characterization, or the range of uncertainty is low (for example, conditions are known to be uniform through previous exploration and site geological factors), then a partial correction factor CF_V of one for site variability may be justified. Additionally, a partial correction factor CF_a of 1 for the quality of pavement aggregate base material may be necessary if the aggregate base is clean washed material with 1% or less fines passing the 200 sieve.

- If the level of uncertainty is high, a partial correction factor CF_V near the low end of the range may be appropriate. Two example scenarios where a low CF_V may be appropriate include:
  - Site conditions are highly variable due to a deposit of ancient landslide debris, or buried stream channels. In these cases, even with many explorations and several pilot infiltration tests, the level of uncertainty may still be high.
  - Conditions are variable, but few explorations and only one pilot infiltration test is conducted. That is, the number of explorations and tests conducted do not match the degree of site variability anticipated.

Runoff Model Representation

Note that if the project is using permeable pavement to only meet The List Approach within I-3.4.5 MR5: On-Site Stormwater Management, there is no need to model the permeable pavement in a continuous runoff model.

The guidance below is to show compliance with the LID Performance Standard in I-3.4.5 MR5: On-Site Stormwater Management, or the standards in I-3.4.6 MR6: Runoff Treatment, I-3.4.7 MR7: Flow Control, and/or I-3.4.8 MR8: Wetlands Protection.

Continuous runoff modeling software include specific modeling elements to use to model the stormwater for permeable pavement.

Within these elements, the model user specifies pavement thickness and porosity, aggregate base material thickness and porosity, maximum allowed ponding depth, and the infiltration rate into the native soil.

- For grades less than 2%, no adjustment to the below ground 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:
    - 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.
    - 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; and an Effective Total Depth of 1 inch. If the continuous runoff model requires the permeable pavement to have an overflow riser to model overflows that occur should the available storage get exceeded, enter 0.04 ft (1/2 inch) for the "Riser Height" and a large Riser Diameter (say 1000 inches) to ensure that there is no head build up.
    - If a drainage pipe is embedded and elevated in the below grade base materials, the pipe should only have perforations 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 drainage pipe is placed at the bottom of the base material, the pavement is modeled as an impervious surface without any gravel trench.
- 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:
    - 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.
    - 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 "Pavement Bottom Width"(width of the bottom of the base material); and the Effective Total Depth. In WWHM2012, the field entilted "Effective Volume Factor" is used by the program to calculate the effective storage volume within the below-grade base materials for roads on a slope. The Effective Volume Factor is the ratio of the average maximum water depth behind a check dam (typically at the middle of the pavement length) to the below-grade base materials depth.

- Each cell should have its own tributary drainage area within the permeable pavement element that includes the road above it, any project site areas whose runoff drains onto and through the road (lateral flow soil or impervious basin), and any off-site areas. Represent each drainage area with a permeable pavement icon and a lateral flow basin icon (if runon occurs).

In the runoff modeling, similar designs throughout a development can be summed and represented as one large facility. For instance, walkways can be summed into one facility. Driveways with similar designs (and enforced through deed restrictions) can be summed into one facility. In these instances, a weighted average of the design infiltration rates (where within a factor of two) for each location may be used. The averages are weighted by the size of their drainage area. The design infiltration rate for each site is the measured K_{sat} multiplied by the appropriate correction factors.

On the Permeable Pavement screen under "Infiltration", there is a field that asks the following "Use Wetted Surface Area?" By default, it is set to "NO". It should stay "NO" if the below-grade base material trench has sidewalls steeper than 2 horizontal to 1 vertical.

Maintenance

Please see Table V-A.22: Maintenance Standards - Permeable Pavement.

Maintenance recommendations for all permeable pavement BMPs:

- Erosion and introduction of sediment from surrounding land uses should be strictly controlled after construction by amending exposed soil with compost and mulch, planting exposed areas as soon as possible, and armoring outfall areas.
- Surrounding landscaped areas should be inspected regularly and possible sediment sources controlled immediately.
- Installations can be monitored for adequate or designed minimum infiltration rates by observing drainage immediately after heavier rainstorms for standing water or infiltration tests using ASTM C1701.
- Clean permeable pavement surfaces to maintain infiltration capacity at least once or twice annually following recommendations below.
- Utility cuts should be backfilled with the same aggregate base used under the permeable paving to allow continued conveyance of stormwater through the base, and to prevent migration of fines from the standard base aggregate to the more open graded permeable base material (Diniz, 1980).
- Ice build up on permeable pavement is reduced and the surface becomes free and clear more rapidly compared to conventional pavement. For western Washington, deicing and sand application may be reduced or eliminated and the permeable pavement installation should be assessed during winter months and the winter traction program developed from those observations. Vacuum and sweeping frequency will likely be required more often if sand is applied.

Porous asphalt and pervious concrete maintenance recommendations:

- Clean surfaces using suction, sweeping with suction or high-pressure wash and suction (sweeping alone is minimally effective). Hand held pressure washers are effective for cleaning void spaces and appropriate for smaller areas such as sidewalks.
- For large scale cleaning use vacuum surface cleaning machines (such as Cyclone, Elgin, etc.) for cleaning pervious concrete and porous asphalt.
- Small utility cuts can be repaired with conventional asphalt or concrete if small batches of permeable material are not available or are too expensive.

Permeable paver maintenance recommendations:

- ICPI recommends cleaning if the measured infiltration rate falls below 10 in/hr.
- Use sweeping with suction when surface and debris are dry 1-2 times annually (see next bullet for exception). Apply vacuum to a paver test section and adjust settings to remove all visible sediment without excess uptake of aggregate from paver openings or joints. If necessary replace No 8, 89 or 9 stone to specified depth within the paver openings. Washing or power washing should not be used to remove debris and sediment in the openings between the pavers (Smith, 2000).
- For badly clogged installations, wet the surface and vacuumed aggregate to a depth that removes all visible fine sediment and replace with clean aggregate.
- If necessary use No 8, 89 or 9 stone for winter traction rather than sand (sand will accelerate clogging).
- Pavers can be removed individually and replaced when utility work is complete.
- Replace broken pavers as necessary to prevent structural instability in the surface.
- The structure of the top edge of the paver blocks reduces chipping from snowplows. For additional protection, skids on the corner of plow blades are recommended.
- For a model maintenance agreement see *Permeable Interlocking Concrete Pavements: Design, Specifications, Construction, Maintenance* (Smith, 2011).

Plastic or concrete grid system maintenance recommendations:

- Remove and replace top course aggregate if clogged with sediment or contaminated (vacuum trucks for stormwater collection basins can be used to remove aggregate).
- Remove and replace grid segments where three or more adjacent rings are broken or damaged.
- Replenish aggregate material in grid as needed.
- Snowplows should use skids to elevate blades slightly above the gravel surface to prevent loss of top course aggregate and damage to plastic grid.
- For grass installations, use normal turf maintenance procedures except do not aerate. Use very slow release fertilizers if needed.

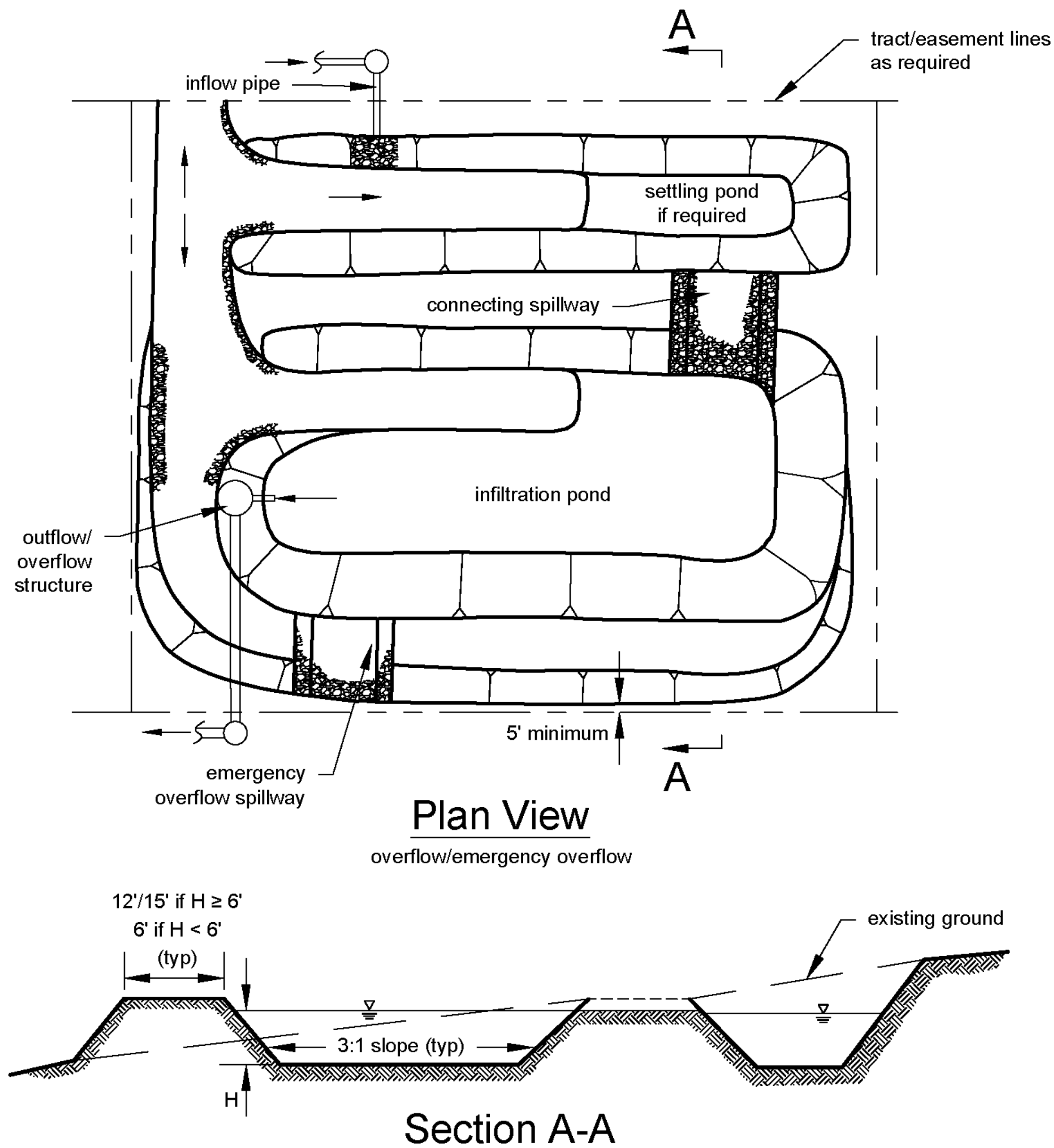
BMP T7.10: Infiltration Basins

Infiltration basins are earthen impoundments used for the collection, temporary storage and infiltration of incoming stormwater runoff.

If this BMP is proposed to be used for Runoff Treatment, the design must show that the criteria for Runoff Treatment in V-5.6 Site Suitability Criteria (SSC) are met.

Refer to the guidance earlier in this chapter for information pertinent to all infiltration BMPs. Guidance specific to infiltration basins is provided below.

Figure V-5.4: Typical Infiltration Pond/Basin



Note:
Detail is a schematic representation only. Actual configuration will vary depending on specific site constraints and applicable design criteria.

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Typical Infiltration Pond/Basin

Revised June 2016

Design Criteria

- Provide access for vehicles to easily maintain the forebay (presettling basin) area and not disturb vegetation, or resuspend sediment any more than absolutely necessary.
- The slope of the infiltration basin bottom should not exceed 3% in any direction.
- Size the infiltration basin for a maximum ponding depth of between 2 and 6 feet.
- 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 basin to the maximum ponding level or from the rim down to the overflow point if overflow or a spillway is included.
- Infiltration basins that are providing Runoff Treatment must have sufficient vegetation established on the basin floor and side slopes to prevent erosion and sloughing and to provide additional pollutant removal. Provide erosion protection of inflow points to the basin (see V-1.4.2 Flow Spreaders). Select suitable vegetative materials to stabilize the basin floor and side slopes. Refer to BMP D.1: Detention Ponds for recommended vegetation.
- Lining material – Infiltration 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. Select a nonwoven geotextile that will function sufficiently without plugging (see geotextile specifications in V-1.3.4 Geotextile Specifications). Replace or clean the filter layer when/if it becomes clogged.
- Vegetation – Stabilize the embankment, emergency spillways, spoil and borrow areas, and other disturbed areas and plant, preferably with grass. Without healthy vegetation, the surface soil pores will quickly plug.

Maintenance Criteria

- Maintain the infiltration basin floor and side slopes to promote dense turf with extensive root growth. This enhances infiltration, prevents erosion and consequent sedimentation of the basin floor, and prevents invasive weed growth. Immediately stabilize and revegetate bare spots.
- Do not allow vegetation growth to exceed 18 inches in height. Mow the slopes periodically and check for clogging and erosion.
- Use the same seed mixtures as those recommended in Table V-12.3: Stormwater Tract "Low Grow" Seed Mix. The use of slow-growing, stoloniferous grasses will permit long intervals between mowing. Mowing twice a year is generally satisfactory. Apply fertilizers only as necessary and in limited amounts to avoid contributing to ground water pollution. Consult the local agricultural or gardening resources such as Washington State University Extension for appropriate fertilizer type, including slow release fertilizers, and application rates.

BMP T7.20: Infiltration Trenches

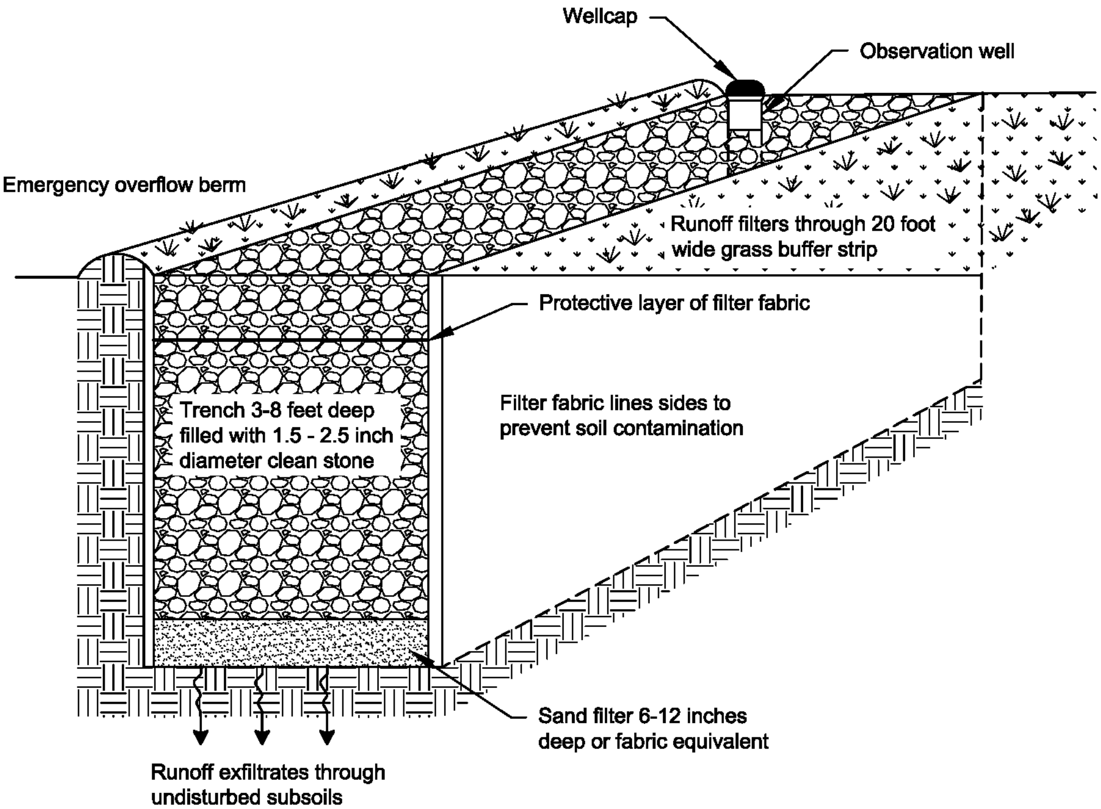
Infiltration trenches are generally at least 24 inches wide, and are backfilled with a coarse stone aggregate, allowing for temporary storage of stormwater runoff in the voids of the aggregate material. Stored runoff then gradually infiltrates into the surrounding soil. The surface of the trench can be covered with grating and/or consist of stone, gabion, sand, or a grassed or asphalt area with a surface inlet. Perforated rigid pipe of at least 8-inch diameter can also be used to distribute the stormwater in an infiltration trench.

Underground Injection Control (UIC) regulations apply to infiltration trenches when perforated pipe is used, and then, provided that the design, operation, and maintenance criteria in this section are met, only the registration requirement applies. Where perforated pipe is not used, the registration requirement does not apply. See I-4 UIC Program for details.

If this BMP is proposed to be used for Runoff Treatment, the design must show that the criteria for Runoff Treatment in V-5.6 Site Suitability Criteria (SSC) are met.

Refer to the guidance earlier in this chapter for information pertinent to all infiltration BMPs. Guidance specific to infiltration trenches is provided below.

Figure V-5.5: Schematic of an Infiltration Trench



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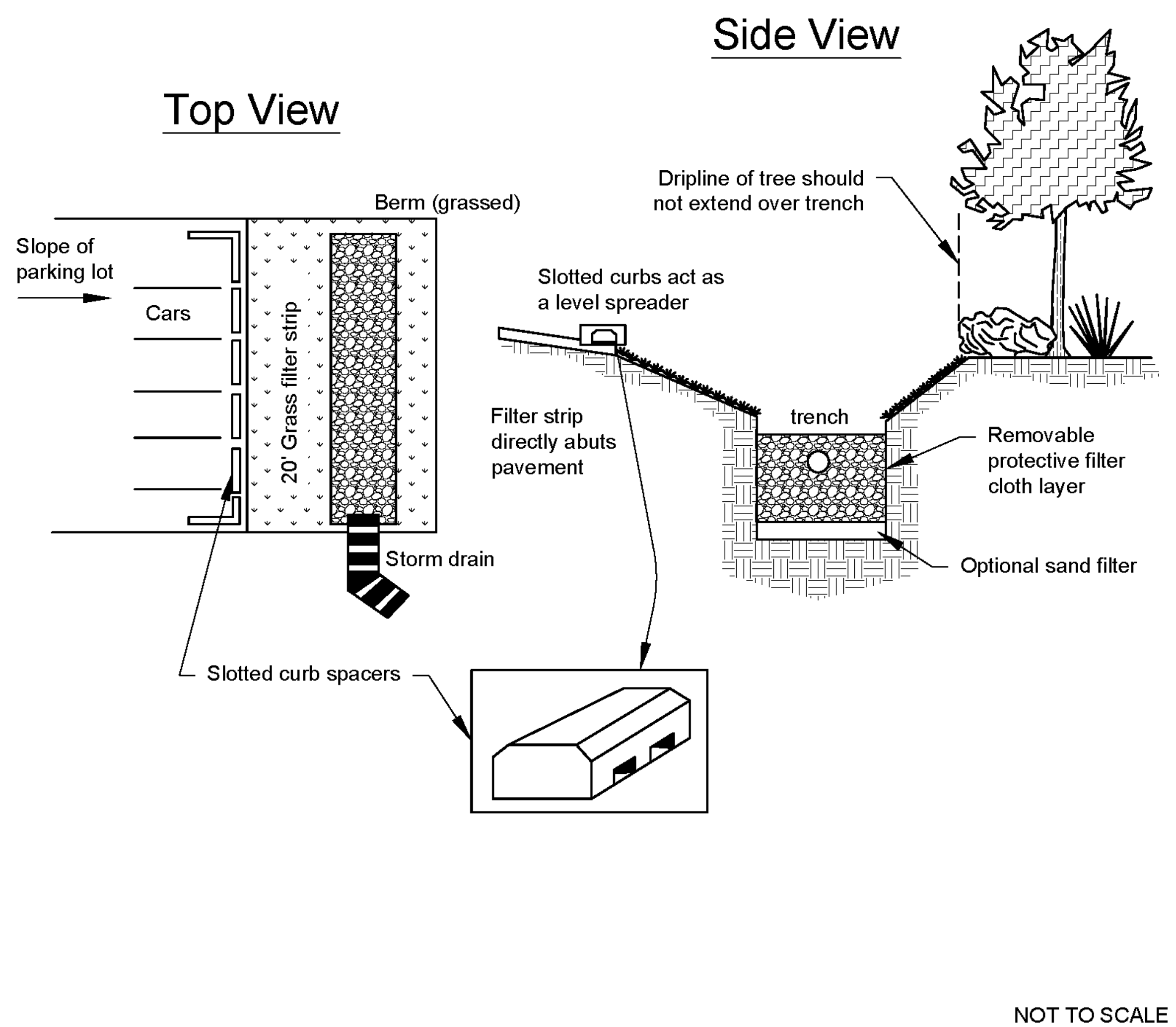
Schematic of an Infiltration Trench

Revised May 2019

Figure V-5.6: Parking Lot Perimeter Trench Design



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Parking Lot Perimeter Trench Design

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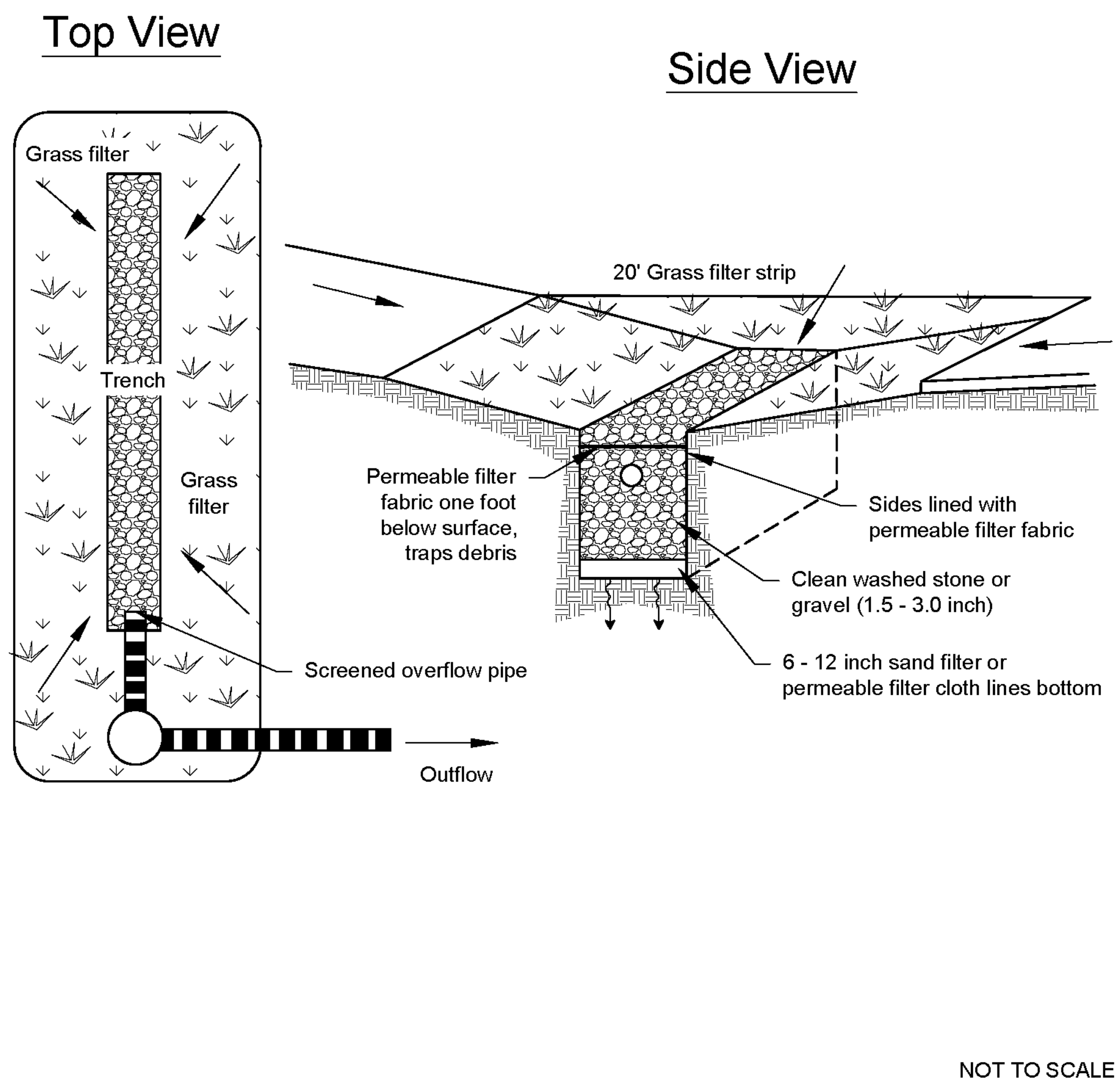
Figure V-5.7: Median Strip Trench Design



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Median Strip Trench Design

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Figure V-5.8: Oversized Pipe Trench Design

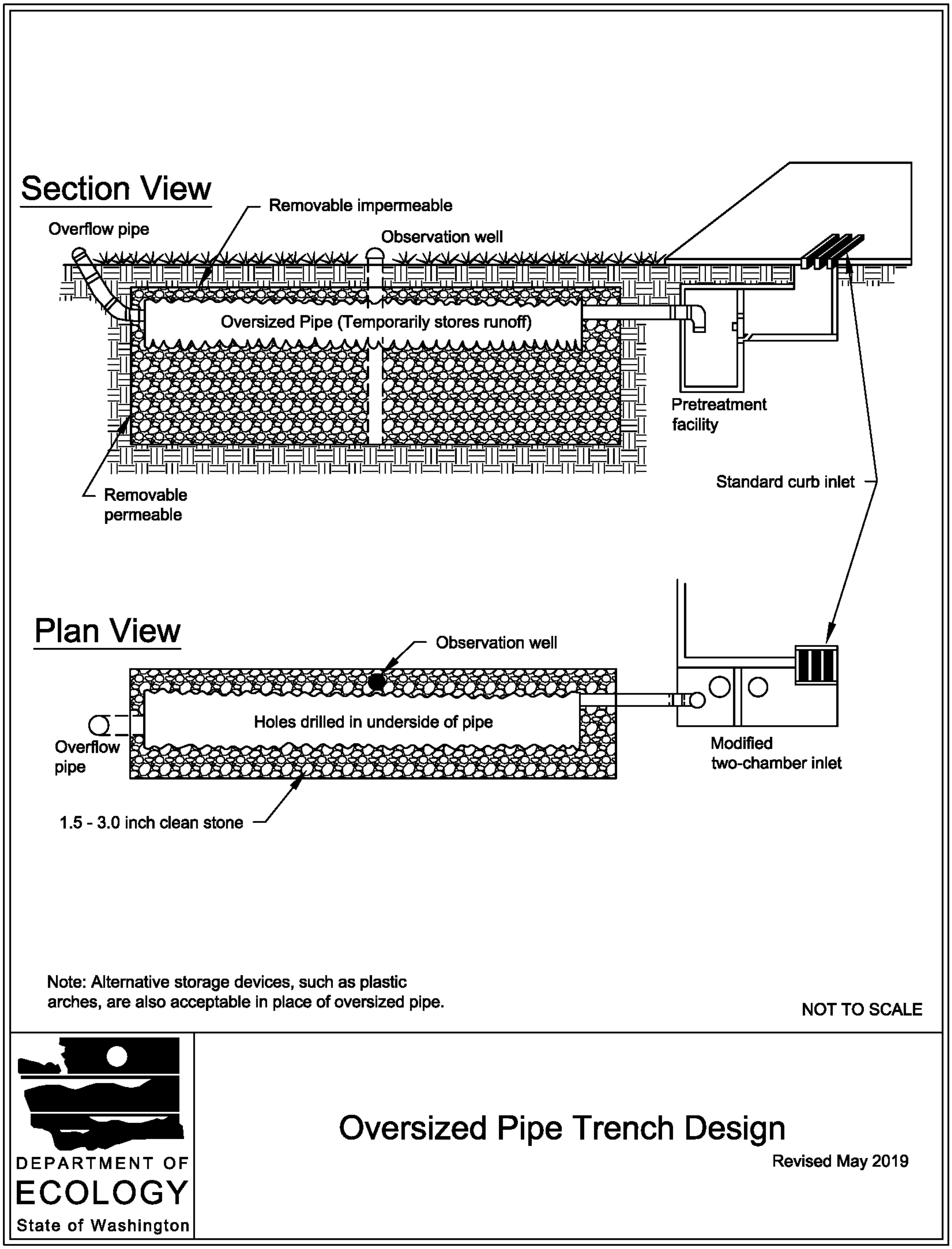


Figure V-5.9: Swale/Trench Design

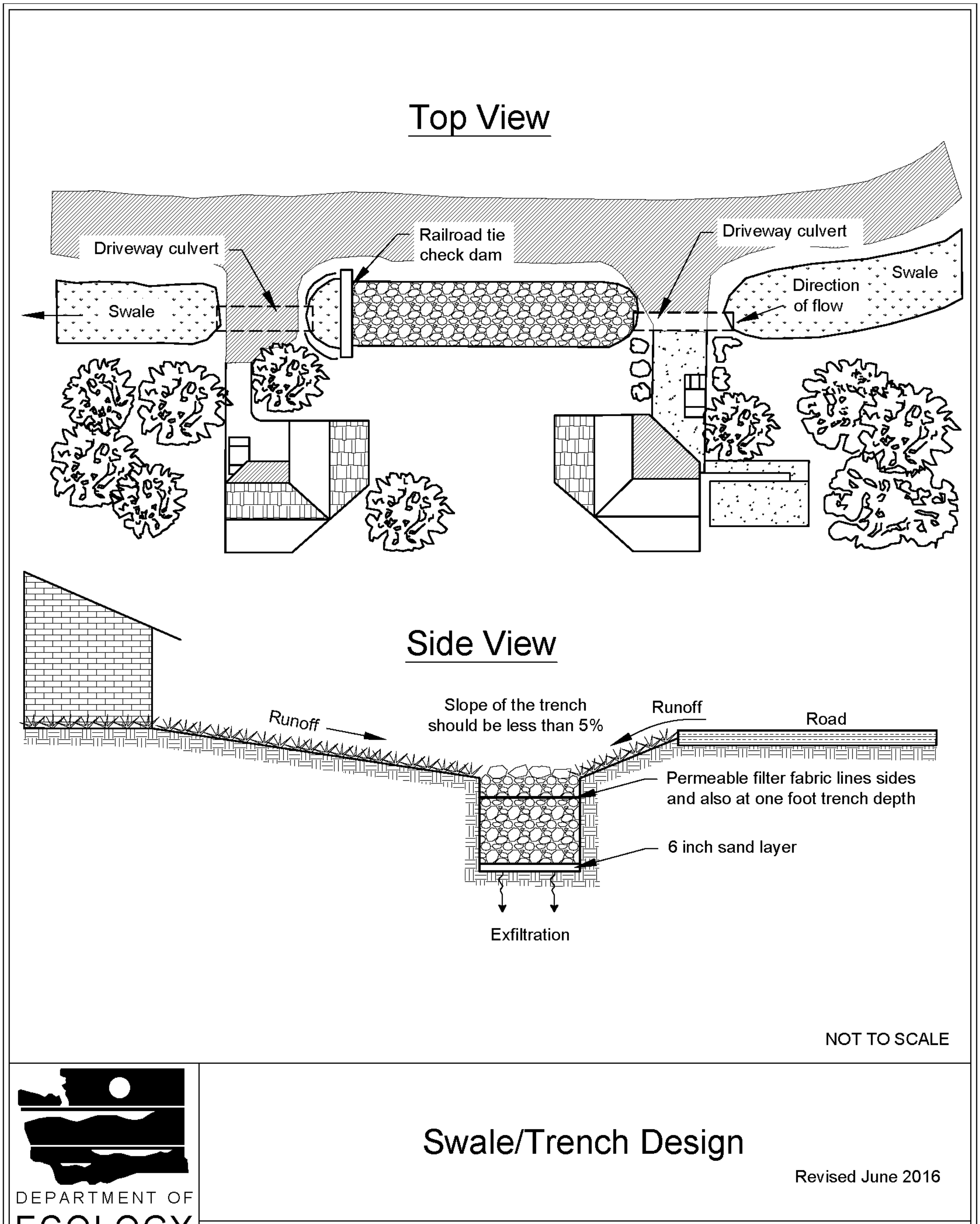
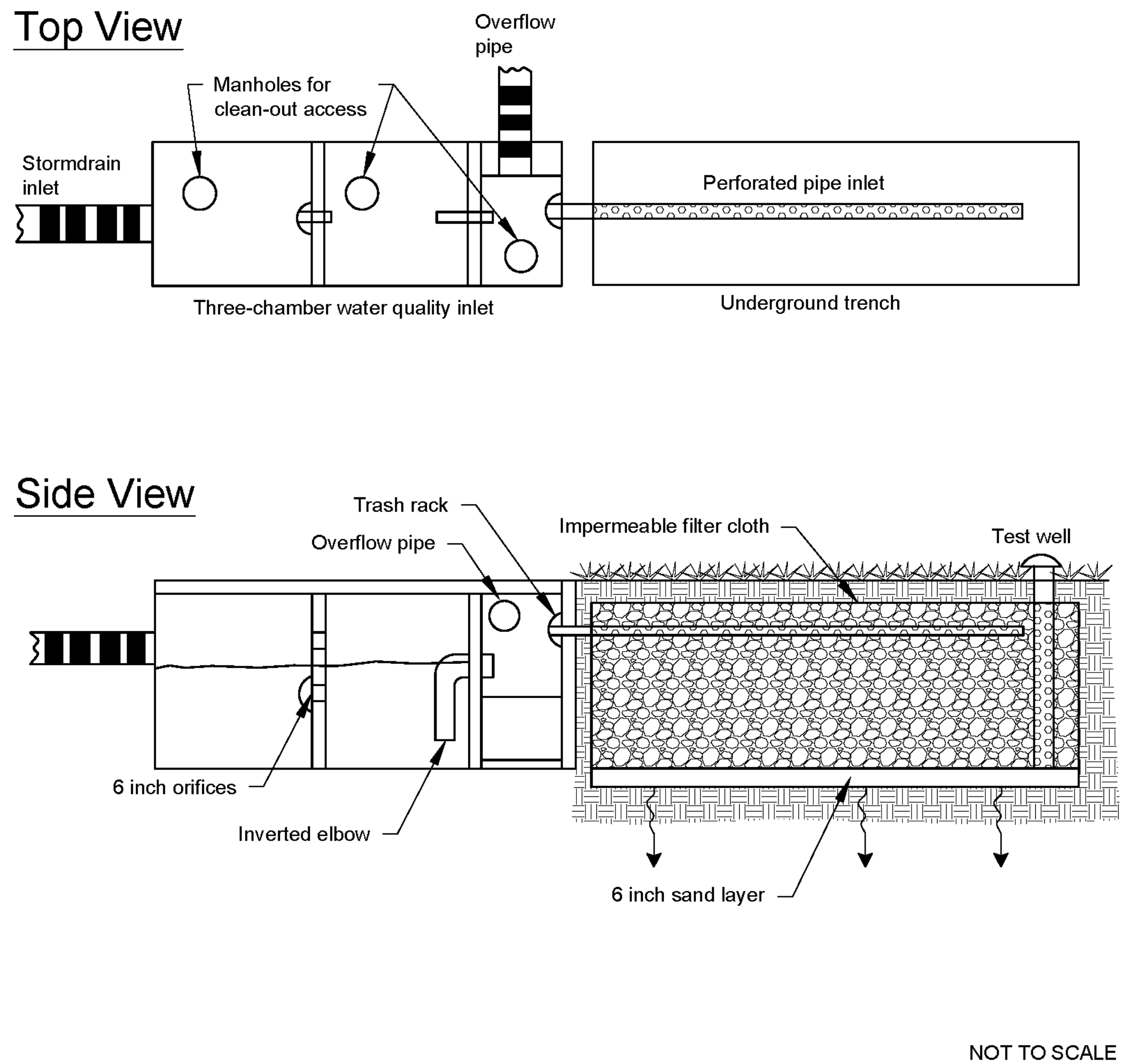


Figure V-5.10: Underground Trench with Oil/Grit Chamber



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Underground Trench with Oil/Grit Chamber

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Design Criteria

- Due to accessibility and maintenance limitations, carefully design and construct infiltration trenches. Contact the local jurisdiction for additional specifications.
- Consider including an access port or open or grated top for accessibility to conduct inspections and maintenance.
- Backfill Material - The aggregate material for the infiltration trench should consist of a clean aggregate with a maximum diameter of 3 inches and a minimum diameter of 1.5 inches. Void space for these aggregates should be in the range of 30 to 40 percent.
- Geotextile fabric liner – Completely encase the aggregate fill material 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. Carefully select geotextile fabric with acceptable properties to avoid plugging (see V-1.3.4 Geotextile Specifications).
- The bottom sand or geotextile fabric as shown in Figure V-5.11: Observation Well Details is optional.

  Refer to the *Geosynthetic Design and Construction Guidelines Participant Notebook* (Holtz et al., 1998) for design guidance on geotextiles in drainage applications. Refer to *Long-Term Performance of Geosynthetics in Drainage Applications* (Koerner et al., 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.
- Overflow Channel - Because an infiltration trench is generally used for small drainage areas, an emergency spillway is not necessary. However, provide a non-erosive overflow channel leading to a stabilized watercourse.
- Surface Cover - A stone filled trench can be placed under a porous or impervious surface cover to conserve space.
- Observation Well - Install an observation well at the lower end of the infiltration trench to check water levels, drawdown time, sediment accumulation, and conduct water quality monitoring. Figure V-5.11: Observation Well Details illustrates observation well details. 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. Cap the top of the well to discourage vandalism and tampering.

Construction Criteria

- Trench Preparation - Place excavated materials away from the trench sides to enhance trench wall stability. Take care to keep this material away from slopes, neighboring property, sidewalks and streets. It is recommended that this material be covered with plastic. (See BMP C123: Plastic Covering).
- Stone Aggregate Placement and Compaction - Place stone aggregate in lifts and compact using plate compactors. In general, a maximum loose lift thickness of 12 inches is recommended. The compaction process ensures geotextile conformity to the excavation sides,

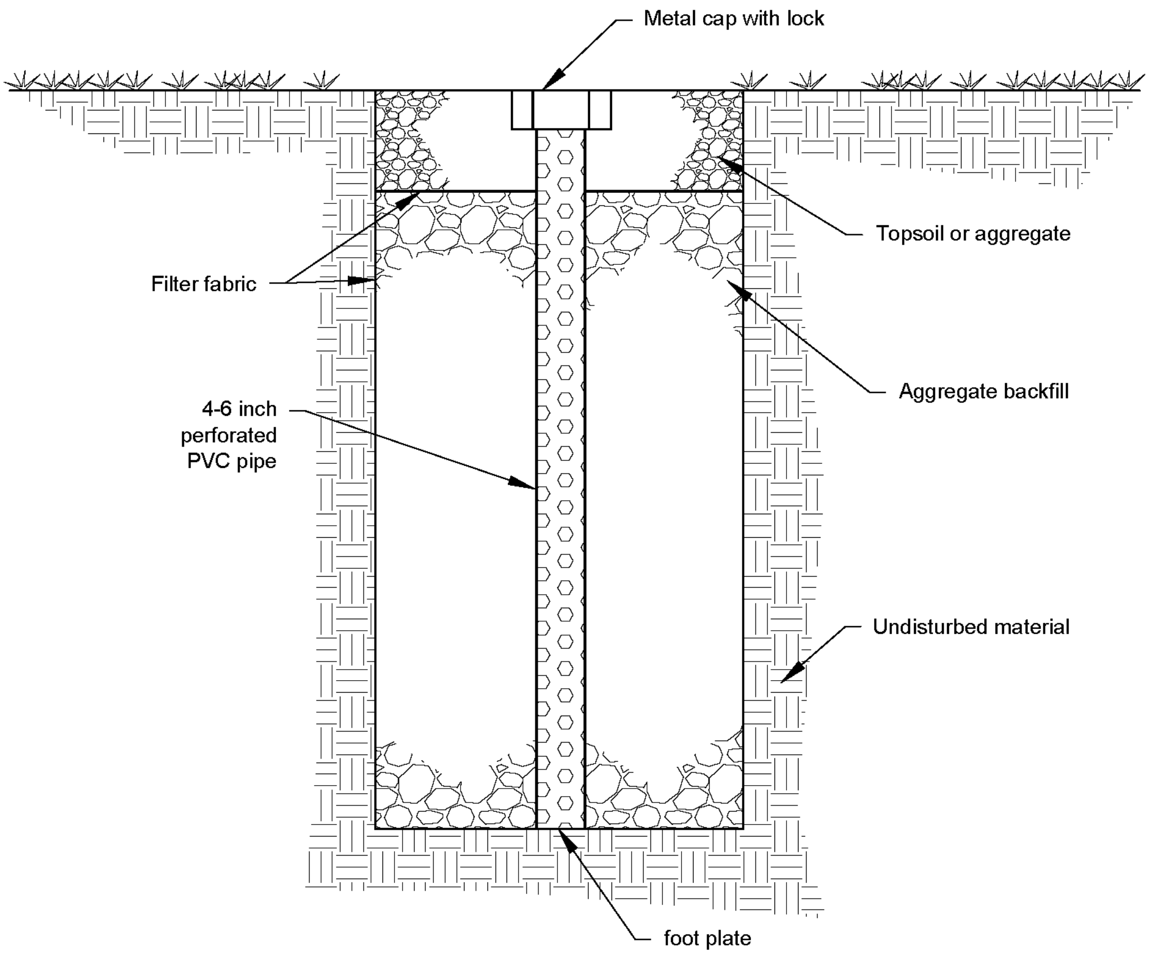
thereby reducing potential piping and geotextile clogging, and settlement problems.

- Potential Contamination - Prevent natural or fill soils from intermixing with the stone aggregate. Remove all contaminated stone aggregate and replaced 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, the upstream roll should overlap a minimum of 2 feet over the downstream roll in order to provide a shingled effect.
- Voids behind Geotextile - Voids between the geotextile and excavation sides must be avoided. Removing boulders or other obstacles from the trench walls is one source of such voids. Place natural soils in these voids at the most convenient time during construction to ensure geotextile conformity to the excavation sides. This remedial process will avoid soil piping, geotextile clogging, and possible surface subsidence.
- 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.

Maintenance Criteria

Monitor sediment buildup in the top foot of stone aggregate or the surface inlet on the same schedule as the observation well.

Figure V-5.11: Observation Well Details



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Observation Well Details

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BMP T7.30: Bioretention

Purpose

Ecology accepts bioretention as having the potential to meet I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.6 MR6: Runoff Treatment and I-3.4.7 MR7: Flow Control for the tributary drainage areas depending upon site conditions and sizing.

The purpose of bioretention is to provide effective removal of many stormwater pollutants, and provide reductions in stormwater runoff quantity and surface runoff flow rates. Where the surrounding native soils have adequate infiltration rates, bioretention can provide both Runoff Treatment and Flow Control. Where the native soils have low infiltration rates, underdrain systems can be installed and the bioretention BMP can still be used as a Runoff Treatment BMP. However, designs utilizing underdrains provide less Flow Control benefits.

Description

Bioretention areas are shallow landscaped depressions, with a designed soil mix (the bioretention soil mix) and plants adapted to the local climate and soil moisture conditions, that receive stormwater from a contributing area.

Bioretention uses the imported bioretention soil mix as a treatment medium. As in infiltration, the pollutant removal mechanisms include filtration, adsorption, and biological action. Bioretention BMPs can be built within earthen swales or placed within vaults. Water that has passed through the bioretention soil mix (or approved equivalent) may be discharged to the ground or collected and discharged to surface water.

The term, bioretention, is used to describe various designs using soil and plant complexes to manage stormwater. The following terminology is used in this manual:

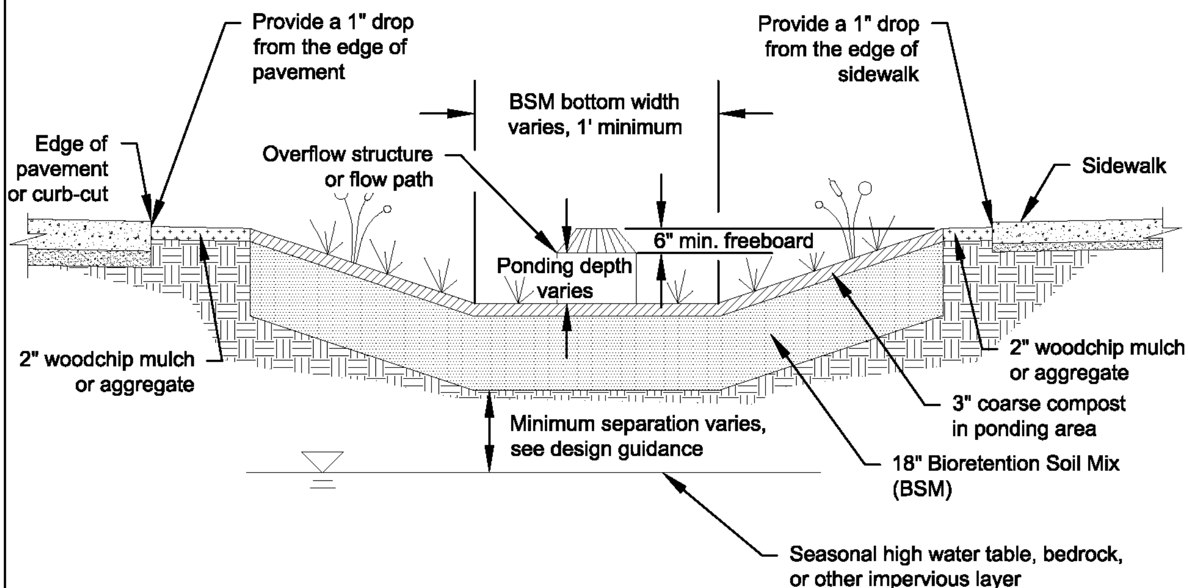
- *Bioretention cells:* Shallow depressions with a designed planting soil mix and a variety of plant material, including trees, shrubs, grasses, and/or other herbaceous plants. Bioretention cells may or may not have an underdrain and are not designed as a conveyance system.
- *Bioretention swales:* Incorporate 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 swales have relatively gentle side slopes and ponding depths that are typically 6 to 12 inches.
- *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 underdrain). Planters have an open bottom and allow infiltration to the subgrade. These designs are often used in ultra-urban settings.

  Stormwater planters in the ROW require urban design and tailoring it to street typology and context. NACTO Urban Street Stormwater Guide provides guidance for designing roadside stormwater planters. https://nacto.org/publication/urban-street-stormwater-guide/

See Figure V-5.12: Typical Bioretention, Figure V-5.13: Typical Bioretention w/Underdrain, Figure V-5.14: Typical Bioretention w/Liner (Not LID), and Figure V-5.15: Example of a Bioretention Planter for examples of various types of bioretention configurations.

Note: Ecology has approved use of certain manufactured treatment devices that use specific, high rate media for treatment. Such systems do not use bioretention soil mix, and are not considered a bioretention BMP (even though marketing materials for these manufactured treatment devices may compare them to bioretention). See V-10 Manufactured Treatment Devices as BMPs for more information on manufactured treatment devices.

Figure V-5.12: Typical Bioretention



Notes:

1. Scarify subgrade 3" min. before bioretention soil installation
2. Compact BSM to 85% per ASTM 1577

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Typical Bioretention

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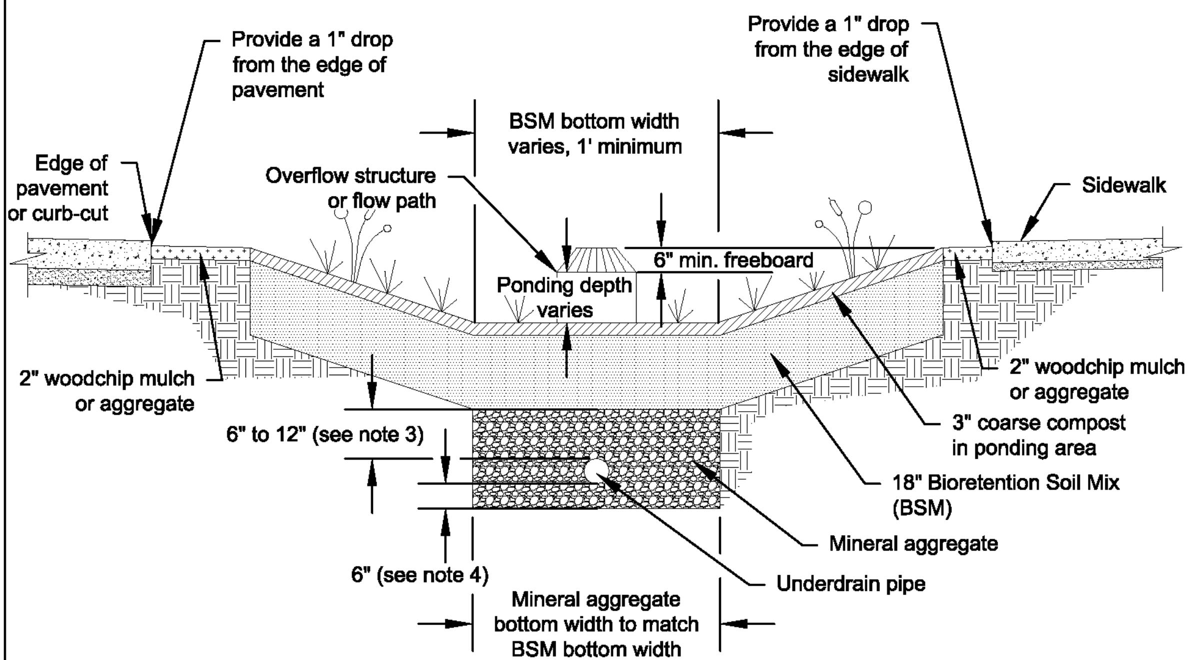
Figure V-5.13: Typical Bioretention w/Underdrain



Notes:

1. Scarify subgrade 3" min. before BSM installation
2. Compact BSM to 85% per ASTM 1577
3. Minimum 6" to discourage fines from entering the underdrain from the BSM. Maximum 12" to prevent unnecessary BMP depth from encroaching into the seasonal high ground water.
4. If depth to the seasonal high ground water allows, this distance may be larger.
5. When an underdrain is used, the design must ensure that the seasonal high ground water does not encroach into the BMP (including the mineral aggregate layer surrounding the underdrain pipe).

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Typical Bioretention w/Underdrain

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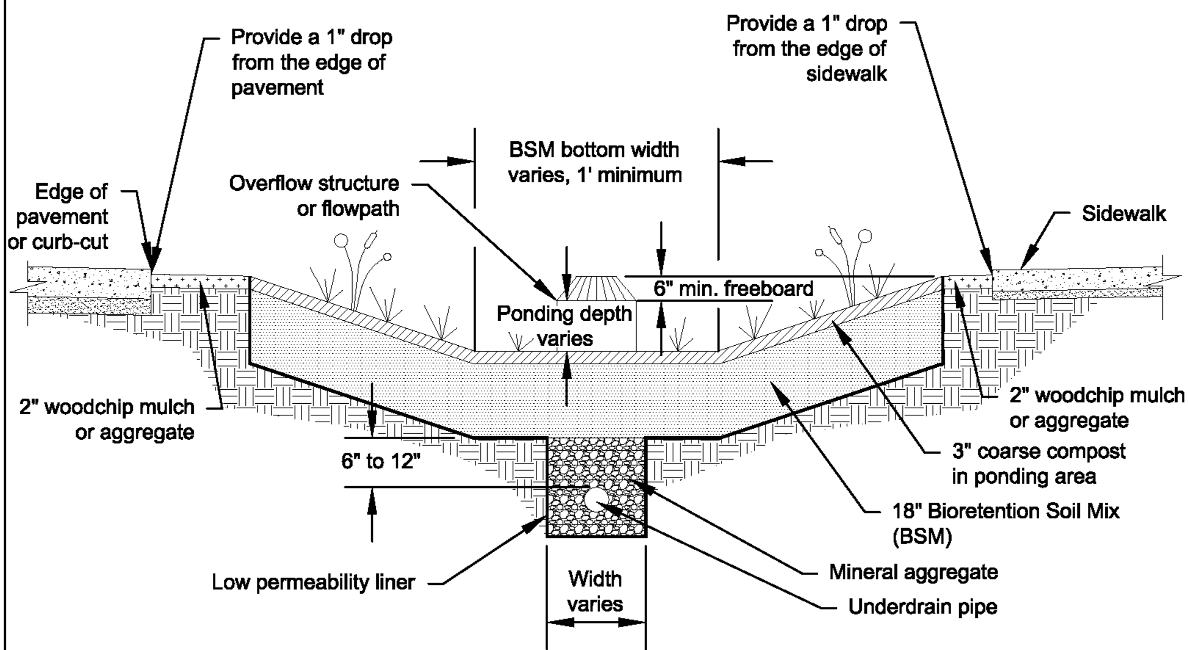
Figure V-5.14: Typical Bioretention w/Liner (Not LID)



Notes:

1. Scarify subgrade 3" min. before bioretention soil installation
2. Compact BSM to 85% per ASTM 1577

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Typical Bioretention w/Liner (Not LID)

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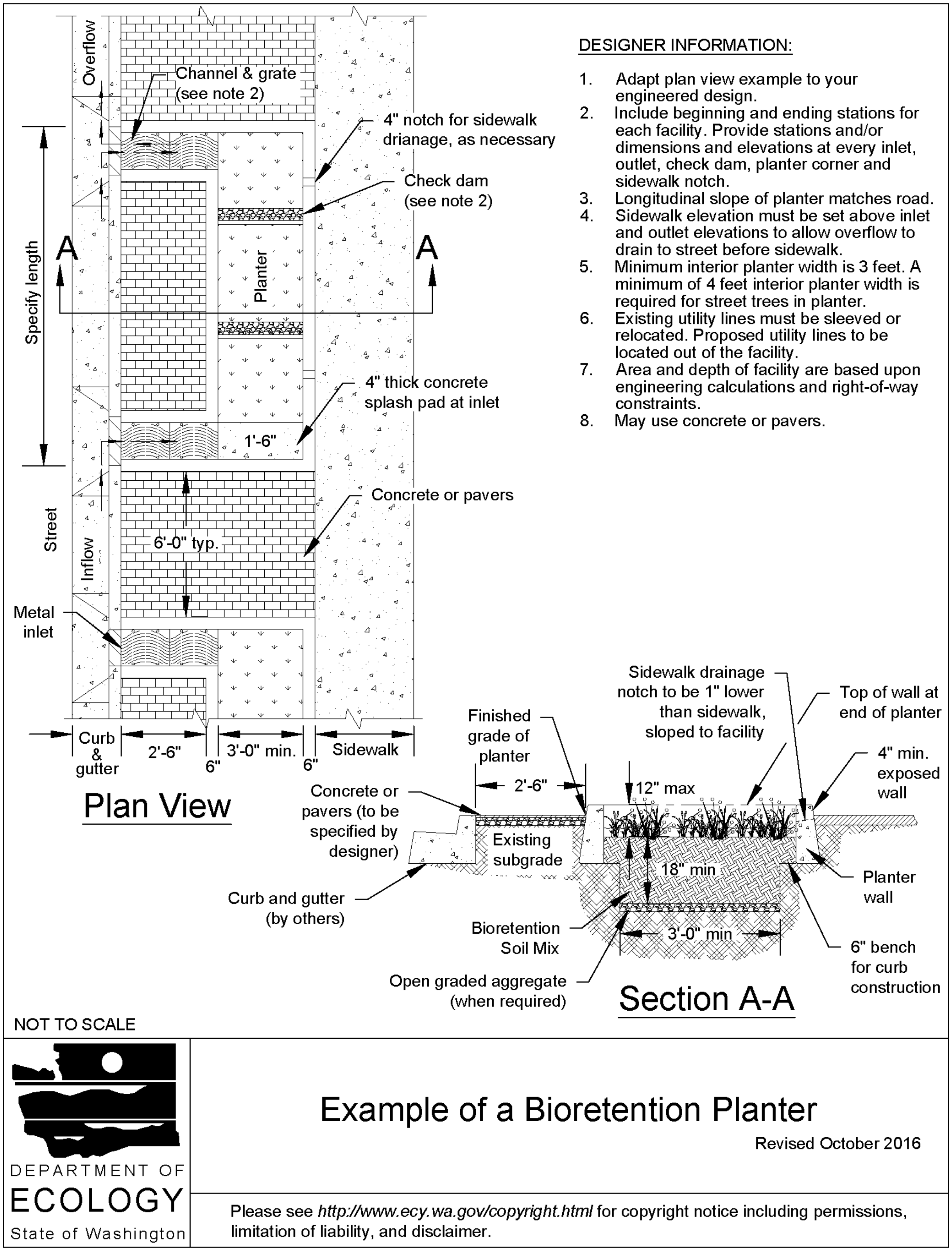
Figure V-5.15: Example of a Bioretention Planter



Applications and Limitations

Because bioretention BMPs use an imported soil mix that has a moderate design infiltration rate, they are best applied for small drainages, and near the source of the stormwater runoff. Bioretention cells may be scattered throughout a subdivision; a bioretention swale may run alongside the access road; or a series of bioretention planter boxes may serve the road. In these situations, they can but are not required to fully meet the requirement to treat 91% of the stormwater runoff file (the Water Quality Design Volume, as described in III-2.6 Sizing Your Runoff Treatment BMPs) from pollution-generating surfaces. The amount of stormwater that is predicted to pass through the bioretention soil mix is treated, and may be subtracted from the 91% volume that must be treated to meet I-3.4.6 MR6: Runoff Treatment. Downstream Runoff Treatment BMPs may be significantly smaller as a result.

Bioretention BMPs that infiltrate into the ground can also provide significant Flow Control. They can, but are not required to fully meet the Flow Control Performance Standard of I-3.4.7 MR7: Flow Control. Because they typically do not have an orifice restricting overflow or underflow discharge rates, they typically don't fully meet I-3.4.7 MR7: Flow Control. However, their performance contributes to meeting the standard, and that can result in much smaller additional Flow Control BMPs at the bottom of the project site. Bioretention can also help achieve compliance with the LID Performance Standard of I-3.4.5 MR5: On-Site Stormwater Management.

Bioretention constructed with imported composted material should not be used within one-quarter mile of phosphorus-sensitive waterbodies if the underlying native soil does not meet the criteria for Runoff Treatment per V-5.6 Site Suitability Criteria (SSC). Preliminary monitoring indicates that new bioretention BMPs can add phosphorus to stormwater. Therefore, they should also not be used with an underdrain when the underdrain water would be routed to a phosphorus-sensitive receiving water.

Applications with or without underdrains vary extensively and can be applied in new development, redevelopment and retrofits. Typical applications include:

- Individual lots for rooftop, driveway, and other on-lot impervious surfaces.
- Shared facilities located in common areas for individual lots.
- Areas within loop roads or cul-de-sacs.
- Landscaped parking lot islands.
- Within right-of-ways along roads (often linear bioretention swales or cells).
- Common landscaped areas in apartment complexes or other multifamily housing designs.
- Planters on building roofs, patios, and as part of streetscapes.

Infeasibility Criteria

The following infeasibility criteria describe conditions that make bioretention infeasible when applying The List Approach within I-3.4.5 MR5: On-Site Stormwater Management. If a project proponent wishes to use a bioretention BMP even though one of the infeasibility criteria within this section are met,, they may propose a functional design to the local government.

Criteria with setback distances are as measured from the bottom edge of the bioretention soil mix.

Any of the following circumstances allow the designer to determine bioretention as "infeasible" when applying the The List Approach within I-3.4.5 MR5: On-Site Stormwater Management:

- Citation of any of the following infeasibility criteria must be based on an evaluation of site-specific conditions and a written recommendation from an appropriate licensed professional (e.g., engineer, geologist, 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 ground water drains into an erosion hazard, or landslide hazard area.
  - Where the only area available for siting would threaten the safety or reliability of pre-existing underground utilities, pre-existing underground storage tanks, pre-existing structures, or pre-existing road or parking lot surfaces.
  - Where the only area available for siting does not allow for a safe overflow pathway to the municipal separate storm sewer system or private storm sewer system.
  - Where there is a lack of usable space for bioretention BMPs at re-development 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.
- The following infeasibility criteria are based on conditions such as topography and distances to predetermined boundaries. Citation of the following criteria do not need site-specific written recommendations from a licensed professional, although some may require professional services to determine:
  - Within setbacks from structures as established by the local government with jurisdiction.
  - Where they are not compatible with the surrounding drainage system as determined by the local government with jurisdiction (e.g., project drains to an existing stormwater collection system whose elevation or location precludes connection to a properly functioning bioretention BMP).
  - Where land for bioretention is within area designated as an erosion hazard or landslide hazard.
  - Where the site cannot be reasonably designed to locate bioretention BMPs on slopes less than 8%.
  - Within 50 feet from the top of slopes that are greater than 20% and over 10 feet of vertical relief.
  - For properties with known soil or ground water 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 ground water modeling indicates infiltration will likely increase or change the direction of the migration of pollutants in the ground water;
  - 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 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.
- Within 10 feet of small on-site sewage disposal drainfield, 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 1100 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 1100 gallons.
- Where the minimum vertical separation of 1 foot to the seasonal high water table, bedrock, or other impervious layer would not be achieved below bioretention that would serve a drainage area that is less than:
  1. 5,000 sq. ft. of pollution-generating impervious surface, and
  2. 10,000 sq. ft. of impervious surface, and
  3. three-quarter (3/4) acres of pervious surface.
- Where the minimum vertical separation of 3 feet to the seasonal high water table, bedrock, or other impervious layer would not be achieved below bioretention that would serve a drainage area that meets or exceeds:
  1. 5,000 sq. ft. of pollution-generating impervious surface, or
  2. 10,000 sq. ft. of impervious surface, or
  3. three-quarter (3/4) acres of pervious surface.

AND

cannot reasonably be broken down into amounts smaller than those listed in 1-3 (above).

  - Where the field testing indicates potential bioretention sites have a measured (a.k.a., initial) native soil saturated hydraulic conductivity less than 0.30 inches per hour.

    If the measured native soil infiltration rate is less than 0.30 in/hour, bioretention should not be used to meet the The List Approach of I-3.4.5 MR5: On-Site Stormwater Management. In these slow draining soils, a bioretention BMP with an underdrain may be used to treat pollution-generating surfaces to help meet I-3.4.6 MR6: Runoff Treatment. If the underdrain is elevated within a base course of gravel, the bioretention BMP will also provide some modest flow reduction benefit that will help achieve the LID Performance Standard within I-3.4.5 MR5: On-Site Stormwater Management and/or the Flow Control Performance Standard within I-3.4.7 MR7: Flow Control.

- A local government may designate geographic boundaries within which bioretention BMPs may be designated as infeasible due to year-round, seasonal or periodic high groundwater conditions, or due to inadequate infiltration rates. Designations must be based upon a preponderance of field data, collected within the area of concern, that indicate a high likelihood of failure to achieve the minimum ground water clearance or infiltration rates identified in the above infeasibility criteria. The local government must develop a technical report and make it available upon request to Ecology. The report must be authored by (a) professional(s) with appropriate expertise (e.g., registered engineer, geologist, hydrogeologist, or certified soil scientist), and document the location and the pertinent values/observations of data that were used to recommend the designation and boundaries for the geographic area. The types of pertinent data include, but are not limited to:

  - Standing water heights or evidence of recent saturated conditions in observation wells, test pits, test holes, and well logs.

  - Observations of areal extent and time of surface ponding, including local government or professional observations of high water tables, frequent or long durations of standing water, springs, wetlands, and/or frequent flooding.

  - Results of infiltration tests

- In addition, a local government can map areas that meet a specific infeasibility criterion listed above provided they have an adequate data basis. Criteria that are most amenable to mapping are:

  - Where land for bioretention is within an area designated by the local government as an erosion hazard, or landslide hazard

  - Within 50 feet from the top of slopes that are greater than 20% and over 10 feet vertical relief

  - Within 100 feet of a closed or active landfill

Design Criteria

General Design Criteria

- Utility conflicts: Consult local jurisdiction requirements for horizontal and vertical separation required for publicly-owned utilities, such as water and sewer. Consult the appropriate franchise utility owners for separation requirements from their utilities, which may include communications and gas. When separation requirements cannot be met, designs should include appropriate mitigation measures, such as impermeable liners over the utility, sleeving utilities, fixing known leaky joints or cracked conduits, and/or adding an underdrain to the bioretention.
- 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.
- Ponding depth and surface water draw-down: Flow Control needs, as well as location in the development, and mosquito breeding cycles will determine draw-down timing. For example, front yards and entrances to residential or commercial developments may require rapid surface dewatering for aesthetics. In no case shall draw down time exceed 48 hours.
- Impacts of surrounding activities: Human activity influences the location of the BMP in the development. For example, locate bioretention BMPs 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: Bioretention BMPs can be used to buffer structures from roads, enhance privacy among residences, and for an aesthetic site feature.
- Site growing characteristics and plant selection: Appropriate plants should be selected for sun exposure, soil moisture, and adjacent plant communities. Native species or hardy cultivars are recommended and can flourish in the properly designed and placed bioretention soil mix with no nutrient or pesticide inputs and 2-3 years irrigation for establishment. Invasive species and noxious weed control will be required as typical with all planted landscape areas.
- Project submission requirements: Submit the results of infiltration (K_{sat}) testing and ground water elevation testing (or other documentation and justification for the rates and hydraulic restriction layer clearances) with the Stormwater Site Plan as justification for the feasibility decision regarding bioretention and as justification for assumptions made in the runoff modeling.
- Legal documentation to track bioretention obligations: Where drainage plan submittals include assumptions with regard to size and location of bioretention BMPs, approval of the plat, short-plat, or building permit should identify the bioretention obligation of each lot; and the appropriate lots should have deed requirements for construction and maintenance of those BMPs
- Much of the design criteria within this BMP originated from the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012). Refer to that document for additional explanations and background.

Note that the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012) is for additional information purposes only. You must follow the guidance within this manual if there are any discrepancies between this manual and the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012).

- Geotechnical analysis is an important first step to develop an initial assessment of the variability of site soils, infiltration characteristics and the necessary frequency and depth of infiltration tests. See V-5.2 Infiltration BMP Design Steps.

Determining the Native Soil Infiltration Rates

Determining infiltration rates of the site soils is necessary to determine feasibility of designs that intend to infiltrate stormwater on-site. It is also necessary to estimate flow reduction benefits of such designs when using a continuous runoff model.

The certified soils professional or engineer can exercise discretion concerning the need for and extent of infiltration rate (saturated hydraulic conductivity, K_{sat}) testing. The professional can consider a reduction in the extent of infiltration (K_{sat}) testing if, in their judgment, information exists confirming that the site is unconsolidated outwash material with high infiltration rates, and there is adequate separation from ground water.

The following provides recommended tests for the soils underlying bioretention BMPs. The test should be run at the anticipated elevation of the top of the native soil beneath the bioretention BMP.

Refer to V-5.4 Determining the Design Infiltration Rate of the Native Soils for further guidance on the methods to determine the infiltration rate of the native soils.

- Small bioretention cells (bioretention BMPs made up of one or multiple cells that receive water from 1 or 2 individual lots or < 1/4 acre of pavement or other impervious surface) have the following options for determining the native soil infiltration rate:

    1. Small-scale pilot infiltration test (PIT) as described in V-5.4 Determining the Design Infiltration Rate of the Native Soils.

    2. If the site is underlain with soils not consolidated by glacial advance (e.g., recessional outwash soils), then the designer may use the grain size analysis method described in V-5.4 Determining the Design Infiltration Rate of the Native Soils based on the layer(s) identified in results of one soil test pit or boring.

- Large bioretention cells (bioretention BMPs made up of one or multiple cells that receive water from several lots or 1/4 acre or more of pavement or other impervious surface) have the following options for determining the native soil infiltration rate:

    1. Multiple small-scale or one large-scale PIT. If using the small-scale test, measurements should be taken at several locations within the area of interest.

    2. If the site is underlain with soils not consolidated by glacial advance (e.g., recessional outwash soils), then the designer may use the grain size analysis method described in V-5.4 Determining the Design Infiltration Rate of the Native Soils. Use the grain size analysis method based on more than one soil test pit or boring. The more test pit-

s/borings used, and the more evidence of consistency in the soils, the less of a correction factor may be used.

- Bioretention swales have the following options for determining the native soil infiltration rate:
  1. Approximately 1 small-scale PIT per 200 feet of swale, and within each length of road with significant differences in subsurface characteristics.
  2. If the site is underlain with soils not consolidated by glacial advance (e.g., recessional outwash soils), then the designer may use the grain size analysis method described in V-5.4 Determining the Design Infiltration Rate of the Native Soils. Approximately 1 soil test pit/boring per 200 feet of swale and within each length of road with significant differences in subsurface characteristics.
- On a single, smaller commercial property, one bioretention BMP will likely be appropriate. In that case, a small-scale PIT – or an alternative small scale test specified by the local government - should be performed at the proposed bioretention location. Tests at more than one site could reveal the advantages of one location over another.
- On larger commercial sites, a small-scale PIT every 5,000 sq. ft. is advisable. If soil characteristics across the site are consistent, a geotechnical professional may recommend a reduction in the number of tests.
- On multi-lot residential developments, multiple bioretention BMPs, or a BMP stretching over multiple properties are appropriate. In most cases, it is necessary to perform small-scale PITs, or other small-scale tests as allowed by the local jurisdiction. A test is advisable at each potential bioretention site. Long, narrow bioretention BMPs, such as one following the road right-of-way, should have a test location at least every 200 lineal feet, and within each length of road with significant differences in subsurface characteristics.

If the site subsurface characterization, including soil borings across the development site, indicate consistent soil characteristics and depths to seasonal high ground water conditions or a hydraulic restriction layer, the number of test locations may be reduced to a frequency recommended by a geotechnical professional.

After concluding an infiltration test, infiltration test sites should be over-excavated 3 feet below the projected bioretention BMP's bottom elevation unless minimum clearances to seasonal high ground water have or will be determined by another method. This overexcavation is to determine if there are restrictive layers or ground water. Observe whether water is infiltrating vertically or only spreading horizontally because of ground water or a restrictive soil layer. Observations through a wet season can identify a seasonal ground water restriction.

If a single bioretention BMP serves a drainage area exceeding 1 acre, a ground water mounding analysis may be necessary in accordance with V-5.2 Infiltration BMP Design Steps.

Assignment of Appropriate Correction Factors to the Native Soil

If the design requires determination of a long-term (design) infiltration rate of the native soils (for example, to demonstrate compliance with the LID Performance Standard and/or the Flow Control Performance Standard), refer to V-5.4 Determining the Design Infiltration Rate of the Native Soils and the following additional guidance specific to bioretention BMPs:

- The overlying bioretention soil mix provides excellent protection for the underlying native soil from sedimentation. Accordingly, when using The Simplified Approach to Calculating the Design Infiltration Rate of the Native Soils as described in V-5.4 Determining the Design Infiltration Rate of the Native Soils, the correction factor for the sub-grade soil does not have to take into consideration the extent of influent control and clogging over time. The correction factor to be applied to in-situ, small-scale infiltration test results for bioretention sites is determined by the site variability and number of locations tested as well as the method used to determine initial K_{sat}. Using Table V-5.1: Correction Factors to be Used With In-Situ Saturated Hydraulic Conductivity Measurements to Estimate Design Rates, the correction factor for bioretention design is revised based on this guidance as:

$$\text{Total Correction Factor, } CF_T = CF_V \times CF_t$$

- Tests should be located and be at an adequate frequency capable of producing a soil profile characterization that fully represents the infiltration capability where the bioretention areas are to be located. The partial correction factor CF_V depends on the level of uncertainty that variable subsurface conditions justify. If a pilot infiltration test is conducted for all bioretention areas or 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 may be adequate to justify a CF_V of one. If the level of uncertainty is high, a CF_V near the low end of the range may be appropriate. Two example scenarios where low CF_Vs may be appropriate include:
    - Site conditions are highly variable due to a deposit of ancient landslide debris, or buried stream channels. In these cases, even with many explorations and several pilot infiltration tests, the level of uncertainty may still be high.
    - Conditions are variable, but few explorations and only one pilot infiltration test is conducted. That is, the number of explorations and tests conducted do not match the degree of site variability anticipated.

Determining the Bioretention Soil Mix Design Infiltration Rate

1. Determine the initial saturated hydraulic conductivity (K_{sat}) based on the type of bioretention soil mix, as follows:
    - If using Ecology's default bioretention soil mix (detailed below), the initial K_{sat} is 12 inches per hour (30.48 cm/hr).
    - If using a custom bioretention soil mix (per the guidance for custom mixes below), use ASTM D 2434 Standard Test Method for Permeability of Granular Soils (Constant Head) with a compaction rate of 85 percent using ASTM D1557 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort. See the additional guidance below for specific procedures for conducting ASTM D 2434. The designer must enter the derived K_{sat} value into the continuous modeling software.
2. After determining the initial K_{sat}, determine the appropriate safety factor:
    - If the contributing area to the bioretention BMP is equal to or exceeds any of the following limitations:

    - 5,000 square feet of pollution-generating impervious surface;
    - 10,000 square feet of impervious surface;
    - ¾ acre of lawn and landscape,

    use 4 as the K_{sat} safety factor.

- If the contributing area is less than all of the above areas, or if the design includes a pre-treatment BMP for solids removal, use 2 as the K_{sat} safety factor.

3. The continuous runoff model has a field for entering K_{sat} and the appropriate safety factor.

Recommended Modifications to ASTM D 2434 When Measuring Hydraulic Conductivity for Bioretention Soil Mixes

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) into1/2 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).

Default Bioretention Soil Mix (BSM)

Projects which use the following requirements for the bioretention soil mix do not have to test the mix for its saturated hydraulic conductivity (K_{sat}). See Determining the Bioretention Soil Mix Design Infiltration Rate.

Mineral Aggregate for Default BSM

Percent Fines: A range of 2 to 4 percent passing the #200 sieve is ideal and fines should not be above 5 percent for a proper functioning specification according to ASTM D422.

Aggregate Gradation for Default BSM

The aggregate portion of the BSM should be well-graded. According to ASTM D 2487-98 (Classification of Soils for Engineering Purposes (Unified Soil Classification System)), well-graded sand should have the following gradation coefficients:

- Coefficient of Uniformity ($C_u = D_{60}/D_{10}$) equal to or greater than 4, and
- Coefficient of Curve ($C_c = (D_{30})^2/D_{60} \times D_{10}$) greater than or equal to 1 and less than or equal to 3.

Table V-5.2: General Guideline for Mineral Aggregate Gradation provides a gradation guideline for the aggregate component of the default bioretention soil mix (Hinman, 2009). The sand gradation below is often supplied as a well-graded utility or screened. With compost this blend provides enough fines for adequate water retention, hydraulic conductivity within recommended range (see below), pollutant removal capability, and plant growth characteristics for meeting design guidelines and objectives.

Table V-5.2: General Guideline for Mineral Aggregate Gradation

Sieve Size	Percent Passing
3/8"	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

Where existing soils meet the above aggregate gradation, those soils may be amended rather than importing mineral aggregate.

Compost to Aggregate Ratio, Organic Matter Content, and Cation Exchange Capacity for Default BSM

- Compost to aggregate ratio: 60-65 percent mineral aggregate, 35 – 40 percent compost by volume.
- Organic matter content: 5 – 8 percent by weight.
- Cation Exchange Capacity (CEC) must be > 5 milliequivalents/100 g dry soil Note: Soil mixes meeting the above specifications do not have to be tested for CEC. They will readily meet the minimum CEC.

Compost for Default BSM

To ensure that the BSM will support healthy plant growth and root development, contribute to biofiltration of pollutants, and not restrict infiltration when used in the proportions cited herein, the following compost standards are required.

- 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 composting facility that is permitted by the jurisdictional health authority. Permitted compost facilities in Washington are included in a spreadsheet titled *Washington composting facilities and material types – 2017* at the following web address:

  https://ecology.wa.gov/Waste-Toxics/Reducing-recycling-waste/Organic-materials/Managing-organics-compost
- The compost product must originate a minimum of 65 percent by volume from recycled plant waste comprised of ”yard debris,” “crop residues,” and “bulking agents” as those terms are defined in WAC 173-350-100. A maximum of 35 percent by volume of “post-consumer food waste” as defined in WAC 173-350-100, but not including biosolids or manure, may be substituted for recycled plant waste.
- Stable (low oxygen use and CO_2 generation) and mature (capable of supporting plant

growth) by tests shown below. This is critical to plant success in bioretention soil mixes.

- Moisture content range: no visible free water or dust produced when handling the material.
- Tested in accordance with the 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.
- Screened to the following size gradations for Fine Compost when tested in accordance with TMECC test method 02.02-B, Sample Sieving for Aggregate Size Classification."

  Fine Compost shall meet the following gradation by dry weight

  Minimum percent passing 2": 100%

  Minimum percent passing 1": 99%

  Minimum percent passing 5/8": 90%

  Minimum percent passing ¼": 75%
- pH between 6.0 and 8.5 (TMECC 04.11-A). "Physical contaminants" (as defined in WAC 173-350-100) content less that 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 (TMECC 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 plantings 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).

Custom Bioretention Soil Mix

Projects which prefer to create a custom bioretention soil mix rather than using the default bioretention soil mix described 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 (K_{sat}) of less than 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 Method s for Laboratory Compaction Characteristics of Soil Using Modified Effort). Also, use Recommended Modifications to ASTM D 2434 When Measuring Hydraulic Conductivity for Bioretention Soil Mixes (as detailed above).
- 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 explained above under Determining the Bioretention Soil Mix Design Infiltration Rate.
- If compost is used in creating the custom bioretention soil mix, it must meet all of the specifications listed above in Compost for Default BSM, except for the gradation specification. An alternative gradation specification must indicate the minimum percent passing for a range of similar particle sizes.

Flow Entrance and Presettling

Flow entrance design will depend on topography, flow velocities and volume entering the pre-treatment and bioretention area, adjacent land use and site constraints. Flow velocities entering bioretention should be less than 1.0 ft/second to minimize erosion potential. Flow entrances should be placed with adequate separation from outlets to ensure that the influent stormwater is treated prior to reaching the overflow. Five primary types of flow entrances can be used for bioretention:

- *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 bioretention. Dispersed flow may not be possible given space limitations or if the BMP is controlling roadway or parking lot flows where curbs are mandatory.
- *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 should include a rock pad, concrete or other erosion protection material in the channel entrance to dissipate energy. Minimum curb cut width should be 12 inches; however, 18 inches is recommended. The designer should calculate the size and choose the style of curb cut that is appropriate for the site conditions and runoff expectations. Avoid the use of angular rock or quarry spalls and instead use round (river) rock if needed. Removing sediment from angular rock is difficult. The flow entrance should slope steeply (at least 1:1) from the curb line to the bioretention, dropping at least 3", and provide an area for settling and periodic removal of sediment and coarse material before flow dissipates to the remainder of the bioretention area.

  Curb cuts used for bioretention areas in high use parking lots or roadways require an increased level of maintenance due to high coarse particulates and trash accumulation in the flow entrance and associated bypass of flows. The following are methods recommended for areas where heavy trash and coarse particulates are anticipated:

  - Curb cut width: 18 inches.
  - At a minimum the flow entrance should drop 2 to 3 inches from the 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.
  - 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 should include rock or other erosion protection material in the channel entrance to dissipate energy and disperse flow.
- *Catch basin:* In some locations where road sanding or higher than usual sediment inputs are anticipated, catch basins can be used to settle sediment and release water to the bioretention area through a grate for filtering coarse material.
- *Trench drains:* 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.

Woody plants can restrict or concentrate flows and can be damaged by erosion around the root ball and should not be placed directly in the bioretention entrance flow path.

Bottom Area and Side Slopes

Bioretention areas are highly adaptable and can fit various settings such as rural and urban roadsides, ultra urban streetscapes and parking lots by adjusting bottom area and side slope configuration. Recommended maximum and minimum dimensions include:

- 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 effective design options. Local jurisdictions may require 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.
- Minimum bottom width for bioretention swales: 2 feet recommended and 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 at bottom widths less than 2 feet.
- Bioretention areas should have a minimum shoulder of 12 inches (30.5 cm) between the road edge and beginning of the bioretention side slope where flush curbs are used. Compaction effort for the shoulder should 90 percent proctor.

Ponding Area

Ponding depth recommendations:

- Maximum ponding depth: 12 inches (30.5 cm).
- Surface pool drawdown time: 24 hours

For design on projects subject to I-3.4.5 MR5: On-Site Stormwater Management, and choosing to use The List Approach of that requirement, the bioretention BMP shall have a horizontally projected surface area below the overflow which is at least 5% of the area draining to it.

The ponding area provides surface storage for storm flows, particulate settling, and the first stages of pollutant treatment within the bioretention BMP. Pool depth and draw-down rate are recommended to provide surface storage, adequate infiltration capability, and soil moisture conditions that allow for a range of appropriate plant species. Soils must be allowed to 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; provide proper soil conditions for biodegradation and retention of pollutants. Maximum designed depth of ponding (before surface overflow to a pipe or ditch) must be considered in light of drawdown time.

For bioretention areas with underdrains, elevating the drain to create a temporary saturated zone beneath the drain is advised to promote denitrification (conversion of nitrate to nitrogen gas) and prolong moist soil conditions for plant survival during dry periods (see the Underdrain (optional) section below for details).

Surface Overflow

Surface overflow can be provided by vertical stand pipes that are connected to underdrain systems, by horizontal drainage pipes or armored overflow channels installed at the designed maximum ponding elevations. Overflow can also be provided by a curb cut at the down-gradient end of the bioretention area to direct overflows back to the street. Overflow conveyance structures are necessary for all bioretention BMPs to safely convey flows that exceed the capacity of the BMP and to protect downstream natural resources and property.

The minimum freeboard from the invert of the overflow stand pipe, horizontal drainage pipe or earthen channel should be 6 inches unless otherwise specified by the local jurisdiction’s design standards.

Soil Depth

The bioretention soil mix depth must be 18 inches to provide Runoff Treatment and good growing conditions for selected plants. Ecology does not recommend bioretention soil mix depths greater than 18 inches due to preliminary monitoring results indicating that phosphorus can leach from the bioretention soil mix.

Filter Fabrics

Do not use filter fabrics between the subgrade and the bioretention soil mix. The gradation between existing soils and bioretention soil mix is not great enough to allow significant migration of fines into the bioretention soil mix. Additionally, filter fabrics may clog with downward migration of fines from the bioretention soil mix.

Underdrain (optional)

Where the underlying native soils have a measured initial K_{sat} between 0.3 and 0.6 inches per hour, bioretention BMPs without an underdrain, or with an elevated underdrain directed to a surface outlet, may be used to satisfy The List Approach of I-3.4.5 MR5: On-Site Stormwater Management. Underdrained bioretention BMPs must meet the following criteria if they are used to satisfy The List Approach of I-3.4.5 MR5: On-Site Stormwater Management:

- the invert of the underdrain must be elevated 6 inches above the bottom of the aggregate bedding layer. A larger distance between the underdrain and bottom of the bedding layer is desirable, but cannot be used to trigger infeasibility due to inadequate vertical separation to the seasonal high water table, bedrock, or other impermeable layer.
- the distance between the bottom of the bioretention soil mix and the crown of the underdrain pipe must be not less than 6 but not more than 12 inches;
- the aggregate bedding layer must run the full length and the full width of the bottom of the bioretention BMP;
- the BMP must not be underlain by a low permeability liner that prevents infiltration into the native soil.

Figure V-5.13: Typical Bioretention w/Underdrain depicts a bioretention BMP with an elevated underdrain. Figure V-5.14: Typical Bioretention w/Liner (Not LID) depicts a bioretention BMP with an underdrain and a low permeability liner. The latter is not considered a low impact development BMP. It cannot be used to implement The List Approach of I-3.4.5 MR5: On-Site Stormwater Management.

The volume above an underdrain pipe in a bioretention BMP provides pollutant filtering and minor detention. However, only the void volume of the aggregate below the underdrain invert and above the bottom of the bioretention BMP (subgrade) can be used in the continuous runoff model for dead storage volume that provides Flow Control benefit. Assume a 40% void volume for the Type 26 mineral aggregate specified below.

Underdrain systems should only be installed when the bioretention BMP is:

- Located near sensitive infrastructure (e.g., unsealed basements) and potential for flooding is likely.
- Used for filtering storm flows from gas stations or other pollutant hotspots (requires impermeable liner).
- Located above native soils with infiltration rates that are not adequate to meet maximum pool and system dewater rates, or are below a minimum rate allowed by the local government.

The underdrain can be connected to a downstream bioretention swale, to another bioretention cell as part of a connected treatment system, daylight to a dispersion area using an effective flow dispersion practice, or to a storm drain.

Underdrain Pipe

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 Aggregate Filter and Bedding Layer below) to prevent migration of the material into the drain. This configuration allows for pressurized water cleaning and root cutting if necessary.

Underdrain pipe recommendations:

- Minimum pipe diameter: 4 inches (pipe diameter will depend on hydraulic capacity required, 4 to 8 inches is common).
- Slotted subsurface drain PVC per ASTM D1785 SCH 40.
- Slots should 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 four rows spaced on 45-degree centers and cover ½ of the circumference of the pipe. See Underdrain Aggregate Filter and Bedding Layer (below) for aggregate gradation appropriate for this slot size.
- Underdrains should be sloped at a minimum of 0.5 percent unless otherwise specified by an engineer.

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. A 6-inch rigid non-perforated observation pipe or other maintenance access should be connected to the underdrain every 250 to 300 feet to provide a clean-out port, as well as an observation well to monitor dewatering rates.

Underdrain Aggregate Filter and Bedding Layer

Aggregate filter and bedding layers buffer the underdrain system from sediment input and clogging. When properly selected for the soil gradation, geosynthetic filter fabrics can provide adequate protection from the migration of fines. However, aggregate filter and bedding layers, with proper gradations, provide a larger surface area for protecting underdrains and are preferred.

Table V-5.3: Mineral Aggregate Gradation for Underdrain Filter and Bedding Layer

Sieve size	Percent Passing
¾ inch	100
¼ inch	30-60
US No. 8	20-50
US No. 50	3-12
US No. 200	0-1
Note: The above gradation is a Type 26 mineral aggregate as detailed for gravel backfill for drains in the *City of Seattle Standard Specifications for Road, Bridge, and Municipal Construction* (Seattle Public Utilities, 2014).	

- Place the underdrain pipe on a bed of the Type 26 aggregate with a minimum thickness of 6 inches and cover with Type 26 aggregate to provide a 1-foot minimum depth around the top and sides of the slotted pipe. See the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012).

Orifice and Other Flow Control sStructures

The minimum orifice diameter should be 0.5 inches to minimize clogging and maintenance requirements.

Check Dams and Weirs

Check dams are 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* (Hinman and Wulkan, 2012) for displays of typical designs.

UIC Discharge

Stormwater that has passed through the bioretention soil mix may also discharge to a gravel-filled dug or drilled drain. Underground Injection Control (UIC) regulations are applicable and must be followed (Chapter 173-218 WAC). See I-4 UIC Program.

Hydraulic Restriction Layers:

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 necessary. See V-1.3.3 Low Permeability Liners for guidelines.
- Geomembrane liners completely block infiltration to subgrade soils and are used for ground water protection when bioretention BMPs are installed to filter storm flows from pollutant hotspots or on sidewalls of bioretention areas to restrict lateral flows to roadbeds or other sensitive infrastructure. Where geomembrane liners are used to line the entire BMP, underdrain systems are necessary. See V-1.3.3 Low Permeability Liners for guidelines.

Plant Materials

In general, the predominant plant material utilized in bioretention areas are species adapted to stresses associated with wet and dry conditions. Soil moisture conditions will vary within the facility from saturated (bottom of cell) to relatively dry (rim of cell). Accordingly, wetland plants may be used in the lower areas, if saturated soil conditions exist for appropriate periods, and drought-tolerant species planted on the perimeter of the facility or on mounded areas. See the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012) for additional guidance and recommended plant species. See also City of Seattle's ROW bioretention plant lists found in Seattle's GSI Manual, Appendix G, at the following web address:

https://www.seattle.gov/util/cs/groups/public/@spu/@engineering/documents/webcontent/1_079167.pdf

The side slopes for the bioretention facility (vertical or sloped) can affect the plant selection and must be considered. Additionally, trees can be planted along the side slopes or bottom of bioretention cells that are unlined.

Mulch Layer

You can design bioretention areas with or without a mulch layer. When used, mulch shall be:

- Medium compost in the bottom of the BMP (compost is less likely to float during cell inundation). Compost shall not include biosolids or manures.
- Shredded or chipped hardwood or softwood on side slopes above ponding elevation and rim area. Arborist mulch is mostly woody trimmings from trees and shrubs and is a good source of mulch material. Wood chip operations are a good source for mulch material that has more control of size distribution and consistency. Do not use shredded construction wood debris or any shredded wood to which preservatives have been added.
- Free of weed seeds, soil, roots and other material that is not bole or branch wood and bark.
- A maximum of 2 to 3 inches thick.

Mulch shall **not** be:

- Grass clippings (decomposing grass clippings are a source of nitrogen and are not recommended for mulch in bioretention areas).
- Pure bark (bark is essentially sterile and inhibits plant establishment).

In bioretention areas where higher flow velocities are anticipated, an aggregate mulch may be used to dissipate flow energy and protect underlying bioretention soil mix. Aggregate mulch varies in size and type, but 1 to 1 1/2 inch gravel (rounded) decorative rock is typical.

Runoff Model Representation

Note that if the project is using bioretention to only meet The List Approach within I-3.4.5 MR5: On-Site Stormwater Management, there is no need to model the bioretention in a continuous runoff model. Size the bioretention as described above in Ponding Area.

The guidance below is to show compliance with the LID Performance Standard in I-3.4.5 MR5: On-Site Stormwater Management, or the standards in I-3.4.6 MR6: Runoff Treatment, I-3.4.7 MR7: Flow Control, and/or I-3.4.8 MR8: Wetlands Protection.

Continuous runoff modeling software include modeling elements for bioretention.

The equations used by the elements are intended to simulate the wetting and drying of soil as well as how the soils function once they are saturated. This group of LID elements uses the modified Green

Ampt equation to compute the surface infiltration into the amended soil. The water then moves through the top amended soil layer at the computed rate, determined by Darcy's and Van Genuchten's equations. As the soil approaches field capacity (i.e., gravity head is greater than matric head), the model determines when water will begin to infiltrate into the second soil layer (lower layer). This occurs when the matric head is less than the gravity head in the first layer (top layer). The second layer is intended to prevent loss of the amended soil layer. As the second layer approaches field capacity, the water begins to move into the third layer – the gravel underlayer. For each layer, the user inputs the depth of the layer and the type of soil.

Within the WWHM continuous runoff model, for the Ecology-recommended soil specifications for each layer in the design criteria for bioretention, the model will automatically assign pre-determined appropriate values for parameters that determine water movement through that soil. These include: wilting point, minimum hydraulic conductivity, maximum saturated hydraulic conductivity, and the Van Genuchten number.

For bioretention with underlying perforated drain pipes that discharge to the surface, the only volume available for storage (and modeled as storage as explained herein) is the void space within the aggregate bedding layer below the invert of the drain pipe. Use 40% void space for the Type 26 mineral aggregate specified in Underdrain (optional) (above).

Modeling:

It is preferable to enter each bioretention device and its drainage area into the approved computer models for estimating their performance.

However, where site layouts involve multiple bioretention facilities, the modeling schematic can become extremely complicated or not accommodated by the available schematic grid.

In those cases, multiple bioretention facilities with similar designs (i.e., soil depth, ponding depth, freeboard height, and drainage area to ponding area ratio), and infiltration rates (Ecology suggests within a factor of 2) may have their drainage areas and ponded areas be combined, and represented in the runoff model as one drainage area and one bioretention device. In this case, use a weighted average of the design infiltration rates at each location. The averages are weighted by the size of their drainage areas.

For bioretention with slide slopes of 3H:1V or flatter, infiltration through the side slope areas can be significant. Where side slopes are 3H:1V or flatter, bioretention can be modeled allowing infiltration through the side slope areas to the native soil. In WWHM, modeling of infiltration through the side slope areas is accomplished by switching the default setting for "Use Wetted Surface Area (sidewalls): from "NO" to "YES."

Installation Criteria

Excavation

Soil compaction can lead to bioretention BMP failure; accordingly, minimizing compaction of the base and sidewalls of the bioretention area is critical. Excavation should never be allowed during wet or saturated conditions (compaction can reach depths of 2-3 feet during wet conditions and mitigation is likely to not be possible). Excavation should be performed by machinery operating adjacent to the bioretention BMP, and no heavy equipment with narrow tracks, narrow tires, or large lugged, high pressure tires should be allowed on the bottom of the bioretention BMP. If machinery must operate in the bioretention area for excavation, use light weight, low ground-contact pressure equipment and rip the base at completion to refracture soil to a minimum of 12 inches. If machinery operates in the BMP footprint, subgrade infiltration rates must be field tested and compared to initial K_{sat} tests obtained during design. Failure to meet or exceed the initial K_{sat} tests will require revised engineering designs to verify achievement of Runoff Treatment and Flow Control benefits that were estimated in the Stormwater Site Plan.

Prior to placement of the bioretention soil mix, the finished subgrade shall:

- Be scarified to a minimum depth of 3 inches.
- Have any sediment deposited from construction runoff removed. To remove all introduced sediment, subgrade soil should be removed to a depth of 3-6 inches and replaced with bioretention soil mix.
- Be inspected by the responsible engineer to verify required subgrade condition.

Sidewalls of the BMP, beneath the surface of the bioretention soil mix, can be vertical if soil stability is adequate. Exposed sidewalls of the completed bioretention area with bioretention soil mix in place should be no steeper than 3H:1V. The bottom of the BMP should be flat.

Soil Placement

On-site soil mixing or placement shall not be performed if bioretention soil mix or subgrade soil is saturated. The bioretention soil mix should be placed and graded by machinery operating adjacent to the bioretention BMP. If machinery must operate in the bioretention cell for soil placement, use light weight equipment with low ground-contact pressure. If machinery operates in the BMP footprint, subgrade infiltration rates must be field tested and compared to initial K_{sat} tests obtained during design. Failure to meet or exceed the initial K_{sat} tests will require revised engineering designs to verify achievement of Runoff Treatment and Flow Control benefits that were estimated in the Stormwater Site Plan.

The soil mixture shall be placed in horizontal layers not to exceed 6 inches per lift for the entire area of the bioretention BMP.

Compact the bioretention soil mix to a relative compaction of 85 percent of modified maximum dry density (ASTM D 1557). Compaction can be achieved by boot packing (simply walking over all areas of each lift), and then apply 0.2 inches (0.5 cm) of water per 1 inch (2.5 cm) of bioretention soil mix depth. Water for settling should be applied by spraying or sprinkling.

Temporary Erosion and Sediment Control (TESC)

Controlling erosion and sediment are most difficult during clearing, grading, and construction; accordingly, minimizing site disturbance to the greatest extent practicable is the most effective sediment management. During construction:

- Bioretention BMPs should not be used as sediment control BMPs, and all drainage should be directed away from bioretention BMPs after initial rough grading. Flow can be directed away from the BMP with temporary diversion swales or other approved protection. If introduction of construction runoff cannot be avoided see below for guidelines.

- Construction on bioretention BMPs should not begin until all contributing drainage areas are stabilized according to erosion and sediment control BMPs and to the satisfaction of the engineer.
- If the design includes curb and gutter, the curb cuts and inlets should be blocked until bioretention soil mix and mulch have been placed and planting completed (when possible), and dispersion pads are in place.

Every effort during design, construction sequencing and construction should be made to prevent sediment from entering bioretention BMPs. However, bioretention areas are often distributed throughout the project area and can present unique challenges during construction. See the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012) for guidelines if no other options exist and runoff during construction must be directed through the bioretention BMPs.

Erosion and sediment control practices must be inspected and maintained on a regular basis.

Verification

If using the default bioretention soil mix, pre-placement laboratory analysis for saturated hydraulic conductivity of the bioretention soil mix is not required. Verification of the mineral aggregate gradation, compliance with the compost specifications, and the mix ratio must be provided.

If using a custom bioretention soil mix, 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 bioretention soil mix 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 (or other small-scale testing allowed by the local government with jurisdiction). If using the PIT method, do not excavate the bioretention soil mix (conduct the test at the elevation of the finished bioretention soil mix), use a maximum of 6 inch ponding depth and conduct the test before plants are installed.

Maintenance

Bioretention areas require annual plant, soil, and mulch layer maintenance to ensure optimum infiltration, storage, and pollutant removal capabilities. In general, bioretention maintenance requirements are typical landscape care procedures and include:

- Watering: Plants should be selected to be drought tolerant and not require watering after establishment (2 to 3 years). Watering may be required during prolonged dry periods after plants are established.
- Erosion control: Inspect flow entrances, ponding area, and surface overflow areas periodically, and replace soil, plant material, and/or mulch layer in areas if erosion has occurred.

Properly designed BMPs with appropriate flow velocities should not have erosion problems except perhaps in extreme events. If erosion problems occur, the following should be reassessed: (1) flow volumes from contributing areas and bioretention cell sizing; (2) flow velocities and gradients within the cell; and (3) flow dissipation and erosion protection strategies in the pretreatment area and flow entrance. If sediment is deposited in the bioretention area, immediately determine the source within the contributing area, stabilize, and remove excess surface deposits.

- Sediment removal: Follow the maintenance plan schedule for visual inspection and remove sediment if the volume of the ponding area has been compromised.
- Plant material: Depending on aesthetic requirements, occasional pruning and removing dead plant material may be necessary. Replace all dead plants and if specific plants have a high mortality rate, assess the cause and replace with appropriate species. Periodic weeding is necessary until plants are established.
- Weeding: Invasive or nuisance plants should be removed regularly and not allowed to accumulate and exclude planted species. At a minimum, schedule weeding with inspections to coincide with important horticultural cycles (e.g., prior to major weed varieties dispersing seeds). Weeding should be done manually and without herbicide applications. The weeding schedule should become less frequent if the appropriate plant species and planting density are used and the selected plants grow to capture the site and exclude undesirable weeds.
- Nutrient and pesticides: The soil mix and plants are selected for optimum fertility, plant establishment, and growth. Nutrient and pesticide inputs should not be required and may degrade the pollutant processing capability of the bioretention area, as well as contribute pollutant loads to receiving waters. By design, bioretention BMPs are located in areas where phosphorous and nitrogen levels may be elevated and these should not be limiting nutrients. If in question, have soil analyzed for fertility.
- Mulch: Replace mulch annually in bioretention BMPs where heavy metal deposition is high (e.g., contributing areas that include gas stations, ports and roads with high traffic loads). In residential settings or other areas where metals or other pollutant loads are not anticipated to be high, replace or add mulch as needed (likely 3 to 5 years) to maintain a 2 to 3 inch depth.
- Soil: Soil mixes for bioretention BMPs are designed to maintain long-term fertility and pollutant processing capability. Estimates from metal attenuation research suggest that metal accumulation should not present an environmental concern for at least 20 years in bioretention systems, but this will vary according to pollutant load. Replacing mulch media in bioretention BMPs where heavy metal deposition is likely provides an additional level of protection for prolonged performance. If in question, have soil analyzed for fertility and pollutant levels.

Refer to Appendix V-A: BMP Maintenance Tables for additional maintenance guidelines.

BMP T7.50: Drywells

This section covers design and maintenance criteria specific for drywells. Drywells are subject to UIC regulations; see I-4 UIC Program.

Drywells are subsurface concrete structures, typically precast, that convey stormwater runoff into the soil matrix. They can be used as standalone structures, or as part of a larger drainage system (i.e., the overflow for a biofiltration swale).

General Criteria

Figure V-5.16: Typical Infiltration Drywell – Type 1 and Figure V-5.17: Typical Infiltration Drywell – Type 2 show typical infiltration drywell systems. These systems are designed as specified below. The following general requirements apply to design of drywells. Check with the local jurisdiction for outflow capacity or other local requirements:

- Drywell bottoms should be a minimum of 5 feet above seasonal high groundwater level or impermeable soil layers. Refer to V-5.6 Site Suitability Criteria (SSC).
- Drywells are typically a minimum of 48 inches in diameter and approximately 5 to 10 feet deep, or more.
- Filter fabric (geotextile) may need to be placed on top of the drain rock and on trench or drywell sides prior to backfilling to prevent migration of fines into the drain rock, depending on local soil conditions and local jurisdiction requirements.
- Drywells should be no closer than 30 feet center to center or twice the depth, whichever is greater.
- Drywells should not be built on slopes greater than 25% (4:1).
- Drywells may not be placed on or above a landslide hazard area or slopes greater than 15% without evaluation by a licensed engineer in the state of Washington with geotechnical expertise or licensed geologist and jurisdiction approval.

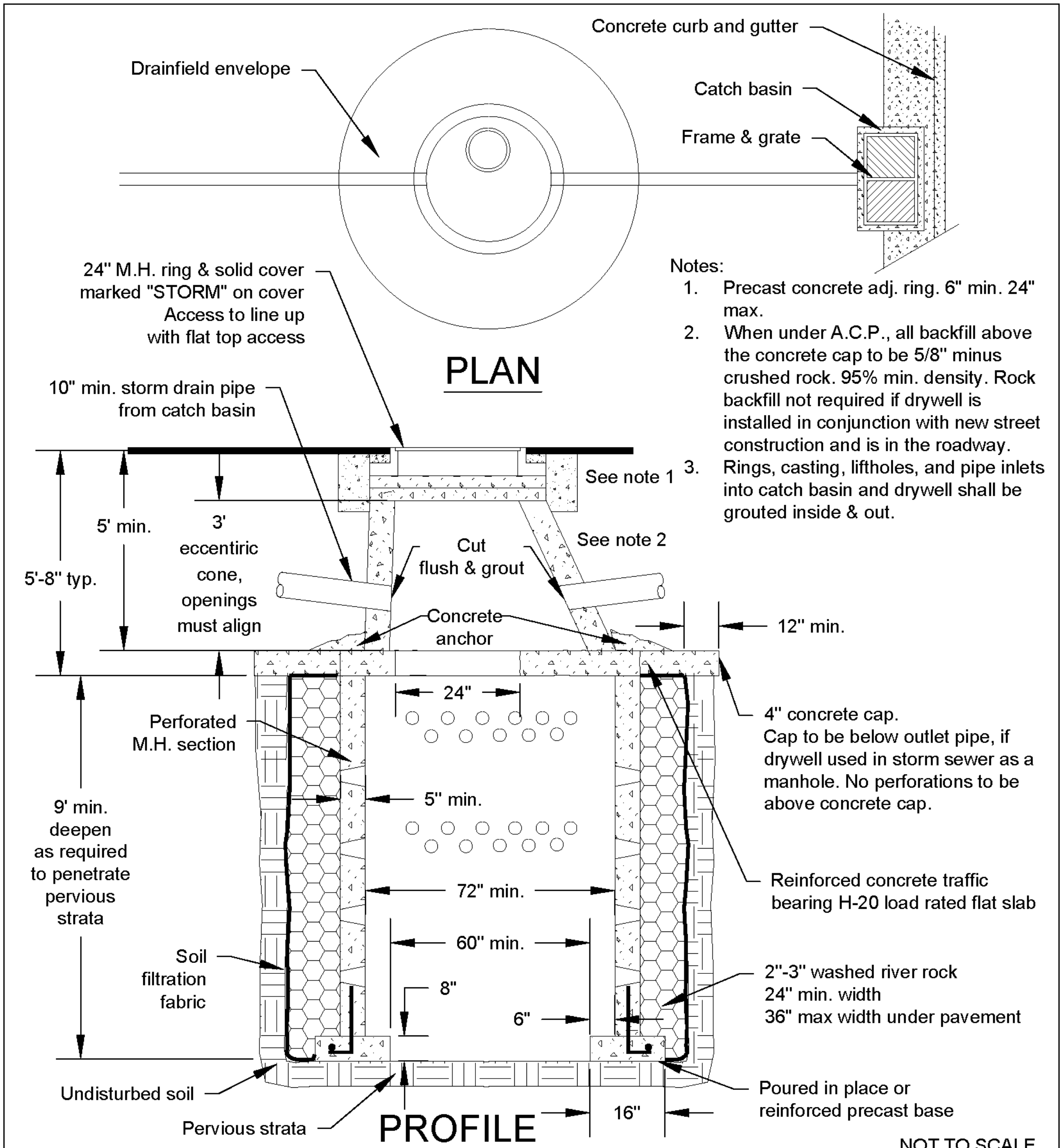
Design Procedure

See V-5.2 Infiltration BMP Design Steps.

Operation and Maintenance Criteria

Remove debris and sediment from the drywell grate on a semi-annual basis, or as required to prevent the buildup of materials that could inhibit infiltration. See Appendix V-A: BMP Maintenance Tables for additional maintenance recommendations for drywells.

Figure V-5.16: Typical Infiltration Drywell – Type 1



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Typical Infiltration Drywell
Type 1

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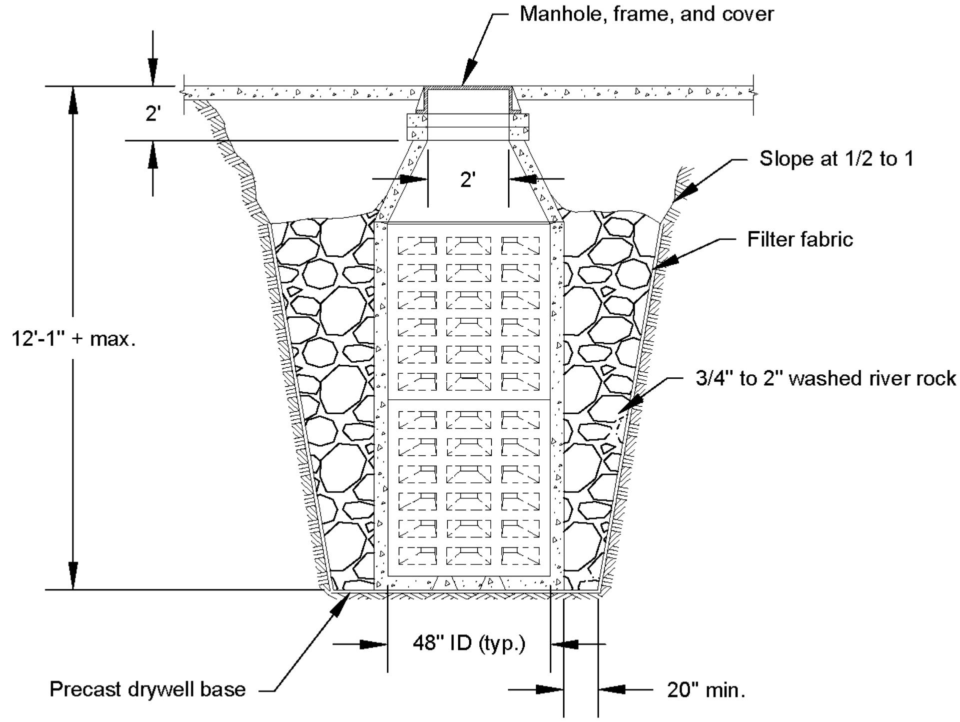
Figure V-5.17: Typical Infiltration Drywell – Type 2



Notes:

1. Backfill above filter fabric to base of asphalt with crushed surfacing base course.

2. Size and spacing of drywells determined by drainage analysis.

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Typical Infiltration Drywell
Type 2

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V-6 Filtration BMPs

V-6.1 Introduction to Filtration BMPs

Filtration BMPs collect and treat stormwater runoff to remove total suspended solids (TSS), phosphorous, and insoluble organics (including oils).

Sand Filtration

A typical sand filtration system consists of a pretreatment system, flow spreader(s), sand bed, and underdrain piping. The sand filter bed includes a geotextile fabric between the sand bed and the bottom underdrain system.

Provide an impermeable liner under the facility if the filtered runoff requires additional treatment to remove soluble ground water pollutants; or where additional ground water protection is mandated.

The variations of a sand filter include BMP T8.10: Basic Sand Filter Basin, BMP T8.11: Large Sand Filter Basin, BMP T8.20: Sand Filter Vault, and BMP T8.30: Linear Sand Filter.

Filtration with Media Filter Drains

The Media Filter Drain (MFD) has four basic components: a gravel no-vegetation zone, a grass strip, the MFD mix bed, and a conveyance system for flows leaving the MFD mix. The MFD mix is composed of gravel, perlite, dolomite, and gypsum. See BMP T8.40: Media Filter Drain.

Applications and Limitations

Filtration BMPs can be used in most residential, commercial, and industrial developments where debris, heavy sediment loads, and oils and greases will not clog or prematurely overload the sand, or where adequate pretreatment is provided for these pollutants. Specific applications include residential subdivisions, parking lots for commercial and industrial establishments, gas stations, sites that require oil control BMPs per III-1.2 Choosing Your Runoff Treatment BMPs, high-density multifamily housing, roadways, and bridge decks.

Locate sand filter BMPs off-line before or after detention (Chang, 2000). BMP T8.20: Sand Filter Vault is also suited for locations with space constraints in retrofit, and new/re-development situations. Design overflow or bypass structures to handle the larger storms. Size off-line systems to treat 91% of the runoff volume predicted by a continuous runoff model. This is accomplished by sizing the filter to be able to pass the offline Water Quality Flow Rate, as described in III-2.6 Sizing Your Runoff Treatment BMPs, through the sand filter. If a project must comply with I-3.4.7 MR7: Flow Control, route both the flows bypassing the filtration BMP and the treated water to a Flow Control BMP.

A pretreatment BMP is necessary to reduce velocities to the sand filter BMP and remove debris, floatables, large particulate matter, and oils. In high water table areas, adequate drainage of the sand filter BMP may require additional engineering analysis and design considerations. Consider an underground sand filter in areas subject to freezing conditions (Urbonas, 1997).

BMP T8.10: Basic Sand Filter Basin

Description

A basic sand filter basin is constructed so that its surface is at grade and open to the elements, similar to BMP T7.10: Infiltration Basins. However, instead of infiltrating into native soils, stormwater filters through a constructed sand bed with an underdrain system. See Figure V-6.1: Sand Filtration Basin Preceded by Presettling Basin (Variation of a Basic Sand Filter), Figure V-6.2: Sand Filter with Pretreatment Cell (Plan View), Figure V-6.3: Sand Filter with Pretreatment Cell (Section View), Figure V-6.4: Sand Filter with Level Spreader (Plan View), and Figure V-6.5: Sand Filter with Level Spreader (Section View) for more details.

Applications and Limitations

Use a basic sand filter basin to capture and treat the Water Quality Design Storm Volume (see III-2.6 Sizing Your Runoff Treatment BMPs); which is 91% of the total runoff volume as predicted by an approved continuous runoff model. Only 9% of the total runoff volume would bypass or overflow from the basic sand filter BMP.

Basic sand filter basins should be sized to pass the Water Quality Design Flow Rate (as described in III-2.6 Sizing Your Runoff Treatment BMPs) through the sand filter. This ensures the sand filter is treating 91% od the runoff volume.

Locate off-line sand filters either upstream or downstream of detention BMPs. Locate on-line sand filters downstream of detention BMPs only to prevent exposure of the sand filter surface to high flow rates that could cause loss of media and previously removed pollutants.

Site Suitability

Consider the following site characteristics when siting a basic sand filter:

- Space availability, including a presettling basin
- Sufficient hydraulic head, at least 4 feet from inlet to outlet
- Adequate operation and maintenance capability, including accessibility for operation and maintenance
- Sufficient pretreatment of oil, debris and solids in the tributary runoff

Design Criteria

Hydraulics

If the drainage area maintains a base flow between storm events, bypass the base flow around the basic sand filter BMP to keep the sand from remaining saturated for extended periods.

Assume a design filtration rate of 1 inch per hour. Though the sand medium specified below will initially infiltrate at a much higher rate, that rate will slow as the sand filter accumulates sediment. When the filtration rate falls to 1 inch per hour, removal of sediment is necessary to maintain rates above the rate assumed for sizing purposes.

On-line Basic Sand Filter Design

- Do NOT place the basic sand filter BMP upstream of a detention BMP. This restriction is to prevent exposure of the sand filter surface to high flow rates that could cause loss of media and previously removed pollutants.
- Size on-line sand filter BMPs placed downstream of a detention BMP using an approved continuous runoff model to filter the Water Quality Design Flow Rate as described in III-2.6 Sizing Your Runoff Treatment BMPs.
- Include an overflow in the design. The overflow height should be at the maximum hydraulic head of the pond above the sand bed. On-line sand filter BMPs shall have overflows (primary, secondary, and emergency) in accordance with the design criteria for BMP D.1: Detention Ponds.

Off-line Basic Sand Filter Design

- Off-line sand filter BMPs placed upstream of a detention BMP must have a flow splitter designed to send all flows at or below the off-line 15-minute Water Quality Design Flow Rate, as detailed in III-2.6 Sizing Your Runoff Treatment BMPs, to the sand filter BMP.
- Size the basic sand filter BMP to filter all the runoff sent to it (no overflows from the BMP should occur). The continuous runoff model allows bypassed flows and flow filtered through the sand filter BMP to be directed to a downstream detention BMP.
- Off-line sand filter BMPs placed downstream of a detention BMP must have a flow splitter designed to send all flows at or below the 2-year flow frequency from the detention BMP to the basic sand filter BMP. The basic sand filter BMP must be sized to filter all the runoff sent to it (no overflows from the basic sand filter BMP should occur).
- For off-line sand filter BMPs downstream of a detention BMP, design the underdrain structure to pass the 2-year peak inflow rate, as determined using 15-minute time steps in an approved continuous runoff model.

Additional Design Criteria

1. Pretreat (see V-9 Pretreatment BMPs) runoff directed to the basic sand filter BMP to remove debris and other solids. For sites that require oil control per III-1.2 Choosing Your Runoff Treatment BMPs, the pretreatment should be an appropriate oil control BMP as described in III-1.2 Choosing Your Runoff Treatment BMPs.
2. Design inlet bypass and flow spreading structures (see V-1.4.1 Flow Splitters and V-1.4.2 Flow Spreaders) to capture the applicable design flow rate, 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 an emergency spillway or overflow structure(s).

a. If the sand filter is curved or an irregular shape, provide a flow spreader for a minimum of 20 percent of the sand filter perimeter.

b. If the length-to-width ration of the sand filter is 2:1 or greater, locate a flow spreader on the longer side of the sand filter and for a minimum length of 20 percent of the sand filter perimeter.

c. Provide erosion protection along the first foot of the sand filter adjacent to the flow spreader. Methods for this include geotextile weighted with sand bags at 15-foot intervals and quarry spalls.

3. The following are design criteria for the underdrain piping:

   Types of acceptable underdrains:

   - A central collector pipe with lateral feeder pipes in an 8-inch gravel backfill or drain rock bed.
   - A central collector pipe with a geotextile drain strip in an 8-inch gravel backfill or drain rock bed.
   - 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 approved continuous runoff model (whether upstream or downstream of a detention BMP). Provide at least one (1) foot of hydraulic head above the invert of the upstream end of the collector pipe. (King County Department of Natural Resources, 1998)
   - Use underdrain pipe with a minimum internal diameter of six (6) inches, with two rows of ½-inch holes spaced 6 inches apart longitudinally (maximum), and rows 120 degrees apart (laid with holes downward). Maintain a maximum perpendicular distance between two feeder pipes, or the edge of the sand filter and a feeder pipe, of 15 feet. For all piping use schedule 40 PVC or piping with a greater wall thickness.
   - Slope the main collector underdrain pipe at 0.5 percent minimum. (King County Department of Natural Resources, 1998)
   - Use a geotextile fabric (specifications in V-1.3.4 Geotextile Specifications) between the sand layer and drain rock or gravel. Cover the geotextile fabric with 1-inch of drain rock-/gravel. Use 0.75-1.5 inch drain rock or gravel backfill, washed free of clay and organic material. (King County Department of Natural Resources, 1998)

   Place cleanout wyes with caps or junction boxes at both ends of the collector pipes. Extend cleanouts to the surface of the sand filter BMP. Supply a valve box for access to the cleanouts. Provide access for cleaning all underdrain piping. This may consist of installing cleanout ports, which tee into the underdrain system and surface above the top of the sand filter. To facilitate maintenance of the sand filter an inlet shutoff/bypass valve is recommended.

4. Sand medium specification: The sand medium shall be 18 inches minimum in depth and must consist of sand meeting the size gradation (by weight) given in Table V-6.1: Sand Medium Specification. The contractor must obtain a grain size analysis from the supplier to certify that

the sand meets the No. 100 and No. 200 sieve requirements.

Note: Standard backfill for sand drains, WSDOT Std. Spec. 9-03.13, does not meet the sand medium specification. Do not use Spec 9-03.13 for sand filter BMPs.

Table V-6.1: Sand Medium Specification

Sieve Number	Percent Passing
4	95-100
8	70-100
16	40-90
30	25-75
50	2-25
100	<4
200	<2
Source: (King County Department of Natural Resources, 1998)	

5. 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 consist of clay, concrete or geomembrane. Clay liners should have a minimum thickness of 12 inches and meet the specifications give in Table V-6.2: Clay Liner Specifications:

Table V-6.2: Clay Liner Specifications

Property	Test Method	Unit	Specification
Permeability	ASTM D-2434	cm/sec	1 x 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
Source: (City of Austin, 1988)			

- If a geomembrane liner is used it should have a minimum thickness of 30 mils and be ultraviolet resistant. Protect the geomembrane liner from puncture, tearing, and abrasion by installing geotextile fabric on the top and bottom of the geomembrane.
- Concrete liners may also be used for sedimentation chambers and for sedimentation and sand filter basins less than 1,000 square feet in area. Concrete should be 5 inches thick Class A or better and reinforced by steel wire mesh. The steel wire mesh should 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 should 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 should be installed that retains the sand and meets the specifications listed in V-1.3.4 Geotextile Specifications, unless the basin has been excavated to bedrock.

- If an impermeable liner is not provided, then an analysis should be made of possible adverse effects of seepage zones on ground water, and near building foundations, basements, roads, parking lots and sloping sites. Sand filters without impermeable liners should not be built on fill sites and should be located at least 20-feet downslope and 100-feet upslope from building foundations.

6. Include an access ramp with a slope not to exceed 7:1, for maintenance purposes at the inlet and the outlet of a surface sand filter. Consider an access port for inspection and maintenance.

7. Side slopes for earthen/grass embankments should not exceed 3:1 to facilitate mowing.

8. High ground water may damage underground structures or affect the performance of sand filter BMP underdrain systems. There should be sufficient clearance (at least 2 feet is recommended) between the seasonal high ground water level (highest level of ground water observed) and the bottom of the sand filter to obtain adequate drainage.

Construction Criteria

No runoff should enter the sand filter BMP prior to completion of construction and approval of site stabilization by the responsible inspector. Construction runoff may be routed to BMP C240: Sediment Trap or BMP C241: Sediment Pond (Temporary), but discharge from those should bypass downstream sand filter BMPs.

Careful level placement of the sand is necessary to avoid formation of voids within the sand filter that could lead to short-circuiting, (particularly around penetrations for underdrain cleanouts) and to prevent damage to the underlying geomembranes and underdrain system.

Over-compaction should be avoided to ensure adequate filtration capacity. Sand is best placed with a low ground pressure bulldozer (4 psig or less). After the sand layer is placed, water settling is recommended. Flood the sand with 10-15 gallons of water per cubic foot of sand.

Maintenance Criteria

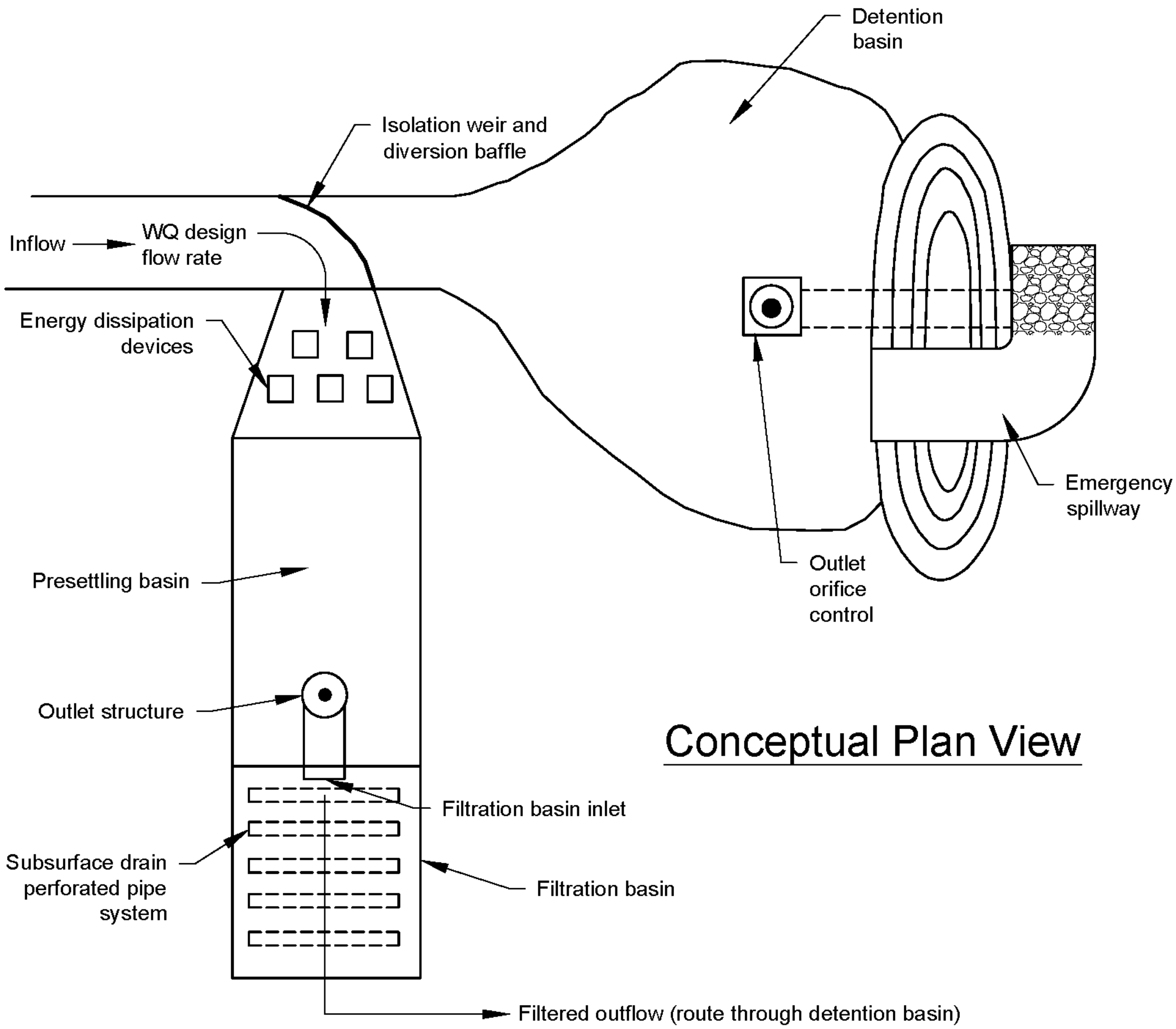
Inspections of sand filters and pretreatment systems should be conducted every 6 months and after storm events as needed during the first year of operation, and annually thereafter if the sand filter performs as designed. Repairs should be performed as necessary. Suggestions for maintenance include:

- Accumulated silt and debris on top of the sand filter should be removed when their depth exceeds 1/2-inch. The silt should be scraped off during dry periods with steel rakes or other devices. Once sediment is removed, the design permeability of the sand medium can typically be restored by then striating the surface layer of the media. Finer sediments that have penetrated deeper into the sand medium can reduce the permeability to unacceptable levels, necessitating replacement of some or all of the sand.

- Sand replacement frequency is not well established and will depend on suspended solids levels entering the sand filter (the effectiveness of the pretreatment BMP can be a significant factor).

- Frequent overflow into the spillway or overflow structure or slow drawdown are indicators of plugging problems. A sand filter should empty in 24 hours following a storm event (24 hours for the pre-settling chamber), depending on pond depth. If the hydraulic conductivity drops to one (1) inch per hour corrective action is needed, e.g.:
    - Scraping the top layer of fine-grain sediment accumulation (mid-winter scraping is suggested)
    - Removal of thatch
    - Aerating the sand filter surface
    - Tilling the sand filter surface (late-summer rototilling is suggested)
    - Replacing the top 4 inches of sand medium.
    - Inspecting geotextiles for clogging
- Rapid drawdown in the sand bed (greater than 12 inches per hour) indicates short-circuiting of the sand filter. Inspect the cleanouts on the underdrain pipes and along the base of the embankment for leakage.
- Drawdown tests for the sand bed could be conducted, as needed, during the wet season. These tests can be conducted by allowing the sand filter to fill (or partially fill) during a storm event, then measuring the decline in water level over a 4-8 hour period. An inlet and an underdrain outlet valve would be necessary to conduct such a test.
- Formation of rills and gullies on the surface of the sand filter indicates improper function of the inlet flow spreader, or poor sand compaction. Check for accumulation of debris on or in the flow spreader and refill rills and gullies with sand medium.
- Avoid driving heavy equipment on the sand filter to prevent compaction and rut formation.

Figure V-6.1: Sand Filtration Basin Preceded by Presettling Basin (Variation of a Basic Sand Filter)



Source: City of Austin

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Sand Filtration Basin Preceded by Presettling Basin (Variation of a Basic Sand Filter)

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Figure V-6.2: Sand Filter with Pretreatment Cell (Plan View)

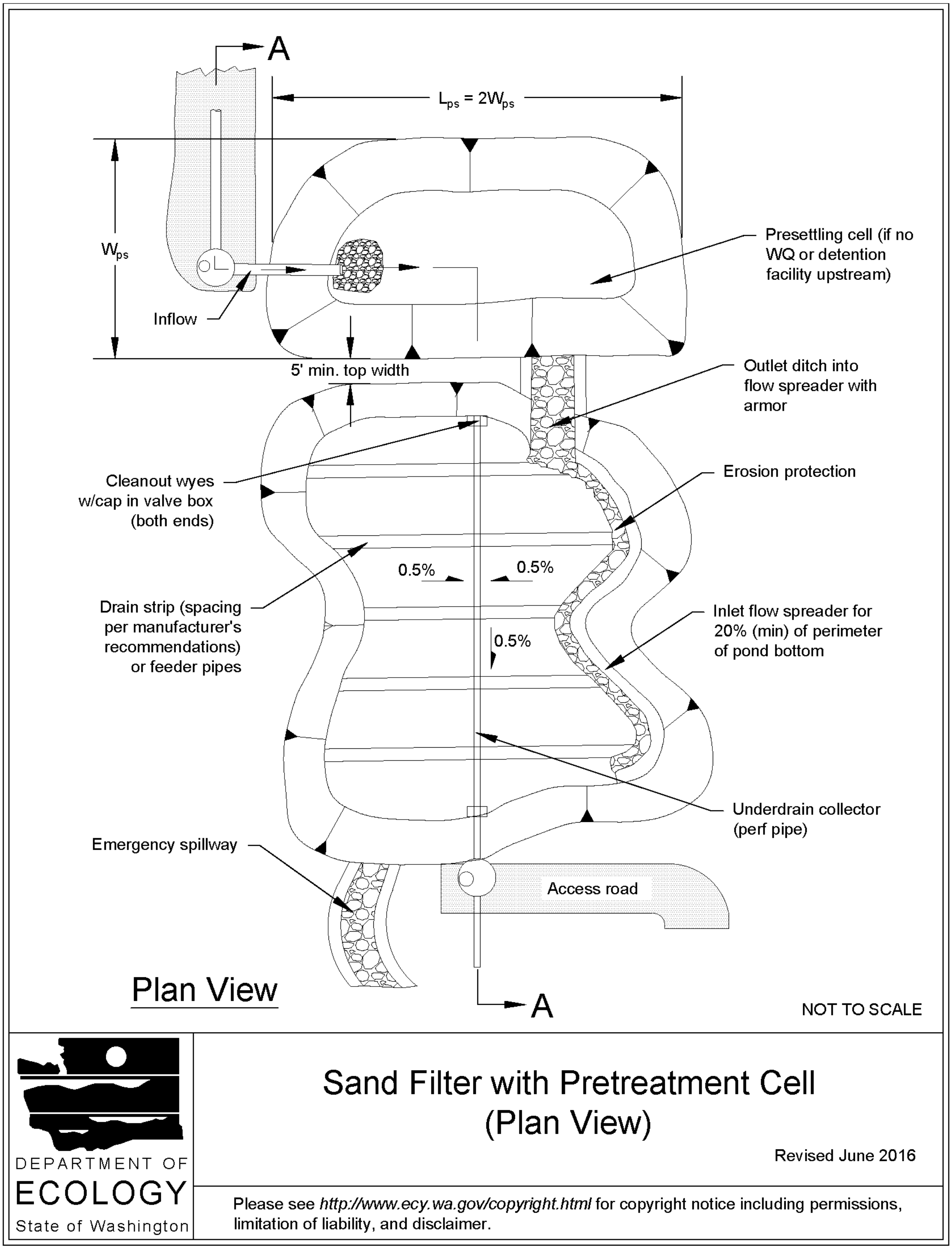
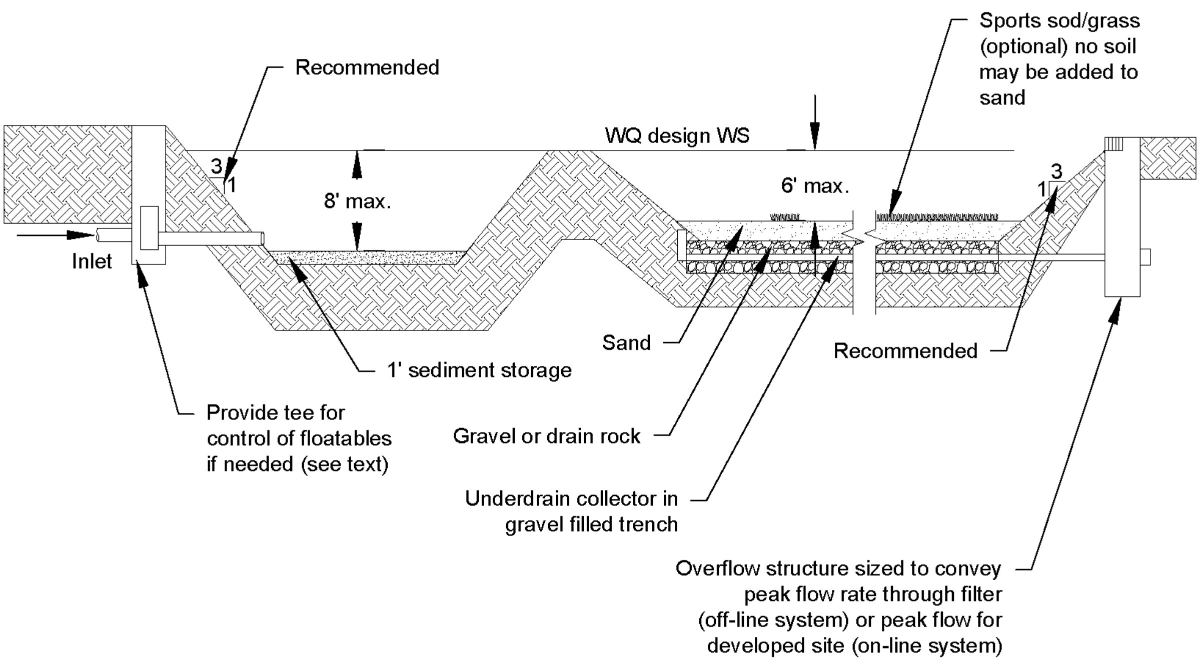


Figure V-6.3: Sand Filter with Pretreatment Cell (Section View)



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Sand Filter with Pretreatment Cell (Section View)

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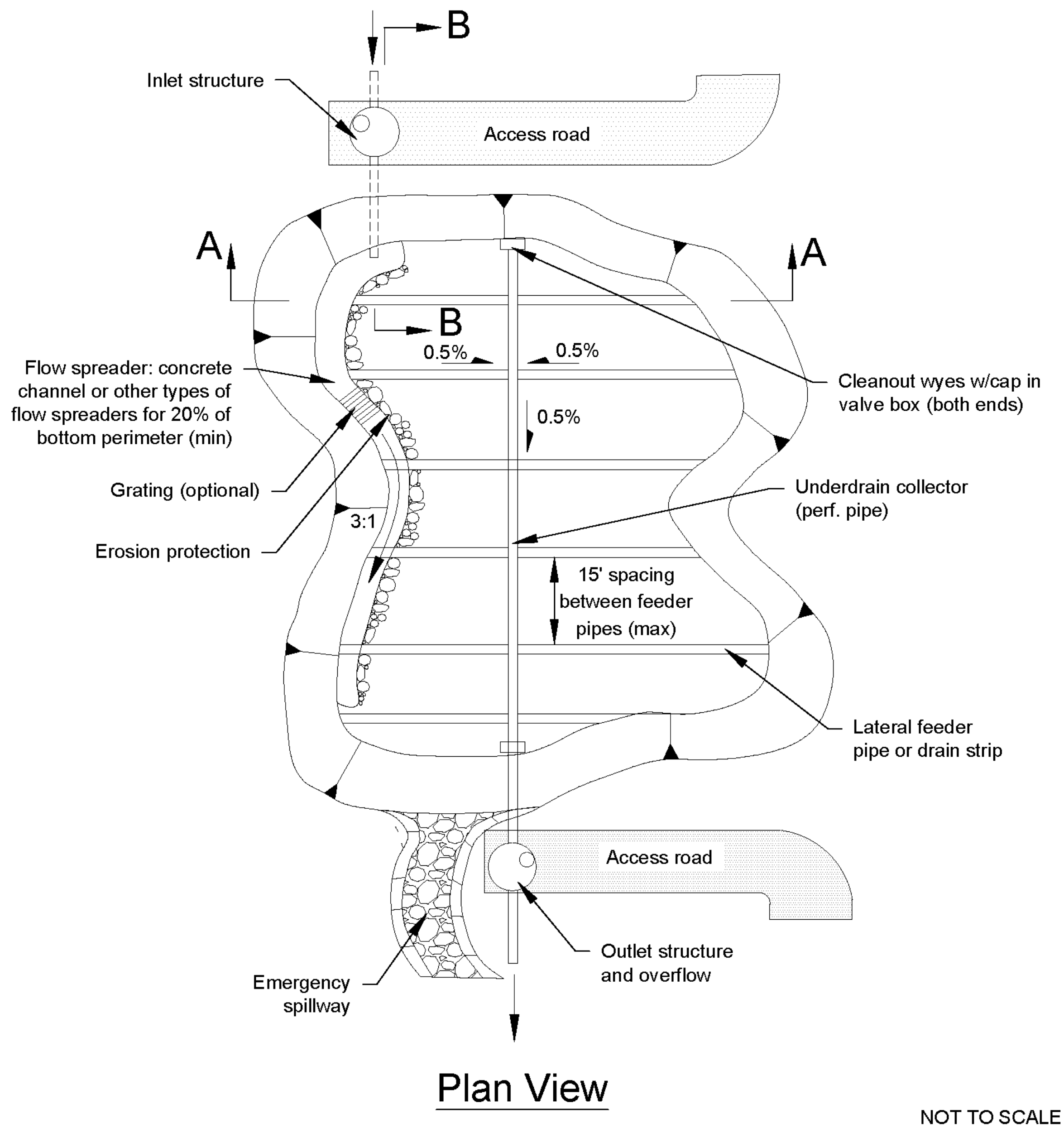
Figure V-6.4: Sand Filter with Level Spreader (Plan View)



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Sand Filter with Level Spreader (Plan View)

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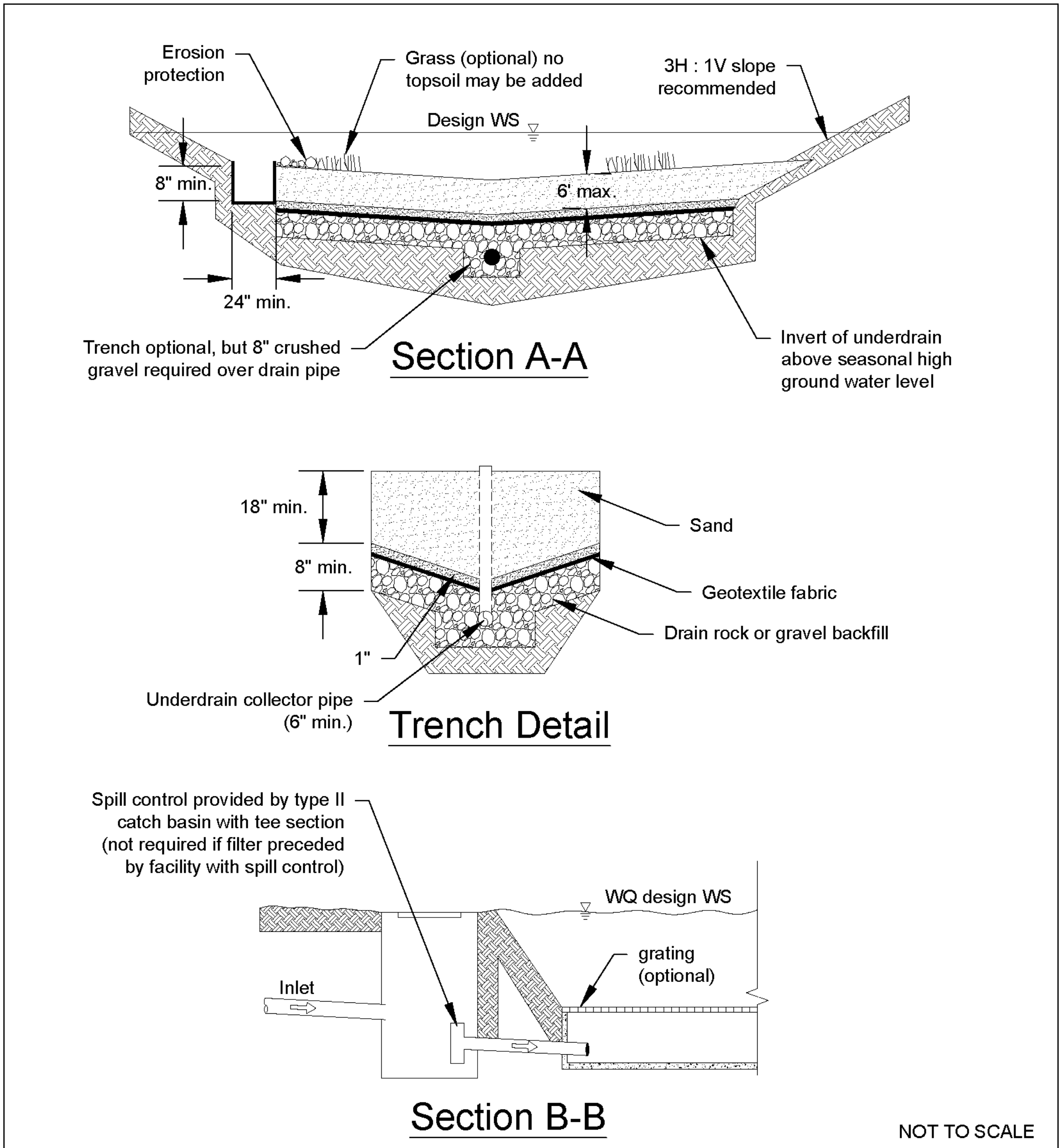
Figure V-6.5: Sand Filter with Level Spreader (Section View)



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Sand Filter with Level Spreader (Section View)

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BMP T8.11: Large Sand Filter Basin

Description

A large sand filter basin is virtually identical to BMP T8.10: Basic Sand Filter Basin except that it is sized to provide a higher level of Runoff Treatment. While BMP T8.10: Basic Sand Filter Basin meets the basic treatment performance goal, a large sand filter basin (this BMP) meets the enhanced treatment and phosphorus treatment performance goals. See III-1.2 Choosing Your Runoff Treatment BMPs for details.

Applications and Limitations

The large sand filter basin is generally subject to the same Applications and Limitations as BMP T8.10: Basic Sand Filter Basin. The difference is that the large sand filter basin uses a higher Water Quality Design Volume: 95% of the runoff volume of the period modeled in the continuous runoff model. Only 5% of the total runoff volume as modeled by a continuous runoff model would bypass or overflow from a large sand filter basin.

Currently approved continuous runoff models do not automatically calculate a flow rate that corresponds to 95% of the runoff volume of the period modeled. Therefore, to size a large sand filter basin, the designer must use an iterative process and verify that 95% of the runoff file volume passes through the large sand filter element within the model.

Site Suitability

The site suitability for the large sand filter basin is the same as BMP T8.10: Basic Sand Filter Basin.

Design Criteria

Design Volume

As stated above, a large sand filter basin should be sized to filter 95% of the runoff volume. Note that this volume is larger than the standard Water Quality Design Volume described in III-2.6 Sizing Your Runoff Treatment BMPs and used for sizing other BMPs.

Overflow and Underdrains

The design flows for the overflow and underdrains must be increased from the sizes used BMP T8.10: Basic Sand Filter Basin.

BMP T8.10: Basic Sand Filter Basin uses the 91% runoff volume as the Water Quality Design Volume, a 2-year return interval peak flow from an approved continuous model. The corresponding overflow and underdrain design flow is the 2 Year Storm.

Thus, the overflow and underdrain design flow can be calculated for this BMP by increasing the 2 year return interval peak flow by the ratio of the 95% runoff volume (the Water Quality Design Volume for this BMP) and the 91% runoff volume (the Water Quality Design Volume for BMP T8.10: Basic Sand Filter Basin). In equation form:

Design Flow Rate for Large Sand Filter Overflow or Underdrain = (95% Runoff Volume)/(91% Runoff Volume) * 2 year return interval peak flow.

For all other design criteria refer to BMP T8.10: Basic Sand Filter Basin.

BMP T8.20: Sand Filter Vault

Description

A sand filter vault is similar to BMP T8.10: Basic Sand Filter Basin and BMP T8.11: Large Sand Filter Basin, except that the sand layer and underdrains are installed below grade in a vault. It consists of presettling and sand filtration cells. See Figure V-6.6: Example Isolation/Diversion Structure, Figure V-6.7: Sand Filter Vault (Plan View) and Figure V-6.8: Sand Filter Vault (Section View) for more details.

Application and Limitations

- Use sand filter vaults where space limitations preclude above ground BMPs.
- Sand filter vaults are not suitable where high water table and heavy sediment loads are expected.
- In high water table areas, buoyancy and infiltration must be accounted for in the design.
- A minimum elevation difference of 4 feet between the inlet and outlet of the sand filter vault is needed.

Design Criteria

See the design criteria for BMP T8.10: Basic Sand Filter Basin or BMP T8.11: Large Sand Filter Basin.

Additional Design Criteria for Vaults

- Sand filter vaults may be designed as off-line systems or on-line for small drainages
- In an off-line system, a diversion structure should be installed to divert the design flow rate into the sediment chamber and bypass the remaining flow to a Flow Control BMP (if necessary to meet I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.7 MR7: Flow Control and/or I-3.4.8 MR8: Wetlands Protection), or to surface water.
- Distribute flows at the inlet of the sand filtration cell to minimize disturbance to the sand bed. A maximum of 8-inch distance between the top of the flow spreader and the top of the sand bed is suggested. 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 should be 8 inches. Multiple inlets are recommended to minimize turbulence and reduce local flow velocities.

- Erosion protection must be provided along the first foot of the sand bed adjacent to the flow spreader. Geotextile fabric secured on the surface of the sand bed, or an equivalent method, may be used.
- The sand filter bed should consist of a sand top layer, and a geotextile fabric second layer with an underdrain system.
- Design the presettling cell for sediment collection and removal. A V-shaped bottom, removable bottom panels, or equivalent sludge handling system should be used. One-foot of sediment storage in the presettling cell must be provided.
- The presettling cell must be sealed to trap oil and trash. This cell is usually connected to the sand filtration cell through an inverted elbow to protect the sand 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. Provision for the passage of flows in the event of plugging must be provided. Access openings and ladders must be provided on both sides of the baffle.
- To prevent anoxic conditions, a minimum of 24 square feet of ventilation grate should be provided 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 bed is small, but placement at each end is preferred. Small grates may also be dispersed over the entire sand bed area.
- Provision for access is the same as for BMP T10.20: Wetvaults. Removable panels must be provided over the entire sand bed.
- Sand filter vaults must conform to the materials and structural suitability criteria specified for BMP T10.20: 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.

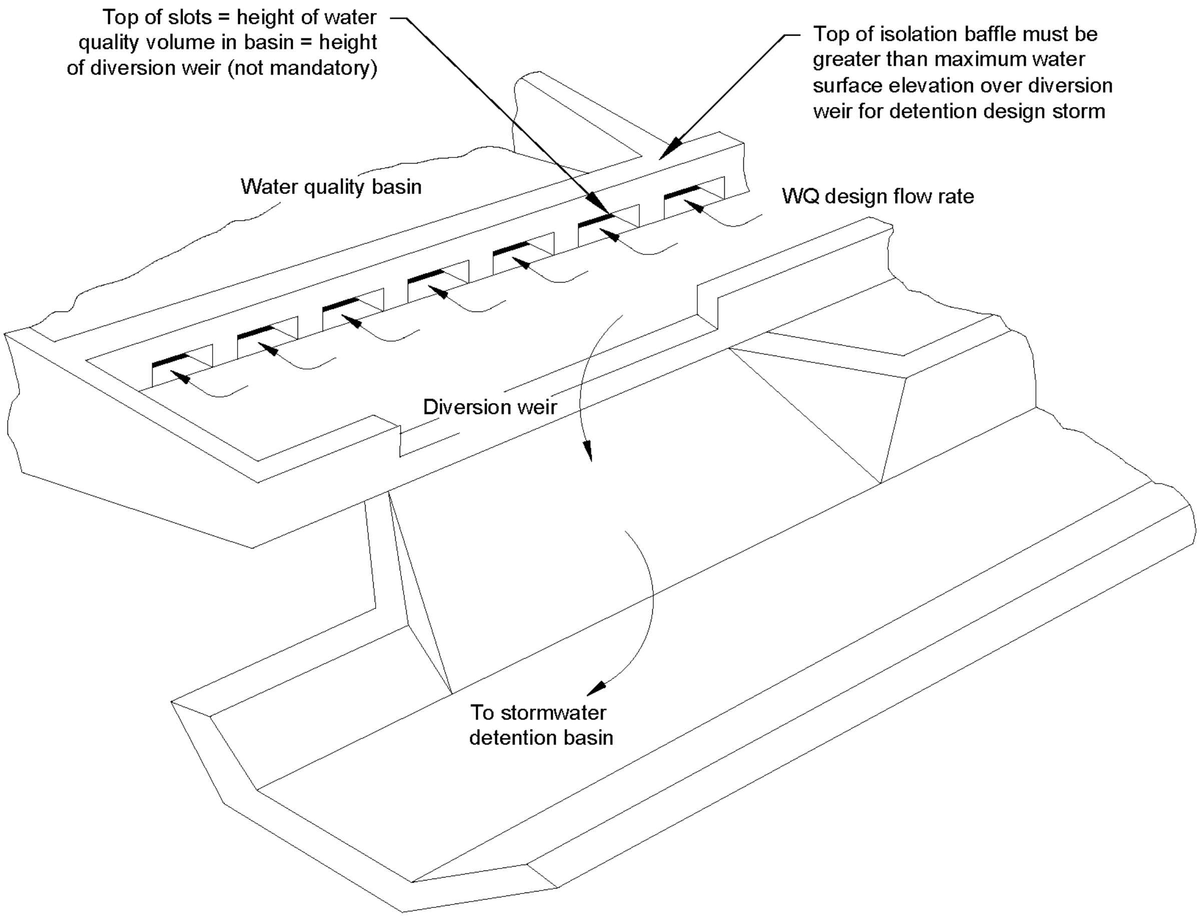
Construction Criteria

See BMP T8.10: Basic Sand Filter Basin and Appendix V-A: BMP Maintenance Tables.

Maintenance Criteria

See BMP T8.10: Basic Sand Filter Basin and Appendix V-A: BMP Maintenance Tables.

Figure V-6.6: Example Isolation/Diversion Structure



Source: City of Austin

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Example of an Isolation/Diversion Structure

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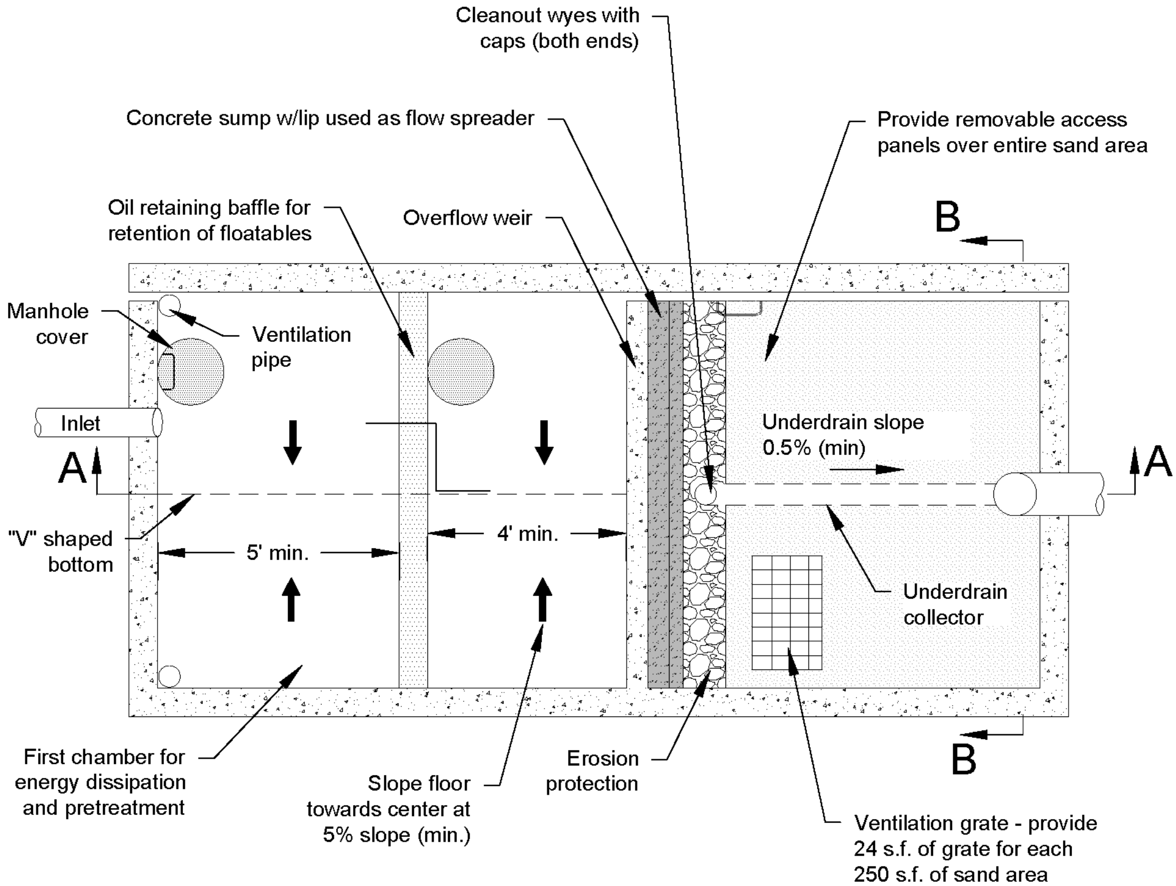
Figure V-6.7: Sand Filter Vault (Plan View)



Plan View

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Sand Filter Vault
(Plan View)

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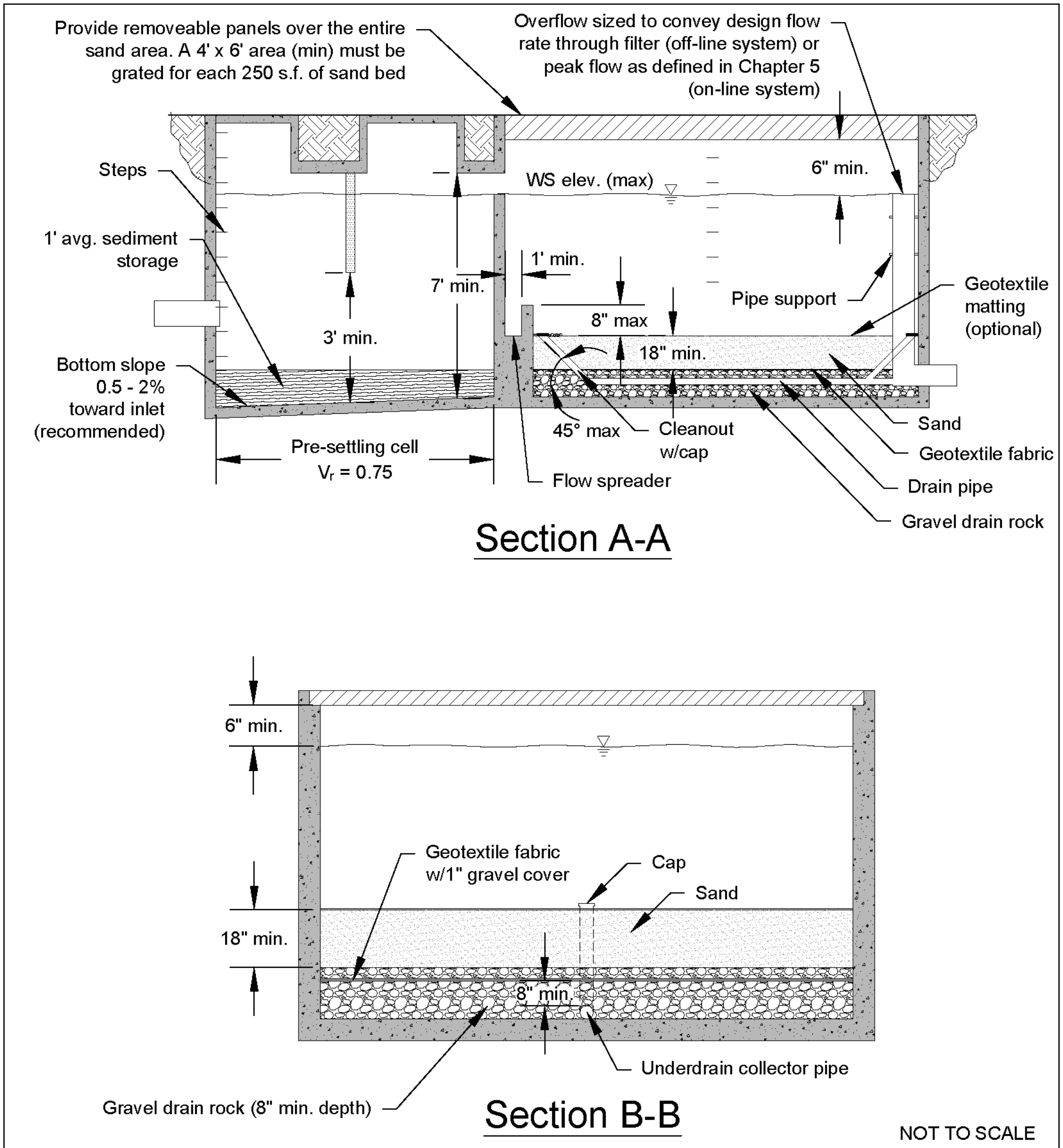
Figure V-6.8: Sand Filter Vault (Section View)



Sand Filter Vault (Section View)

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BMP T8.30: Linear Sand Filter

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 a sand filter bed. Stormwater flows into the second cell via a weir section that also functions as a flow spreader. See Figure V-6.9: Linear Sand Filter.

Application and Limitations

- Linear sand filters are applicable in long narrow spaces such as the perimeter of a paved surface.
- Linear sand filters can be used as a part of a treatment train downstream of BMP T9.40: Vegetated Filter Strip, upstream of an infiltration BMP, or upstream of BMP T10.10: Wetponds - Basic and Large or a biofiltration BMP for oil control.
- Linear sand filters are appropriate to treat runoff from small contributing basins (less than 2 acres of impervious area).
- Linear sand filters are appropriate to treat runoff from sites that require an oil control BMP, per III-1.2 Choosing Your Runoff Treatment BMPs.

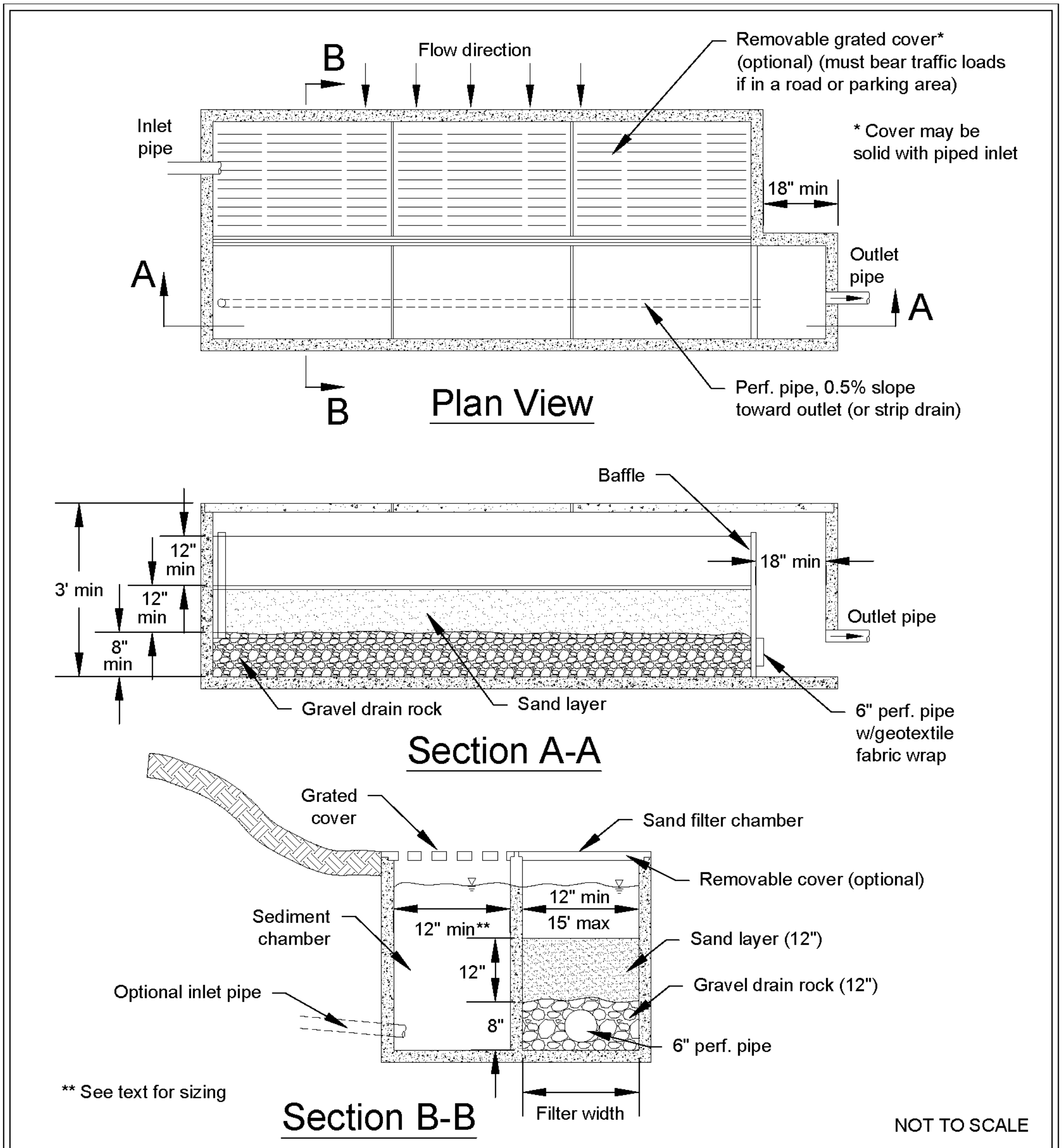
Design Criteria

- The two cells should be divided by a divider wall that is level and extends a maximum of 12 inches (minimum of 6 inches) above the top of the sand bed.
- Stormwater may enter the presettling cell by sheet flow or a piped inlet.
- The width of the sand filter 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.
- Maximum sand bed ponding depth: 1-foot.
- Must be vented as described in BMP T8.20: Sand Filter Vault.
- Linear sand filters must conform to the materials and structural suitability criteria specified for BMP T10.20: Wetvaults.
- Set the presettling cell width as follows:

Table V-6.3: Linear Sand Filter Presettling Cell Width

Item	Dimensions			
Sand filter width, (w) inches	12-24	24-48	48-72	72+
Presettling cell width, inches	12	18	24	w/3

Figure V-6.9: Linear Sand Filter



BMP T8.40: Media Filter Drain

Description

The media filter drain is a linear flow-through stormwater Runoff Treatment BMP that can be sited along highway side slopes (conventional design) and medians (dual media filter drains), borrow ditches, or other linear depressions. Cut-slope applications may also be considered. The media filter drain can be used where available right of way is limited, sheet flow from the highway surface is feasible, and lateral gradients are generally less than 25% (4H:1V). Although not a proprietary manufactured treatment device, the media filter drain completed Ecology's TAPE approval process and has a General Use Level Designation (GULD) for basic, enhanced, and phosphorus treatment (see V-10 Manufactured Treatment Devices as BMPs for more information about the TAPE approval process).

Media filter drains have four basic components: a gravel no-vegetation zone, a grass strip, the media filter drian mix bed, and a conveyance system for flows leaving the media filter drain mix. This conveyance system usually consists of a gravel-filled underdrain trench or a layer of crushed surfacing base course (CSBC). This layer of CSBC must be porous enough to allow treated flows to freely drain away from the media filter drain mix.

Typical media filter drain configurations are shown in Figure V-6.10: Media Filter Drain: Cross Section, Figure V-6.11: Dual Media Filter Drain: Cross Section, and Figure V-6.12: Media Filter Drain Without Underdrain Trench.

The media filter drain removes suspended solids, phosphorus, and metals from highway runoff through physical straining, ion exchange, carbonate precipitation, and biofiltration.

Runoff flowing through a media filter drain goes through the following treatment steps:

1. Stormwater runoff enters the media filter drain and is conveyed via sheet flow over a vegetation-free gravel zone to ensure sheet dispersion and provide some pollutant trapping.

2. Next, a grass strip, which may be amended with composted material, is incorporated into the top of the fill slope to provide pretreatment, further enhancing filtration and extending the life of the system.

3. The runoff is then filtered through a bed of porous, alkalinity-generating granular medium—the media filter drain mix. Media filter drain mix is a fill material composed of crushed rock (sized by screening), dolomite, gypsum, and perlite. The dolomite and gypsum additives serve to buffer acidic pH conditions and exchange light metals for heavy metals. Perlite is incorporated to improve moisture retention, which is critical for the formation of biomass epilithic biofilm to assist in the removal of solids, metals, and nutrients.

4. Treated water drains from the media filter drain mix bed into the conveyance system below the media filter drain mix. Geotextile lines the underside of the media filter drain mix bed and the conveyance system.

   The underdrain trench is an option for hydraulic conveyance of treated stormwater to a desired location, such as a downstream Flow Control BMP or stormwater outfall. The trench's perforated underdrain pipe is a protective measure to ensure free flow through the media filter drain mix and to prevent prolonged ponding. 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 media filter drain mix and underdrain trench.

Figure V-6.10: Media Filter Drain: Cross Section

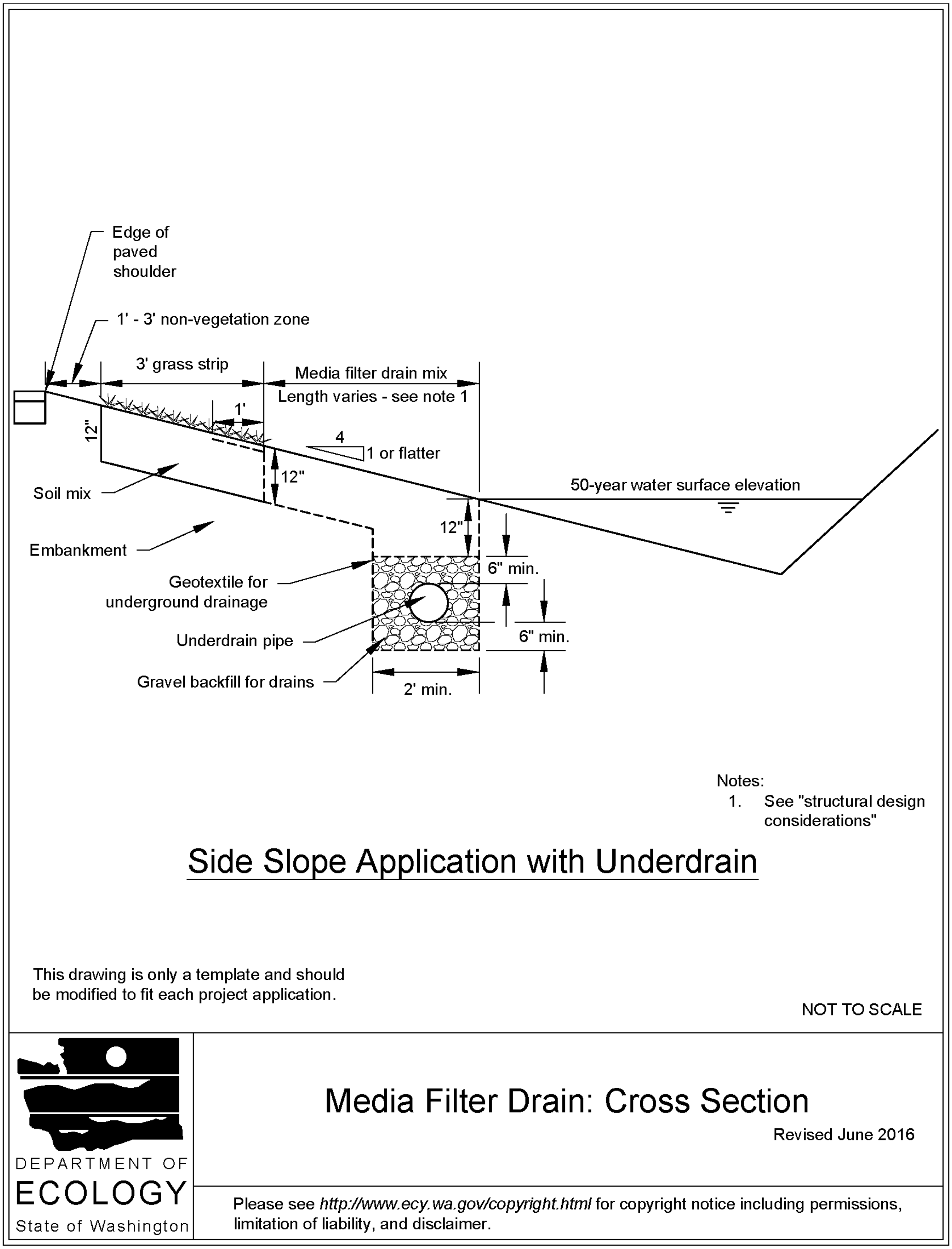
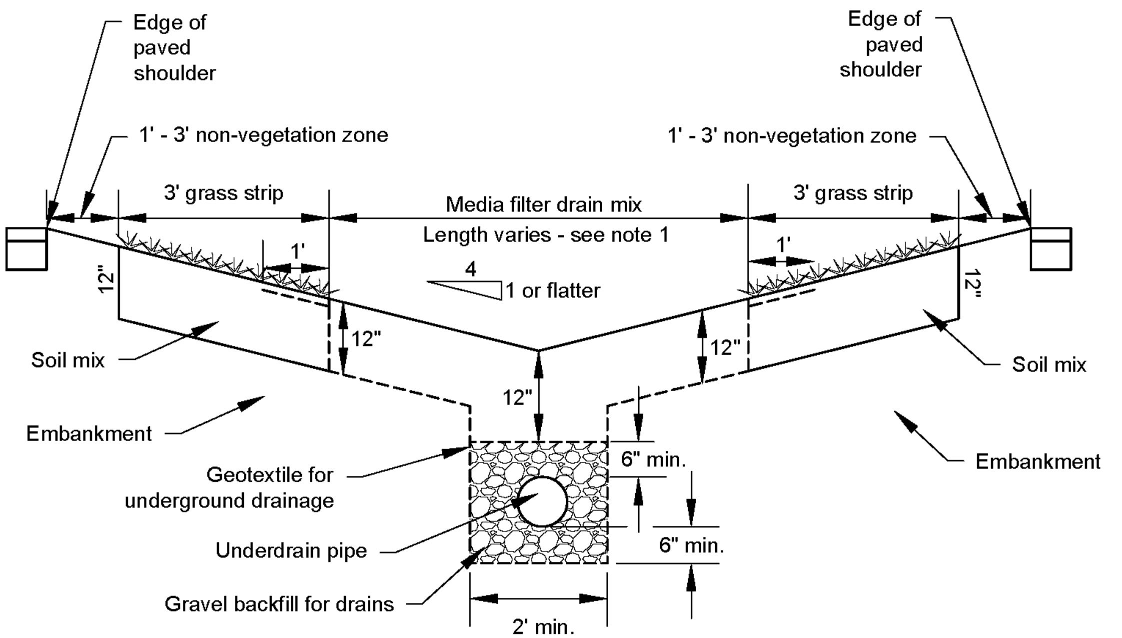


Figure V-6.11: Dual Media Filter Drain: Cross Section



Notes:

1. See "structural design considerations"

Median Application

This drawing is only a template and should be modified to fit each project application.

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Dual Media Filter Drain: Cross Section

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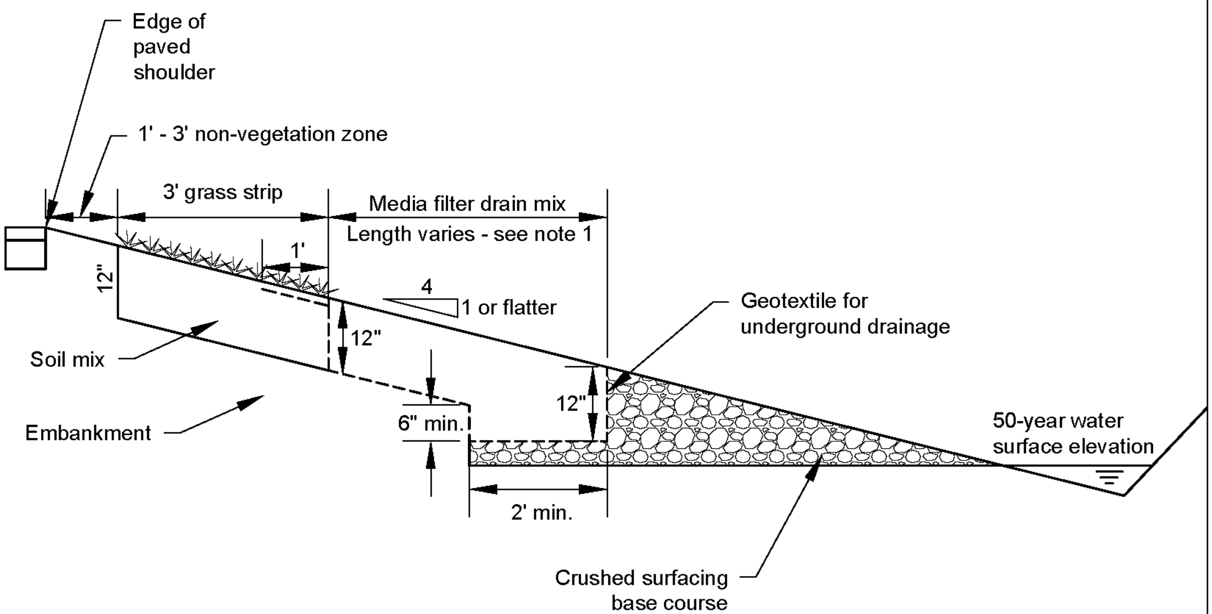
Figure V-6.12: Media Filter Drain Without Underdrain Trench



Notes:

1. See "structural design considerations"

Side Slope Application without Underdrain

This drawing is only a template and should be modified to fit each project application.

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Media Filter Drain without Underdrain Trench

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Applications and Limitations

In many instances, conventional Runoff Treatment is not feasible due to right of way constraints (such as adjoining wetlands and geotechnical considerations). The media filter drain and the dual media filter drain designs are Runoff Treatment options that can be sited in most right of way confined situations. In many cases, a media filter drain or a dual media filter drain can be sited without the acquisition of additional right of way needed for conventional Runoff Treatment BMPs.

Since maintaining sheet flow across the media filter drain is required for its proper function, the ideal locations for media filter drains in highway settings are highway side slopes or other long, linear grades with lateral side slopes less than 4H:1V and longitudinal slopes no steeper than 5%. 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. The longest flow path from the contributing area delivering sheet flow to the media filter drain should not exceed 150 feet.

If there is sufficient roadway embankment width, the designer should consider placing the grass strip and media filter drain mix downslope when feasible. The design should ensure the media filter drain does not intercept seeps, springs, or ground water.

The dual media filter drain is fundamentally the same as the side-slope version. It differs in siting and is more constrained with regard to drainage options. Prime locations for dual media filter drains in a highway setting are medians, roadside drainage or borrow ditches, or other linear depressions. It is especially critical for water to sheet flow across the dual media filter drain. Channelized flows or ditch flows running down the middle of the dual media filter drain (continuous off-site inflow) should be minimized.

The designer should consider the following limitations when considering a media filter drain for their project:

- Steep slopes: Avoid construction on longitudinal slopes steeper than 5%. Avoid construction on 3H:1V lateral slopes, and preferably use less than 4H:1V slopes. In areas where lateral slopes exceed 4H:1V, it may be possible to construct terraces to create 4H:1V slopes or to otherwise stabilize up to 3H:1V slopes.
- Wetlands: Do not construct in wetlands and wetland buffers. In many cases, a media filter drain (due to its small lateral footprint) can fit within the highway fill slopes adjacent to a wetland buffer. In those situations, where the highway fill prism is located adjacent to wetlands, an interception trench/underdrain will need to be incorporated as a design element in the media filter drain.
- Shallow ground water: Mean high water table levels at the project site need to be determined to ensure the media filter drain mix bed and the underdrain (if needed) will not become saturated by shallow ground water.
- Unstable slopes: In areas where slope stability may be problematic, consult a geotechnical engineer.
- Areas of seasonal ground water inundations or basement flooding: Site-specific piezometer data may be needed in areas of suspected seasonal high ground water inundations. The performance of the dual media filter drain may be compromised due to backwater effects and lack

of sufficient hydraulic gradient.

- Narrow roadway shoulders: In areas where there is a narrow roadway shoulder that does not allow enough room for a vehicle to fully stop or park, consider placing the media filter drain farther down the embankment slope. This will reduce the amount of rutting in the media filter drain and decrease overall maintenance repairs.

Design Criteria

Flows to Be Treated

The basic design concept behind the media filter drain and dual media filter drain is to fully filter all runoff through the media filter drain mix. Therefore, the infiltration capacity of the media filter drain mix and the drainage below needs to match or exceed the hydraulic loading rate.

Vegetation-Free Gravel Zone

The vegetation-free gravel zone is a shallow gravel zone located directly adjacent to the highway pavement. The vegetation-free gravel zone is a crucial element in a properly functioning media filter drain. The vegetation-free gravel zone functions as a level spreader to promote sheet flow and a deposition area for coarse sediments. The vegetation-free gravel zone should be 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. Within these bounds, width varies depending on maintenance spraying practices.

Grass Strip

The width of the grass strip is dependent on the availability of space within the highway side slope. The baseline design criterion for the grass strip component of the media filter drain is a 3-foot-minimum-width, but wider grass strips are recommended if additional space is available. The designer may 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 media filter drain. Composted material used in the grass strip shall meet the specifications for compost used in Bioretention Soil Mix (BSM). See BMP T7.30: Bioretention.

Media Filter Drain Mix Bed

The media filter drain mix is a mixture of crushed rock, 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 media filter drain mix. The combination of physical filtering, precipitation, ion exchange, and biofiltration enhances the Runoff Treatment capacity of the mix. The media filter drain 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 media filter drain should be 10 inches per hour.

The width of the media filter drain mix bed is determined by the amount of contributing pavement routed to the embankment. The surface area of the media filter drain mix bed needs to be sufficiently large to fully infiltrate the Water Quality Design Flow Rate (as described in III-2.6 Sizing Your Runoff Treatment BMPs) using the long-term filtration rate of the media filter drain mix. For design purposes, a 50% safety factor is incorporated into the long-term media filter drain mix filtration rate to accommodate variations in slope, resulting in a design filtration rate of 10 inches per hour. The media filter drain mix bed should have a bottom width of at least 2 feet in contact with the conveyance system below the media filter drain mix.

The media filter drain mix used in the media filter drain mix bed consists of the amendments listed in Table V-6.4: 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.

Table V-6.4: Media Filter Drain Mix

Amendment	Quantity

Mineral Aggregate: Aggregate for Media Filter Drain Mix
Aggregate for media filter drain mix shall be manufactured from ledge rock, talus, or gravel in accordance with Section 3-01 of the *Standard Specifications for Road, Bridge, and Municipal Construction (2002)*, which meets the following test requirements for quality. The use of recycled material is not permitted.
• Los Angeles Wear, 500 Revolutions: 35% max.
• Degradation Factor: 30 min.
• Aggregate for the media filter drain mix shall conform to the following requirements for grading and quality:
  ◦ Sieve Size: Percent Passing (by weight)
    ▪ 1/2" square: 100
    ▪ 3/8" square: 90-100
    ▪ U.S. No. 4: 30-56
    ▪ U.S. No. 10: 0-10
    ▪ U.S. No. 200: 0-1.5
  ◦ % fracture, by weight, min.: 75
    The fracture requirement shall be at least two fractured faces and will apply to material retained on the U.S. No. 10.
  ◦ Static stripping test: Pass
Aggregate for the media filter drain shall be substantially free from adherent coatings. The presence of a thin, firmly adhering film of weathered rock shall not be considered as coating unless it exists on more than 50% of the surface area of any size between successive laboratory sieves.
	3 cubic yards

Perlite • Horticultural grade, free of any toxic materials)	1 cubic yard per 3 cubic yards of min-

Table V-6.4: Media Filter Drain Mix (continued)

Amendment	Quantity
• 0-30% passing US No. 18 Sieve • 0-10% passing US No. 30 Sieve	eral aggreg-ate
Dolomite: CaMg(CO3)2 (calcium magnesium carbonate) • Agricultural grade, free of any toxic materials) • 100% passing US No. 8 Sieve • 0% passing US No. 16 Sieve	10 pounds per cubic yard of perlite
Gypsum: Noncalcined, agricultural gypsum CaSO4•2H2O (hydrated calcium sulfate) • Agricultural grade, free of any toxic materials) • 100% passing US No. 8 Sieve • 0% passing US No. 16 Sieve	1.5 pounds per cubic yard of perlite

Consider the following guidance when sizing the media filter drain mix bed:

- The media filter drain mix should be a minimum of 12 inches deep, including the section on top of the underdrain trench.
- For Runoff Treatment, sizing the media filter drain mix bed is based on the requirement that the Water Quality Design Flow Rate from the pavement area, $Q_{Highway}$, cannot exceed the long-term infiltration capacity of the media filter drain, $Q_{Infiltration}$:

  $$Q_{Highway} \leq Q_{Infiltration}$$

  See III-2.6 Sizing Your Runoff Treatment BMPs for more information about the Water Quality Design Flow Rate.
- The long-term infiltration capacity of the media filter drain is based 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 media filter drain is the same as the length of the contributing

pavement, solve for the width of the media filter drain mix bed:

$$W \geq \frac{Q_{Highway} \times C \times SF}{LTIR \times L}$$

- Western Washington project applications of this design procedure have shown that, in almost every case, the calculated width of the media filter drain mix bed does not exceed 1.0 foot. Therefore, Table V-6.5: Western Washington Design Widths for Media Filter Drains was developed to simplify the design steps and should be used to establish an appropriate width.

Table V-6.5: Western Washington Design Widths for Media Filter Drains

Pavement width that contributes runoff to the media filter drain	Minimum media filter drain mix bed width*
≤ 20 feet	2 feet
≥ 20 and ≤ 35 feet	3 feet
> 35 feet	4 feet
* Width does not include the required 1–3 foot gravel vegetation-free zone or the 3-foot filter strip width (see Figure 8.5.8).	

Conveyance System/Underdrain Below Media Filter Drain Mix

The gravel underdrain trench provides hydraulic conveyance when treated runoff needs to be conveyed to a desired location such as a downstream Flow Control BMP or stormwater outfall.

In Group C and D soils, an underdrain pipe would help to ensure free flow of the treated runoff through the media filter drain mix bed. In some Group A and B soils, an underdrain pipe may be unnecessary if most water percolates into the subsoil from the underdrain trench. The need for an underdrain pipe should be evaluated in all cases. The underdrain trench should be a minimum of 2 feet wide for either the conventional or dual media filter drain.

The gravel underdrain trench may be eliminated if there is evidence to support that flows can be conveyed laterally to an adjacent ditch or onto a fill slope that is properly vegetated to protect against erosion. The media filter drain mix should be kept free draining up to the 50-year storm event water surface elevation represented in the downstream ditch.

These materials should be used in accordance with the following sections within WSDOT's *Standard Specifications for Road, Bridge, and Municipal Construction* (WSDOT, 2012):

- Gravel Backfill for Drains, 9-03.12(4)
- Underdrain Pipe, 7-01.3(2)
- Construction Geotextile for Underground Drainage, 9-33.1
- If the design is configured to allow the media filter drain to drain laterally into a ditch, the crushed surfacing base course below the media filter drain should conform to Section 9-03.9 (3).

Underdrain pipe can provide a protective measure to ensure free flow through the media filter drain mix and is sized similar to storm drains. For media filter drain underdrain sizing, an additional step is required to determine the flow rate that can reach the underdrain pipe. This is done by comparing the contributing basin flow rate to the infiltration flow rate through the media filter drain mix, and then using the smaller of the two to size the underdrain. The analysis described below considers the flow rate per foot of media filter drain, which allows the flexibility of incrementally increasing the underdrain diameter where long lengths of underdrain are required. When underdrain pipe connects to a drainage system, place the invert of the underdrain pipe above the 25-year water surface elevation in the storm drain to prevent backflow into the underdrain system.

The following describes the procedure for sizing underdrains installed in combination with media filter drains.

1. Calculate the flow rate per foot from the contributing basin to the media filter drain. The design storm event used to determine the flow rate should be relevant to the purpose of the underdrain. For example, if the media filter drain installation is in western Washington and the underdrain will be used to convey treated runoff to a detention BMP, size the underdrain for the 50-year storm event.

$$\frac{Q_{highway}}{ft} = \frac{Q_{highway}}{L_{MFD}}$$

   where:

   $\frac{Q_{highway}}{ft} =$ contributing flow rate per foot (cfs/ft)

   L_{MFD} = length of media filter drain contributing runoff to the underdrain (ft)

2. Calculate the media filter drain flow rate of runoff per foot given an infiltration rate of 10 in/hr through the media filter drain mix.

$$Q_{\frac{MFD}{ft}} = \frac{f \times W \times 1ft}{ft} \times \frac{1ft}{12in} \times \frac{1hr}{3600\ \text{sec}}$$

   where:

   $Q_{\frac{MFD}{ft}}$ = flow rate of runoff through the media filter drain mix layer (cfs/ft)

   W = width of underdrain trench (ft); the minimum width is 2 ft

   f = infiltration rate though the media filter drain 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 flow rate or the flow rate through the media filter drain mix layer.

$$Q_{\frac{UD}{ft}} = smaller\left\{Q_{\frac{highway}{ft}}\, or Q_{\frac{MFD}{ft}}\right\}$$

   where:

$Q_{\frac{UD}{ft}}$ = underdrain design flow rate per foot (cfs/ft)

4. Determine the underdrain design flow rate using the length of the media filter drain and a factor of safety of 1.2.

$$Q_{UD} = 1.2 \times Q_{\frac{UD}{ft}} \times W \times L_{MFD}$$

where:

Q_{UD} = estimated flow rate to the underdrain (cfs)

W = width of the underdrain trench (ft); the minimum width is 2 ft

LMFD = length of the media filter drain contributing runoff to the underdrain (ft)

5. Given the underdrain design flow rate, determine the underdrain diameter. Round pipe diameters up to the nearest standard pipe size and have a minimum diameter of 6 inches.

$$D = 16\left(\frac{(Q_{UD} \times n)}{s^{0.5}}\right)^{3/8}$$

where:

D = underdrain pipe diameter (inches)

n = Manning's coefficient

s = slope of pipe (ft/ft)

Length

In general, the length of a media filter drain or dual media filter drain is the same as the contributing pavement. Any length is acceptable as long as the surface area of the media filter drain mix bed is sufficient to fully infiltrate the Water Quality Design Flow Rate.

Cross Section

In profile, the surface of the media filter drain should preferably 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 if approved by Ecology, to ensure slope stability up to 3H:1V. If sloughing is a concern on steeper slopes, consideration should be given to incorporating permeable soil reinforcements, such as geotextiles, open-graded/permeable pavements, or commercially available ring and grid reinforcement structures, as top layer components to the media filter drain mix bed. Consultation with a geotechnical engineer is required.

Inflow

Runoff is conveyed to a media filter drain using sheet flow from the pavement area. The longitudinal pavement slope contributing flow to a media filter drain should be less than 5%.

Although there is no lateral pavement slope restriction for flows going to a media filter drain, the designer should ensure flows remain as sheet flow.

Landscaping (Planting Considerations)

Landscaping for the grass strip is the same as for BMP T9.10: Basic Biofiltration Swale unless otherwise specified in the special provisions for the project's construction documents.

Signing

Nonreflective guideposts will delineate the media filter drain. This practice allows personnel to identify where the system is installed and to make appropriate repairs should damage occur to the system. If the media filter drain is in a critical aquifer recharge area for drinking water supplies, signage prohibiting the use of pesticides must be provided.

Construction Criteria

Keep effective erosion and sediment control measures in place until the grass strip is established.

Do not allow vehicles or traffic on the media filter drain to minimize rutting and maintenance repairs.

Operations and Maintenance

Maintenance will consist of routine roadside management. While herbicides must not be applied directly over the media filter drain, it may be necessary to periodically control noxious weeds with herbicides in areas around the media filter drain as part of a roadside management program. The use of pesticides may be prohibited if the media filter drain is in a critical aquifer recharge area for drinking water supplies. The designer should check with the local area water purveyor or local health department.

Replace areas of the media filter drain that show signs of physical damage.

V-7 Biofiltration BMPs

V-7.1 Introduction to Biofiltration BMPs

Biofiltration BMPs use vegetation in conjunction with slow and shallow-depth flow for Runoff Treatment. As runoff passes through the vegetation, pollutants are removed through the combined effects of sedimentation, filtration, infiltration, settling, and/or plant uptake. These effects are aided by the reduction of the velocity of stormwater as it passes through the biofilter. Biofiltration BMPs include swales that are designed to convey and treat concentrated runoff at shallow depths and slow velocities, and filter strips that are broad areas of vegetation for treating sheet flow runoff.

Biofiltration BMPs remove low concentrations and quantities of total suspended solids (TSS), heavy metals, petroleum hydrocarbons, and/or nutrients from stormwater.

Biofiltration BMPs can be used as basic treatment BMPs for contaminated stormwater runoff from roadways, driveways, parking lots, and highly impervious ultra-urban areas or as the first stage of a treatment train. In cases where hydrocarbons, high TSS, or debris would be present in the runoff, such as sites requiring oil control BMPs per III-1.2 Choosing Your Runoff Treatment BMPs, a pre-treatment BMP for those components would be necessary. Off-line placement is preferred to avoid flattening vegetation and the erosive effects of high flows. Consider biofiltration BMPs in retrofit situations where appropriate. (Center for Watershed Protection, 1998)

Consider the following factors for determining site suitability for biofiltration BMPs:

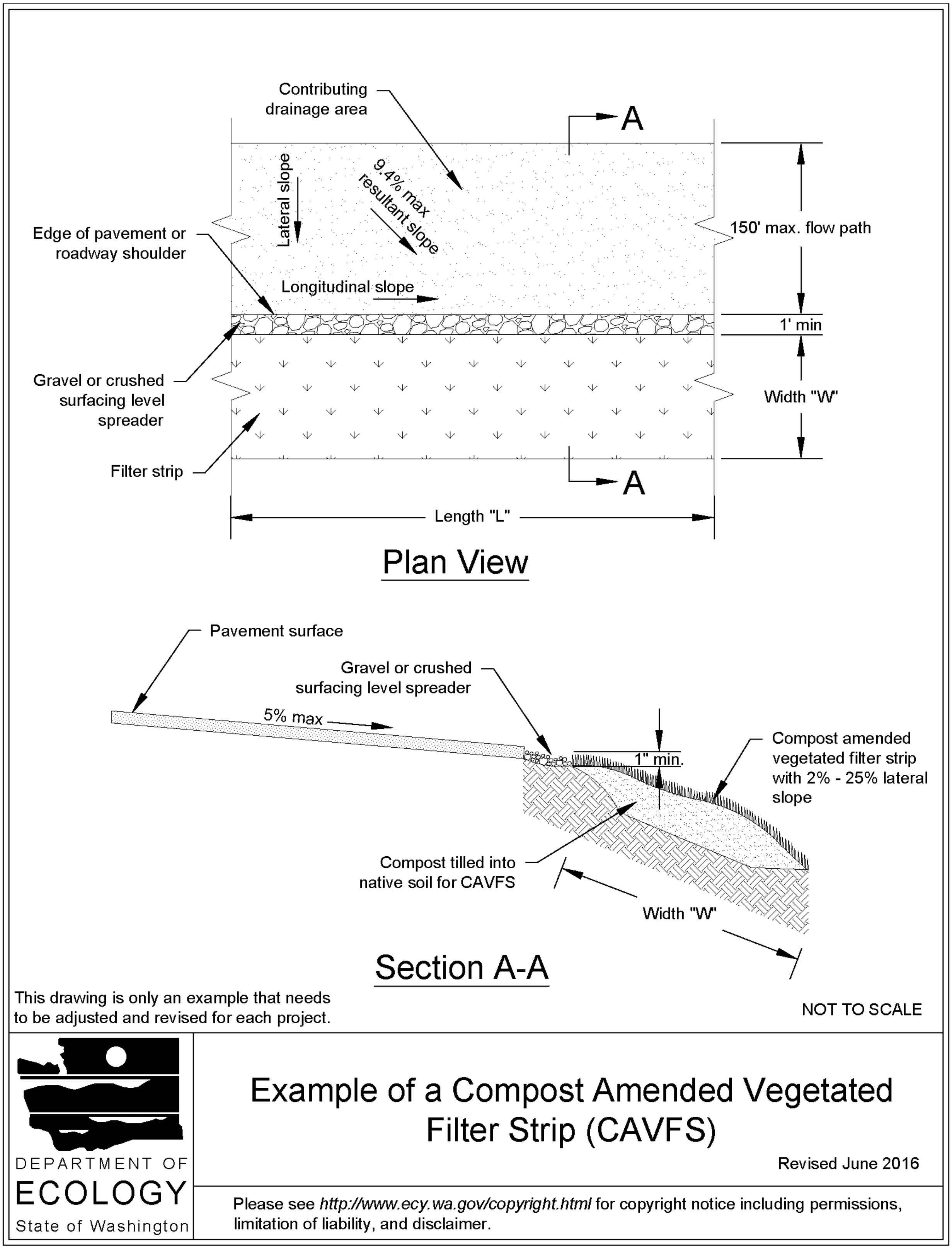
- Are the target pollutants amenable to biofiltration treatment?
- Is there accessibility for Operation and Maintenance?
- Is there a suitable growth environment; (soil, etc.) for the vegetation?
- If high petroleum hydrocarbon levels (oil/grease) or high TSS loads could impair treatment capacity or efficiency, is there adequate siting for a pre-treatment BMP?
- If the biofilter within the biofiltration BMP can be impacted by snowmelts and ice, refer to (Caraco and Claytor, 1997) for additional design criteria.

BMP T7.40: Compost-Amended Vegetated Filter Strips (CAVFS)

Description

The compost-amended vegetated filter strip (CAVFS) is a variation of BMP T9.40: Vegetated Filter Strip that adds soil amendments to the roadside embankment (See Figure V-7.1: Example of a Compost Amended Vegetated Filter Strip (CAVFS)). The soil amendments improve infiltration characteristics, increase surface roughness, and improve plant sustainability. Once permanent vegetation is established, the advantages of the CAVFS are higher surface roughness; greater retention and infiltration capacity; improved removal of soluble cationic contaminants through sorption; improved overall vegetative health; and a reduction of invasive weeds. CAVFS have somewhat higher construction costs than BMP T9.40: Vegetated Filter Strip due to more expensive materials, but require less land area for Runoff Treatment, which can reduce overall costs.

Figure V-7.1: Example of a Compost Amended Vegetated Filter Strip (CAVFS)



Applications

CAVFS can be used to meet basic and enhanced Runoff Treatment performance goals, as described in III-1.2 Choosing Your Runoff Treatment BMPs. It has practical application in areas where there is space for roadside embankments that can be built to the CAVFS specifications.

Design Criteria

The CAVFS design incorporates composted material into the native soils per the criteria in BMP T5.13: Post-Construction Soil Quality and Depth for turf areas. However, as noted below, the compost shall not contain biosolids or manure. The goal is to create a healthy soil environment for a lush growth of turf.

Soil/Compost Mix

- *Presumptive approach*: Place and rototill 1.75 inches of composted material into 6.25 inches of soil (a total amended depth of about 9.5 inches), for a settled depth of 8 inches. Water or roll to compact soil to 85% maximum. Plant grass.

- *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 grass.

  The amount of compost or other soil amendments used varies by soil type and organic matter content. If there is a good possibility that site conditions may already contain a relatively high organic content, then it may be possible to modify the pre-approved rate described above and still be able to achieve the 5% organic content target.

- The final soil mix (including compost and soil) should have an initial saturated hydraulic conductivity less than 12 inches per hour, and a minimum long-term hydraulic conductivity of 1.0 inch/hour per ASTM Designation D 2434 (Standard Test Method for Permeability of Granular Soils) at 85% compaction per ASTM Designation D 1557 (Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort).

  Infiltration rate and hydraulic conductivity are assumed to be approximately the same in a uniform mix soil. The long term saturated hydraulic conductivity of the soil mix is determined by applying the appropriate infiltration correction factors as explained in Determining the Bioretention Soil Mix Design Infiltration Rate within BMP T7.30: Bioretention.

- The final soil mixt should have a minimum organic content of 5% by dry weight per ASTM Designation D 2974 (Standard Test Method for Moisture, Ash and Organic Matter of Peat and Other Organic Soils) (Tackett, 2004).

- Achieving the above recommendations will depend on the specific soil and compost characteristics. In general, the recommendation can be achieved with 60% to 65% loamy sand mixed with 25% to 30% compost or 30% sandy loam, 30% coarse sand, and 30% compost.

- The final soil mixture should be tested prior to installation for fertility, micronutrient analysis, and organic material content.

- Clay content for the final soil mix should be less than 5%.
- Compost must not contain biosolids, manure, any street or highway sweepings, or any catch basin solids.
- The pH for the soil mix should be between 5.5 and 7.0 (Stenn, 2003). If the pH falls outside the acceptable range, it may be modified with lime to increase the pH or iron sulfate plus sulfur to lower the pH. The lime or iron sulfate must be mixed uniformly into the soil prior to use in LID areas (Low-Impact Development Center, 2004).
- The soil mix should be uniform and free of stones, stumps, roots, or other similar material larger than 2 inches.
- When placing topsoil, it is important that the first lift of topsoil is mixed into the top of the existing soil. This allows the roots to penetrate the underlying soil easier and helps prevent the formation of a slip plane between the two soil layers.

Soil Component

The texture for the soil component of the soil mix should be loamy sand (USDA Soil Textural Classification).

Compost Component

Follow the specifications for compost in BMP T7.30: Bioretention.

Runoff Model Representation

The CAVFS will have an "Element" in the approved continuous runoff model that must be used for determining the amount of water that is treated by the CAVFS. To fully meet Runoff Treatment requirements, Ninety-one percent of the influent runoff file must pass through the soil profile of the CAVFS. Water that merely flows over the surface is not considered treated. Approved continuous runoff models should be able to report the amount of water that it estimates will pass through the soil profile.

Maintenance

Compost, as with other filter mediums, can become plugged with fines and sediment, which may require removal and replacement. Including vegetation with compost helps prevent the medium from becoming plugged with sediment by breaking up the sediment and creating root pathways for stormwater to penetrate into the compost. It is expected that soil amendments will have a removal and replacement cycle; however, this time frame has not yet been established.

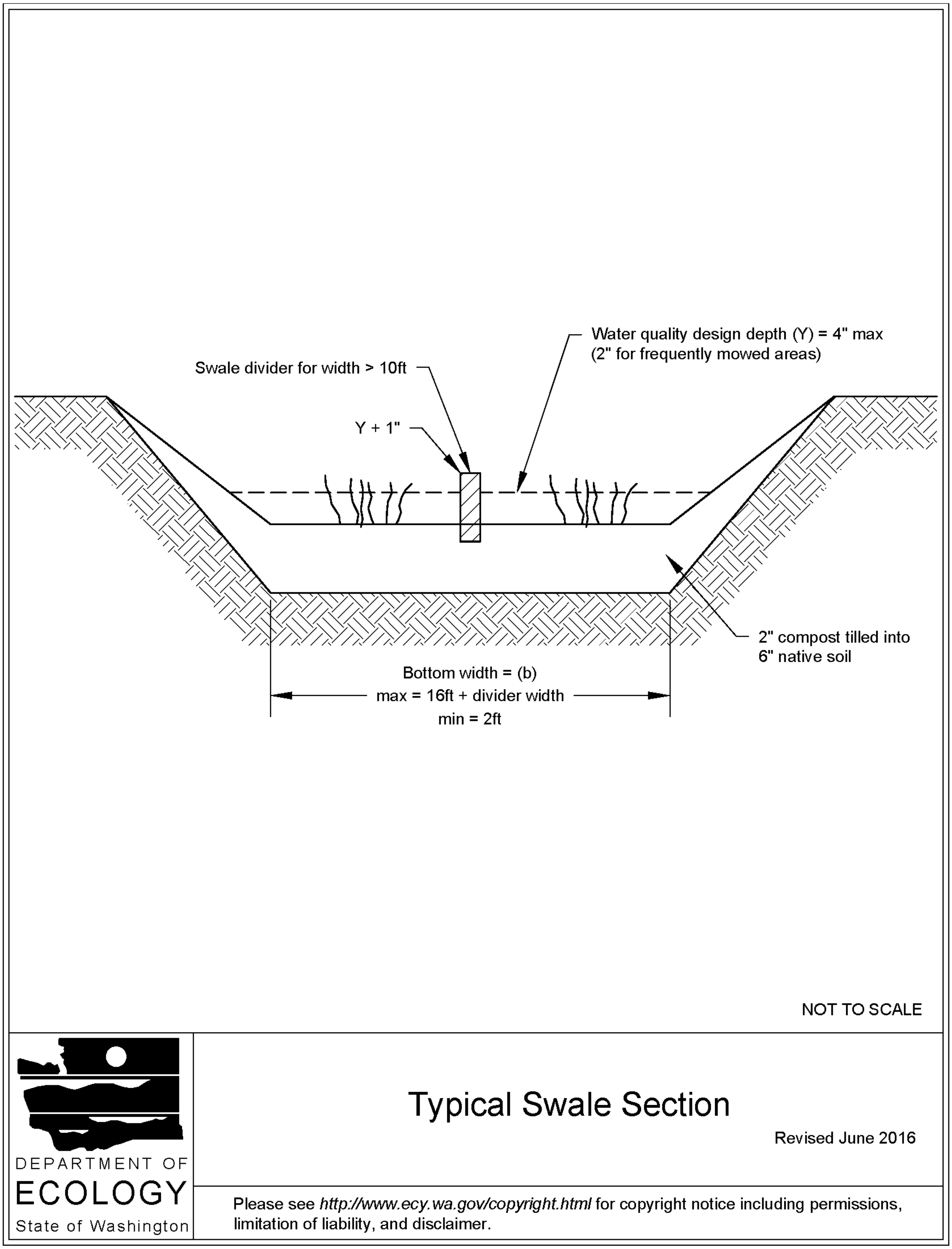
BMP T9.10: Basic Biofiltration Swale

Description

Biofiltration swales are typically shaped as a trapezoid or a parabola as shown in Figure V-7.2: Typical Swale Section.

This section provides Ecology's guidance for the design of biofiltration swales. There are alternative methods to determine the appropriate size of biofiltration swales located within other stormwater design manuals. One example is in the WSDOT Highway Runoff Manual (HRM) BMP RT.04 – Biofiltration Swale. Designers should coordinate with the local jurisdiction to see if they have a preferred method.

Figure V-7.2: Typical Swale Section



Limitations

Data suggests that the performance of biofiltration swales is highly variable from storm to storm. Ecology recommends considering other treatment methods that perform more consistently, such as BMP T8.10: Basic Sand Filter Basin and BMP T10.10: Wetponds - Basic and Large, before using a biofiltration swale. Biofiltration swales downstream of Runoff Treatment BMPs of equal or greater effectiveness can convey runoff; but the designer should not consider them to offer additional Runoff Treatment benefit (Horner, 2000).

Design Criteria

- Table V-7.1: Sizing Criteria for Biofiltration Swales specifies design criteria. Use a 9 minute hydraulic residence time at a multiple of the peak 15 minute Water Quality Design Flow Rate (Q) representing 91% runoff volume as determined by an Ecology approved continuous runoff model.
- Check the hydraulic capacity/stability for inflows greater than design flows. Bypass high flows, or control release rates into the biofiltration swale, if necessary.
- Install flow spreaders (min. 1-inch gravel, see V-1.4.2 Flow Spreaders) at the head and every 50 feet in biofiltration swales of ≥4 feet width. Include sediment cleanouts (weir, settling basin, or equivalent) at the head of the biofiltration swale as needed.
- Use energy dissipators (riprap) for increased downslopes (see V-1.4.3 Outfall Systems).

Guidance for Bypassing Off-line Biofiltration Swales

Most biofiltration swales are currently designed to be on-line facilities. However, an off-line design is possible. Biofiltration swales designed as an off-line BMP should engage a bypass around the biofiltration swale when the flow rate entering the biofiltration swale exceeds the off-line Water Quality Design Flow Rate (as determined by an approved continuous runoff model) multiplied by the ratio determined in Figure V-7.8: Ratio of SBUH Peak/WQ Flow (Offline). This modified off-line design flow rate is an estimate of the design flow rate determined by using SBUH procedures. The only advantage of designing a swale to be off-line is that the stability check, which may make the swale larger, is not necessary.

Sizing Procedure for Biofiltration Swales

This guide provides biofiltration swale design procedures in full detail, along with examples.

Preliminary Steps (P)

1. *Step P-1:* Determine the Water Quality Design Flow Rate, Q (see III-2.6 Sizing Your Runoff Treatment BMPs. Use the correct flow rate, off-line or on-line, for the design situation.
2. *Step P-2:* Establish the longitudinal slope of the proposed biofiltration swale.
3. *Step P-3:* Select a vegetation cover suitable for the site. Refer to Table V-7.2: Guide for Selecting Degree of Retardance, Table V-7.3: Grass Seed Mixes Suitable for Biofiltration Swale Treatment Areas, and Table V-7.4: Groundcovers and Grasses Suitable for the Upper Side

Slopes of a Biofiltration Swale in Western Washington to select vegetation for western Washington.

Design Steps for Biofiltration Swale Capacity (D)

The procedure recommended here is an adaptation from the design procedure originated by Chow (Chow, 1959) for biofiltration applications in the Puget Sound region.

This procedure reverses Chow's order, designing first for capacity and then for stability. The capacity analysis emphasizes the promotion of biofiltration, rather than transporting flow with the greatest possible hydraulic efficiency. Therefore, it is based on criteria that promote sedimentation, filtration, and other pollutant removal mechanisms. Because these criteria include a lower maximum velocity than permitted for stability, the biofiltration swale dimensions usually do not have to be modified after a stability check.

1. *Step D-1:* Select the type of vegetation and design depth of flow (based on frequency of mowing and type of vegetation). See Vegetation Criteria (below) and Table V-7.1: Sizing Criteria for Biofiltration Swales.

2. *Step D-2:* Select a value of Manning's n. See Table V-7.1: Sizing Criteria for Biofiltration Swales.

Table V-7.1: Sizing Criteria for Biofiltration Swales

Design parameter	Biofiltration Swale Sizing
Longitudinal Slope	0.015 - 0.025[1]
Maximum velocity	1 ft / sec (@ K multiplied by the WQ design flow rate ; for stability, 3 ft/sec max.
Maximum water depth[2]	2" - if mowed frequently; 4" if mowed infrequently
Manning coefficient (n)	(0.2 - 0.3)[3] (0.24 if mowed infrequently)
Bed width (bottom)	(2 - 10 ft)[4]
Freeboard height	0.5 ft
Minimum hydraulic residence time at Water Quality Design Flow Rate	9 minutes (18 minutes for continuous inflow) (See Appendix III-C: Rainfall Amounts and Statistics)
Minimum length	100 ft
Maximum sideslope	3 H : 1 V 4H:1V preferred

1. For swales, if the slope is less than 1.5% install an underdrain using a perforated pipe, or equivalent. Amend the soil if necessary to allow effective percolation of water to the underdrain. Install the low-flow

Table V-7.1: Sizing Criteria for Biofiltration Swales (continued)

Design parameter	Biofiltration Swale Sizing
drain 6” deep in the soil. Slopes greater than 2.5% need check dams (riprap) at vertical drops of 12-15 inches. Underdrains can be made of 6 inch Schedule 40 PVC perforated pipe with 6” of drain gravel on the pipe. The gravel and pipe must be enclosed by geotextile fabric. (See Figure V-7.3: Biofiltration Swale Underdrain Detail and Figure V-7.4: Biofiltration Swale Low-Flow Drain Detail) 2. Below the design water depth install an erosion control blanket, at least 4” of topsoil, and the selected biofiltration mix. Above the water line use a straw mulch or sod. 3. This range of Manning’s n can be used in the equation: $b = \frac{Qn}{1.49y^{1.67}s^{0.5}} - Zy$ with wider bottom width b, and lower depth, y, at the same flow. This provides the designer with the option of varying the bottom width of the swale depending on space limitations. Designing at the higher n within this range at the same flow decreases the hydraulic design depth, thus placing the pollutants in closer contact with the vegetation and the soil. 4. For swale widths up to 16 feet the cross-section can be divided with a berm (concrete, plastic, compacted earthfill) using a flow spreader at the inlet (Figure V-7.5: Swale Dividing Berm)	

Figure V-7.3: Biofiltration Swale Underdrain Detail

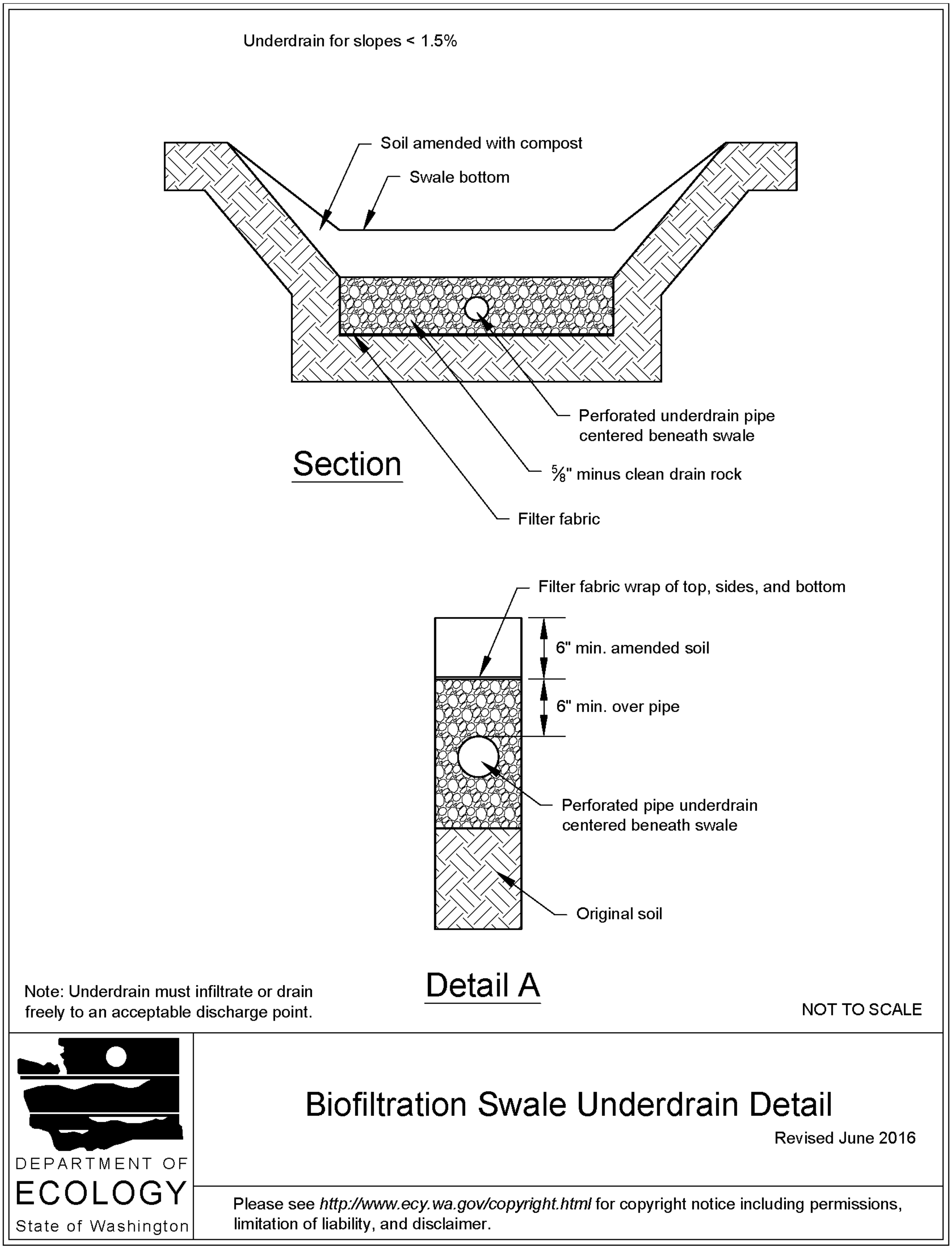
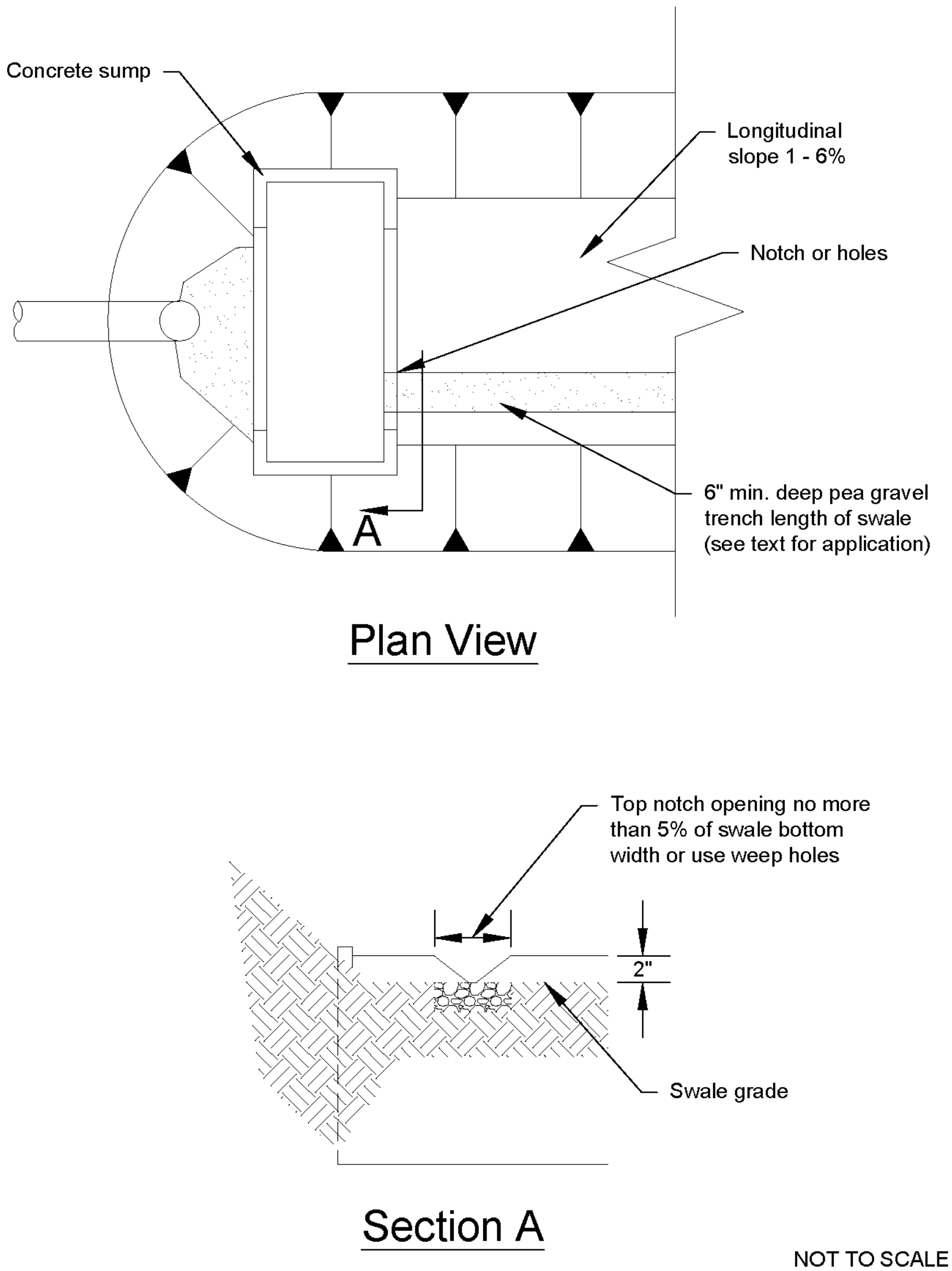


Figure V-7.4: Biofiltration Swale Low-Flow Drain Detail



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Biofiltration Swale Low-Flow Drain Detail

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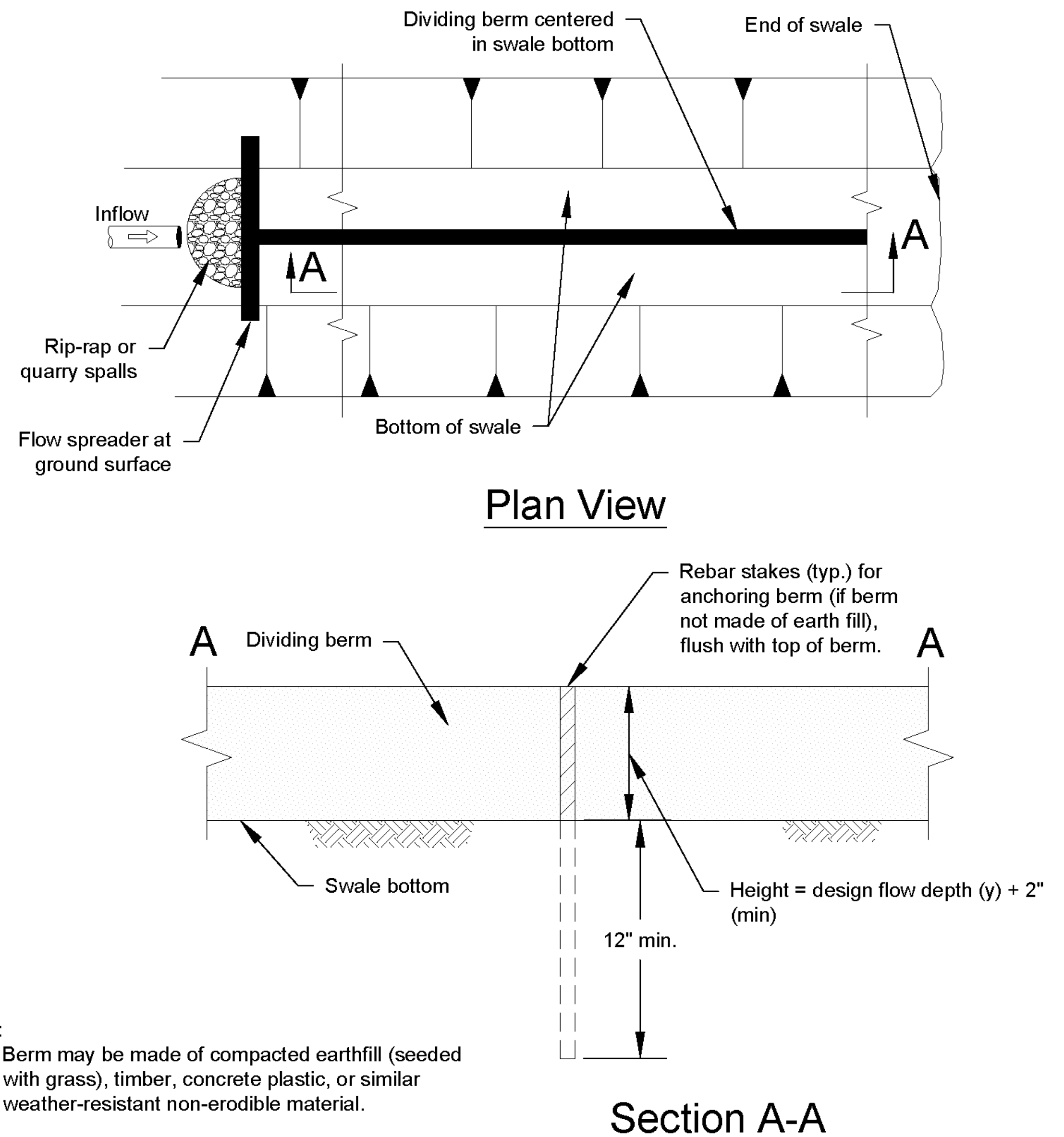
Figure V-7.5: Swale Dividing Berm



Notes:

1. Berm may be made of compacted earthfill (seeded with grass), timber, concrete plastic, or similar weather-resistant non-erodible material.

2. Rebar stakes or similar berm anchoring materials needed if berm made of timber, plastic, or concrete curbing - stake placement required at both ends of each individual member (at a minimum).

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Swale Dividing Berm

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3. *Step D-3:* Select the biofiltration swale shape. The shape is typically trapezoidal or parabolic.
4. *Step D-4:* Use Manning's equation and first approximations relating hydraulic radius and dimensions for the selected biofiltration swale shape to obtain a working value of the biofiltration swale width dimension:

   (equation 1):

   $$Q = \frac{1.49AR^{0.67}s^{0.5}}{n}$$

   (equation 2):

   $$A_{rectangle} = Ty$$

   (equation 3):

   $$R_{rec\tan gle} = \frac{Ty}{T+2y}$$

   Where:

   Q = Water Quality Design Flow Rate per III-2.6 Sizing Your Runoff Treatment BMPs, (ft^3/s, cfs)

   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)

   T = top width of trapezoid or width of a rectangle (ft)

   y = depth of flow (ft)

   b = bottom width of trapezoid (ft)

   If equations 2 and 3 are substituted into equation 1 and solved for T, complex equations result that are difficult to solve manually. However, approximate solutions can be found by recognizing that T>>y and Z^2>>1, and that certain terms are nearly negligible. The approximation solutions for rectangular and trapezoidal shapes are:

   $$R_{rectangle} \approx y,\ R_{trapezoid} \approx y,\ R_{parabolic} \approx 0.67y,\ R_V \approx 0.5y$$

   Substitute $R_{trapezoid}$ and $A_{trapezoid} = by + Zy^2$ into Equation 1, and solve for the bottom width b (trapezoidal swale):

   $$b \approx \frac{2.5Qn}{1.49y^{1.67}s^{0.5}} - Zy$$

   For a trapezoid, select a side slope Z of at least 3. Compute b and then top width T, where T = b + 2yZ. Note: An adjustment factor of 2.5 accounts for the difference between Water Quality

Design Flow Rate (Q) and the SBUH design flow. This equation is used to estimate an initial cross-sectional area. It does not affect the overall biofiltration swale size.

If b for a swale is greater than 10 ft, either investigate how Q can be reduced, divide the flow by installing a low berm, or arbitrarily set b = 10 ft and continue with the analysis. For other biofiltration swale shapes refer to Figure V-7.6: Geometric Formulas for Common Swale Shapes.

Figure V-7.6: Geometric Formulas for Common Swale Shapes

Source: Livingston, et al, 1984

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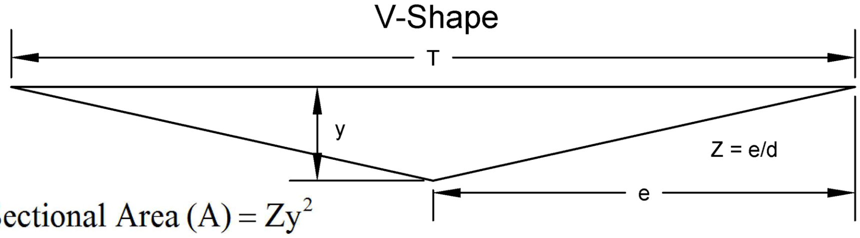
Channel Geometry

V-Shape

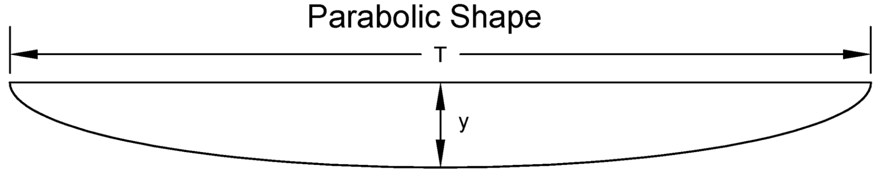


$$\text{Cross-Sectional Area (A)} = Zy^2$$

$$\text{Top Width (T)} = 2yZ$$

$$\text{Hydraulic Radius (R)} = \frac{Zy}{2\sqrt{Z^2+1}}$$

Parabolic Shape

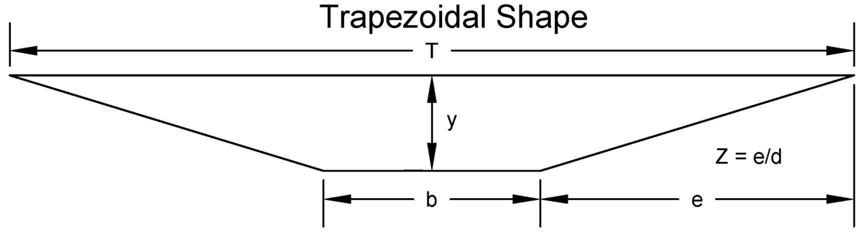


$$\text{Cross-Sectional Area (A)} = \frac{2}{3}Ty$$

$$\text{Top Width (T)} = \frac{1.5A}{y}$$

$$\text{Hydraulic Radius (R)} = \frac{T^2y}{1.5T^2+4y^2}$$

Trapezoidal Shape



$$\text{Cross-Sectional Area (A)} = by + Zy^2$$

$$\text{Top Width (T)} = b + 2yz$$

$$\text{Hydraulic Radius (R)} = \frac{by + Zy^2}{b + 2y\sqrt{Z^2+1}}$$

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Geometric Formulas for Common Swale Shapes

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5. *Step D-5:* Compute A:

$$A_{rectangle} = Ty$$

$$A_{trapazoid} = by + Zy^2$$

$$A_{filter\ strip} = Ty$$

6. *Step D-6:* Compute the SBUH design flow velocity (V) at the Water Quality Design Flow Rate (Q):

$$V = K\frac{Q}{A}$$

Where:

K = A ratio of the peak volumetric flow rate calculated using a 10-minute time step by SBUH to the Water Quality Design Flow Rate as described in III-2.6 Sizing Your Runoff Treatment BMPs. The value of K is determined from Figure V-7.7: Ratio of SBUH Peak/WQ Flow (Online) for on-line biofiltration swales, or Figure V-7.8: Ratio of SBUH Peak/WQ Flow (Off-line) for off-line biofiltration swales.

If V > 1.0 ft/sec (or V > 0.5 ft/sec for BMP T9.40: Vegetated Filter Strip), repeat steps D-1 to D-6 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 biofiltration swale. If the value of V suggests that a longer biofiltration swale will be needed than space permits, investigate how Q can be reduced (e.g., use of LID BMPs), or increase y and/or T (up to the allowable maximum values) and repeat the analysis.

7. *Step D-7:* Compute the biofiltration swale length (L, ft)

$$L = Vt\ (60\ sec/min)$$

Where: t = hydraulic residence time (min)

Use t = 9 minutes for this calculation (use t = 18 minutes for BMP T9.30: Continuous Inflow Biofiltration Swale). If a biofiltration swale length is greater than the space permits, follow the advice in step D-6.

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.

8. *Step D-8:* If there is still not sufficient space for the biofiltration swale, the local government and the project proponent should consider the following solutions (listed in order of preference):

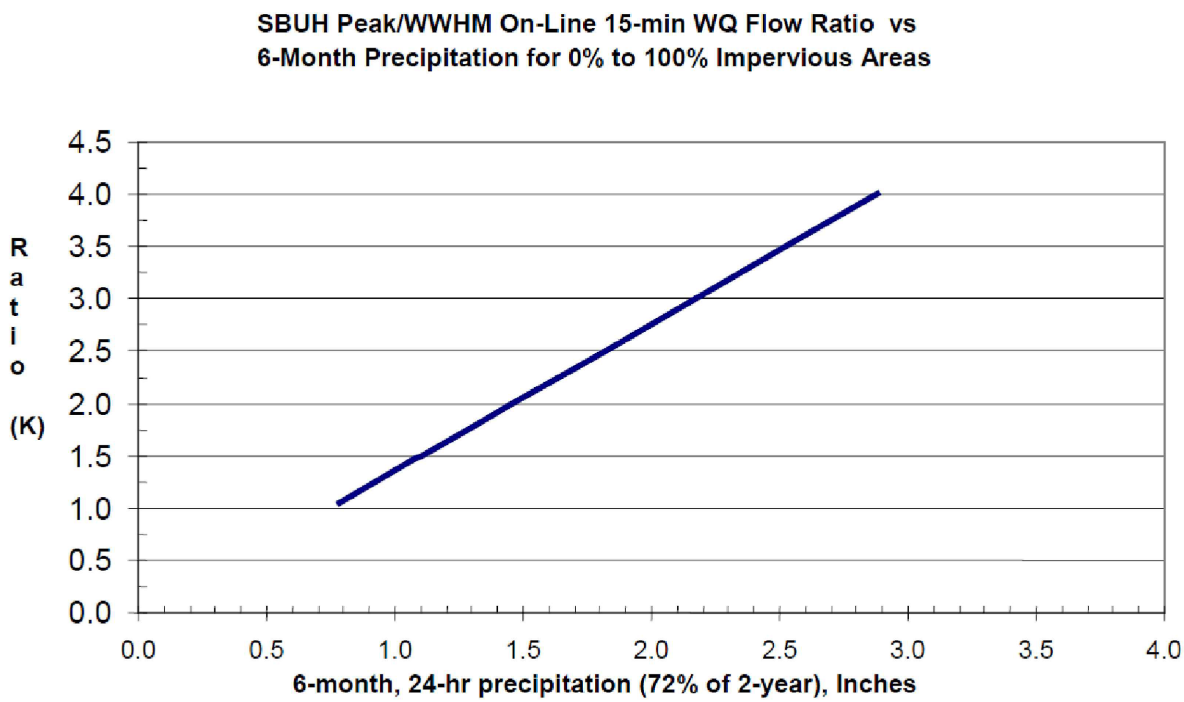
    1. Divide the site drainage to flow to multiple biofiltration BMPs.

    2. Use infiltration to provide lower discharge rates to the biofiltration swale (only if the

conditions for infiltration in V-5.6 Site Suitability Criteria (SSC) are met).

3. Increase vegetation height and design depth of flow. The design must ensure that vegetation remains standing during the design flow.
4. Reduce the developed surface area to gain space for the biofiltration swale.
5. Increase the longitudinal slope.
6. Increase the side slopes.
7. Nest the biofiltration swale within or around another Runoff Treatment BMP.

Figure V-7.7: Ratio of SBUH Peak/WQ Flow (Online)



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Ratio of SBUH Peak/WQ Flow (Online)

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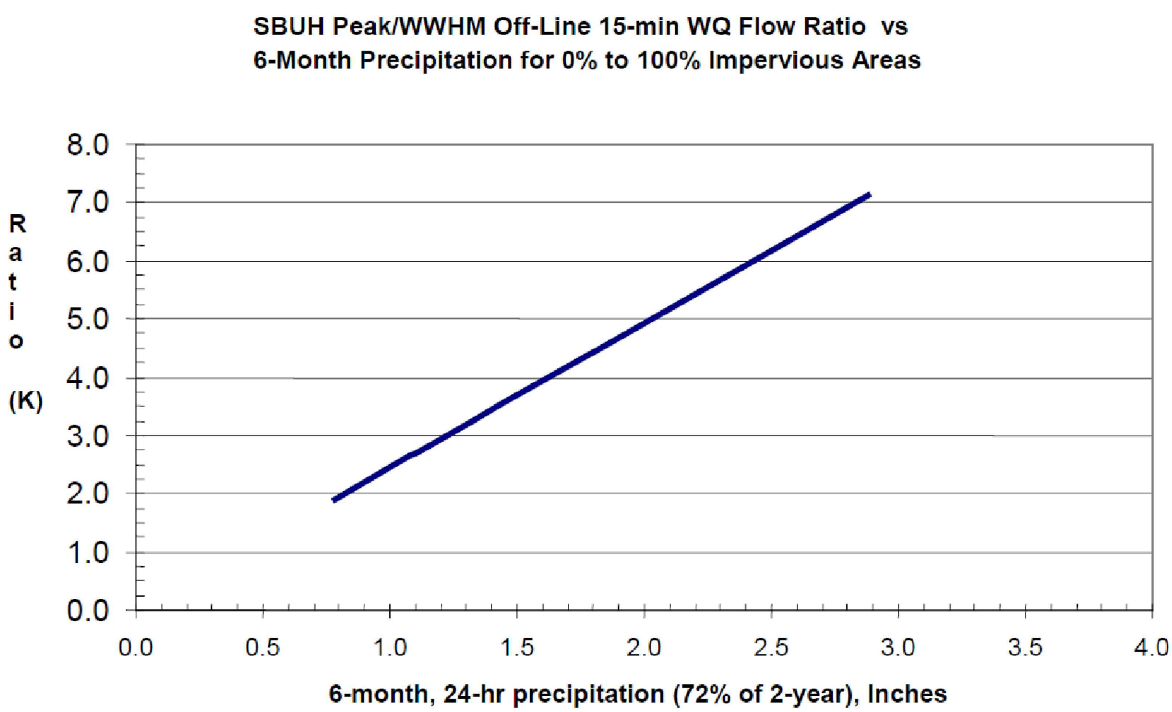
Figure V-7.8: Ratio of SBUH Peak/WQ Flow (Offline)



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Ratio of SBUH Peak/WQ Flow (Offline)

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Stability Check Steps (SC)

The stability 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 "off-line" from the primary conveyance/detention system (see Guidance for Bypassing Off-line Biofiltration Swales). Maintain the same units as in the biofiltration swale capacity analysis detailed above.

1. *Step SC-1:* Perform the stability check for the 100-year, return frequency flow using 15-minute time steps using an approved continuous runoff model.

2. *Step SC-2:* Estimate the vegetation coverage ("good" or "fair") and height on the first occasion that the biofiltration swale will receive flow, or whenever the coverage and height will be least. Avoid flow introduction during the vegetation establishment period by timing planting or bypassing.

3. *Step SC-3:* Estimate the degree of retardance from Table V-7.2: Guide for Selecting Degree of Retardance. When uncertain, be conservative by selecting a relatively low degree.

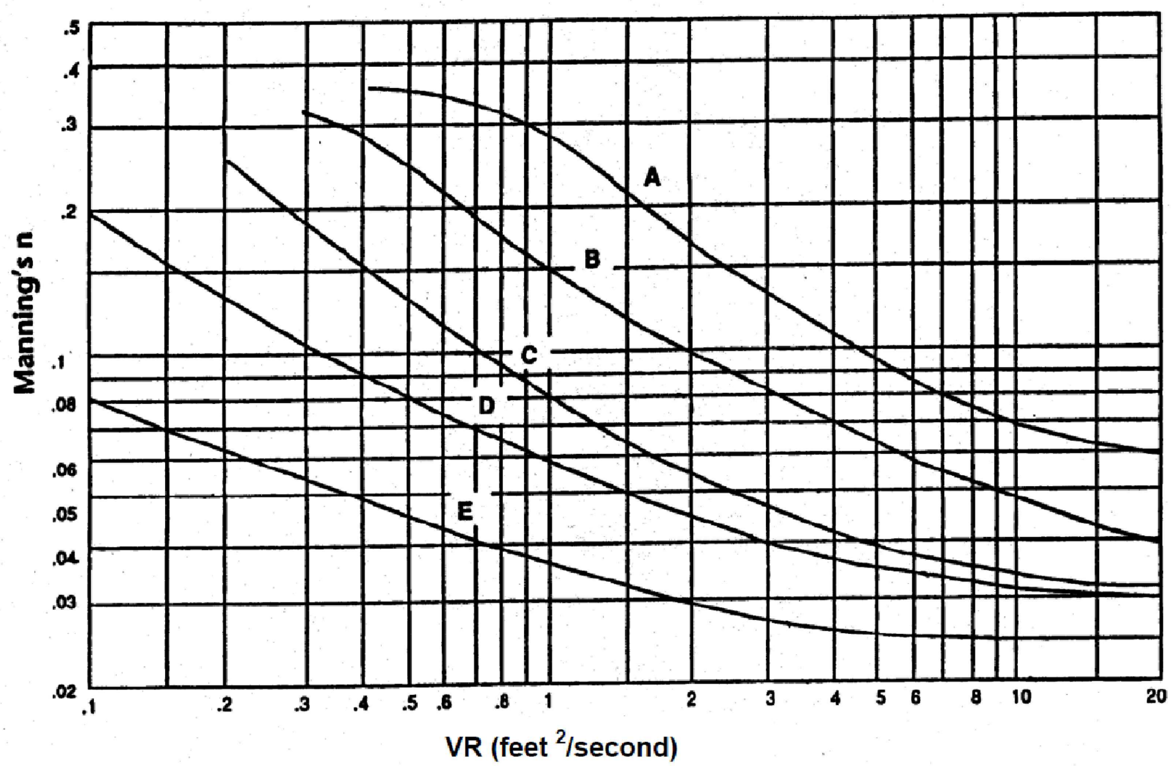
   The maximum permissible velocity for erosion prevention (Vmax) is 3 feet per second.

Table V-7.2: Guide for Selecting Degree of Retardance

Coverage	Average Grass Height (inches)	Degree of Retardance
Good	< 2	E. Very Low
	2 - 6	D. Low
	6 - 10	C. Moderate
	11 - 24	B. High
	> 30	A. Very High
Fair	< 2	E. Very Low
	2 - 6	D. Low
	6 - 10	D. Low
	11 - 24	C. Moderate
	> 30	B. High
See (Chow, 1959). In addition, Chow recommended selection of retardance C for a grass-legume mixture 6-8 inches high and D for a mixture 4-5 inches high. No retardance recommendations have appeared for emergent wetland species. Therefore, judgment must be used. Since these species generally grow less densely than grasses, using a "fair" coverage would be a reasonable approach.		

4. *Step SC-4:* Select a trial Manning's n for the high flow condition. The minimum value for poor vegetation cover and low height (possibly, knocked from the vertical by high flow) is 0.033. A good initial choice under these conditions is 0.04.

Figure V-7.9: The Relationship of Manning's n with VR for Various Degrees of Flow Retardance (A-E)



Note: VR is the product of velocity and hydraulic radius

Source: Livingston, et al, 1984

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The Relationship of Manning's n with VR for Various Degrees of Flow Retardance (A-E)

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5. *Step SC-5:* Refer to Figure V-7.9: The Relationship of Manning's n with VR for Various Degrees of Flow Retardance (A-E) to obtain a first approximation for VR of 3 feet/second.
6. *Step SC-6:* Compute the hydraulic radius, R, from VR in Figure V-7.9: The Relationship of Manning's n with VR for Various Degrees of Flow Retardance (A-E) and a Vmax.
7. *Step SC-7:* Use Manning's equation to solve for the actual VR.
8. *Step SC-8:* Compare the actual VR from step SC-7 and the first approximation of VR from step SC-5. If they do not agree within 5 percent, repeat steps SC-4 to SC-8 until acceptable agreement is reached. If n < 0.033 is needed to get agreement, set n = 0.033, repeat step SC-7, and then proceed to step SC-9.
9. *Step SC-9:* Compute the actual V for the final design conditions. Check to be sure V < Vmax of 3 feet/second.
10. *Step SC-10:* Compute the required biofiltration swale cross-sectional area, A, for stability.
11. *Step SC-11:* Compare the A computed in step SC-10 to the A computed in step D-5.

    If less area is required for stability (the A from SC-10) than is provided for capacity (the A from D-5), the capacity design is acceptable. If not, use A from step SC-10 of the stability analysis and recalculate the biofiltration swale dimensions.
12. *Step SC-12:* Calculate the depth of flow at the stability check design flow rate condition for the final dimensions and use A from step SC-10.
13. *Step SC-13:* Compare the depth from step SC-12 to the depth used in the biofiltration swale capacity design (Step D-1). Use the larger of the two and add 0.5 ft. of freeboard to obtain the total depth (yt) of the biofiltration swale. Calculate the top width for the full depth using the appropriate equation.
14. *Step SC-14:* Recalculate the hydraulic radius. Use b from Step D-4 calculated previously for the biofiltration swale capacity, or Step SC-11, as appropriate, and y_t = total depth from Step SC-13.
15. *Step SC-15:* Make a final check for capacity based on the stability check design storm (this check will ensure that capacity is adequate if the largest expected event coincides with the greatest retardance). Use Equation 1, a Manning's n selected in step D-2, and the calculated channel dimensions, including freeboard, to compute the flow capacity of the channel under these conditions. Use R from step SC-14, above, and $A = b(y_t) + Z(y_t)^2$ using b from Step D-4, D-15, or SC-11 as appropriate.

    If the flow capacity is less than the stability check design storm flow rate, increase the channel cross-sectional area as needed for this conveyance. Specify the new channel dimensions.

Completion Step (CO)

1. *Step CO-1:* Review all of the criteria and guidelines for biofiltration swale planning, design, installation, and operation above and specify all of the appropriate features for the application.

Example of Sizing Calculations for Biofiltration Swales

Preliminary Steps (Example)

1. *Step P-1:* Assume that the Water Quality Design Flow Rate, Q, is 0.2 cfs. Assume an on-line BMP.
2. *Step P-2:* Assume the slope (s) is 2 percent.
3. *Step P-3:* Assume the vegetation will be a grass-legume mixture and it will be infrequently mowed.

Design Steps for Biofiltration Swale Capacity (Example)

1. *Step D-1:* Set the winter grass height at 5" and the design flow depth (y) at 3 inches.
2. *Step D-2:* Use n = 0.20 to n_2 = 0.30
3. *Step D-3:* Base the design on a trapezoidal shape, with a side slope Z = 3.
4. *Step D-4(a):* Calculate the bottom width, b;

   Where:

   n = 0.20

   y = 0.25 ft

   Q = 0.2 cfs

   s = 0.02

   Z = 3

   $$b \approx \frac{2.5Qn}{1.49y^{1.67}s^{0.5}} - Zy$$

   b ≈ 4.0 ft

   At n_2; b_2 = 6.5 feet

   Step D-4(b): Calculate the top width (T)

   T = b + 2yZ = 4.0+ [2(0.25)(3)] = 5.5 feet
5. *Step D-5:* Calculate the cross-sectional area (A)

   A = by + Zy^2 = (4.0)(0.25) + (3)(0.25^2) = 1.19 ft^2
6. *Step D-6:* Calculate the flow velocity (V)

   $$V = K\frac{Q}{A} = 0.17 ft/\sec$$

   for K = 1. Actual K is determined per Figure V-7.7: Ratio of SBUH Peak/WQ Flow (Online)

   0.17<1.0 ft/sec , therefore OK
7. *Step D-7:* Calculate the Length (L)

   L = Vt(60 sec/min)

= 0.17 (9)(60)

For t = 9 min, L = 92 ft. at n; expand to a minimum of 100 foot length per design criterion

At n_2; L = 100 ft.

Note: Where b is less than the maximum value, it may be possible to reduce L by increasing b. In this case, because L is determined by the requirement for a minimum length of 100 feet, it is not possible.

Stability Check Steps (Example)

1. *Step SC-1:* Base the check on passing the 100-year, return frequency flow (15 minute time steps) through the biofiltration swale with a mixture of Kentucky bluegrass and tall fescue on loose erodible soil. Assume that the peak Q is 1.92 cfs.
2. *Step SC-2:* Base the check on a grass height of 3 inches with "fair" coverage (lowest mowed height and least cover, assuming flow bypasses or does not occur during grass establishment).
3. *Step SC-3:* From Table V-7.2: Guide for Selecting Degree of Retardance, Degree of Retardance = D (low)

   Set V_{max} = 3 ft/sec
4. *Step SC-4:* Select trial Manning's n = 0.04
5. *Step SC-5:* From Figure V-7.9: The Relationship of Manning's n with VR for Various Degrees of Flow Retardance (A-E), VR_{appx} = 3 ft^2/s
6. *Step SC-6:* Calculate R

   $$R = \frac{VR_{appx}}{V_{\max}} = 1.0 ft$$
7. *Step SC-7:* Calculate VR_{actual}

   $$VR_{actual} = \frac{1.49}{n} R^{1.67} s^{0.5} = 5.25 \frac{ft^2}{\sec}$$
8. *Step SC-8:* VR_{actual} from step SC-7 > VR_{appx} from step SC-5 by > 5%.

   Select new trial n = 0.0475

   Figure V-7.9: The Relationship of Manning's n with VR for Various Degrees of Flow Retardance (A-E): VR_{appx} = 1.7 ft^2/s

   R = 0.57 ft.

   VR_{actual} = 1.73 ft^2/s (within 5% of VR_{appx} = 1.7)
9. *Step SC-9:* Calculate V

$V = \frac{VR_{actual}}{R} = \frac{1.73}{0.57} = 3ft/\sec$

V = 3 ft/sec ≤ 3 ft/sec, therefore Vmax OK

10. *Step SC-10:* Calculate Stability Area

    $A_{Stability} = \frac{Q}{V} = \frac{1.92}{3} = 0.64ft^2$

11. *Step SC-11:* Stability Check

    $A_{Stability}$ = 0.64 ft^2 is less than $A_{Capacity}$ from step D-5 ($A_{Capacity}$ = 1.19 ft^2). Therefore OK

    If $A_{Stability}$ > $A_{Capacity}$, it will be necessary to select new trial sizes for width and flow depth (based on space and other considerations), recalculate $A_{Capacity}$, and repeat steps SC-10 and SC-11.

12. *Step SC-12:* Calculate depth of flow at the stability design flow rate condition using the quadratic equation solution:

    $y = \frac{-b \pm \sqrt{b^2 - 4Z(-A)}}{2Z}$

    For b = 4, y = 0.14 ft (positive root)

13. *Step SC-13:* Use the greater value of y from SC-12 or that assumed in D-1. In this case, the greater depth is 0.25-foot, which was the basis for the biofiltration capacity design. Add 0.5 feet freeboard to that depth.

    Total channel depth = 0.75 ft

    Top Width = b + 2yZ

    = 4 + (2)(0.75)(3)

    = 8.5 ft

14. *Step SC-14:* Recalculate hydraulic radius and flow rate

    For b = 4 ft, y = 0.75 ft

    Z = 3, s = 0.02, n = 0.2

    A = by + Zy^2 = 4.68 ft^2

    R = {by + Zy^2}/{b + 2y(Z^2 + 1)$^{0.5}$} = 0.53 ft.

15. *Step SC-15:* Calculate Flow Capacity at Greatest Resistance

    $Q = \frac{1.49AR^{0.67}s^{0.5}}{n} = 3.2cfs$

    Q = 3.2 cfs > 1.92 cfs, therefore OK

Completion Step (Example)

1. *Step CO-1:* Assume 100 feet of swale length is available.

   The final channel dimensions are:

   Bottom width, b = 4 feet

   Channel depth = 0.75 feet

   Top width = b + 2yZ = 8.5 feet

   No check dams are needed for a 2% slope.

Soil Criteria

- Till the following top soil mix to a depth of at least 8-inches:
  - Sandy loam 60-90 %
  - Clay 0-10 %
  - Composted material, 10-30 %

    Use compost amended soil where practicable. Composted material shall meet the specifications for compost used in the Bioretention Soil Mix (BMP T7.30: Bioretention). This excludes use of biosolids and manures.
- For longitudinal slopes of < 2 percent use more sand to obtain more infiltration.
- If ground water contamination is a concern, seal the bed with low permeability liner per V-1.3.3 Low Permeability Liners.

Vegetation Criteria

- See Table V-7.3: Grass Seed Mixes Suitable for Biofiltration Swale Treatment Areas, Table V-7.4: Groundcovers and Grasses Suitable for the Upper Side Slopes of a Biofiltration Swale in Western Washington and Table V-7.5: Recommended Plants for Wet Biofiltration Swale 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 biofiltration swale to prevent erosion
- Fertilizing a biofiltration swale should be avoided if at all possible in any application where

nutrient control is an objective. Test the soil for nitrogen, phosphorous, and potassium and consult with a landscape professional about the need for fertilizer in relation to soil nutrition and vegetation requirements. If use of a fertilizer cannot be avoided, use a slow-release fertilizer formulation in the least amount needed.

Table V-7.3: Grass Seed Mixes Suitable for Biofiltration Swale Treatment Areas

Mix 1		Mix 2	
75-80 percent	tall or meadow fescue	60-70 percent	tall fescue
		10-15 percent	seaside/ colonial bentgrass
10-15 percent	seaside/colonial bentgrass	10-15 percent	meadow foxtail
		6-10 percent	alsike clover
5-10 percent	Redtop	1-5 percent	marshfield big trefoil
		1-6 percent	Redtop
Note: all percentages are by weight.			

Table V-7.4: Groundcovers and Grasses Suitable for the Upper Side Slopes of a Biofiltration Swale in Western Washington

Groundcovers
kinnikinnick (*Arctostaphylos uva-ursi*)
epimedium (*Epimedium grandiflorum*)
creeping forget-me-not (*Omphalodes verna*)
Euonymus lanceolatus
yellow-root (*Xanthorhiza simplissima*)
Genista (multiple species)
white lawn clover (*Trifolium repens*)
crinkle-leaf creeper (*Rubus calycinoides*)
strawberry (*Fragaria chiloensis*)
broadleaf lupine (*Lupinus latifolius*)
Grasses (drought- tolerant, minimum mowing)
dwarf tall fescues (*Festuca* - multiple species, e.g. Many Mustang, Silverado)
hard fescue (*Festuca ovina duriuscula* - e.g., Reliant, Aurora)
tufted fescue (*Festuca amethystine*)
buffalo grass (*Buchloe dactyloides*)

Table V-7.4: Groundcovers and Grasses Suitable for the Upper Side Slopes of a Biofiltration Swale in Western Washington (continued)

Groundcovers
red fescue (*Festuca rubra*)
tall fescue grass (*Festuca arundinacea*)
blue oatgrass (*Helictotrichon sempervirens*)

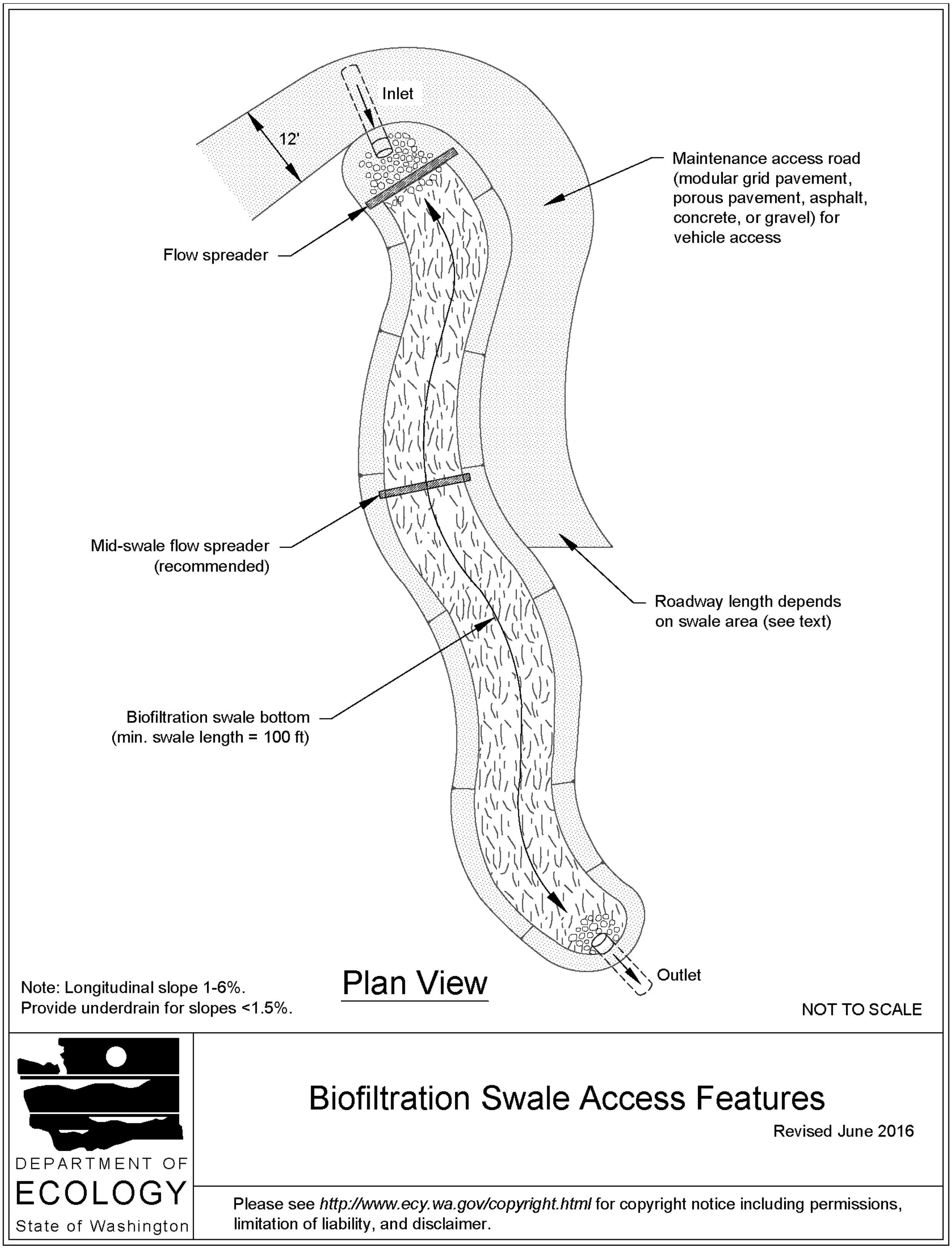
Construction Criteria

The biofiltration swale should not be put into operation until areas of exposed soil in the contributing drainage catchment have been sufficiently stabilized. Deposition of eroded soils can impede the growth of grass in the biofiltration swale and reduce Runoff Treatment effectiveness. Thus, effective erosion and sediment control measures should remain in place until the biofiltration swale vegetation is established (see Volume II for erosion and sediment control BMPs). Avoid compaction during construction. Grade biofiltration swales to attain uniform longitudinal and lateral slopes.

Maintenance Criteria

- Inspect biofiltration swales at least once every 6 months, preferably during storm events, and also after storm events of > 0.5 inch rainfall/24 hours. Maintain adequate grass growth and eliminate bare spots.
- Mow grasses, if needed for good growth (typically maintain at 4 – 9 inches and not below design flow level (King County Department of Natural Resources, 1998)).
- Remove sediment as needed at the head of the biofiltration swale if grass growth is inhibited in greater than 10 percent of the swale, or if the sediment is blocking the distribution and entry of the water (King County Department of Natural Resources, 1998).
- Remove leaves, litter, and oily materials, and re-seed or resod, and regrade, as needed. Clean curb cuts and level spreaders as needed.
- Prevent scouring and soil erosion in the biofiltration swale. If flow channeling occurs, regrade and reseed the biofiltration swale, as necessary.
- Maintain access to the biofiltration swale inlet, outlet, and to mowing (see Figure V-7.10: Biofiltration Swale Access Features).
- If a biofiltration swale is equipped with underdrains, vehicular traffic on the swale bottom (other than grass mowing equipment) should be avoided to prevent damage to the underdrain.

Figure V-7.10: Biofiltration Swale Access Features



BMP T9.20: Wet Biofiltration Swale

Description

A wet biofiltration swale is a variation of BMP T9.10: Basic Biofiltration Swale. Designers can use wet biofiltration swales when the longitudinal slope is slight, water tables are high, or a continuous low base flow is likely to result in saturated soil. Where saturation exceeds about 2 weeks, typical grasses will die. Thus, use vegetation specifically adapted to saturated soil conditions. Different vegetation in turn requires modification of several of the design parameters for BMP T9.10: Basic Biofiltration Swale.

Wet biofiltration swales are Runoff Treatment BMPs that remove low concentrations of pollutants such as TSS, heavy metals, nutrients, and petroleum hydrocarbons.

Applications/Limitations

Wet biofiltration swales are applied where BMP T9.10: Basic Biofiltration Swale is desired but not allowed or advisable because one or more of the following conditions exist:

- The swale is on 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 are slight (generally less than 2 percent).

Design Criteria

Use the same design approach as for BMP T9.10: Basic Biofiltration Swale, except to add the following:

Adjustment for Extended Wet Season Flow

If the wet biofiltration swale will be downstream of a detention pond providing Flow Control, multiply the treatment area (the bottom width times the bottom length) of the swale by 2, and readjust the swale length, if desired. Maintain a 5:1 length to width ratio.

Intent: An increase in the treatment area of biofiltration swales following detention ponds is required because of the differences in vegetation established in a constant flow environment. Flows following detention are much more prolonged. These prolonged flows result in more stream-like conditions than are typical for other wet biofiltration swale situations. Since vegetation growing in streams is often less dense, this increase in treatment area is needed to ensure that equivalent pollutant removal is achieved in extended flow situations.

Swale Geometry

Same as specified for BMP T9.10: Basic Biofiltration Swale, except for the following modifications:

- The bottom width may be increased to 25 feet maximum, but a minimum length-to-width ratio of 5:1 must be provided. No longitudinal dividing berm is needed. The minimum swale length is still 100 feet.

- If longitudinal slopes are greater than 2 percent, the wet biofiltration 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. No underdrain or low-flow drain is required.

High-Flow Bypass

Wet biofiltration swales must be designed as off-line facilities.

A high-flow bypass (i.e., an off-line design) is required for flows greater than the off-line Water Quality Design Flow Rate multiplied by the ratio indicated in Figure V-7.8: Ratio of SBUH Peak/WQ Flow (Offline). The bypass is necessary to protect wetland vegetation from damage. Unlike grass, wetland vegetation will not quickly regain an upright attitude after being laid down by high flows. New growth, usually from the base of the plant, often taking several weeks, is required to regain its upright form. The bypass may be an open channel parallel to the wet biofiltration swale.

Water Depth and Base Flow

Same as for BMP T9.10: Basic Biofiltration Swale, except the design water depth shall be 4 inches for all wetland vegetation selections, and no underdrains or low-flow drains are required.

Flow Velocity, Energy Dissipation, and Flow Spreading

Same as for BMP T9.10: Basic Biofiltration Swale, except no flow spreader is needed.

Access

Same as for BMP T9.10: Basic Biofiltration Swale, except access is only required to the inflow and the outflow of the wet biofiltration swale; access along the length of the wet biofiltration swale is not required. Also, wheel strips may not be used for access in the wet biofiltration swale.

Intent: An access road is not required along the length of a wet biofiltration swale because of infrequent access needs. Frequent mowing or harvesting is not desirable. In addition, wetland plants are fairly resilient to sediment-induced changes in water depth, so the need for access should be infrequent.

Soil Criteria

Same as for BMP T9.10: Basic Biofiltration Swale.

Vegetation Criteria

Same as for BMP T9.10: Basic Biofiltration Swale, except for the following modifications:

1. A list of acceptable plants and recommended spacing is shown in Table V-7.5: Recommended Plants for Wet Biofiltration Swale. In general, it is best to plant several species to increase the likelihood that at least some of the selected species will find growing conditions favorable.

2. 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 2/3 of the swale after four weeks.

Table V-7.5: Recommended Plants for Wet Biofiltration Swale

Common Name	Scientific Name	Spacing (on center)
Shortawn foxtail	*Alopecurus aequalis*	seed
Water foxtail	*Alopecurus geniculatus*	seed
Spike rush	*Eleocharis spp.*	4 inches
Slough sedge*	*Carex obnupta*	6 inches or seed
Sawbeak sedge	*Carex stipata*	6 inches
Sedge	*Carex spp.*	6 inches
Western mannagrass	*Glyceria occidentalis*	seed
Velvetgrass	*Holcus mollis*	seed
Slender rush	*Juncus tenuis*	6 inches
Watercress*	*Rorippa nasturtium-aquaticum*	12 inches
Water parsley*	*Oenanthe sarmentosa*	6 inches
Hardstem bulrush	*Scirpus acutus*	6inches
Small-fruited bulrush	*Scirpus microcarpus*	12 inches
** Good choices for wet biofiltration swales with significant periods of flow, such as those downstream of a detention facility.*		
Note: Cattail (Typha latifolia) is not appropriate for most wet biofiltration swales because of its very dense and clumping growth habit which prevents water from filtering through the clump.		

Construction Criteria

Same as for BMP T9.10: Basic Biofiltration Swale.

Maintenance Criteria

Same as for BMP T9.10: Basic Biofiltration Swale, except mowing of wetland vegetation is not required. However, harvesting of very dense vegetation may be desirable in the fall after plant die-back to prevent the sloughing of excess organic material into receiving waters. Many native *Juncus* species remain green throughout the winter; therefore, fall harvesting of *Juncus* species is not recommended.

BMP T9.30: Continuous Inflow Biofiltration Swale

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 (this BMP) – is needed. The basic biofiltration swale design presented in BMP T9.10: Basic Biofiltration Swale is modified by increasing the biofiltration swale length to achieve an equivalent average residence time.

Applications

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 biofiltration 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 should carry more than about 10 percent of the flow.

A continuous inflow biofiltration swale is not appropriate for a situation in which significant lateral flows enter a biofiltration swale at some point downstream from the head of the biofiltration swale. In this situation, the biofiltration swale width and length must be recalculated from the point of confluence to the discharge point in order to provide adequate treatment for the increased flows.

Design Criteria

Same as specified for BMP T9.10: Basic Biofiltration Swale except for the following:

- The design flow for continuous inflow biofiltration swales must include runoff from the pervious side slopes draining to the swale along the entire swale length. Therefore, they must be on-line facilities.
- If only a single design flow is used, the flow rate at the outlet should be used. The goal is to achieve an average residence time through the continuous inflow biofiltration swale of 9 minutes as calculated using the on-line Water Quality Design Flow Rate (as described in III-2.6 Sizing Your Runoff Treatment BMPs) multiplied by the ratio, K, in Figure V-7.7: Ratio of SBUH Peak/WQ Flow (Online). Assuming an even distribution of inflow into the side of the swale, double the hydraulic residence time to a minimum of 18 minutes.
- For continuous inflow biofiltration swales, interior side slopes above the WQ design treatment elevation shall be planted in grass. A typical lawn seed mix or the seed mixes presented in BMP T9.10: Basic Biofiltration Swale 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.

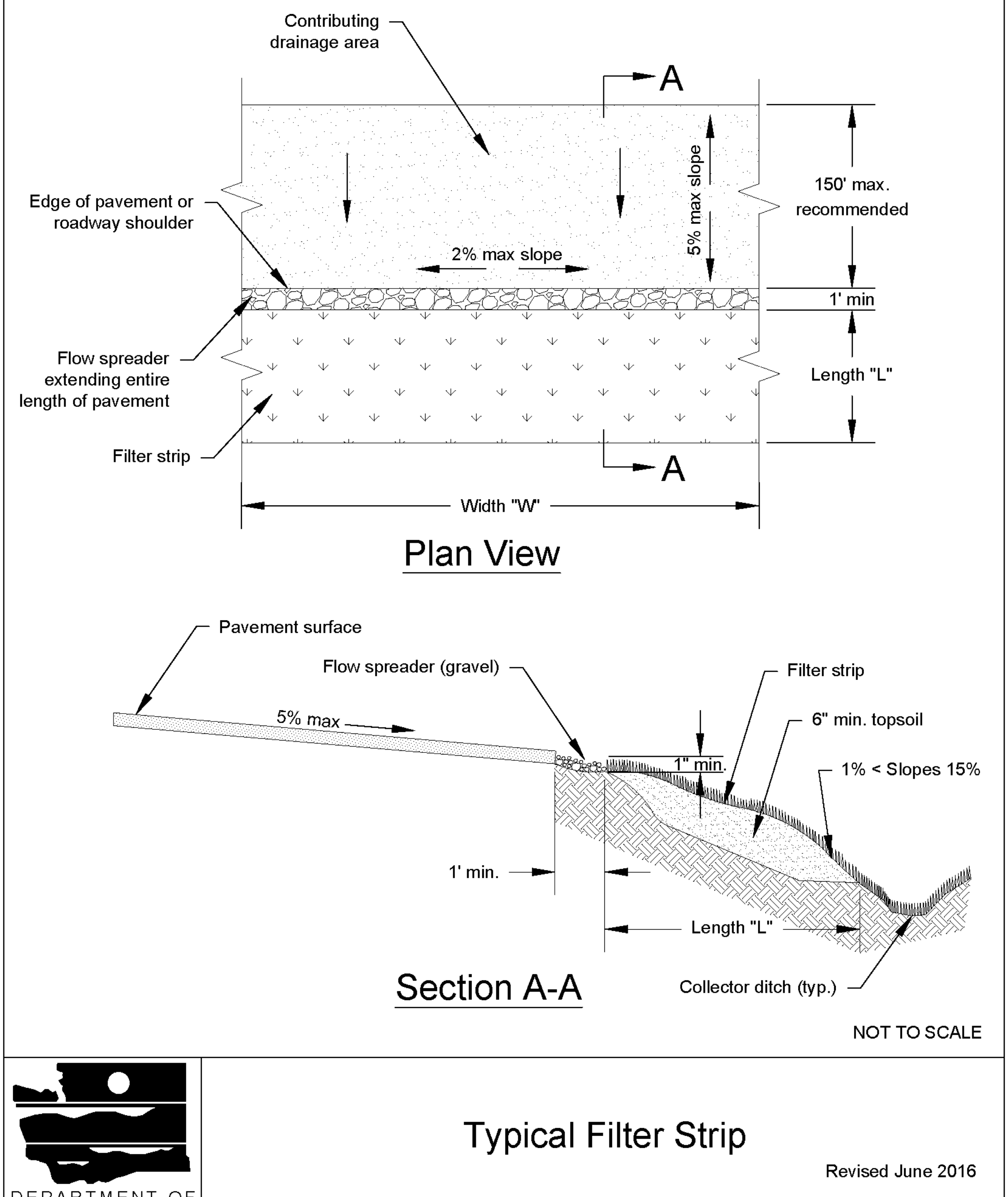
  Intent: The use of grass on interior side slopes reduces the chance of soil erosion and transfer of pollutants from landscape areas to the continuous inflow biofiltration swale treatment area.

BMP T9.40: Vegetated Filter Strip

Description

A vegetated filter strip is flat with no side slopes (Figure V-7.11: Typical Filter Strip). Contaminated stormwater is distributed as sheet flow across the inlet width of the vegetated filter strip. Runoff Treatment is provided by passage of water over the surface and through grass.

Figure V-7.11: Typical Filter Strip



Applications and Limitations

The vegetated filter strip is typically used on-line and adjacent and parallel to a paved area such as parking lots, driveways, and roadways.

Design Criteria

- Use the design criteria specified in Table V-7.6: Sizing Criteria for Vegetated Filter Strips.
- Vegetated filter strips should only receive sheet flow.
- Use curb cuts ≥ 12-inch wide and 1-inch above the vegetated filter strip inlet.
- Calculate the design flow depth using Manning's equation as follows:

  $$KQ = (1.49AR^{0.67} s^{0.5})/n$$

  Substituting for AR:

  $$KQ = (1.49Ty^{1.67} s^{0.5})/n$$

  Where:

  $Ty = A_{rectangle}$, ft^2

  $y \approx R_{rectangle}$, design depth of flow, ft. (1 inch maximum)

  Q = peak Water Quality Design Flow Rate as described in III-2.6 Sizing Your Runoff Treatment BMPs, ft^3/sec

  K = The ratio determined by using Figure V-7.7: Ratio of SBUH Peak/WQ Flow (Online)

  n = Manning's roughness coefficient

  s = Longitudinal slope of the vegetated filter strip, parallel to the direction of flow

  T = Width of the vegetated filter strip, perpendicular to the direction of flow, ft.

  A = Vegetated filter strip inlet cross-sectional flow area (rectangular), ft^2

  R = hydraulic radius, ft.

  Rearranging for y:

  $$y = [KQn/1.49Ts^{0.5}]^{0.6}$$

  y must not exceed 1 inch

  Note: As in biofiltration swale design, an adjustment factor of K accounts for the differential between the Water Quality Design Flow Rate calculated by an approved continuous simulation model and the SBUH design flow rate.

- Calculate the design flow velocity V, ft./sec., through the filter strip:

$$V = KQ/Ty$$

V must not exceed 0.5 ft./sec

- Calculate the required length, ft., of the vegetated filter strip at the minimum hydraulic residence time, t, of 9 minutes:

$$L = tV = 540V$$

Table V-7.6: Sizing Criteria for Vegetated Filter Strips

Design Parameter	Vegetated Filter Strip Sizing
Longitudinal Slope	0.01 - 0.33
Maximum velocity	0.5 ft / sec @ K multiplied by the WQ Design Flow Rate
Maximum water depth[1]	1-inch max.
Manning coefficient	0.35
Minimum hydraulic residence time at Water Quality Design Flow Rate	9 minutes
Minimum length	Sufficient to achieve hydraulic residence time in the vegetated filter strip
Maximum sideslope	Inlet edge ≥ 1" lower than contributing paved area
Max. tributary drainage flowpath	150 feet
Max. longitudinal slope of contributing area	0.05 (steeper than 0.05 needs upslope flow spreader and energy dissipation)
Max. lateral slope of contributing area	0.02 (at the edge of the vegetated filter strip inlet)
1. Below the design water depth install an erosion control blanket, at least 4” of topsoil, and the selected biofiltration seed mix. Above the water line use a straw mulch or sod.	

V-8 Wetpool BMPs

V-8.1 Introduction to Wetpool BMPs

Wetpools provide Runoff Treatment by allowing settling of particulates during quiescent conditions (sedimentation), by biological uptake, and by vegetative filtration.

Wetpool BMPs are recognized as effective Runoff Treatment BMPs. Refer to III-1.2 Choosing Your Runoff Treatment BMPs for the level of Runoff Treatment achieved by each individual BMP. Wetpool BMPs may be single-purpose facilities, providing only Runoff Treatment, or they may be combined with a detention pond or vault to also provide Flow Control. If combined, the wetpool BMP can often be stacked under the detention BMP with little to no further loss of development area.

This chapter presents the methods, criteria, and details for analysis and design of wetpool BMPs

Wetpool BMPs are designed as on-line BMPs. See III-2.6 Sizing Your Runoff Treatment BMPs for more information on "off-line" and "on-line" BMPs.

Wetpool BMPs are volume based Runoff Treatment BMPs, and are sized by calculating the Water Quality Design Volume as described in III-2.6 Sizing Your Runoff Treatment BMPs.

BMP T10.10: Wetponds - Basic and Large

Purpose and Definition

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. Peak flow control can be provided in the "live storage" area above the permanent pool. Figure V-8.1: Wetpond (Plan View) and Figure V-8.2: Wetpond (Section View) illustrates a typical wet pond BMP.

The following design, construction, and operation and maintenance criteria cover two wetpond applications - the basic wetpond and the large wetpond. Large wetponds are designed for higher levels of pollutant removal.

Applications and Limitations

A wetpond requires a larger area than a biofiltration swale (see V-7 Biofiltration BMPs) or a sand filter (see V-6 Filtration BMPs), but it can be integrated to the contours of a site fairly easily. In till soils, the wetpond holds a permanent pool of water that provides an attractive aesthetic feature. In more porous soils, wetponds may still be used, but water seepage from unlined cells could result in a dry pond, particularly in the summer months. Lining the first cell with a low permeability liner (see V-1.3.3 Low Permeability Liners) is one way to deal with this situation. As long as the first cell retains a permanent pool of water, the pond will function as an effective Runoff Treatment BMP.

Wetponds work best when the water already in the pond is moved out en masse by incoming flows, a phenomenon called "plug flow.” Because treatment works on this displacement principle, the wet-pool storage of wetponds may be provided below the ground water level without interfering unduly with treatment effectiveness. However, if combined with a detention function, the live storage must be above the seasonal high ground water level.

Design Criteria

The primary design factor that determines a wetpond's treatment efficiency is the volume of the wet-pool. The larger the wetpool volume, the greater the potential for pollutant removal.

Also important are the avoidance of short-circuiting and the promotion of plug flow. Plug flow describes the hypothetical condition of stormwater moving through the pond as a unit, displacing the "old" water in the pond with incoming flows. To prevent short-circuiting and promote plug flow, the pond should be designed to force the waterto flow, to the extent practical, to all potentially available flow routes, avoiding "dead zones" and maximizing the time the water stays in the pond during the active part of a storm.

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 flow path between inlet and outlet, including the vertical path, also enhances treatment by increasing residence time.

Sizing Procedure

Procedures for determining a wetpond's dimensions and volume are outlined below.

1. Identify the required wetpool volume within the wetpond using one of the methods described in III-2.6 Sizing Your Runoff Treatment BMPs.
    - For a basic wetpond, the wetpool volume provided shall be equal to or greater than the Water Quality Design Volume, as described in III-2.6 Sizing Your Runoff Treatment BMPs.
    - For a large wetpond, the wetpool volume provided shall be equal to or greater than 1.5 times the Water Quality Design Volume, as described in III-2.6 Sizing Your Runoff Treatment BMPs.
2. Determine the wetpool dimensions to satisfy the design criteria outlined below and illustrated in Figure V-8.1: Wetpond (Plan View) and Figure V-8.2: Wetpond (Section View). A simple way to check the volume of each wetpool cell is to use the following equation:

$$V = \frac{h(A_1+A_2)}{2}$$

where

V = wetpool volume (cf)

h = wetpool average depth (ft)

A_1 = water quality design surface area of wetpool (sf)

A_2 = bottom area of wetpool (sf)

3. Design the pond outlet pipe and determine the primary overflow water surface. The pond outlet pipe shall be placed on a reverse grade from the pond's second wetpool cell to the outlet structure. Use the following procedure to design the pond outlet pipe and determine the primary overflow water surface elevation:

   a. Use the nomographs in Figure V-8.3: Headwater Depth for Smooth Interior Pipe Culverts with Inlet Control and Figure V-8.4: Headwater Depth for Corrugated Pipe Culverts with Inlet Control to select a trial size for the pond outlet pipe sufficient to pass the on-line Water Quality Design Flow Rate (as described in III-2.6 Sizing Your Runoff Treatment BMPs), Q_{wq} indicated by an approved continuous runoff model.

   b. Use Figure V-8.5: Critical Depth of Flow for Circular Culverts to determine the critical depth d_c at the outflow end of the pipe for Q_{wq}.

   c. Use Figure V-8.6: Circular Channel Ratios to determine the flow area A_c at critical depth.

   d. Calculate the flow velocity at critical depth (V_c) using the continuity equation:

   $$V_c = Q_{wq} / A_c$$

   e. Calculate the velocity head (V_H):

   $$V_H = V_c^2 / 2g$$

   where g is the gravitational constant, 32.2 feet per second).

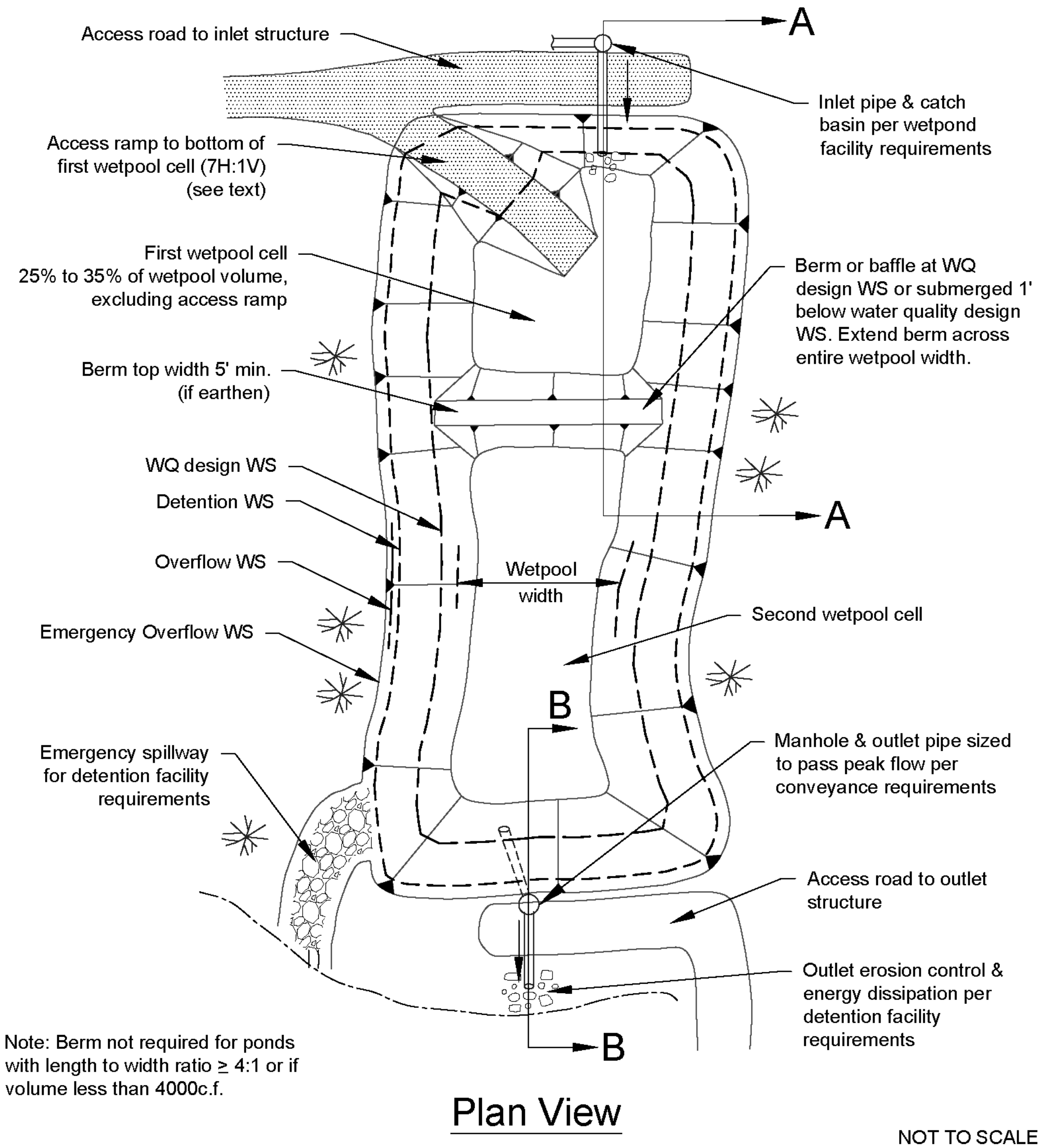
   f. Determine the primary overflow water surface elevation by adding the velocity head (V_H) and critical depth (d_c) to the invert elevation at the outflow end of the pond outlet pipe:

   $$\text{overflow water surface elevation} = \text{outflow invert} + d_c + V_H$$

   g. Adjust the outlet pipe diameter as needed and repeat Steps (a) through (e).

4. Determine the wetpond dimensions that include the dimensions for the two wetpool cells. General wetpond design criteria and concepts are shown in Figure V-8.1: Wetpond (Plan View) and Figure V-8.2: Wetpond (Section View).

Figure V-8.1: Wetpond (Plan View)



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Wetpond (Plan View)

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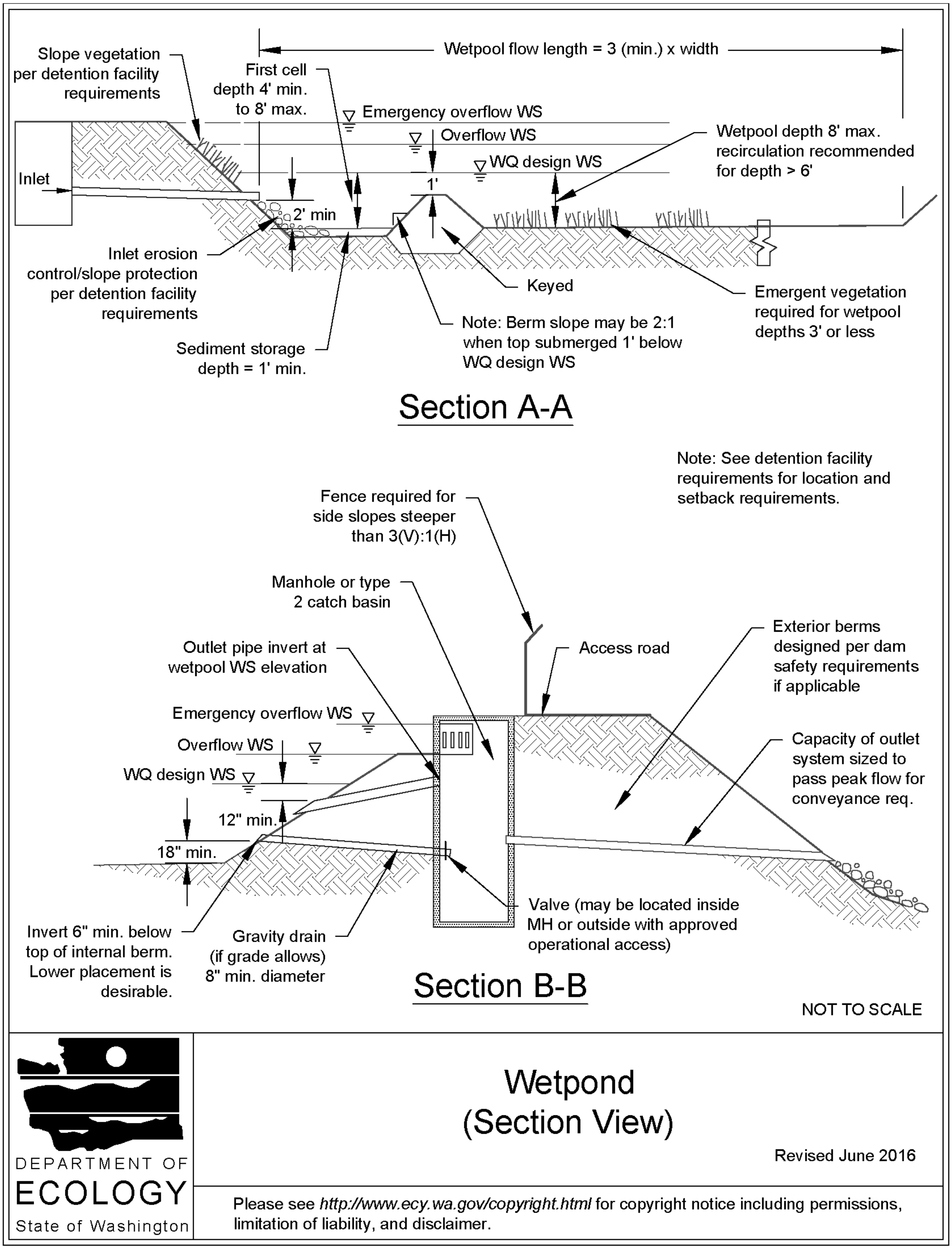
Figure V-8.2: Wetpond (Section View)



Wetpool Geometry

- The total wetpool volume shall be divided into two cells within the wetpond, separated by a baffle or berm. The first wetpool cell shall contain 25 to 35 percent of the total wetpool volume. The baffle or berm volume shall not count as part of the total wetpool volume. The term baffle means a vertical divider placed across the entire width of the pond, stopping short of the bottom. A berm is a vertical divider typically built up from the bottom, or if in a vault, connects all the way to the bottom.

  Intent: The full-length berm or baffle promotes plug flow and enhances quiescence and laminar flow through as much of the entire wetpool volume as possible. Alternative methods to the full-length berm or baffle that provide equivalent flow characteristics may be approved on a case-by-case basis by the Local Plan Approval Authority.

- Sediment storage shall be provided in the first cell. The sediment storage shall have a minimum depth of 1-foot. A fixed sediment depth monitor should be installed 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). Pool depths of 3 feet or shallower (second cell) shall be planted with emergent wetland vegetation (see Planting Requirements below).
- Inlets and outlets shall be placed to maximize the flowpath through the wetpool cells. 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 flow path length be maximized. The ratio of flow path 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. If there are multiple inlets, the length-to-width ratio shall be based on the average flowpath length for all inlets.
- The first cell must be lined in accordance with the liner requirements contained in V-1.3.1 General Liner Design.

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 equal to 50 percent of the embankment cross-sectional height and width. This requirement may be waived if recommended by a geotechnical engineer 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 should be 3H:1V. Berm side slopes may be steeper (up to 2:1) if the berm is submerged 1-foot.

  Intent: Submerging the berm is intended to enhance safety by discouraging pedestrian access when side slopes are steeper than 3H:1V. An alternative to the submerged berm design is the use of barrier planting to prevent easy access to the divider berm in an unfenced wetpond.

- If good vegetation cover is not established on the berm, erosion control measures should 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 licensed engineer in the state of Washington. If a baffle or retaining wall is used, it should be submerged one foot below the design water surface to discourage access by pedestrians.

- Criteria for wetpond side slopes are included in V-1.2 Setbacks, Slopes, and Embankments.

Embankments

Embankments that impound water must comply with the Washington State Dam Safety Regulations (Chapter 173-175 WAC). If the impoundment has a storage capacity (including both water and sediment storage volumes) greater than 10 acre-feet (435,600 cubic feet or 3.26 million gallons) above natural ground level, or has an embankment height of > 6 feet at the downstream toe, then dam safety design and review are required by Ecology. See Dam Safety for Detention BMPs in BMP D.1: Detention Ponds.

Inlet and Outlet

See Figure V-8.1: Wetpond (Plan View) and Figure V-8.2: Wetpond (Section View) for details on the following requirements:

- The inlet to the wetpond shall be submerged with the inlet pipe invert a minimum of two feet from the pond bottom (not including sediment storage). The top of the inlet pipe should be submerged at least 1-foot, if possible.

  Intent: The inlet is submerged to dissipate energy of the incoming flow. The distance from the bottom is set to minimize resuspension of settled sediments. Alternative inlet designs that accomplish these objectives are acceptable.

- An outlet structure shall be provided. Either a Type 2 catch basin with a grated opening (jail house window) or a manhole with a cone grate (birdcage) may be used (see Figure V-12.11: Overflow Structure for an illustration). No sump is required in the outlet structure for wetponds that do not provide detention storage. The outlet structure receives flow from the pond outlet pipe. The grate or birdcage openings provide an overflow route should the pond outlet pipe become clogged. The overflow criteria provided below specifies the sizing and position of the grate opening.

- 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. Note: A floating outlet, set to draw water from 1-foot below the water surface, is also acceptable if vandalism concerns are adequately addressed.

Intent: The inverted outlet pipe provides for trapping of oils and floatables in the wetpond.

- The pond outlet pipe shall be sized, at a minimum, to pass the on-line Water Quality Design Flow Rate. Note: The highest invert of the outlet pipe sets the WQ design water surface elevation.
- The overflow criteria for single-purpose (Runoff Treatment only, not combined with Flow Control) wetponds are as follows:
    a. The requirement for primary overflow is satisfied by either the grated inlet to the outlet structure or by a birdcage above the pond outlet structure.
    b. The bottom of the grate opening in the outlet structure shall be set at or above the height needed to pass the Water Quality Design Flow Rate through the pond outlet pipe. Note that the grate invert elevation sets the overflow water surface elevation.
    c. The grated opening should be sized to pass the 100-year design flow. The capacity of the outlet system should be sized to pass the peak flow for the conveyance requirements.
- An emergency spillway shall be provided and designed according to the requirements for detention ponds (see BMP D.1: Detention Ponds).
- The Local Plan Approval Authority 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.

  Intent: It is anticipated that sediment removal will only be needed for the first cell in the majority of cases. The gravity drain is intended to allow water from the first cell to be drained to the second cell when the first cell is pumped dry for cleaning.

    - The gravity 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.

      Intent: To prevent highly sediment-laden water from escaping the pond when drained for maintenance.

    - The gravity 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.

      Intent: Shear gates often leak if water pressure pushes on the side of the gate opposite the seal. The gate should be situated so that water pressure pushes toward the seal.

        - Operational access to the valve shall be provided 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.

- All metal parts shall be corrosion-resistant. Galvanized materials should not be used unless unavoidable.

  Intent: Galvanized metal contributes zinc to stormwater, sometimes in very high concentrations.

Access and Setbacks

- Wetponds shall be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the local government, and 100 feet from any septic tank/drainfield.

- Wetponds shall be a minimum of 50 feet from any steep (greater than 15 percent) slope. A geotechnical report must address the potential impact of a wetpond on a steep slope.

- Access and maintenance roads shall be provided and designed according to the requirements for BMP D.1: Detention Ponds. Access and maintenance roads shall extend to both the wetpond inlet and outlet structures. An access ramp (7H minimum:1V) shall be provided 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.

- If the dividing berm is also used for access, it should be built to sustain loads of up to 80,000 pounds.

Planting Requirements

Planting requirements for BMP D.1: Detention Ponds also apply to wetponds.

- Large wetponds intended for use as a Phosphorus Treatment BMP should not be planted within the cells, as the plants will release phosphorus in the winter when they die off.

- If the second cell of a basic wetpond is 3 feet or shallower, the bottom area shall be planted with emergent wetland vegetation. See Table V-8.1: Emergent Wetland Plant Species Recommended for Wetponds for recommended emergent wetland plant species for wetponds.

  Intent: Planting of shallow pond areas helps to stabilize settled sediment and prevent resuspension.

  Note: The recommendations in Table V-8.1: Emergent Wetland Plant Species Recommended for Wetponds are for western Washington only. Local knowledge should be used to adapt this information if used in other areas.

- Cattails (Typha latifolia) are not recommended because they tend to crowd out other species and will typically establish themselves anyway.

- 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. For banks that are berms, no planting is allowed if the berm is regulated by dam safety requirements. The purpose of planting is to discourage waterfowl use of the pond and to provide shading. Some suitable trees and shrubs include vine maple (*Acer circinatum*), wild cherry (*Prunus emarginata*), red osier dogwood (*Cornus stolonifera*), California myrtle (*Myrica californica*), Indian plum (*Oemleria cerasiformis*), and Pacific yew (*Taxus brevifolia*) as well as numerous ornamental species.

Table V-8.1: Emergent Wetland Plant Species Recommended for Wetponds

Species	Common Name	Notes	Maximum Depth
INUNDATION TO 1-FOOT			
Agrostis exarata(1)	Spike bent grass	Prairie to coast	to 2 feet
Carex stipata	Sawbeak sedge	Wet ground	
Eleocharis palustris	Spike rush	Margins of ponds, wet meadows	to 2 feet
Glyceria occidentalis	Western Mannagrass	Marshes, pond margins	to 2 feet
Juncus tenuis	Slender rush	Wet soils, wetland margins	
Oenanthe sarmentosa	Water parsley	Shallow water along stream and pond margins; needs saturated soils all summer	
Scirpus atrocinctus (formerly S. cyperinus)	Woolgrass	Tolerates shallow water, tall clumps	
Scirpus microcarpus	Small-fruited bulrush	Wet ground to 18 inches depth	18 inches
Sagittaria latifolia	Arrowhead		
INUNDATION 1 TO 2 FEET			
Agrostis exarata(1)	Spike bent grass	Prairie to coast	
Alisma plantago-aquatica	Water plantain		
Eleocharis palustris	Spike ruh	Margins of ponds, wet meadows	
Glyceria occidentalis	Western mannagrass	Marshes, pond margins	
Juncus effusus	Soft rush	Wet meadows, pastures, wetland margins	
Scirpus microcarpus	Small-fruited bulrush	Wet ground to 18 inches depth	18 inches
Sparganium emmersum	Bur reed	Shallow standing water, saturated soils	
INUNDATION 1 TO 3 FEET			

Table V-8.1: Emergent Wetland Plant Species Recommended for Wetponds (continued)

Species	Common Name	Notes	Maximum Depth
Carex obnupta	Slough sedge	Wet ground or standing water	1.5 to 3 feet
Beckmania syzigachn(1)	Western sloughgrass	Wet prairie to pond margins	
Scirpus acutus(2)	Hardstem bulrush	Single tall stems, not clumping	to 3 feet
Scirpus validus(2)	Softstem bulrush		
INUNDATION GREATER THAN 3 FEET			
Nuphar polysepalum	Spatterdock	Deep water	3 to 7.5 feet
Nymphaea odorata (1)	White waterlily	Shallow to deep ponds	to 6 feet

Notes:

(1) Non-native species. *Beckmania syzigachne* is native to Oregon. Native species are preferred.

(2) *Scirpus* tubers must be planted shallower for establishment, and protected from foraging waterfowl until established. Emerging aerial stems should project above water surface to allow oxygen transport to the roots.

Primary sources:(Kulzer, 1990), (Shank, 1991), (Hitchcock et al., 1973)

Recommended Design Features

The following design features should be incorporated into the wetpond design where site conditions allow:

- The method of construction of soil/landscape systems can cause natural selection of specific plant species. Consult a soil restoration or wetland soil scientist for site-specific recommendations. The soil formulation will impact the plant species that will flourish or suffer on the site, and the formulation should be such that it encourages desired species and discourages undesired species.
- 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 flow length-to-width ratio greater than the 3:1 minimum is desirable. If the ratio is 4:1 or greater, then the dividing berm is not required, and the pond may consist of one cell rather than two. A one-cell pond must provide at least 6-inches of sediment storage depth. A one cell pond must also provide a minimum depth of 4 feet for the volume equivalent to the first cell of a two-cell design.
- 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.
- A small amount of base flow is desirable to maintain circulation and reduce the potential for

low oxygen conditions during late summer.

- 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 attendant phosphorus enrichment problems they cause. Trees should be set back so that the branches will not extend over the pond.

  Intent: Evergreen trees or shrubs are preferred to avoid problems associated with leaf drop. Columnar deciduous trees (e.g., hornbeam, Lombardy poplar) typically have fewer leaves than other deciduous trees.

- The number of inlets to the wetpond 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 wetpond.

- The access and maintenance road could be extended along the full length of the wetpond and could double as playcourts or picnic areas. Placing finely ground bark or other natural material over the road surface would render it more pedestrian friendly.

- 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 (3:1 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.

Construction Criteria

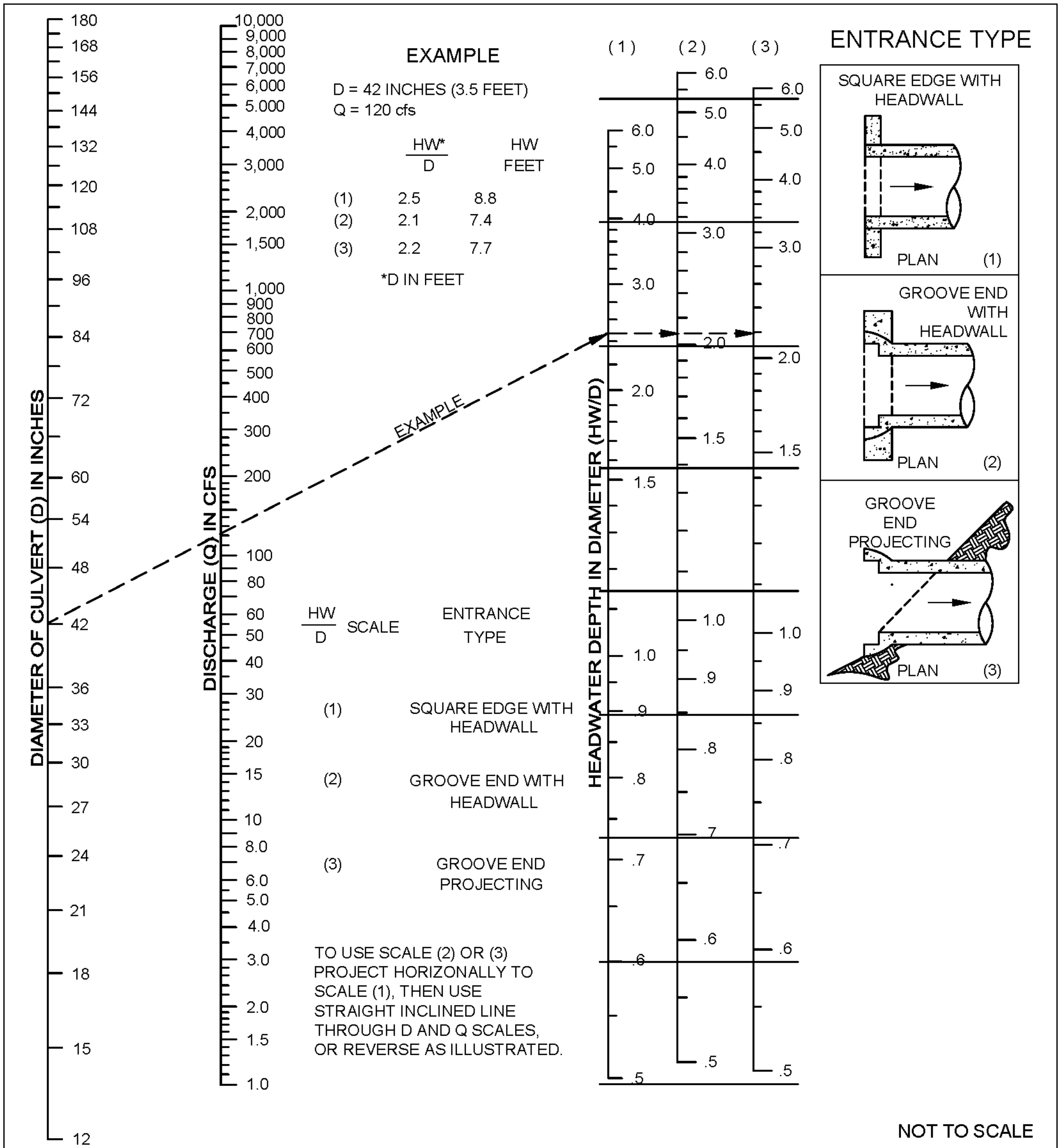
- Sediment that has accumulated in the pond must be removed after construction in the drainage area of the pond is complete (unless used for a liner - see below).

- Sediment that has accumulated in the pond at the end of construction may be used in excessively drained soils to meet the liner requirements if the sediment meets the criteria for low permeability or treatment liners in keeping with guidance in V-1.3 Liners and Geotextiles. Sediment used for a soil liner must be graded to provide uniform coverage and must meet the thickness specifications in V-1.3 Liners and Geotextiles. The sediment must not reduce the volume of the wetpool. The wetpool must be over-excavated initially to provide sufficient room for the sediments to serve as a liner.

Operation and Maintenance

- Maintenance is of primary importance if wetponds are to continue to function as originally designed. A local government, a designated group such as a homeowners' association, or a property owner shall accept the responsibility for maintaining the structures and the impoundment area. A specific maintenance plan shall be formulated outlining the schedule and scope of maintenance operations.
- The wetpond should be inspected by the local government annually. The maintenance standards contained in Appendix V-A: BMP Maintenance Tables are measures for determining if maintenance actions are required as identified through the annual inspection.
- Site vegetation should be trimmed as necessary to keep the wetpond free of leaves and to maintain the aesthetic appearance of the site. Slope areas that have become bare should be revegetated and eroded areas should be regraded prior to being revegetated.
- Sediment should be removed when the 1-foot sediment zone is full plus 6 inches. Sediments should be tested for toxicants in compliance with current disposal requirements. Sediments must be disposed in accordance with current local health department requirements and the Minimum Functional Standards for Solid Waste Handling (Chapter 173-304 WAC). See Appendix IV-B: Management of Street Waste Solids and Liquids for additional guidance.
- Any standing water removed during the maintenance operation must be properly disposed of. The preferred disposal option is discharge to a sanitary sewer at an approved location. Other disposal options include discharge back into the wetpool BMP or the storm sewer system if certain conditions are met. See Appendix IV-B: Management of Street Waste Solids and Liquids for additional guidance.

Figure V-8.3: Headwater Depth for Smooth Interior Pipe Culverts with Inlet Control



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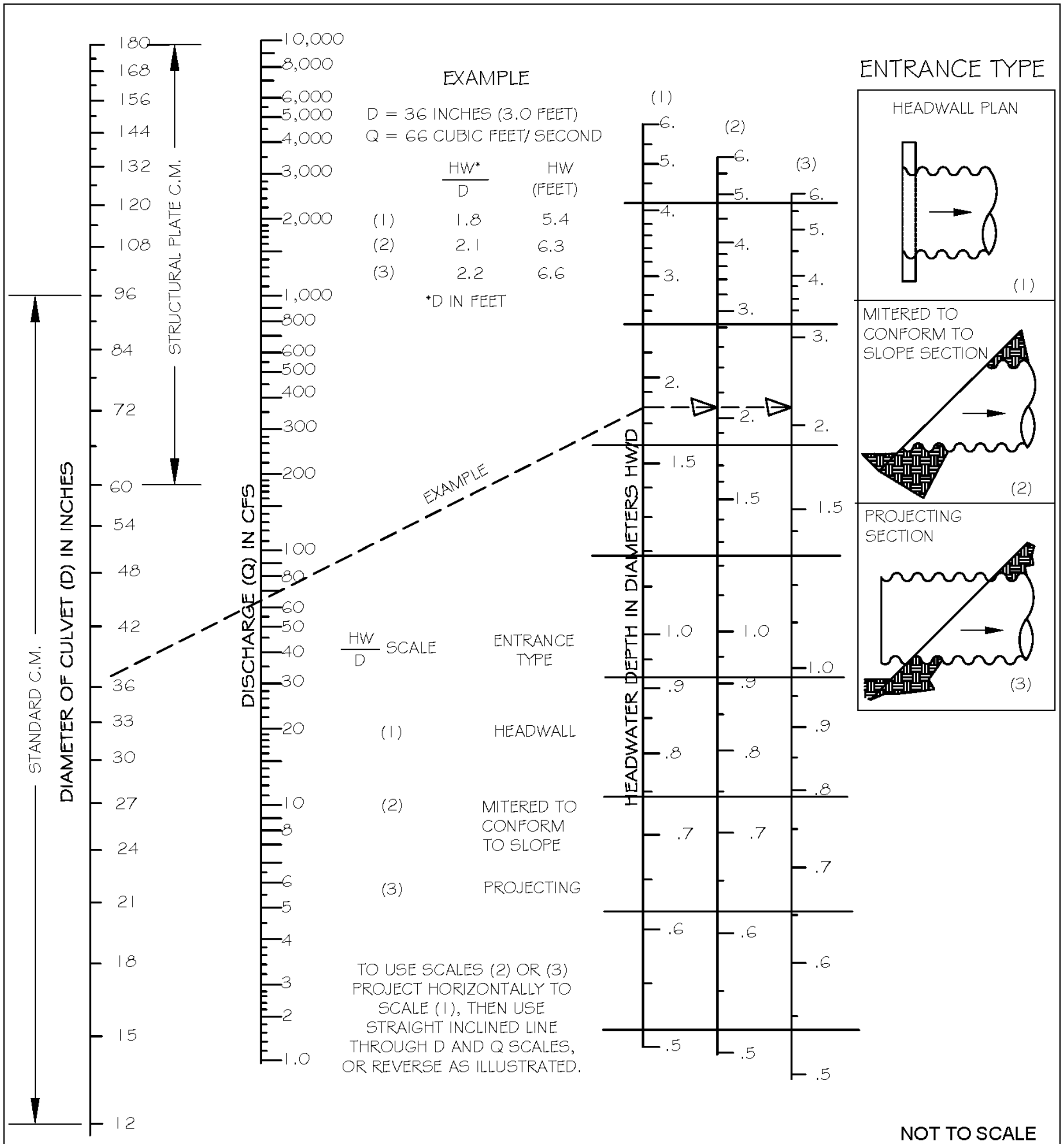
Headwater Depth for Smooth Interior Pipe Culverts with Inlet Control

Revised June 2016

Figure V-8.4: Headwater Depth for Corrugated Pipe Culverts with Inlet Control



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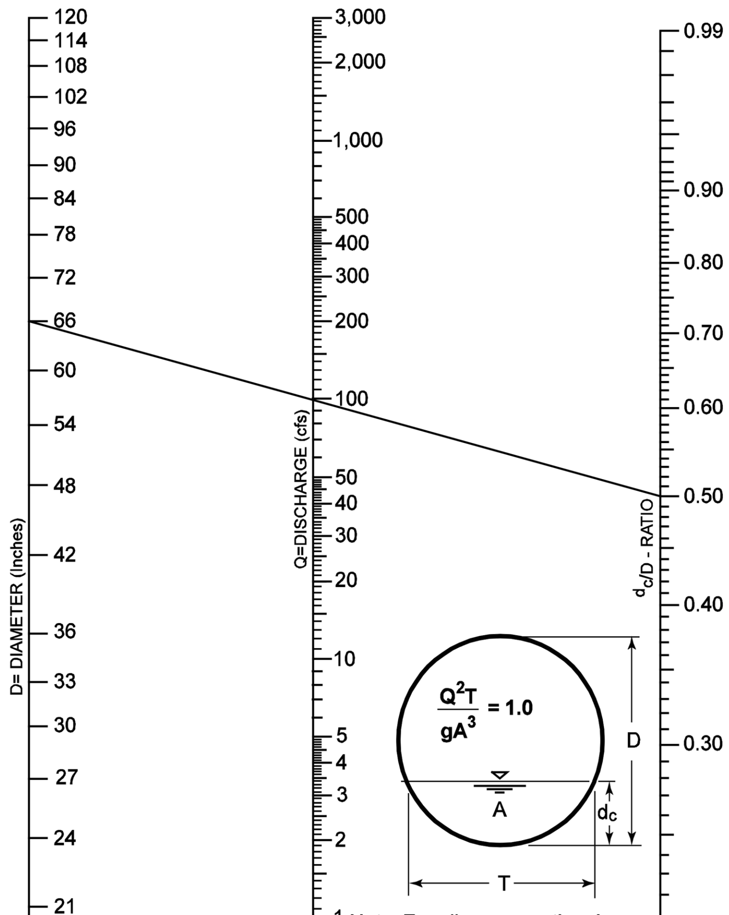
Headwater Depth for Corrugated Pipe Culverts with Inlet Control

Revised June 2016

Figure V-8.5: Critical Depth of Flow for Circular Culverts



Note: For all cross-sectional shapes, d_c can be calculated by trial and error knowing that the quantity **(Q^2T/gA^3)=1.0** at critical depth.

EXAMPLE

D = 66 inches, Q = 100cfs

d_c/D - Ratio = 0.50

d_c = (0.50)(66 inches)= 33 inches √ (12 inches/ft)

d_c= 2.75 feet

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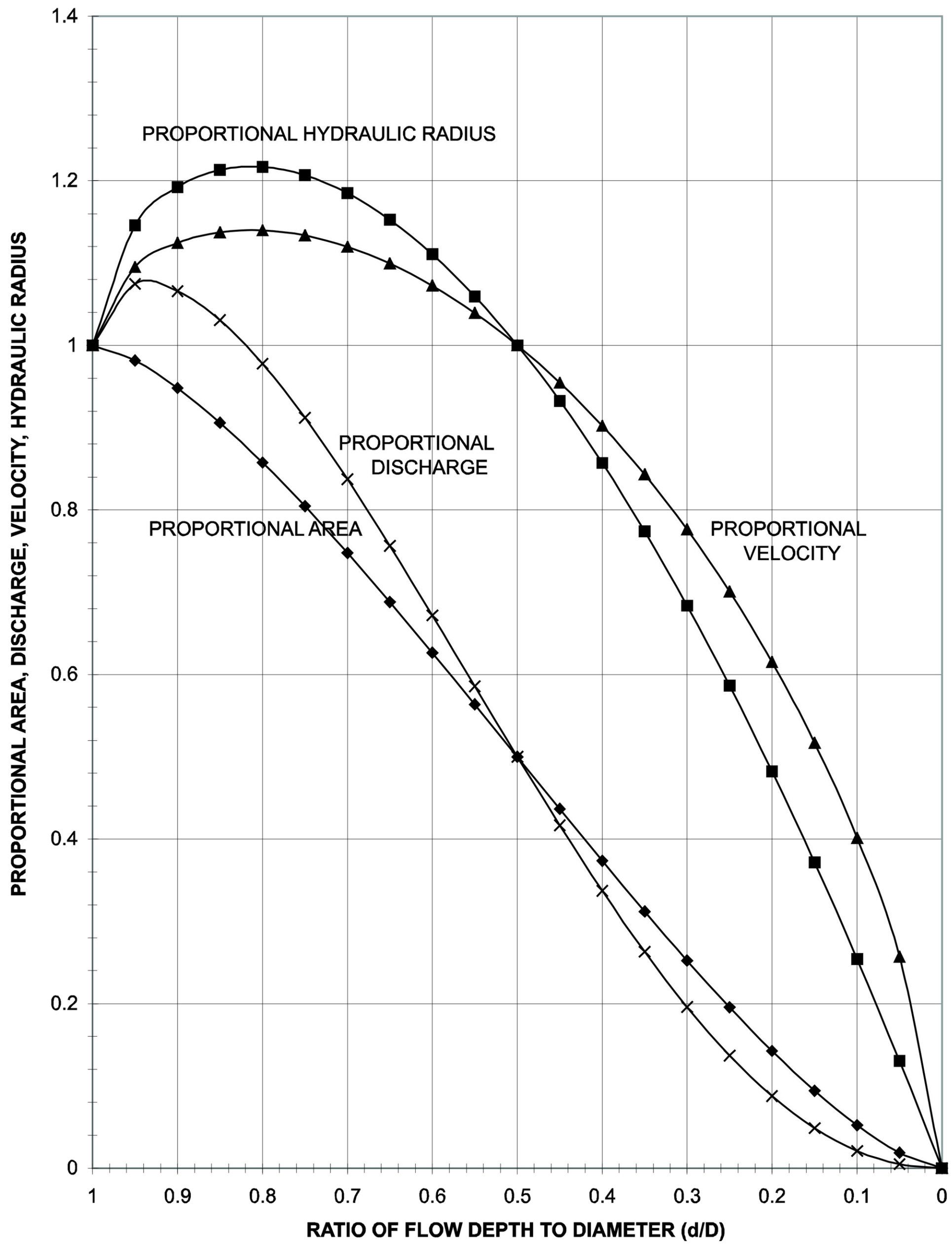
Critical Depth of Flow for Circular Culverts

Revised June 2016

Figure V-8.6: Circular Channel Ratios



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Circular Channel Ratios

Revised June 2016

BMP T10.20: Wetvaults

Purpose and Definition

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 V-8.7: Wetvault). Being underground, the wetvault lacks the biological pollutant removal mechanisms, such as algae uptake, present in BMP T10.10: Wetponds - Basic and Large and BMP T10.30: Stormwater Treatment Wetlands.

Applications and Limitations

A wetvault may be used for commercial, industrial, or roadway projects if there are space limitations precluding the use of other Runoff Treatment BMPs. The use of wetvaults for residential development is highly discouraged. Combined detention and wetvaults are allowed; see BMP T10.40: Combined Detention and Wetpool Facilities.

A wetvault is believed to be ineffective in removing dissolved pollutants such as soluble phosphorus or metals such as copper. There is also concern that oxygen levels will decline, especially in warm summer months, because of limited contact with air and wind. However, the extent to which this potential problem occurs has not been documented.

Below-ground structures like wetvaults are relatively difficult and expensive to maintain. The need for maintenance is often not seen and as a result routine maintenance does not occur.

If an Oil Control BMP is required for a project, a wetvault may be combined with BMP T11.10: API (Baffle type) Separator.

Design Criteria

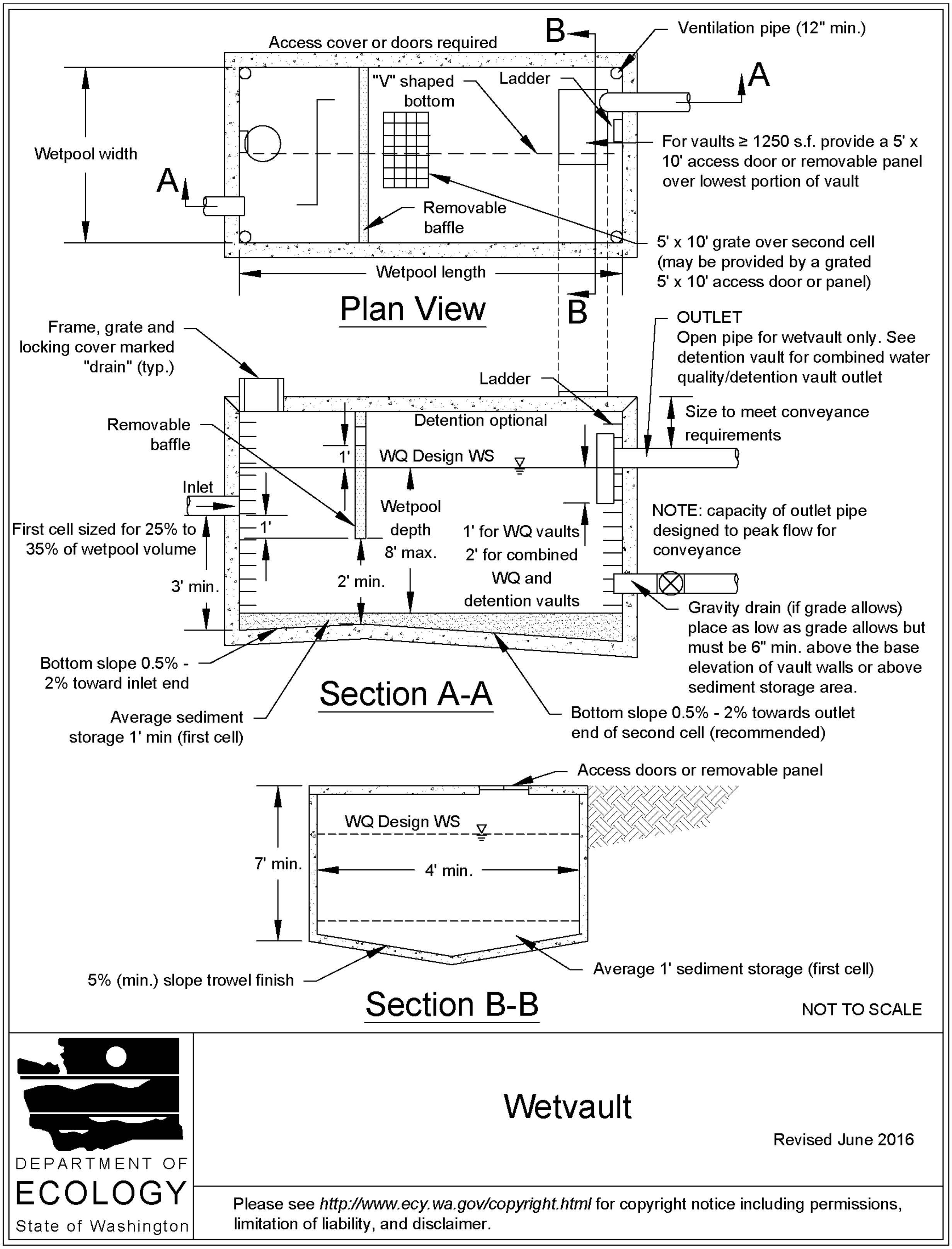
Sizing Procedure

As with wetponds, the primary design factor that determines the removal efficiency of a wetvault is the volume of the wetpool. The larger the volume, the higher the potential for pollutant removal. Performance is also improved by avoiding dead zones (like corners) where little exchange occurs, using large length-to-width ratios, dissipating energy at the inlet, and ensuring that flow rates are uniform to the extent possible and not increased between cells.

The sizing procedure for a wetvault is identical to the sizing procedure for BMP T10.10: Wetponds - Basic and Large. Refer to BMP T10.10: Wetponds - Basic and Large for sizing guidance.

Typical design details and concepts for the wetvault are shown in Figure V-8.7: Wetvault.

Figure V-8.7: Wetvault



Wetpool Geometry

The geometry of the wetpool within the wetvault is the same as specified for wetponds (see BMP T10.10: Wetponds - Basic and Large), except for the following two modifications:

- The sediment storage depth 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 the vault width according to Table V-8.2: Sediment Storage Depth Requirements for Wetvaults

Table V-8.2: Sediment Storage Depth Requirements for Wetvaults

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 resuspension of sediment in shallow water as it can in open ponds.

Vault Structure

- The vault shall be separated into two cells by a wall or a removable baffle. If a wall is used, a 5-foot by 10-foot removable maintenance access must be provided for both cells. If a removable baffle is used, the following criteria apply:
    1. 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.
    2. 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.
- The two wetpool cells of a wetvault should not be divided 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 wetpool cells must be positioned so as to lengthen, rather than divide, the flowpath.

  Intent: Treatment effectiveness in wetpool facilities is related to the extent to which plug flow is achieved and short-circuiting and dead zones are avoided. Structural walls placed within the wetpool cells can interfere with plug flow and create significant dead zones, reducing treatment effectiveness.

- The bottom of the first cell shall be sloped toward the access opening. The slope should 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. The intent of sloping the bottom is to direct the sediment accumulation to the closest access point for maintenance purposes. Sloping the second cell towards the access opening for the first cell is also acceptable.
- The vault bottom shall slope 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 Local Plan Approval Authority may allow the vault bottom to be flat if removable panels are provided over the entire vault. Removable panels should 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.
- The design must provide for passage of flows should the outlet plug.
- 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.

  Intent: To prevent decreasing the surface area available for oxygen exchange.
- Wetvaults shall conform with the Materials and Structural Stability criteria specified for detention vaults in BMP D.3: Detention Vaults.
- Where pipes enter and leave the wetvault below the WQ design water surface, they shall be sealed using a non-porous, non-shrinking grout.

Inlet and Outlet

- The inlet to the wetvault shall be submerged with the inlet pipe invert a minimum of 3 feet from the vault bottom. The top of the inlet pipe should be submerged at least 1-foot, if possible.

  Intent: The submerged inlet is to dissipate energy of the incoming flow. The distance from the bottom is to minimize resuspension of settled sediments. Alternative inlet designs that accomplish these objectives are acceptable.
- The capacity of the outlet pipe and available head above the outlet pipe should be designed to convey the 100-year design flow rate 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 a tee section, the lower arm of which should extend 1 foot below the WQ design water surface to provide for trapping of oils and floatables in the vault.
- The Local Plan Approval Authority may require a bypass/shutoff valve to enable the vault to be taken offline for maintenance.

Access Requirements

The access requirements for wetvaults are the same as for detention vaults (see BMP D.3: Detention Vaults) except for the following additional requirement for wetvaults:

- A minimum of 50 square feet of grate should be provided over the second cell. For wetvaults in which the surface area of the second cell is greater than 1,250 square feet, 4 percent of the top should be grated. This requirement may be met by one grate or by many smaller grates distributed over the second cell area. Note: a grated access door can be used to meet this requirement.

  Intent: The grate allows air contact with the wetpool in order to minimize stagnant conditions which can result in oxygen depletion, especially in warm weather.

Access Roads, Right of Way, and Setbacks

The requirements for access roads, right of way, and setbacks for wetvaults are the same as for detention vaults (see BMP D.3: Detention Vaults).

Recommended Design Features

The following design features should be incorporated into wetvaults where feasible, but they are not specifically required:

- The floor of the second cell should slope toward the outlet for ease of cleaning.
- The inlet and outlet should be at opposing corners of the vault to increase the flowpath.
- A flow length-to-width ratio greater than 3:1 minimum is desirable.
- Lockable grates instead of solid manhole covers are recommended to increase air contact with the wetpool.
- Galvanized materials shall not be used unless unavoidable.
- 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.

Construction Criteria

Sediment that has accumulated in the vault must be removed after construction in the drainage area is complete. If no more than 12 inches of sediment have accumulated after the infrastructure is built, cleaning may be left until after building construction is complete. In general, sediment accumulation from stabilized drainage areas is not expected to exceed an average of 4 inches per year in the first cell. If sediment accumulation is greater than this amount, it will be assumed to be from construction unless it can be shown otherwise.

Operation and Maintenance

- Accumulated sediment and stagnant conditions may cause noxious gases to form and accumulate in the vault. Vault maintenance procedures must meet OSHA confined space entry 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.

- Wetvaultss should be inspected by the local government annually. The maintenance standards contained in Appendix V-A: BMP Maintenance Tables are measures for determining if maintenance actions are required as identified through the annual inspection.
- Sediment should be removed when the 1-foot sediment zone is full plus 6 inches. Sediments should be tested for toxicants in compliance with current disposal requirements. Sediments must be disposed in accordance with current local health department requirements and the Minimum Functional Standards for Solid Waste Handling (Chapter 173-304 WAC). See Appendix IV-B: Management of Street Waste Solids and Liquids for additional guidance.
- Any standing water removed during the maintenance operation must be properly disposed of. The preferred disposal option is discharge to a sanitary sewer at an approved location. Other disposal options include discharge back into the wetpool facility or the storm sewer system if certain conditions are met. See Appendix IV-B: Management of Street Waste Solids and Liquids for additional guidance.

Modifications for Combining with a Baffle Oil/Water Separator

If the project site requires an Oil Control BMP and a wetvault is proposed, the vault may be combined with BMP T11.10: API (Baffle type) Separator to meet the Runoff Treatment requirements with one facility rather than two. Structural modifications and added design criteria are given below. However, the maintenance requirements for BMP T11.10: API (Baffle type) Separator must be adhered to, in addition to those for a wetvault. This will result in more frequent inspection and cleaning than for a wetvault used only for TSS removal. See BMP T11.10: API (Baffle type) Separator for information on maintenance of baffle oil/water separators.

1. The sizing procedures for the baffle oil/water separator (BMP T11.10: API (Baffle type) Separator) should be run as a check to ensure the wetvault is large enough. If the oil/water separator sizing procedures result in a larger vault size, increase the wetvault size to match.
2. An oil retaining baffle shall be provided in the second cell near the vault outlet. The baffle should not contain a high-flow overflow, or else the retained oil will be washed out of the vault during large storms.
3. The vault shall have a minimum length-to-width ratio of 5:1.
4. The vault shall have a design water depth-to-width ratio of between 1:3 to 1:2.
5. The vault shall be watertight and shall be coated to protect from corrosion.
6. 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. A valve box and riser shall also be provided.
7. Wetvaults used as oil/water separators must be off-line and must bypass flows greater than the off-line WQ design flow around the oil/water separator and into the second cell.

Intent: This design minimizes the entrainment and/or emulsification of previously captured oil during very high flow events.

BMP T10.30: Stormwater Treatment Wetlands

Purpose and Definition

In land development situations, wetlands are usually constructed for one of two main reasons: to replace or mitigate impacts when natural wetlands are filled or impacted by development (mitigation wetlands), or to treat stormwater runoff (stormwater treatment wetlands, this BMP). Stormwater treatment wetlands are shallow man-made ponds that are designed to treat stormwater through the biological processes associated with emergent aquatic plants (see the stormwater wetland details in Figure V-8.8: Stormwater Wetland — Option One and Figure V-8.9: Stormwater Wetland — Option Two).

Wetlands created to mitigate disturbance impacts, such as filling, may not also be used as stormwater treatment BMPs. This is because of the different, incompatible functions of the two kinds of wetlands. Mitigation wetlands are intended to function as full replacement habitat for fish and wildlife, providing the same functions and harboring the same species diversity and biotic richness as the wetlands they replace. Stormwater treatment wetlands are used to capture and transform pollutants, just as wetponds are, and over time pollutants will concentrate in the sediment. This is not a healthy environment for aquatic life. Stormwater treatment wetlands are used to capture pollutants in a managed environment so that they will not reach natural wetlands and other ecologically important habitats. In addition, vegetation must occasionally be harvested and sediment dredged in stormwater treatment wetlands, further interfering with use for wildlife habitat.

In general, stormwater treatment wetlands perform well to remove sediment, metals, and pollutants that bind to humic or organic acids. Phosphorus removal in stormwater treatment wetlands is highly variable.

Applications and Limitations

The stormwater treatment wetland design occupies about the same surface area as wetponds, but has the potential to be better integrated aesthetically into a site because of the abundance of emergent aquatic vegetation. The most critical factor for a successful design is the provision of an adequate supply of water for most of the year. Careful planning is needed to be sure sufficient water will be retained to sustain good wetland plant growth. Since water depths are shallower than in wetponds, water loss by evaporation is an important concern. Stormwater treatment wetlands are a good Runoff Treatment BMP choice in areas with high winter ground water levels.

Design Criteria

When used for Runoff Treatment, stormwater treatment wetlands employ some of the same design features 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.

Sizing Procedure

The procedure for determining a stormwater treatment wetland's dimensions and volume are outlined below.

1. The volume of a basic wetpond (see BMP T10.10: Wetponds - Basic and Large) is used as a template for sizing the stormwater treatment wetland. The design volume for the stormwater treatment wetland is the Water Quality Design Volume, as described in III-2.6 Sizing Your Runoff Treatment BMPs.

2. The surface area of the stormwater treatment wetland shall be the same as the top area of a wetpond sized for the same site conditions. Calculate the surface area of the stormwater treatment wetland by using the volume from Step 1 and dividing by the average water depth (use 3 feet).

3. Determine the surface area of the first cell (the presettling cell) of the stormwater treatment wetland. Use the volume determined from Criterion 2 under Wetland Geometry, and the actual depth of the first cell.

4. Determine the surface area of the second cell (the wetland cell). Subtract the surface area of the first cell (Step 3) from the total surface area (Step 2).

5. Determine the 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 Criterion 8 under Wetland Geometry below. Note: This will result in a facility that holds less volume than that determined in Step 1 above. This is acceptable.

   Intent: The surface area of the stormwater treatment wetland is set to be roughly equivalent to that of a wetpond designed for the same site so as not to discourage use of this option.

6. Choose plants. See Table V-8.1: Emergent Wetland Plant Species Recommended for Wetponds for a list of plants recommended for wetpond water depth zones, or consult a wetland scientist.

Wetland Geometry

1. Stormwater treatment wetlands shall consist of two cells, a presettling cell and a wetland cell.

2. The presettling cell shall contain approximately 33 percent of the wetpool volume calculated in Step 1 of the sizing procedure (above).

3. The depth of the presettling cell shall be between 4 feet (minimum) and 8 feet (maximum), excluding sediment storage.

4. One-foot of sediment storage shall be provided in the presettling cell.

5. The wetland cell shall have an average water depth of about 1.5 feet (plus or minus 3 inches).

6. The "berm" separating the two cells shall be shaped such that its downstream side gradually slopes to form the shallow wetland cell (see the section view in Figure V-8.8: Stormwater Wetland — Option One). Alternatively, the wetland cell may be graded naturalistically from the top of the dividing berm (see Criterion 8 below).

7. The top of berm shall be either at the WQ design water surface or submerged 1-foot below the WQ design water surface, as with BMP T10.10: Wetponds - Basic and Large. 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.

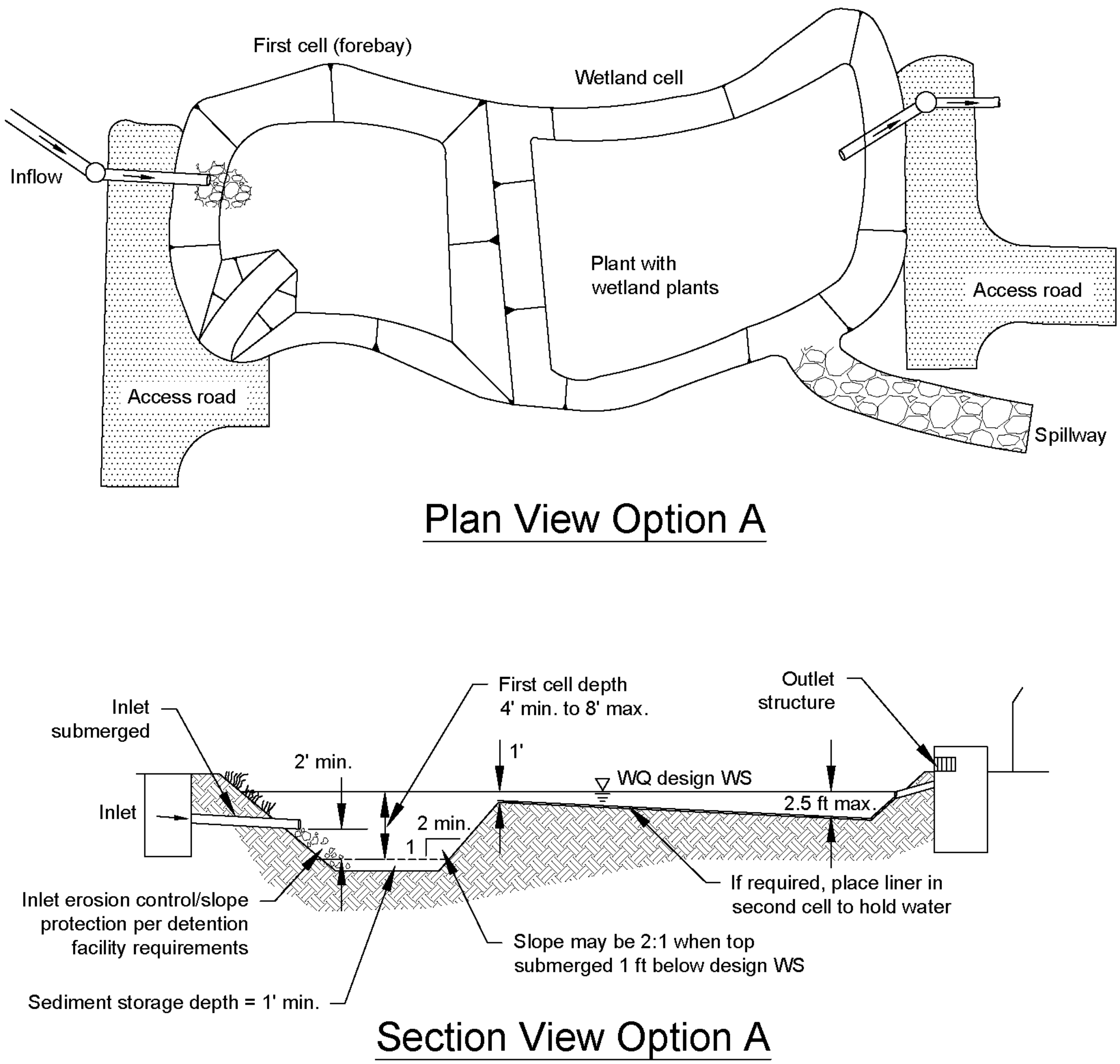
    b. If the top of berm is submerged 1-foot, the upstream side slope may be up to 2H:1V. If the berm is at the water surface, then for safety reasons, its slope should be not greater than 3:1, just as the pond banks should not be greater than 3:1 if the pond is not fenced. A steeper slope (2:1 rather than 3:1) is allowable if the berm is submerged in 1 foot of water. If submerged, the berm is not considered accessible, and the steeper slope is allowable.

8. Two examples are provided for grading the bottom of the wetland cell. One example is a shallow, evenly graded slope from the upstream to the downstream edge of the wetland cell (see Figure V-8.8: Stormwater Wetland — Option One). The second example is a "naturalistic" alternative, with the specified range of depths intermixed throughout the second cell (see Figure V-8.9: Stormwater Wetland — Option Two). A distribution of depths shall be provided in the wetland cell depending on whether the dividing berm is at the water surface or submerged (see Table V-8.3: Distribution of Depths in Wetland Cell). The maximum depth is 2.5 feet in either configuration. Other configurations within the wetland geometry constraints listed above may be approved by the Local Plan Approval Authority.

Table V-8.3: 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

Figure V-8.8: Stormwater Wetland — Option One



Note: See detention facility requirements for location and setback requirements

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Stormwater Wetland - Option 1

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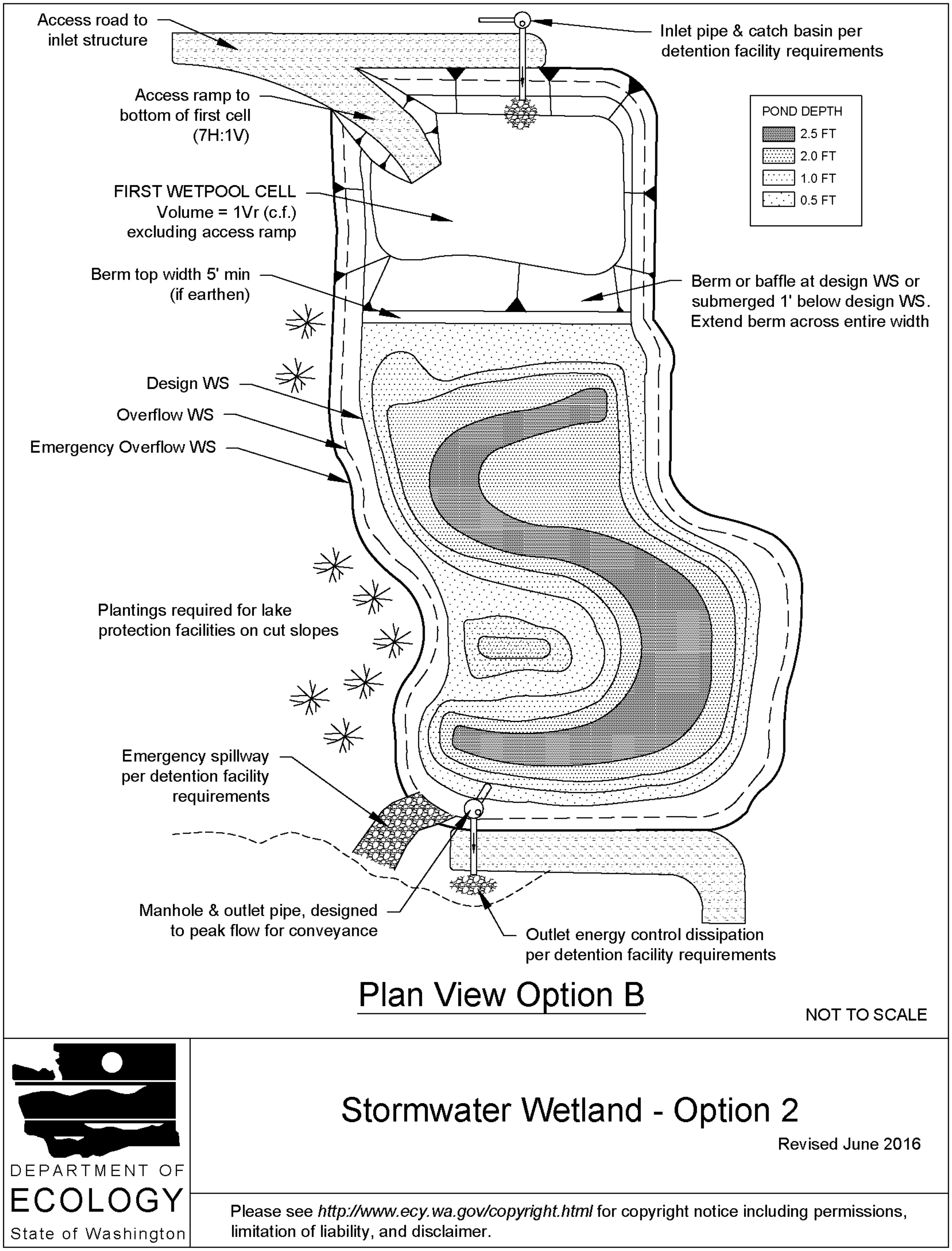
Figure V-8.9: Stormwater Wetland — Option Two



Stormwater Wetland - Option 2

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Lining Requirements

Stormwater treatmentwetlands are not intended to infiltrate. In infiltrative soils, both cells of the stormwater treatment wetland shall be lined. 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 (the wetland cell) must retain water for at least 10 months of the year.
2. The first cell (the presettling cell) must retain at least three feet of water year-round.
3. A complete precipitation record shall be used when establishing these conditions. Evapotranspiration losses shall be taken into account as well as infiltration losses.

Intent: 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.

If a low permeability liner is used, a minimum of 18 inches of native soil amended with good topsoil or compost (one part compost mixed with 3 parts native soil) must be placed over the liner. The compost must not contain biosolids. For geomembrane liners, a soil depth of 3 feet is recommended to prevent damage to the liner during planting. Hydric soils are not required.

The criteria for liners given in V-1.3 Liners and Geotextiles must be observed.

Inlet and Outlet

The design guidance for inlets and outlets to stormwater treatment wetlands are the same as for wetponds (see BMP T10.10: Wetponds - Basic and Large).

Access and Setbacks

- Location of the stormwater treatment wetland relative to site constraints (e.g., buildings, property lines) shall be the same as for BMP D.1: Detention Ponds. See V-1.2 Setbacks, Slopes, and Embankments for typical setback requirements for water quality BMPs.
- Access and maintenance roads shall be provided and designed according to the requirements for BMP D.1: Detention Ponds. Access and maintenance roads shall extend to both the wetland inlet and outlet structures. An access ramp (7H minimum:1V) shall be provided to the bottom of the first cell unless all portions of the cell can be reached and sediment loaded from the top of the wetland side slopes.
- If the dividing berm is also used for access, it should be built to sustain loads of up to 80,000 pounds.

Planting Requirements

The wetland cell shall be planted with emergent wetland plants following the recommendations given in Table V-8.1: Emergent Wetland Plant Species Recommended for Wetponds or the recommendations of a wetland specialist. Note: Cattails (Typha latifolia) are not recommended. They tend to escape to natural wetlands and crowd out other species. In addition, the shoots die back each fall and will result in oxygen depletion in the wetpool unless they are removed.

Construction Criteria

- Construction and maintenance considerations are the same as for BMP T10.10: Wetponds - Basic and Large.
- Construction of the naturalistic alternative (see Figure V-8.9: Stormwater Wetland — Option Two) can be easily done 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.

Operation and Maintenance

- Stormwater treatment wetlands should be inspected at least twice per year during the first three years during both growing and non-growing seasons to observe plant species presence, abundance, and condition; bottom contours and water depths relative to the plans; and sediment, outlet, and buffer conditions.
- Maintenance should be scheduled around sensitive wildlife and vegetation seasons.
- Plants may require watering, physical support, mulching, weed removal, or replanting during the first three years.
- Nuisance plant species should be removed and desirable species should be replanted.
- The effectiveness of harvesting for nutrient control is not well documented. There are many drawbacks to harvesting, including possible damage to the wetlands and the inability to remove nutrients in the below-ground biomass. If harvesting is practiced, it should be done in the late summer.

BMP T10.40: Combined Detention and Wetpool Facilities

Purpose and Definition

Combined detention and wetpool BMPs have the appearance of a detention BMP, 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 wetpool BMP when combined with a detention BMP. The following combined facilities are addressed:

- BMP D.1: Detention Ponds / BMP T10.10: Wetponds - Basic and Large
- BMP D.3: Detention Vaults / BMP T10.20: Wetvaults
- BMP D.1: Detention Ponds / BMP T10.30: Stormwater Treatment Wetlands

There are two sizes of the combined wetpond (basic and large), but only a basic size for the combined wetvault and combined stormwater treatment wetland. The facility sizes (basic and large) are related to the pollutant removal goals. See III-1.2 Choosing Your Runoff Treatment BMPs for more information about Runoff Treatment performance goals.

Applications and Limitations

Combined detention and wetpool BMPs are very efficient for sites that have both Runoff Treatment and Flow Control requirements. The wetpool BMP may often be placed beneath the detention BMP without increasing the combined facility's surface area. However, the fluctuating water surface of the live storage will create unique challenges for both plant growth and aesthetics.

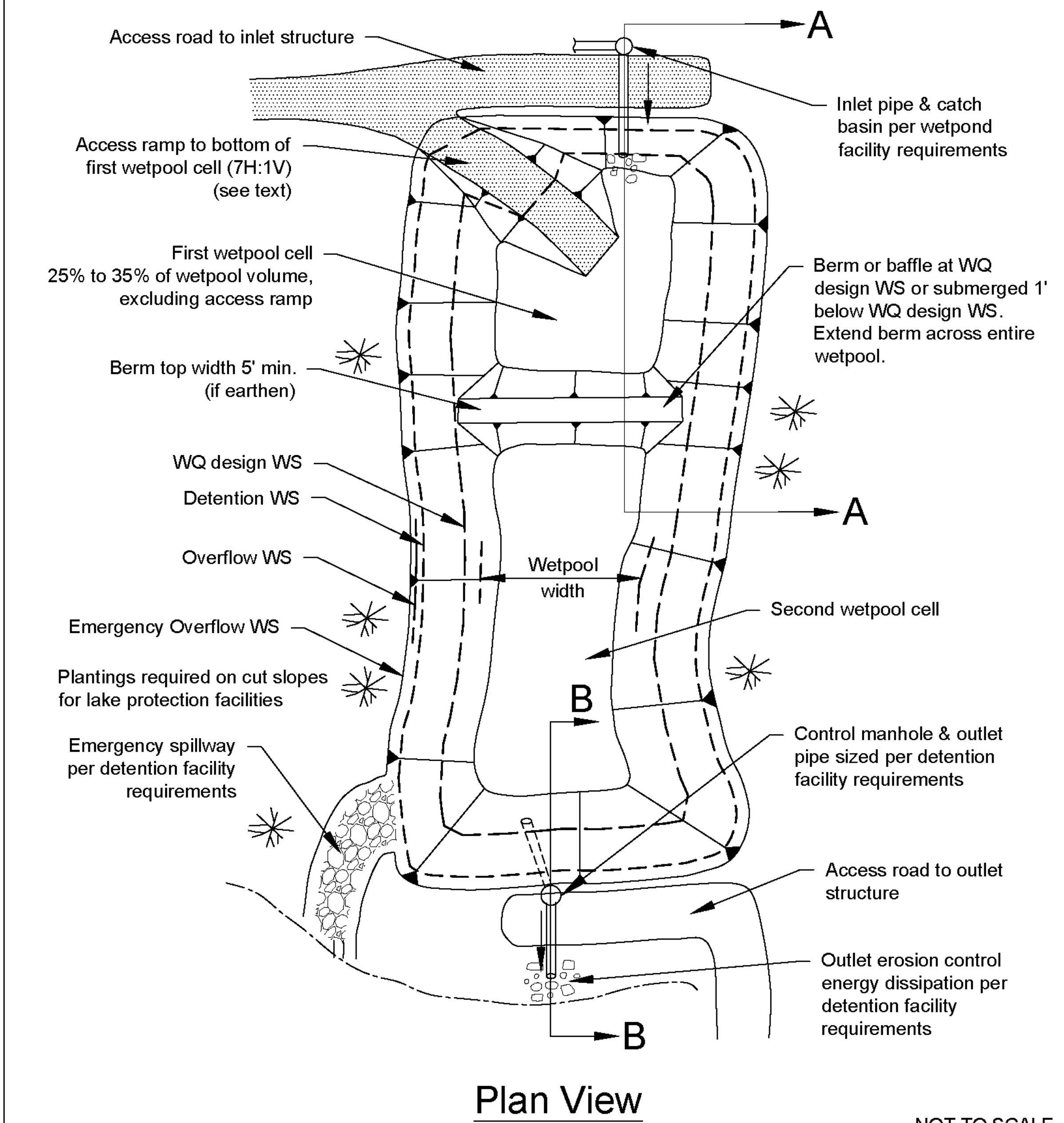
The basis for pollutant removal in combined detention and wetpool facilities is the same as in the stand-alone wetpool BMPs. However, in the combined facility, the detention function creates fluctuating water levels and added turbulence. For simplicity, the positive effect of the extra live storage volume and the negative effect of increased turbulence are assumed to balance, and are thus ignored when sizing the wetpool volume. For a combined detention/stormwater treatment wetland facility, criteria that limit the extent of water level fluctuation are specified to better ensure survival of the wetland plants.

Unlike the wetpool volume, the live storage component of the combined detention and wetpool facility should be provided above the seasonal high water table.

Design Criteria for Combined Detention and Wetpond (Basic and Large)

Typical design details and concepts for a combined detention and wetpond are shown in Figure V-8.10: Combined Detention and Wetpond (Plan View) and Figure V-8.11: Combined Detention and Wetpond (Section View). The detention portion of the facility shall meet the design criteria and sizing procedures set forth in BMP D.1: Detention Ponds.

Figure V-8.10: Combined Detention and Wetpond (Plan View)



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Combined Detention and Wetpond (Plan View)

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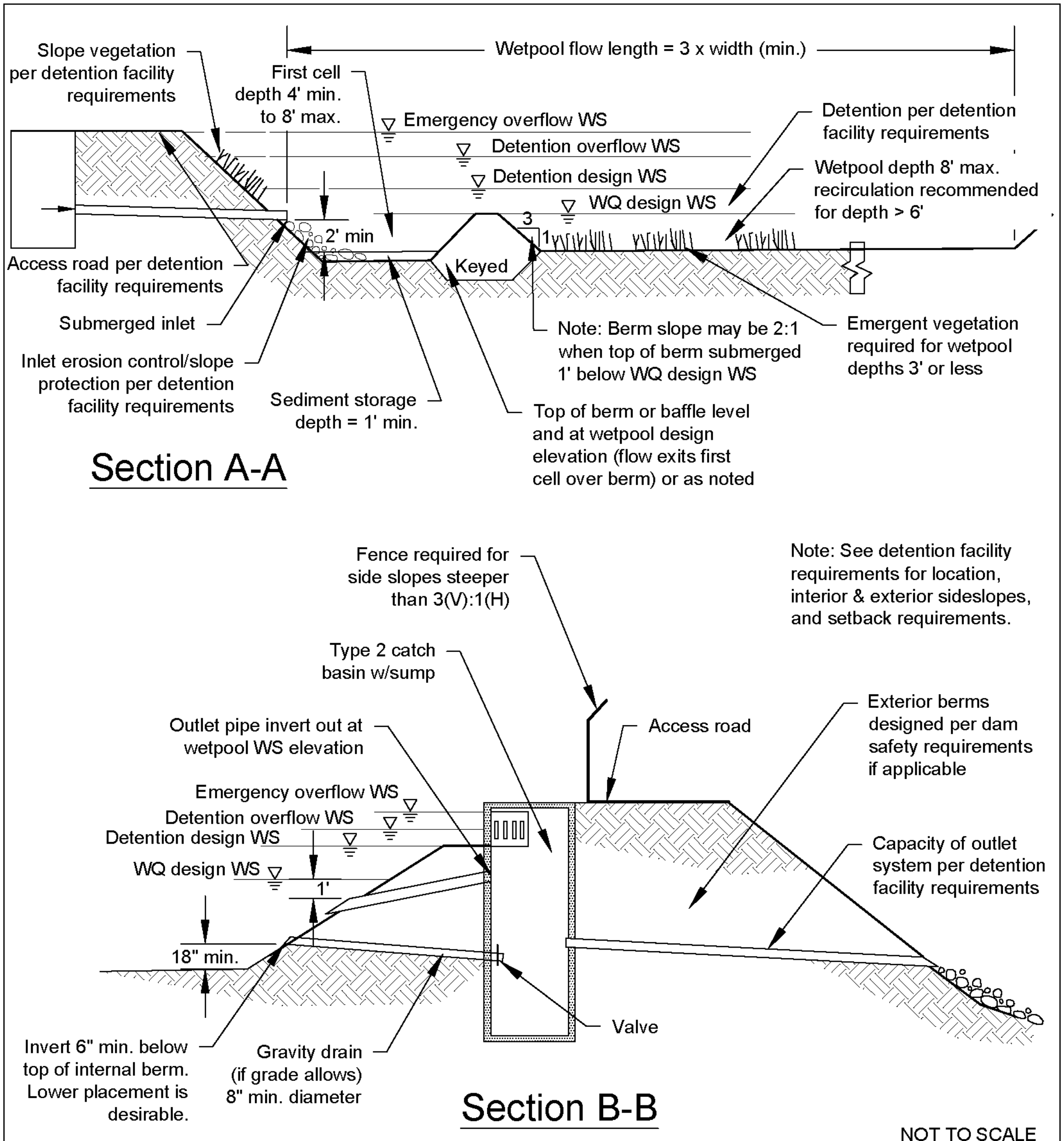
Figure V-8.11: Combined Detention and Wetpond (Section View)



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Combined Detention and Wetpond (Section View)

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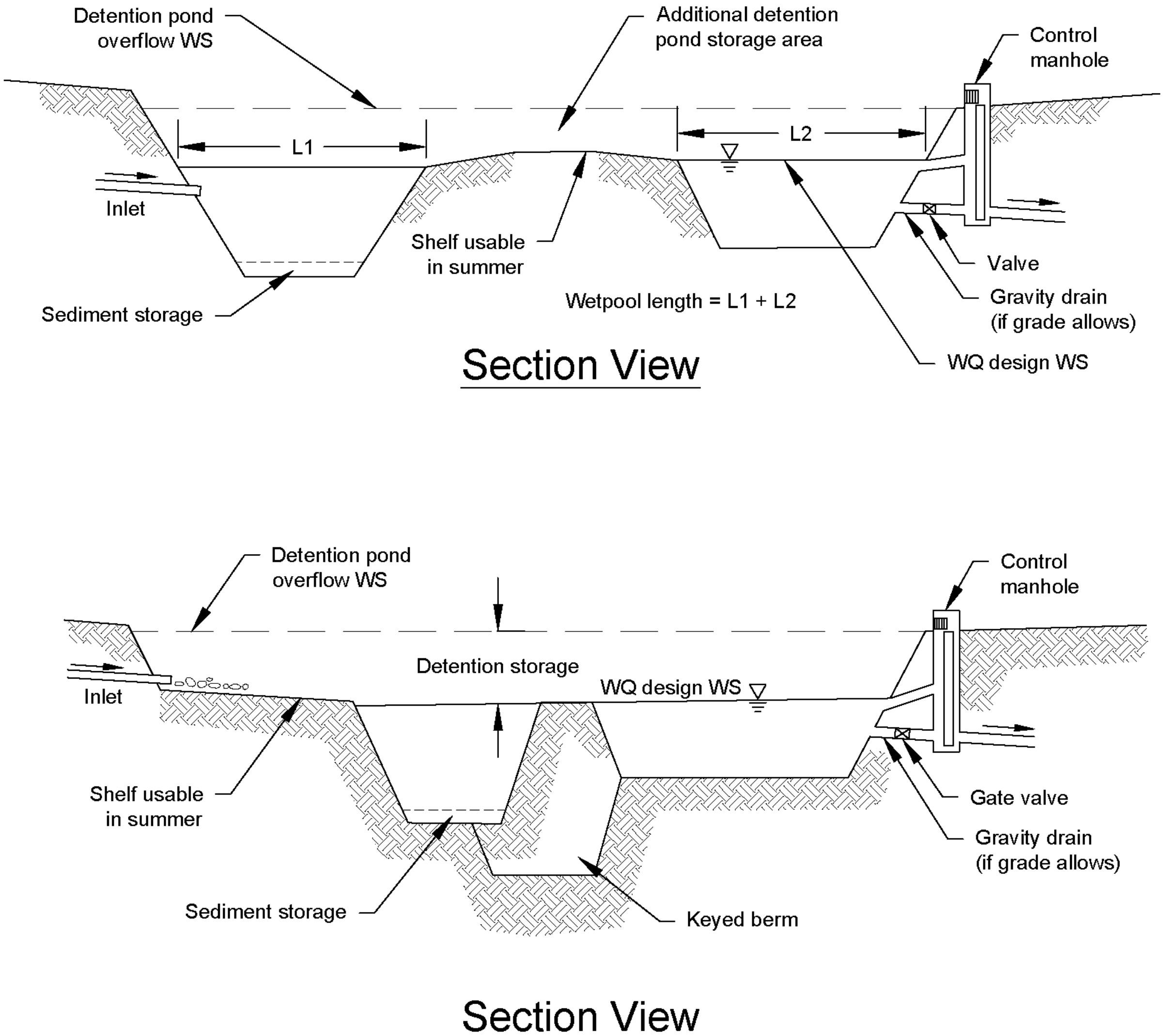
Figure V-8.12: Alternative Configurations of Detention and Wetpool Areas



Note: These examples show how the combined detention/wetpool can be configured to allow for "shelves" for joint use opportunities in dry weather. Other options may also be acceptable.

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Alternative Configurations of Detention and Wetpool Areas

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Sizing Procedure

The sizing procedure for combined detention and wetponds are identical to those outlined for wetponds and for detention facilities. Refer to the guidance in BMP T10.10: Wetponds - Basic and Large to size the wetpool volume (either basic or large) for a combined facility. Refer to the guidance in BMP D.1: Detention Ponds to size the detention portion of the pond.

Detention and Wetpool Geometry

The wetpool and sediment storage volumes shall not be included in the required detention volume.

The Wetpool Geometry criteria for wetponds (see BMP T10.10: Wetponds - Basic and Large) shall apply with the following modifications/clarifications:

- The wetpool may be made shallower to take up most of the pond bottom, or deeper and positioned to take up only a limited portion of the bottom. Note, however, that having the first wetpool cell at the inlet allows for more efficient sediment management than if the cell is moved away from the inlet. Wetpond criteria governing water depth must still be met. See Figure V-8.12: Alternative Configurations of Detention and Wetpool Areas for two possibilities for wetpool cell placement.

  Intent: This flexibility in positioning cells is provided to allow for multiple use options, such as volleyball courts in live storage areas in the drier months.

- 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, but 6 inches of sediment storage must be added to the second cell to comply with the detention sediment storage requirement.

Berms, Baffles, and Slopes

The requirements for berms, baffles, and slopes for combined detention and wetponds are the same as for wetponds (see BMP T10.10: Wetponds - Basic and Large).

Inlet and Outlet

The Inlet and Outlet criteria for wetponds (see BMP T10.10: Wetponds - Basic and Large) shall apply with the following modifications:

- A sump must be provided in the outlet structure of combined detention and wetponds.
- The detention flow restrictor and its outlet pipe shall be designed according to the requirements for detention ponds (see BMP D.1: Detention Ponds).

Access and Setbacks

The requirements for access and setbacks for combined detention and wetponds are the same as for BMP T10.10: Wetponds - Basic and Large.

Planting Requirements

The planting requirements for combined detention and wetponds are the same as for BMP T10.10: Wetponds - Basic and Large.

Design Criteria for Combined Detention and Wetvault

The sizing procedure for combined detention and wetvaults is identical to those outlined for wetvaults and for detention facilities. Refer to the guidance in BMP T10.20: Wetvaults to size the wet-pool volume for a combined facility. Refer to the guidance in BMP D.3: Detention Vaults to size the detention portion of the vault.

The design criteria for BMP D.3: Detention Vaults and BMP T10.20: 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 does 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.

  Intent: The greater depth of the baffle in relation to the WQ design water surface compensates for the greater water level fluctuations experienced in the combined vault. The greater depth is deemed prudent to better ensure that separated oils remain within the vault, even during storm events.
- A combined detention and wetvault may not be be combined with BMP T11.10: API (Baffle type) Separator to function as an Oil Control BMP, as is allowed for wetvaults in BMP T10.20: Wetvaults. This is because the added pool fluctuation in the combined detention and wetvault does not allow for the quiescent conditions needed for oil separation.

Design Criteria for Combined Detention and Stormwater Treatment Wetland

The sizing procedure for combined detention and stormwater treatment wetlands is identical to those outlined for stormwater treatment wetlands and for detention facilities. Refer to the guidance in BMP T10.30: Stormwater Treatment Wetlands to size the stormwater treatment wetland. Refer to the guidance in BMP D.1: Detention Ponds to size the detention portion of the combined detention and wetland facility.

The design criteria for BMP D.1: Detention Ponds and BMP T10.30: Stormwater Treatment Wetlands must both be met, except for the following modifications or clarifications:

- The Wetland Geometry criteria for BMP T10.30: Stormwater Treatment Wetlands are 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.

Intent: Since emergent plants are limited to shallower water depths, the deeper water created before sediments accumulate is considered detrimental to robust emergent growth. Therefore, sediment storage is confined to the first cell which functions as a pre-settling cell.

- The Inlet and Outlet criteria for BMP T10.10: Wetponds - Basic and Large shall apply with the following modifications:
  - A sump must be provided in the outlet structure of combined detention and stormwater treatment wetlands.
  - The detention flow restrictor and its outlet pipe shall be designed according to the requirements for detention ponds (see BMP D.1: Detention Ponds).
- The Planting Requirements for BMP T10.30: Stormwater Treatment Wetlands are modified to use the following plants which are better adapted to water level fluctuations:
  - *Scirpus acutus* (hardstem bulrush): 2 - 6' depth
  - *Scirpus microcarpus* (small-fruited bulrush): 1 - 2.5' depth
  - *Sparganium emersum* (burreed): 1 - 2' depth
  - *Sparganium eurycarpum* (burreed): 1 - 2' depth
  - *Veronica sp.* (marsh speedwell): 0 - 1' depth
  - In addition, the shrub *Spirea douglasii* (Douglas spirea) may be used in combined detention and stormwater treatment wetlands.
- 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 treatment 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.

  Intent: This criterion is designed to dampen the most extreme water level fluctuations expected in combined detention and stormwater treatment wetlands to better ensure that fluctuation-tolerant wetland plants will be able to survive. It is not intended to protect native wetland plant communities and is not to be applied to natural wetlands.

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V-9 Pretreatment BMPs

V-9.1 Introduction to Pretreatment BMPs

This chapter presents BMPs that may be used to provide pretreatment prior to other basic, phosphorus, or enhanced Runoff Treatment BMPs. Pretreatment must be provided in the following applications:

- For sand filters and infiltration BMPs, as directed in V-6 Filtration BMPs and V-5 Infiltration BMPs, to protect them from excessive siltation and debris.
- Where the basic, phosphorus, or enhanced Runoff Treatment BMP or the receiving water may be adversely affected by non-targeted pollutants (e.g., oil), or may by overwhelmed by a heavy load of targeted pollutants (e.g., suspended solids).

BMP T6.10: Presettling Basin is a typical pretreatment BMP used to remove suspended solids. Any Basic Treatment BMPs, or detention ponds, vaults, or tanks designed to meet I-3.4.7 MR7: Flow Control, can also be used for pre-treatment. If an oil/water separator is necessary for oil control, it could also function as the pre-settling basin as long as the influent suspended solids concentrations are not high. However, frequent inspections are necessary to determine when accumulated solids exceed the 6-inch depth at which clean-out is recommended (See Appendix V-A: BMP Maintenance Tables).

Ecology has approved some emerging technologies for pretreatment through the TAPE process. See V-10 Manufactured Treatment Devices as BMPs for details.

BMP T6.10: Presettling Basin

Purpose and Definition

A presettling basin provides pretreatment of runoff in order to remove suspended solids, which can impact other Runoff Treatment BMPs.

Application and Limitations

Runoff treated by a presettling basin may not be discharged directly to a receiving water; it must be further treated by a basic or enhanced Runoff Treatment BMP.

Design Criteria

1. A presettling basin shall be designed with a wetpool. The treatment volume shall be at least 30 percent of the total volume of runoff from the 6-month, 24-hour storm event. See III-2.3 Single Event Hydrograph Method for guidance on how to calculate this volume.
2. If the runoff in the presettling basin will be in direct contact with the soil, it must be lined per the liner requirement in V-1.3.1 General Liner Design.
3. The presettling basin shall conform to the following:

a. The length-to-width ratio shall be at least 3:1. Berms or baffles may be used to lengthen the flowpath through the presettling basin.

b. The minimum depth shall be 4 feet; the maximum depth shall be 6 feet.

4. Inlets and outlets shall be designed to minimize velocity and reduce turbulence. Inlet and outlet structures should be located at extreme ends of the presettling basin in order to maximize particle-settling opportunities.

Site Constraints and Setbacks

Site constraints are any manmade restrictions such as property lines, easements, structures, etc. that impose constraints on development. Constraints may also be imposed from natural features such as requirements of the local government's Sensitive Areas Ordinance and Rules. These should also be reviewed for specific application to the proposed development.

Presettling basins shall be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the local government.

Presettling basins shall be 100 feet from any septic tank/drainfield.

Presettling basins shall be a minimum of 50 feet from any steep (greater than 15 percent) slope.

Embankments that impound water (including presettling basins) must comply with the Washington State Dam Safety Regulations (Chapter 173-175 WAC). If the impoundment has a storage capacity (including both water and sediment storage volumes) greater than 10 acre-feet (435,600 cubic feet or 3.26 million gallons) above natural ground level, or has an embankment height of > 6 feet at the downstream toe, then dam safety design and review are required by Ecology. See Dam Safety for Detention BMPs in BMP D.1: Detention Ponds for more detail.

V-10 Manufactured Treatment Devices as BMPs

V-10.1 Introduction to Manufactured Treatment Devices as BMPs

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 to develop new manufactured stormwater treatment devices.

Manufactured treatment devices are emerging technologies that are new 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.

Ecology has established a program, the Technology Assessment Protocol – Ecology (TAPE), to evaluate the capabilities of manufactured treatment devices. Manufactured treatment devices that have been evaluated by TAPE are approved at some level of use designation under specified conditions. Their use is restricted in accordance with their evaluation as explained in V-10.3 Approval Process for Manufactured Treatment Devices. The recommendations for use of individual manufactured treatment devices may change as we collect more data on their performance. Updated recommendations on their use are posted to Ecology's TAPE website at the following address:

https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies

Manufactured treatment devices can also be considered for retrofit situations, where TAPE approval is not required.

V-10.2 Use Level Designations of Manufactured Treatment Devices

Ecology's Technology Assessment Protocol - Ecology (TAPE) program developed "use level designations" to assess levels of development for manufactured treatment devices. 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 (PULD),
- conditional use level designation (CULD), and
- general use level designation (GULD).

Ecology's TAPE website includes a menu for manufactured treatment devices that have a use level designation for the following levels of Runoff Treatment:

- pretreatment,
- oil control,
- phosphorous treatment,
- enhanced treatment, and
- basic treatment.

For more information, refer to Ecology's TAPE website at the following address:

https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies

Pilot Use Level Designation (PULD)

For manufactured treatment devicess that have limited performance data, the pilot use level designation allows limited use to conduct field-testing. Ecology may give pilot use level designations 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's TAPE program.

PULD manufactured treatment devices may be installed at sites that are pre-approved by Ecology and the local government with jurisdiction, provided that the vendor and/or developer agree to conduct field testing based on TAPE requirements. Ecology limits the number of installations to five during the pilot use level period and the manufacturer must monitor all five sites. Local governments should not approve manufactured treatment devices that have a PULD for a new or redevelopment project unless Ecology has concurred in the use of the manufactured treatment device at that project site.

Government entities covered by a municipal stormwater NPDES permit must notify Ecology when a PULD technology is proposed for installation. The form is available in Ecology's *Technical Guidance Manual for Evaluating Emerging Stormwater Treatment Technologies* (Ecology, 2011b).

Conditional Use Level Designation (CULD)

Ecology established the CULD for manufactured treatment devices that have considerable performance data not collected per the TAPE protocol. Ecology may give a conditional use level designation if a manufacturer collected field data through a protocol reasonably consistent with (but not fully meeting) the TAPE protocol. The field data must meet the statistical goals set out in the *Technical Guidance Manual for Evaluating Emerging Stormwater Treatment Technologies* (Ecology, 2011b). Manufacturers may use laboratory data to supplement field data. Ecology will allow the use of manufactured treatment devices that receive a CULD for a specified time, during which the manufacturer must complete the field testing necessary to obtain a general use level designation (GULD) and must submit a TER to Ecology's TAPE program. Ecology limits 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). Manufactured treatment devices with a GULD may be used for new development, re-development, or retrofit situations anywhere in Washington, subject to conditions that Ecology places within the use designation document. Manufactured treatment devices with a GULD can have an unlimited number of installations.

V-10.3 Approval Process for Manufactured Treatment Devices

Ecology's Role in Evaluating Manufactured Treatment Devices

To aid local governments in selecting manufactured treatment devices 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 manufactured treatment devices at the TAPE website:

  https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies

- Created a Board of External Reviewers (BER) to provide expert review services in the review of Quality Assurance Project Plans (QAPPs) and Technical Evaluation Reports (TERs).
- Created a Stakeholder Advisory Group (SAG) of local stakeholders to advise Ecology on the program protocols and develop new guidance.
- Participates in all activities which include reviewing manufacturer performance data and providing recommendations on use level designations (see V-10.2 Use Level Designations of Manufactured Treatment Devices).
- 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.

For full details on the TAPE process for evaluating a manufactured treatment device, refer to *Technical Guidance Manual for Evaluating Emerging Stormwater Treatment Technologies* (Ecology, 2011b).

Local Government's Role in Evaluating Manufactured Treatment Devices

Local governments should consider the following as they make decisions concerning the use of manufactured treatment devices in their jurisdiction:

- Remember the goal
    - The goal of any stormwater management program or BMP is to treat and release stormwater in a manner that does not harm beneficial uses.
- Exercise reasonable caution
    - Before allowing the use of a manufactured treatment device, the local government should review evaluation information based on the TAPE or CTAPE protocols.
    - A manufactured treatment device cannot be used for new or redevelopment unless it has a use level designation. Having a use level designation means that Ecology and the TRC or CTRC reviewed the system performance data, and believe the device has the ability to provide the level of treatment claimed by the manufacturer.
    - To achieve the goals of the Clean Water Act and the Endangered Species Act, local governments may find it necessary to retrofit stormwater pollutant control systems for many existing stormwater discharges. In retrofit situations, the use of any BMP that makes substantial progress toward these goals is a step forward and is encouraged by Ecology. To the extent practical, the performance of BMPs used in retrofit situations should be evaluated using the TAPE or CTAPE protocols.

TAPE Performance Goals and Water Quality Parameters

In addition to other requirements, Ecology's TAPE program uses the Runoff Treatment Performance Goals detailed in III-1.2 Choosing Your Runoff Treatment BMPs to evaluate manufactured treatment devices.

Proponents attempting to obtain a GULD for a manufactured treatment device must demonstrate the achievement of applicable performance goals by monitoring the water quality parameters listed in Table V-10.1: TAPE Treatment Goals and Water Quality Parameters.

Two additional performance goals that are used for TAPE and CTAPE evaluations are listed below. These performance goals are not detailed in III-1.2 Choosing Your Runoff Treatment BMPs.

Pretreatment Performance Goal

- For influent concentrations of less than 100 mg/L: achieve effluent goals of 50 mg/L coarse total suspended solids.
- For influent concentrations of greater than 100 mg/L, but less than 200 mg/L: achieve 50% removal of total suspended solids.

Construction Stormwater BMP Performance Goal

Achieve a maximum of 5 NTUs above background (background of 50 NTUs or less), not more than 10% increase in turbidity where background is greater than 50 NTUs, pH of 6.5-8.5 in freshwater and 7.0-8.5 in marine water, and no visible oil sheen.

Table V-10.1: TAPE Treatment Goals and Water Quality Parameters

Performance Goal	Influent Range	Criteria	Required Water Quality Parameters
Basic Treatment	20-100 m/L TSS	Effluent goal ≤ 20 mg/L TSS[b]	TSS
	100-200 mg/L TSS	≥ 80 % TSS removal[c]	
	> 200 mg/L TSS	> 80 % TSS removal[c]	
Dissolved Metals Treatment[d]	Dissolved Copper 0.005-0.02 mg/L	Must meet basic treatment goal and better than basic treatment currently defined as > 30% dissolved copper removal [c,e]	TSS, hardness, total and dissolved Cu and Zn
	Dissolved Zinc 0.02- 0.3 mg/L	Must meet basic treatment goal and better than basic treatment currently defined as > 60% dissolved zinc removal [c,e]	
Phosphorus Treatment	Total phosphorus (TP) 0.1 to 0.5 mg/L	Must meet basic treatment goal and exhibit ≥ 50% TP removal b	TSS, TP, orthophosphate
Oil Treatment	Total petroleum hydrocarbons (TPH) >10 mg/L[f]	1) No ongoing or recurring visible sheen in effluent 2) Daily average effluent TPH concentration < 10 mg/L [b,f] 3) Maximum effluent TPH concentration of 15 mg/L [b,f] for a discrete (grab) sample	NWTPH-Dx, visible sheen
Pretreatment[g]	50-100 mg/L TSS	Effluent goal ≤ 50 mg/L TSS[b]	TSS
	100-200 mg/L	> 50% TSS removal [c]	

mg/L - milligrams per liter

Cu - copper

NWTPH-Dx - Northwest Total Petroleum Hydrocarbons-Motor Oil and Diesel fractions

TP - total phosphorus

TPH - total petroleum hydrocarbons

TSS - total suspended solids

Table V-10.1: TAPE Treatment Goals and Water Quality Parameters (continued)

Performance Goal	Influent Range	Criteria	Required Water Quality Parameters
Zn - zinc a - Samples with influent concentrations that are greater than the range may be included by artificially setting the value at the upper end of the concentration range prior to completing the pollutant removal efficiency calculations. If the applicant opts to include samples with concentrations that are greater than the influent concentration range, they must include all valid samples that are greater than the range (i.e. applicants cannot "cherry pick" data). b - The upper one-sided 95 percent confidence interval around the mean effluent concentration for the treatment system being evaluated must be lower than this performance goal to meet the performance goal with the required 95 percent confidence. c - The lower one-sided 95 percent confidence interval around the mean removal efficiency for the treatment system being evaluated must be higher than this performance goal to meet the performance goal with the required 95 percent confidence. d - Referred to as Enhanced Treatment in the *Stormwater Management Manual for Western Washington* (Ecology, 2005c) and Metals Treatment in the *Stormwater Management Manual for Eastern Washington* (Ecology, 2004b). Must meet the removal goal for both dissolved copper and dissolved zinc in order to achieve a Dissolved Metals Treatment GULD. Meeting the removal goal for only one of these dissolved metals is not sufficient. e - This percent removal was determined based on an analysis of the basic treatment BMP dissolved metals removal data from the International Stormwater BMP database to define performance goals for dissolved metals treatment (Washington Stormwater Center and Herrera 2011). Data from the International Stormwater BMP database was reviewed and screened based on influent concentrations, geographic location, data quality, BMP design, and monitoring problems to develop a subset of data that was representative and suitable for determining BMP performance. f - This performance goal should be evaluated based on the motor oil fraction of TPH-Dx only. g - Pretreatment technologies generally apply to (1) project sites using infiltration treatment and (2) treatment systems where pretreatment is needed to ensure and extend performance of the downstream basic or dissolved metals treatment facilities.			

V-10.4 Which Manufactured Treatment Devices Have Ecology Approval?

Ecology's TAPE website lists manufactured treatment devices that have obtained a use level designation through the Technology Assessment Protocol – Ecology (TAPE) process. Ecology's TAPE website also provides additional guidance regarding the TAPE process and application forms.

In addition to Ecology certification, local jurisdiction approval is required for installation of manufactured treatment devices with Pilot (PULD), Conditional (CULD), or General (GULD) Use Level Designations. Local jurisdictions may choose not to accept devices approved through TAPE, or may require additional testing prior to consideration for local approval.

See Ecology's TAPE website at the following address for details:

https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies

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V-11 Miscellaneous LID BMPs

V-11.1 Introduction to Miscellaneous LID BMPs

BMPs in this chapter have been grouped because they have the following in common:

- They employ Low Impact Development (LID) Principles
- They cannot be used to meet I-3.4.6 MR6: Runoff Treatment
- They cannot, by themselves, be used to meet the Flow Control Performance Standard or the LID Performance Standard.
    - Some of the BMPs in this chapter do allow for some amount of Flow Control credit. See the guidance for each individual BMP for details.
- The design methods for each BMP in this chapter are unique. They do not have strong enough design similarities to other BMPs in this volume to place them in the other BMP categories identified in this volume.

BMP T5.13: Post-Construction Soil Quality and Depth

Purpose and Definition

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.

Establishing soil quality and depth regains greater stormwater functions in the post development landscape, provides increased treatment of pollutants and sediments that result from development and habitation, and minimizes the need for some landscaping chemicals, thus reducing pollution through prevention.

Applications and Limitations

Establishing a minimum soil quality and depth is not the same as preservation of naturally occurring soil and vegetation. However, establishing a minimum soil quality and depth will provide improved on-site management of stormwater flow and water quality.

Soil organic matter can be attained through numerous materials such as compost, composted woody material, biosolids, and forest product residuals. It is important that the materials used to meet this BMP be appropriate and beneficial to the plant cover to be established. Likewise, it is important that imported topsoils improve soil conditions and do not have an excessive percent of clay fines.

This BMP can be considered infeasible on till soil slopes greater than 33 percent.

Design Guidelines

Soil Retention

Retain, in an undisturbed state, the duff layer and native topsoil to the maximum extent practicable. In any areas requiring grading, remove and stockpile the duff layer and topsoil on site in a designated, controlled area, not adjacent to public resources and critical areas, to be reapplied to other portions of the site where feasible.

Soil Quality

All areas subject to clearing and grading that have not been covered by impervious surface, incorporated into a drainage facility or engineered as structural fill or slope shall, at project completion, demonstrate the following:

1. A topsoil layer with a minimum organic matter content of 10% dry weight in planting beds, and 5% organic matter content in turf areas, and a pH from 6.0 to 8.0 or matching the pH of the undisturbed soil. The topsoil layer shall have 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.
2. Mulch planting beds with 2 inches of organic material.
3. Use compost and other materials that meet the following organic content requirements:
    a. The organic content for "pre-approved" amendment rates can be met only using compost meeting the compost specification for BMP T7.30: Bioretention, with the exception that the compost may have up to 35% biosolids or manure.

       The compost must also have an organic matter content of 40% to 65%, and a carbon to nitrogen ratio below 25:1.

       The carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.

    b. Calculated amendment rates may be met through use of composted material meeting (a.) above; or other organic materials amended to meet the carbon to nitrogen ratio requirements, and not exceeding the contaminant limits identified in Table 220-B, Testing Parameters, in WAC 173-350-220.

The resulting soil should be conducive to the type of vegetation to be established.

Implementation Options

The soil quality design guidelines listed above can be met by using one of the methods listed below:

1. Leave undisturbed native vegetation and soil, and protect from compaction during construction.
2. Amend existing site topsoil or subsoil either at default “pre-approved” rates, or at custom calculated rates based on tests of the soil and amendment.
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 “pre-approved” rate or at a custom calculated rate.
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.

Planning/Permitting/Inspection/Verification Guidelines & Procedures

Local governments are encouraged to adopt guidelines and procedures similar to those recommended in *Building Soil: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13 in WDOE Stormwater Management Manual for Western Washington* (Stenn et al., 2016).

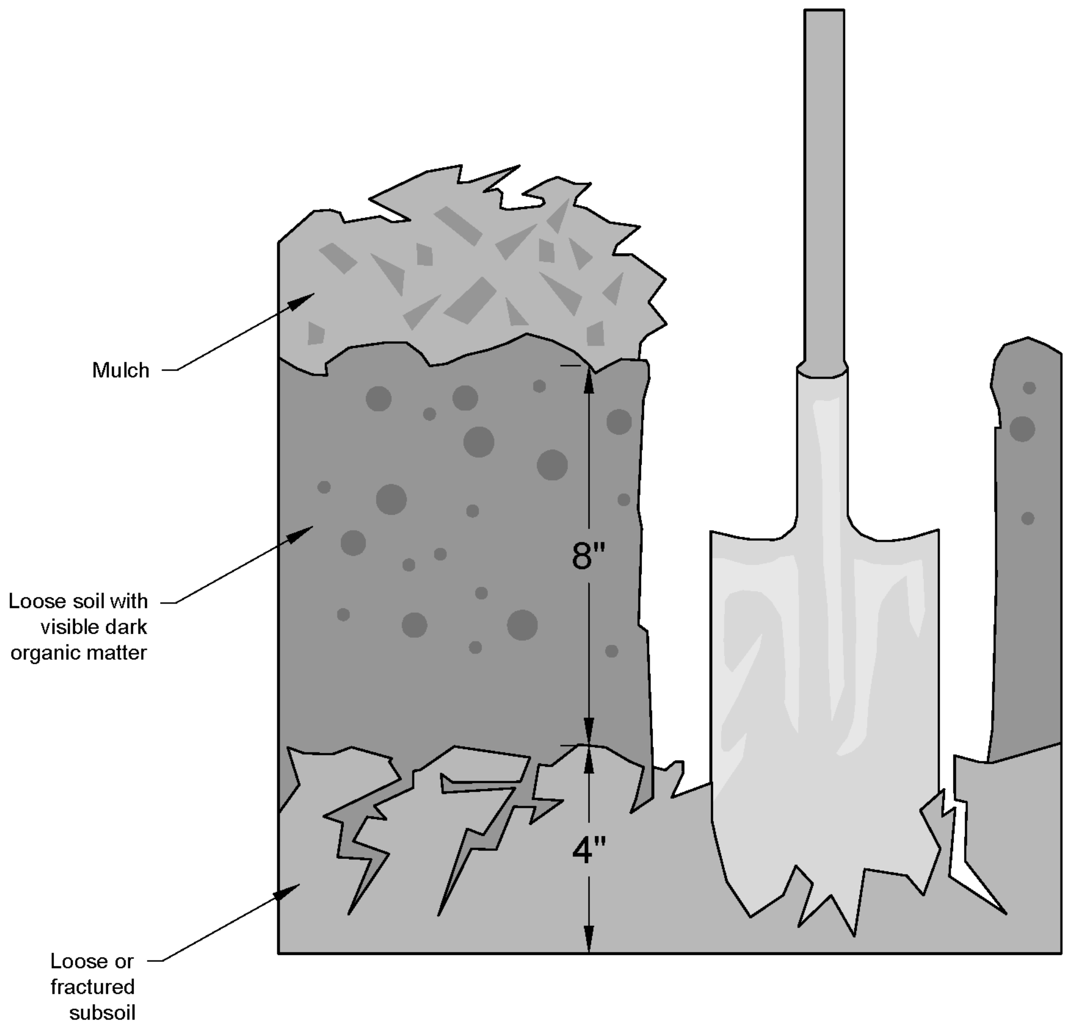
Maintenance

- 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.

Runoff Model Representation

All areas meeting the soil quality and depth design criteria may be entered into approved runoff models as “Pasture” rather than “Lawn/Landscaping”.

Figure V-11.1: Planting Bed Cross-Section



Reprinted from *Guidelines and Resources For Implementing Soil Quality and Depth BMP T5.13 in WDOE Stormwater Management Manual for Western Washington*, 2010, Washington Organic Recycling Council

NOT TO SCALE

DEPARTMENT OF ECOLOGY
State of Washington

Planting Bed Cross-Section

Revised June 2016

BMP T5.14: Rain Gardens

Purpose and Definition

Rain gardens are an LID BMP that can provide effective removal of many stormwater pollutants, and provide reductions in stormwater runoff quantity and surface runoff flow rates. Although rain gardens provide these benefits, the amount of benefit is unquantifiable. Therefore, rain gardens cannot be used to meet any of the following:

- the LID Performance Standard or List #2 within I-3.4.5 MR5: On-Site Stormwater Management,
- I-3.4.6 MR6: Runoff Treatment,
- I-3.4.7 MR7: Flow Control, or
- I-3.4.8 MR8: Wetlands Protection

Rain gardens are non-engineered, shallow, landscaped depressions with compost-amended soils and adapted plants. The depression ponds and temporarily stores stormwater runoff from adjacent areas. A portion of the influent stormwater passes through the amended soil profile and into the native soil beneath. Stormwater that exceeds the storage capacity is designed to overflow to an adjacent drainage system.

Applications and Limitations

Rain gardens are an LID BMP within The List Approach compliance option for I-3.4.5 MR5: On-Site Stormwater Management.

Infeasibility criteria for rain gardens are the same as for BMP T7.30: Bioretention. Please see the infeasibility criteria in BMP T7.30: Bioretention.

Although not required, Ecology recommends installation by a landscaping company with experience in rain garden construction.

Rain gardens constructed with imported compost materials should not be used within one-quarter mile of phosphorus-sensitive waterbodies. Preliminary monitoring indicates that new rain gardens can add phosphorus to stormwater. Therefore, they should also not be used with an underdrain when the underdrain water would be routed to a phosphorus-sensitive receiving water.

Design Guidelines

Refer to the *Rain Garden Handbook for Western Washington: A Guide for Design, Installation, and Maintenance* (Hinman et al., 2013) for rain garden specifications and construction guidance.

For amending the native soil within the rain garden, Ecology recommends use of compost that meets the compost specification for BMP T7.30: Bioretention. Compost that includes biosolids or manures shall not be used.

For design on projects subject to I-3.4.5 MR5: On-Site Stormwater Management, and choosing to use List #1 of that requirement, rain gardens shall have a horizontally projected surface area below the overflow which is at least 5% of the total impervious surface area draining to it. If lawn/landscape area will also be draining to the rain garden, Ecology recommends that the rain garden's horizontally projected surface area below the overflow be increased by 2% of the lawn/landscape area.

Underdrains

Ecology does not recommend the use of underdrains for rain gardens. Design and construction of an underdrain system likely requires professional expertise. Where a municipality intends to require or allow underdrained rain gardens in areas with initial infiltration rates between 0.3 and 0.6 inches per hour, the invert of the underdrain shall be 6 inches above the bottom of the aggregate bedding for the underdrain. A larger distance between the underdrain and the bottom of the aggregate bedding is desirable, but cannot be used to trigger infeasibility due to inadequate vertical separation to the seasonal high water table, bedrock, or other impermeable layer.

Ecology recommends that the municipality establish standard design specifications and drawings.

Infiltration Testing Guidance Specific to Rain Gardens

The site procedures and design guidelines described here are meant to be implemented after a preliminary project layout has been developed, per III-3 Stormwater Site Plans. The designer must perform sufficient infiltration tests to confirm the feasibility of proposed rain garden sites. Testing should occur between December 1 and April 1.

The certified soils professional or engineer can exercise discretion concerning the need for and extent of infiltration rate (saturated hydraulic conductivity, K_{sat}) testing. The professional can consider a reduction in the extent of infiltration (K_{sat}) testing if, in their judgment, information exists confirming that the site is unconsolidated outwash material with high infiltration rates, and there is at least 1 foot separation from the bottom of a rain garden to ground water.

Perform a Small-Scale Pilot Infiltration Test (see V-5.4 Determining the Design Infiltration Rate of the Native Soils) – or an alternative small scale test specified by the local government – to determine if the minimum measured infiltration rate of 0.3 in/hr is exceeded at the proposed rain garden location. Also determine whether the site has at least one foot separation from the bottom of the rain garden to the seasonal high ground water or other hydraulic restriction layer.

Legal Documentation to Track Rain Garden Obligations

Where drainage plan submittals include assumptions with regard to size and location of rain gardens, approval of the plat, short-plat, or building permit should identify the rain garden obligation of each lot; and the appropriate lots should have deed requirements for construction and maintenance of the rain gardens.

Runoff Model Representation

Due to the variability in rain garden soils, rain gardens do not provide Flow Control or Runoff Treatment that is quantifiable using continuous runoff modeling software. Rain gardens are not represented in Ecology approved continuous runoff models.

Maintenance

Refer to the *Rain Garden Handbook for Western Washington: A Guide for Design, Installation, and Maintenance* (Hinman et al., 2013) for tips on mulching, watering, weeding, pruning, and soil management.

Guidance Document: Western Washington Low Impact Development (LID) Operation and Maintenance (O&M) (Herrera and WSC, 2013) may be consulted for more detailed maintenance guidance.

BMP T5.16: Tree Retention and Tree Planting

Purpose and Definition

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 and newly planted trees receive credits toward meeting the LID Performance Standard within I-3.4.5 MR5: On-Site Stormwater Management and/or the Flow Control Performance Standard within I-3.4.7 MR7: Flow Control.

The degree of Flow Control provided by a tree depends on the tree type (i.e., evergreen or deciduous), canopy area, and whether or not the tree canopy overhangs impervious surfaces. Flow Control credits may be applied to project sites of all sizes.

Tree Retention Design Criteria

Setbacks of proposed infrastructure from existing trees are critical considerations. Tree protection requirements limit grading and other disturbances in proximity to the 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).

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. For existing trees smaller than this, the newly planted tree credit may be applied.

The retained tree canopy 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. If trees are clustered, overlapping canopies are not double counted.

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 and within 20 feet of new and/or replaced ground level impervious or other hard surfaces (e.g., driveway or patio) on the development site. Distance from impervious or other hard surfaces is measured from the tree trunk center.

An arborist report may be required if impervious surface is proposed within the critical root zone of the existing tree. The critical root zone is defined as the line encircling the base of the tree with half the diameter of the dripline. If the arborist report concludes that impervious surface should not be placed within 20 feet of the tree and canopy overlap with impervious surface is still anticipated given a longer setback, the higher tree Flow Control credit may be approved.

Protection During Construction

The existing tree roots, trunk, and canopy shall be fenced and protected during construction activities.

Retention and Protection

Trees shall be retained, maintained, and protected on the site after construction and for the life of the development or until any approved redevelopment occurs in the future. Trees that are removed or die shall be replaced with like species during the next planting season (typically in the fall). Trees shall be pruned according to industry standards (ANSI A 300 standards).

Tree Retention Flow Control Credit

Flow Control credits for retained trees are provided in Table V-11.1: Flow Control Credits for Retained Trees by tree type. These credits can be applied to reduce impervious or other hard surface area requiring Flow Control. Credits are given as a percentage of the existing tree canopy area. The minimum credit for existing trees ranges from 50 to 100 square feet.

Table V-11.1: Flow Control Credits for Retained Trees

Tree Type	Credit
Evergreen	20% of canopy area (minimum of 100 sq. ft./tree)
Deciduous	10% of canopy area (minimum of 50 sq. ft./tree)

Impervious/Hard Surface Area Mitigated =

$$(\Sigma \text{ Evergreen Canopy Area x .2}) + (\Sigma \text{ Deciduous Canopy Area x 0.1})$$

Flow Control 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 the impervious or other hard surface area requiring mitigation.

Newly Planted Tree Design Criteria

Tree Species

Each jurisdiction should adopt a list of approved tree species for stormwater credit. An example list of trees is provided below in Table V-11.3: Recommended Newly Planted Tree Species for Flow Control Credit.

Tree Size

To receive Flow Control credit, new deciduous trees at the time of planting shall be at least 1.5 inches in diameter measured 6 inches above the ground. New evergreen trees shall be at least 4 feet tall.

Tree Location

Trees shall be sited according to sun, soil, and moisture requirements. Planting 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 planted trees depends upon proximity to ground level impervious surfaces. To receive a credit, the tree must be planted on the development site and within 20 feet of new and/or replaced ground level impervious surfaces (e.g., driveway, patio, or parking lot). 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 planted trees shall accommodate mature tree spread. In no circumstance shall Flow Control credit be given for new tree density exceeding 10 feet on center spacing.

Plant Material and Planting Specifications

Recommended guidelines for planting materials and methods are provided in City of Seattle Standard Specifications 8-02 and 9-14, and Standard Plans 100a, 100b, and 101.

Irrigation

Provisions shall be made for supplemental irrigation during the first three growing seasons after installation to help ensure tree survival.

Retention and Protection

Trees shall be retained, maintained, and protected on the site after construction and for the life of the development as required for retained trees.

Newly Planted Tree Flow Control Credit

Flow Control credits for newly planted trees are provided in Table V-11.2: Flow Control Credits for Newly Planted Trees by tree type. These credits can be applied to reduce the impervious or other hard surface area requiring Flow Control. Credits range from 20 to 50 square feet per tree.

Table V-11.2: Flow Control Credits for Newly Planted Trees

Tree Type	Credit
Evergreen	50 sq. ft. per tree
Deciduous	20 sq. ft. per tree

Impervious/Hard Surface Area Mitigated =

Σ Number of Trees x Credit (sq. ft.)

Flow Control 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 the impervious or other hard surface area requiring mitigation.

Runoff Model Representation

If the design criteria for this BMP are followed, the total impervious/hard surface areas entered into the runoff model may be reduced by the amount indicated in the design criteria above.

Table V-11.3: Recommended Newly Planted Tree Species for Flow Control Credit

Botanical Name	Common Name	Height	Spread	Comments	Native Tree (Y/N)
Large Group					
Abies grandis	Grand Fir	100	35	Grows at 0-1500 m in moist conifer forests.	Y
Abies procera	Noble Fir	90	30		N
Acer freemanii 'Autumn Blaze'	Autumn Blaze Maple	50	40		N
Acer macrophyllum	Big Leaf Maple	100	80	Very large native.	Y
Acer platanoides 'Emerald Queen'	Emerald Queen Norway Maple	50	40		N
Acer saccharum 'Bonfire'	Bonfire Sugar Maple	50	40	Fastest growing sugar maple.	N
Acer saccharum 'Commemoration'	Commemoration Sugar Maple	50	35	Resistant to leaf tatter.	N
Acer saccharum 'Legacy'	Legacy Sugar Maple	50	35	Limited use - where sugar maple is desired in standard planting strips	N

Table V-11.3: Recommended Newly Planted Tree Species for Flow Control Credit (continued)

Botanical Name	Common Name	Height	Spread	Comments	Native Tree (Y/N)
Aesculus flava	Yellow Buckeye	70	40	Yellow flowers - least susceptible to leaf blotch - large fruit	N
Alnus rubra	Red Alder	70	35	Nitrogen fixing.	Y
Cercidiphyllum japonicum	Katsura Tree	40	40	Needs lots of water when young	N
Fagus sylvatica	Green Beech	50	40	Silvery-grey bark.	N
Fagus sylvatica 'Asplenifolia'	Fernleaf Beech	60	60	Beautiful cut leaf	N
Fraxinus latifolia	Oregon Ash	60	35	Only native ash in PNW.	Y
Fraxinus pennsylvanica 'Urbanite'	Urbanite Ash	50	40	Tolerant of city conditions.	N
Gymnocladus dioicus 'Espresso'	Espresso Kentucky Coffeetree	50	35	Very coarse branches - extremely large bi-pinnately compound leaf.	N
Liriodendron tulipifera	Tulip Tree	60	30	Fast-growing tree.	N
Nothofagus antarctica	Antarctic Beech	50	35	Rugged twisted branching and petite foliage.	N
Picea sitchensis	Sitka Spruce	100	30	Native environment is characterized by cool, moist maritime climate.	Y
Pinus monticola	Western White Pine	100	35	Occurs in lowland fog forests or on moist mountain soils - primary host.	Y
Platanus x acerifolia 'Bloodgood'	Bloodgood London Planetre	50	40	More anthracnose resistant - needs space.	N
Platanus x acerifolia 'Yarwood'	Yarwood London Planetree	50	40	High resistance to powdery mildew.	N
Psuedotsuga menziesii	Douglas Fir	150	35		Y
Quercus bicolor	Swamp White Oak	45	45	Shaggy peeling bark.	N
Quercus coccinea	Scarlet Oak	50	40	Best oak for fall color.	N
Quercus garryana	Oregon Oak	45	40	Native to Pacific Northwest.	Y
Quercus imbricaria	Shingle Oak	60	50	Nice summer foliage - leaves	N

Table V-11.3: Recommended Newly Planted Tree Species for Flow Control Credit (continued)

Botanical Name	Common Name	Height	Spread	Comments	Native Tree (Y/N)
				can persist throughout the winter.	
Quercus muhlenbergii	Chestnut Oak	60	50	Coarsely toothed leaf.	N
Quercus robur	English Oak	50	40	Large, sturdy tree.	N
Quercus rubra	Red Oak	50	45	Fast growing oak - needs space.	N
Quercus velutina	Black Oak	60	50		N
Thuja plicata	Western Red Cedar	125	40	Growth is stunted on dry soils.	Y
Tsuga heterophylla	Western Hemlock	130	30		Y
Ulmus 'Homestead'	Homestead Elm	60	35		N
Ulmus 'Pioneer'	Pioneer Elm	60	50	Resistant to Dutch elm disease.	N
Ulmus parvifolia 'Emer II'	Allee Elm	50	35	Exfoliating bark and nice fall color.	N
Zelkova serrata 'Greenvase'	Green Vase Zelkova	50	40	Vigorous.	N
Medium/Large Group					
Acer campestre	Hedge Maple	30	30		N
Acer campestre 'Evelyn'	Queen Elizabeth Hedge Maple	35	30	More upright branching than the species.	N
Acer miyabei 'Morton'	State Street Maple	45	30		N
Acer platanoides 'Parkway'	Parkway Norway Maple	40	25	Tolerant of verticillium wilt.	N
Acer pseudoplatanus 'Atropurpureum'	Spaethii Maple	40	30	Leaves green on top purple underneath.	N
Acer saccharum 'Green Mountain'	Green Mountain Sugar Maple	45	35	Reliable fall color.	N
Aesculus x carnea	Briottii' Red Horsechestnut	30	35	Resists heat and drought better than other horsechestnuts	N

Table V-11.3: Recommended Newly Planted Tree Species for Flow Control Credit (continued)

Botanical Name	Common Name	Height	Spread	Comments	Native Tree (Y/N)
Betula albosinensis var septentrionalis	Chinese Red Birch	45	35	White/pink peeling bark.	N
Betula jacquemontii	Jacquemontii Birch	40	30	White bark makes for good winter interest - best for aphid resistance.	N
Betula papyrifera	Paper Birch	60	35	High susceptibility to aphid infestation.	Y
Chamaecyparis pisifera	Sawara Cypress	45	25	Special site approval needed- many cultivars avail-able.	N
Corylus colurna	Turkish Filbert	40	25	Tight, formal, dense crown - not for high pedestrian areas.	N
Eucommia ulmoides	Hardy Rubber Tree	50	40	Dark green shiny leaves.	N
Fagus sylvatica 'Rohanii'	Purple Oak Leaf Beech	50	30	Attractive purple leaves with wavy margins.	N
Fraxinus americana 'Autumn Applause'	Autumn Applause Ash	40	25	Compact tree - reportedly seedless.	N
Fraxinus americana 'Empire'	Empire Ash	50	25	Use for areas adjacent to taller buildings when ash is desired.	N
Fraxinus pennsylvan-ica 'Patmore'	Patmore Ash	45	35	Extremely hardy, may be seedless.	N
Ginko biloba 'Autumn Gold'	Autumn Gold Ginkgo	45	35	Narrow when young.	N
Halesia monticola	Mountain Silverbell	45	25	Attractive small white flower.	N
Koelreuteria pan-iculata	Goldenrain Tree	30	30	Midsummer blooming.	N
Liquidambar styra-ciflua 'Rotundiloba'	Rotundiloba Sweet-gum	45	25	Only sweetgum that is entirely fruitless. Smooth rounded leaf lobes.	N
Magnolia denudata	Yulan Magnolia	40	40	6" fragrant white blossoms in spring.	N
Metasequoia glyptostroboides	Dawn Redwood	50	25	Fast growing deciduous con-ifer.	N

Table V-11.3: Recommended Newly Planted Tree Species for Flow Control Credit (continued)

Botanical Name	Common Name	Height	Spread	Comments	Native Tree (Y/N)
Nyssa sylvatica	Tupelo	60	20	Handsomely chunky bark.	N
Phellodendron amurense 'Macho'	Macho Cork Tree	40	40	Male selection - fruitless - another good variety is 'His Majesty'.	N
Pinus nigra	Austrian Pine	45	25	Special site approval needed - fairly tolerant of heat, pollution, urban	N
Pinus pinea	Italian Stone Pine	40	30	Special site approval needed.	N
Populus tremuloides	Quaking Aspen	50	30		Y
Pyrus calleryana 'Aristocrat'	Aristocrat Pear	40	30	Good branch angles - one of the tallest pears.	N
Quercus frainetto	Italian Oak	50	30	Drought reistant.	N
Quercus robur 'fastigiata'	Skyrocket Oak	40	15	Columnar variety of oak.	N
Salix lasiandra	Pacific Willow	40	30		Y
Sophora japonica 'Regent'	Japanese Pagodatree	50	40	Can have trunk canker or twig blight.	N
Taxodium distichum	Bald Cypress	5	30	A deciduous conifer.	N
Taxodium distichum 'Mickelson'	Shawnee Brave Bald Cypress	55	20	Deciduous conifer - tolerates city conditions.	N
Tilia americana 'Redmond'	Redmond Linden	45	30	Pyramidal, needs water.	N
Tilia cordata 'Greenspire'	Greenspire Linden	40	30	Symmetrical, pyramidal form.	N
Zelkova serrata 'Village Green'	Village Green Zelkova	40	38		N
Medium/Small Group					
Acer nigrum 'Green Column'	Green Column Black Maple	50	10	Good close to buildings.	N
Acer platanoides 'Columnar'	Columnar Norway Maple	40	15	Good close to buildings.	N
Acer rubrum 'Bowhall'	Bowhall Maple	40	15		N

Table V-11.3: Recommended Newly Planted Tree Species for Flow Control Credit (continued)

Botanical Name	Common Name	Height	Spread	Comments	Native Tree (Y/N)
Acer rubrum 'Karpick'	Karpick Maple	35-40	20	May work under very high power lines with arborist's approval.	N
Acer rubrum 'Scarsen'	Scarlet Sentinel Maple	40	20		N
Acer truncatum x A. platanoides 'Keiths-form'	Norwegian Sunset Maple	35	25	Limited use under wires.	N
Acer truncatum x A. platanoides 'War-renred'	Pacific Sunset Maple	30	25	Limited use under wires.	N
Alnus sinuata	Sitka Alder	40	25	Prefers a heavy moist soil - usually found above 3000'.	Y
Carpinus betulus	'Fastigiata' Pyr-amidal European Hornbeam	35	15	Broadens when older.	N
Cladrastis kentukea	Yellowwood	40	40	White flowers in spring, resembling wisteria flower.	N
Cornus controversa 'June Snow'	Giant Dogwood	40	30	Large white flower clusters that appear in June.	N
Crataegus crus-galli 'Inermis'	Thornless Cockspur Hawthorne	25	30	Red persistent fruit.	N
Crataegus phaen-opyrum	Washington Hawthorne	25	20	Thorny.	N
Crataegus suksdorfii	Suksdorf's Hawthorne	30	25	Shorter spines than C. Douglasii.	Y
Crataegus x lavalii	Lavalle Hawthorne	28	20	Thorns on younger trees.	N
Davidia involucrata	Dove Tree	40	30	Large, unique white flowers in May.	N
Ginko biloba 'Prin-ceton Sentry'	Princeton Sentry Ginkgo	40	15	Very narrow growth.	N
Halesia tetraptera	Carolina Silverbell	35	30	Attractive bark for seasonal interest.	N
Libocedrus decur-rens	Incense Cedar	35	20	Special site approval needed.	N

Table V-11.3: Recommended Newly Planted Tree Species for Flow Control Credit (continued)

Botanical Name	Common Name	Height	Spread	Comments	Native Tree (Y/N)
Liquidambar styraciflua	Moraine Sweetgum	40	20	Light green foliage. More compact than other varieties.	N
Maackia amurensis	Amur Maackia	30	20	Attractive bark and summer flowers - grows in tough conditions.	N
Magnolia 'Elizabeth'	Elizabeth Magnolia	30	20	Yellow Flowers.	N
Magnolia 'Galaxy'	Galaxy Magnolia	35	25	Reddish-purple flowers in spring.	N
Magnolia grandiflora 'Victoria'	Victoria Evergreen Magnolia	25	20		N
Magnolia Kobus	Wada's Memory Magnolia	35	20	Does not flower well when young.	N
Ostrya virginiana	Ironwood	40	25	Hop like fruit.	N
Parrotia persica	Persian Parrotia	30	20	Select or prune for single stem; can be multi-trunked.	N
Pinus densiflora 'Umbraculifera'	Umbrella Pine	25	20	Special site approval needed.	N
Prunus x yedoensis 'Akebono'	Akebono Flowering Cherry	25	25		N
Pterostyrax hispida	Fragrant Epaulette Tree	40	35	Pendulous creamy white flowers - fragrant.	N
Pyrus calleryana 'Cambridge'	Cambridge Pear	40	15	Narrow tree with good branch angles and form.	N
Pyrus calleryana 'Glen's Form'	Chanticleer or Cleveland Select Pear	40	15	Vigorous.	N
Pyrus calleryana 'Redspire'	Redspire Pear	35	25	Pyramidal.	N
Quercus 'Crimschmidt'	Crimson Spire Oak	45	15	Hard to find.	N
Robinia x ambigua	Pink Idaho Locust	35	25	Fragrant flowers.	N
Sciadopitys verticillata	Japanese Umbrella Pine	30	20	Grows slowly - pristine evergreen foliage - special site approval.	N

Table V-11.3: Recommended Newly Planted Tree Species for Flow Control Credit (continued)

Botanical Name	Common Name	Height	Spread	Comments	Native Tree (Y/N)
Sorbus alnifolia	Korean Mountain Ash	40	30	Simple leaves. Beautiful pink-red fruit - may be short lived.	N
Sorbus aucuparia 'Mitchred'	Cardinal Royal Mt. Ash	35	20	Bright red berries.	N
Sorbus x hybridia	Oakleaf Royal Mt. Ash	30	20		N
Stewartia monodelpha	Orange Bak Ste-wartia	30	20	Orange peeling bark - white flowers in spring.	N
Taxus brevifolia	Pacific Yew	40	25	Typically occurs as an under-story tree 3-5 m tall west of the Cascades.	Y
Tilia cordata 'De Groot'	De Groot Littleleaf Linden	30	20	Compct, suckers less than other Lindens.	N
Tilia cordata 'Chan-cole'	Chancelor Linden	35	20	Pyramidal.	N

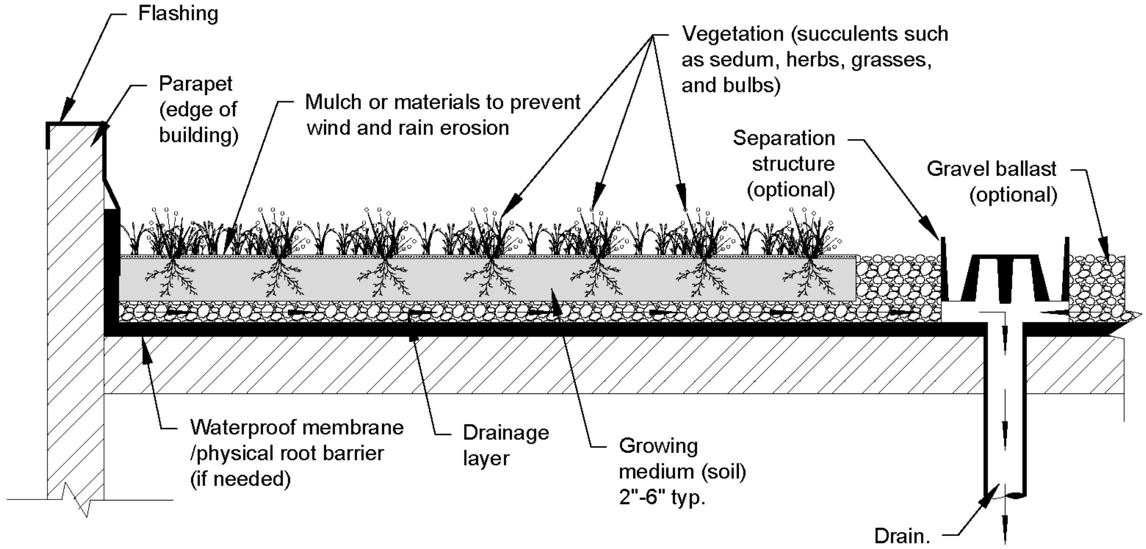
BMP T5.17: Vegetated Roofs

Purpose and Definition

Vegetated roofs (also known as ecoroofs and green roofs) are thin layers of engineered soil and vegetation constructed on top of conventional flat or sloped roofs. Vegetated roofs can provide multiple benefits, including stormwater volume reduction and flow attenuation, resulting in some amount of Flow Control. The range of benefits for a green roof depends on a number of design factors such as plant selection, depth and composition of soil mix, location of the roof, orientation and slope, weather patterns, and the maintenance plan.

All vegetated roofs consist of four basic components: a waterproof membrane, a drainage layer, a light-weight growth medium, and vegetation (see Figure V-11.2: Example of a Vegetated Roof Section). In addition to these basic components, many systems may also incorporate a protection layer and root barrier to preserve the integrity of the waterproof membrane, a separation/filter layer to stabilize fine particles, capillary mats and mulch/mats to retain moisture and prevent surface erosion due to rain and wind scour.

Figure V-11.2: Example of a Vegetated Roof Section



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Example of a Vegetated Roof Section

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Applications and Limitations

While vegetated roofs can be installed on slopes up to 40 degrees, slopes between 5 and 20 degrees (1:12 and 5:12) are most suitable and can provide natural drainage by gravity. Roofs with slopes greater than 10 degrees (2:12) require an analysis of engineered slope stability.

Vegetated roofs are not included as an option in the The List Approach within I-3.4.5 MR5: On-Site Stormwater Management. However, they are an option available to project designers who want to use other methods to meet the LID Performance Standard within I-3.4.5 MR5: On-Site Stormwater Management, or the Flow Control Performance Standard within I-3.4.7 MR7: Flow Control.

Design Criteria

The reader is directed to the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012) for a more detailed description of the components of and design criteria for vegetated roofs. It also includes references to other sources of information and design guidance.

Note that the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012) is for additional informational purposes only. You must follow the guidance within this manual if there are any discrepancies between this manual and the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012)

Runoff Model Representation

When modeling the project using an approved continuous runoff model, use the element intended by the modeling software to represent a vegetated roof. If using WWHM2012, this is the "green roof" element. The user specifies the media thickness, vegetation type, roof slope, and length of drainage within the model.

Maintenance

Proper maintenance and operation are essential to ensure that designed performance and benefits continue over the full life cycle of the installation. Each vegetated roof installation will have specific design, operation and maintenance guidelines provided by the manufacturer and installer. The following guidelines are for extensive roof systems and provide a general set of standards for prolonged vegetated roof performance.

General Maintenance Guidelines

- All facility components, including structural components, waterproofing, drainage layers, soil substrate, vegetation, and drains should be inspected for proper operation throughout the life of the vegetated roof.
- Drain inlets should provide unrestricted stormwater flow from the drainage layer to the roof drain system unless the assembly is specifically designed to impound water as part of an irrigation or stormwater management program.
- The property owner should provide the maintenance and operation plan and inspection schedule.

- Written guidance and/or training for operating and maintaining vegetated roofs should be provided along with the operation and maintenance agreement to all property owners and tenants.
- All elements of an extensive roof installation should be inspected twice annually.
- The facility owner should keep a maintenance log recording inspection dates, observations, and activities.
- Inspections should be scheduled to coincide with maintenance operations and with important horticultural cycles (e.g., prior to major weed varieties dispersing seeds).

Refer to Appendix V-A: BMP Maintenance Tables for additional maintenance guidelines.

BMP T5.18: Reverse Slope Sidewalks

Purpose and Definition

Reverse slope sidewalks are sloped to drain away from the road and onto adjacent vegetated areas.

Design Criteria

The design must include more than 10 feet of vegetated surface downslope of the reverse slope sidewalk that is not directly connected into the drainage system.

The vegetated surface receiving flow from the reverse slope sidewalk must be native soil or meet the guidelines in BMP T5.13: Post-Construction Soil Quality and Depth.

Runoff Model Representation

Use the lateral flow elements to send the impervious area runoff onto the lawn/landscape area that will be used for dispersion.

Ecology may develop guidance for representing multiple impervious reverse slope sidewalks in a project site. If such guidance is not forthcoming, in situations where multiple impervious reverse slope sidewalks will occur, Ecology may allow the impervious area to be modeled as a landscaped area so that the project schematic in the model becomes manageable.

BMP T5.19: Minimal Excavation Foundations

Purpose and Definition

Minimal excavation foundations are defined as those foundation technologies that engage intact existing soil strength with minimal or no excavation, and do not disturb, or significantly compact the natural soil profile within the footprint of the structure when installed. This preserves most of the hydrologic properties of the native soil. Pin pile, screw pile, and cluster pile foundations are examples of minimal excavation foundations, as well as post and beam, grade beam or fin wall structures.

Applications and Limitations

To minimize soil compaction, heavy equipment, including pile driving equipment that would degrade the natural soil profile's ability to retain, drain and/or filter stormwater cannot be used within or immediately surrounding the building. Tracked equipment weighing 650 psf or less is acceptable.

Runoff Model Representation

- Where residential roof runoff is dispersed on the up-gradient side of a structure in accordance with the design criteria and guidelines in BMP T5.10B: Downspout Dispersion Systems, the tributary roof area may be modeled as pasture on the native soil, provided the dispersed runoff is not cut off by an embedded grade beam, wall, or skirt structure from reaching the preserved permeable soils below the building.
- If roof runoff is dispersed down gradient of the structure in accordance with the design criteria and guidelines in BMP T5.10B: Downspout Dispersion Systems, AND there is at least 50 feet of vegetated flow path through native material or lawn/landscape area that meets the guidelines in BMP T5.13: Post-Construction Soil Quality and Depth, the tributary roof areas may be modeled as lawn/landscaped area.
- Where terracing on a slope below the building or vegetated flow path, as defined above, is necessary for construction, the square footage of roof that can be modeled as pasture or lawn/landscaped 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.

BMP T5.20: Rainwater Harvesting

Purpose and Definition

Rainwater harvesting is the capture and storage of rainwater for beneficial use. Roof runoff may be routed to cisterns for storage and nonpotable uses such as irrigation, toilet flushing, and cold water laundry. Rainwater harvesting can help reduce peak stormwater flows, durations, and volumes. The amount of reduction achieved with cistern storage is a function of contributing area, storage volume, and rainwater use rate.

Design Criteria

In order to use the guidance below for Runoff Model Representation, the design must show 100% reuse of the annual average runoff volume. The designer must use an approved continuous runoff model to calculate the annual average for drainage area.

System designs involving interior uses must have a monthly water balance that demonstrates adequate capacity for each month and reuse of all stored water annually.

Restrict the use of this BMP to 4 homes/acre housing and lower densities when the captured water is solely for outdoor use.

Runoff Model Representation

If the design criteria for this BMP are followed, the area draining to the rainwater harvesting BMP is not entered into the runoff model.

V-12 Detention BMPs

V-12.1 Introduction to Detention BMPs

This section presents guidance for design and analysis of detention BMPs. These BMPs provide Flow Control by providing temporary storage of the increased surface water runoff that results from development. See I-3.4.7 MR7: Flow Control for details on the performance requirements for Flow Control.

The concept of detention is to collect runoff from a developed area and, using a control structure, release it at a slower rate than it enters the collection system (see V-12.2 Control Structure Design). The reduced release rate requires temporary storage of the excess runoff in a pond, tank, or vault, with release occurring over a few hours or days. The volume of temporary storage needed is dependent on:

1. The size of the drainage area.
2. The extent of disturbance of the natural vegetation, topography, and soils and creation of effective impervious surfaces (surfaces that drain to a stormwater collection system).
3. How rapidly the water is allowed to leave the detention pond; i.e., the target release rates.

If runoff from surfaces that require Flow Control is not separated from runoff from other existing surfaces (whether on-site or off-site), refer to the guidance in III-2.4 Flow Bypass and Additional Area Inflow for additional guidance when sizing the detention BMPs.

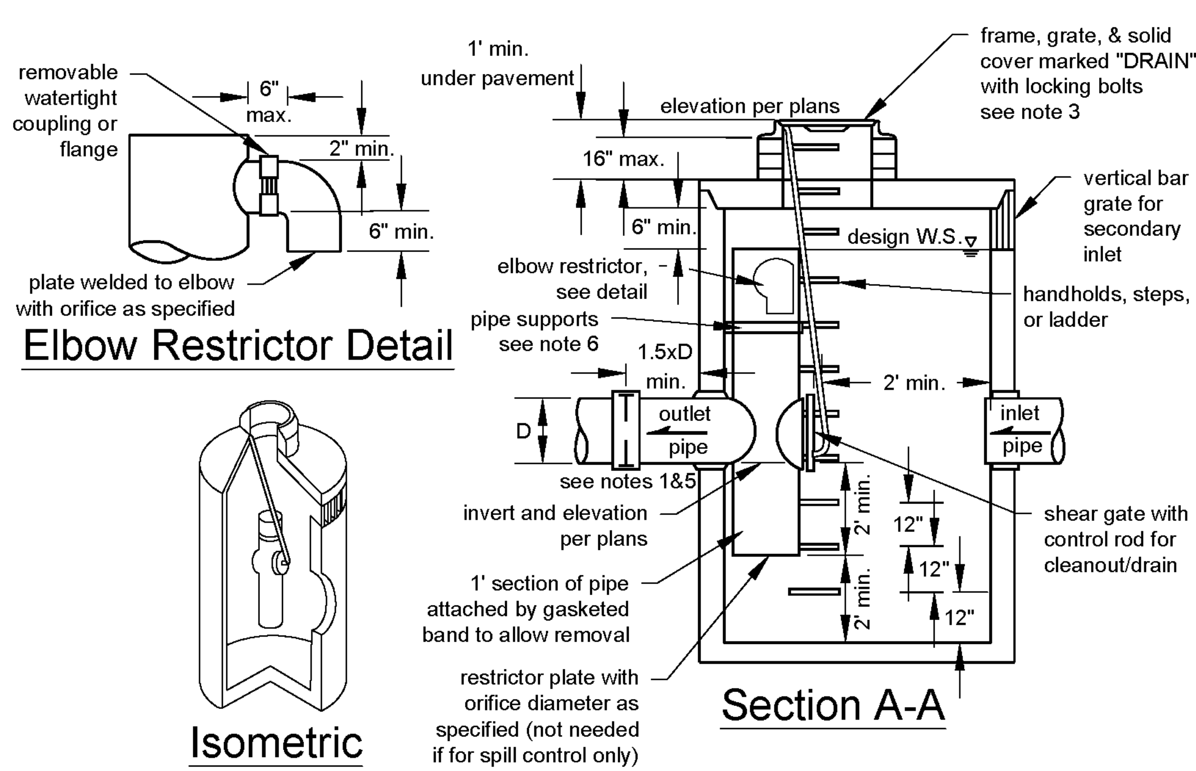
V-12.2 Control Structure Design

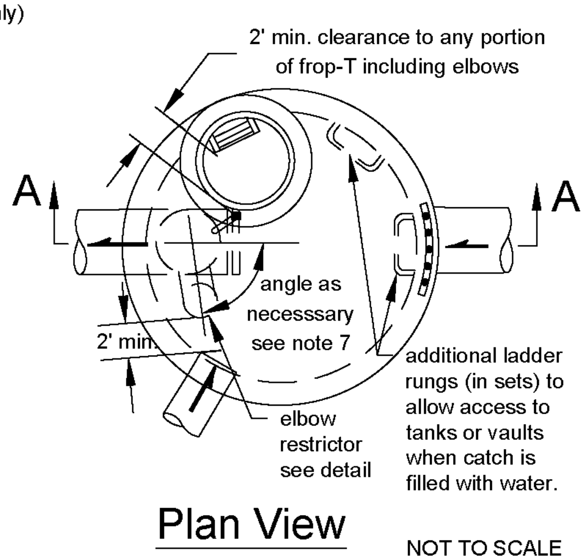
Control structures are catch basins or manholes with a restrictor device for controlling outflow from a detention BMP to meet the desired performance standard. Riser type restrictor devices (“tees” or “FROP Ts”) also provide some incidental oil and water separation to temporarily detain oil or other floatable pollutants in runoff due to accidental spill or illegal dumping.

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 V-12.1: Flow Restrictor (TEE), Figure V-12.2: Flow Restrictor (Baffle), and Figure V-12.3: Flow Restrictor (Weir).

Figure V-12.1: Flow Restrictor (TEE)





Notes:

1. Use a minimum of a 54" diameter type 2 catch basin.
2. Outlet Capacity: 100-yr developed peak flow.
3. Metal Parts: Corrosion resistant. Non-Galvanized parts preferred. Galvanized pipe parts to have asphalt treatment 1.
4. 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.
5. If metal outlet pipe connects to cement concrete pipe: outlet pipe to have smooth O.D. equal to concrete pipe I.D. less ¼".
6. Provide at least one 3" x 0.90 inches support bracket anchored to concrete wall. (maximum 3'-0" vertical spacing)
7. Locate elbow restrictor(s) as necessary to provide minimum clearance as shown.
8. Locate additional ladder rungs in structures used as access to tanks or vaults to allow access when catch basin is filled with water.

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Flow Restrictor (TEE)

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Figure V-12.2: Flow Restrictor (Baffle)

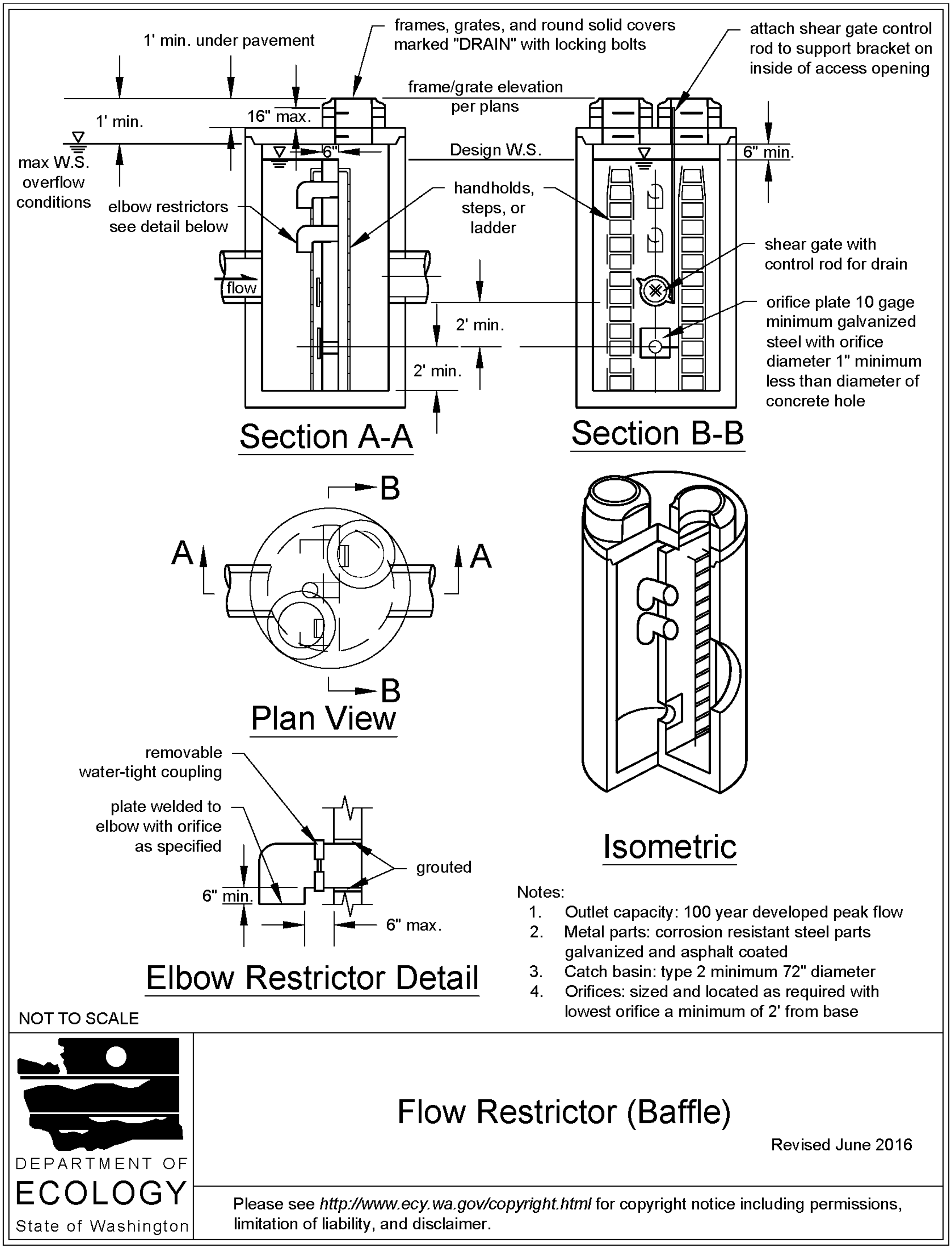
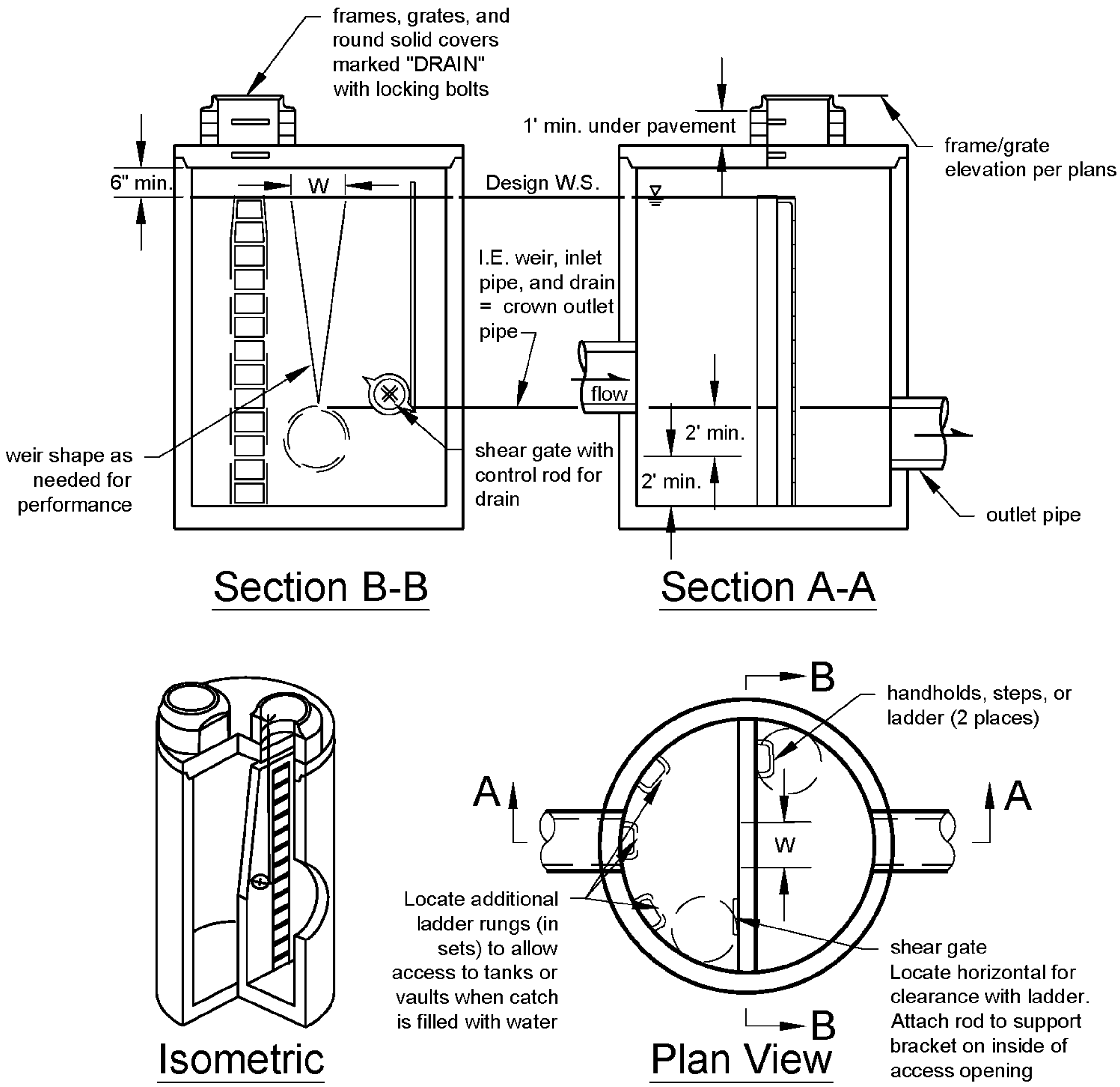


Figure V-12.3: Flow Restrictor (Weir)



Notes:

1. Outlet Capacity: 100-year developed peak flow.
2. Metal Parts: corrosion resistant steel parts galvanized and asphalt coated.
3. Catch Basin: type 2 min. 72" diameter.
4. Baffle Wall: to be designed with concrete reinforcing as required.
5. Spill containment must be provided to temporarily detain oil or floatable pollutants in runoff due to accidental spill or illegal dumping.

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Flow Restrictor (Weir)

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Design Criteria

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 the detention storage volume. Several orifices may be located at the same elevation if necessary to meet performance requirements.

1. The 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, the live storage depth need not be reduced to less than 3 feet in an attempt to meet the performance standards. Also, under such circumstances, flow-throttling devices may be a feasible option. These devices will throttle flows while maintaining a plug-resistant opening.

2. Orifices may be constructed on a tee section as shown in Figure V-12.1: Flow Restrictor (TEE) or on a baffle as shown in Figure V-12.2: Flow Restrictor (Baffle).

3. 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 V-12.5: Rectangular, Sharp Crested Weir).

4. Consider the backwater effect of water surface elevations in the downstream conveyance system. High tailwater elevations may affect performance of the restrictor system and reduce live storage volumes.

Riser and Weir Restrictor

1. Properly designed weirs may be used as flow restrictors (see Figure V-12.3: Flow Restrictor (Weir), Figure V-12.5: Rectangular, Sharp Crested Weir, Figure V-12.6: V-Notch, Sharp-Crested Weir, and Figure V-12.7: Sutro Weir). However, they must be designed to provide for primary overflow of the developed 100-year peak flow discharging to the detention BMP.

2. 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 100 year peak flow assuming all orifices are plugged. Figure V-12.8: Riser Inflow Curves can be used to calculate the head in feet above a riser of given diameter and flow.

Access

1. Provide an access road to the control structure for inspection and maintenance. Design and construct the access road as specified in BMP D.1: Detention Ponds.

2. Manhole and catch basin lids for control structures must be locking, and rim elevations must match proposed finish grade.

3. Manholes and catch basins must meet 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, just under the access lid.

Information Plate

It is recommended that a brass or stainless steel plate be permanently attached inside each control structure with the following information engraved on the plate:

- Name and file number of the project
- Name and organization of (1) project proponent, (2) engineer, and (3) contractor
- Date constructed
- Name and date of manual used for design
- Outflow performance criteria
- Release mechanism size, type, and invert elevation
- List of stage, discharge, and volume at one foot increments
- Elevation of overflow
- Recommended frequency of maintenance.

Maintenance

Control structures have a history of maintenance-related problems and it is imperative to establish a good maintenance program for them to function properly. Typically, sediment builds up inside the structure, which blocks or restricts flow to the inlet. To prevent this problem, routinely clean out control structures at least twice per year. Conduct regular inspections of control structures to detect the need for non-routine cleanout, especially if construction or land-disturbing activities occur in the contributing drainage area.

Appendix V-A: BMP Maintenance Tables provides maintenance recommendations for control structures.

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.

Orifices

Flow through orifice plates in the standard tee section or turned 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 V-12.4: 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:

$$d = \sqrt{\frac{36.88Q}{\sqrt{h}}}$$

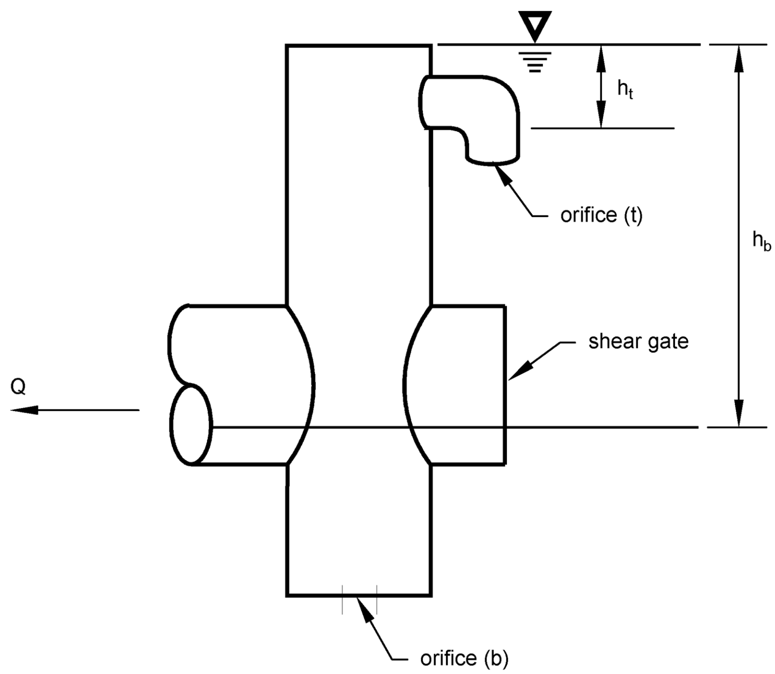
where

d = orifice diameter (inches)

Q = flow (cfs)

h = hydraulic head (ft)

Figure V-12.4: Simple Orifice



$$Q = CA_b\sqrt{2gh_b} + CA_t\sqrt{2gh_t}$$
$$= C\sqrt{2g}(A_b\sqrt{h_b} + A_t\sqrt{h_t})$$

h_b = distance from hydraulic grade line at the 2 – year flow of the outflow pipe to the overflow elevation

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Simple Orifice

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Rectangular Sharp Crested Weir

The rectangular sharp crested weir design shown in Figure V-12.5: Rectangular, Sharp Crested Weir may be analyzed using standard weir equations for the fully contracted condition.

$$Q=C(L - 0.2H)H^{3/2}$$

where

Q = flow (cfs)

C = 3.27 + 0.40 H/P (ft)

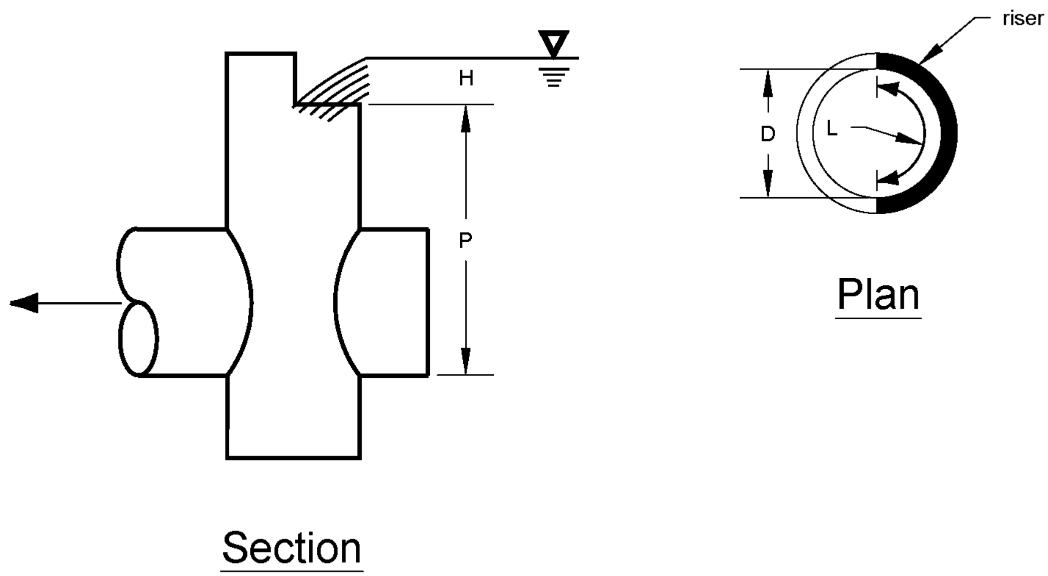
H, P are as shown in Figure V-12.5: Rectangular, Sharp Crested Weir

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 that this equation accounts for side contractions by subtracting 0.1H from L for each side of the notch weir.

Figure V-12.5: Rectangular, Sharp Crested Weir



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Rectangular, Sharp-Crested Weir

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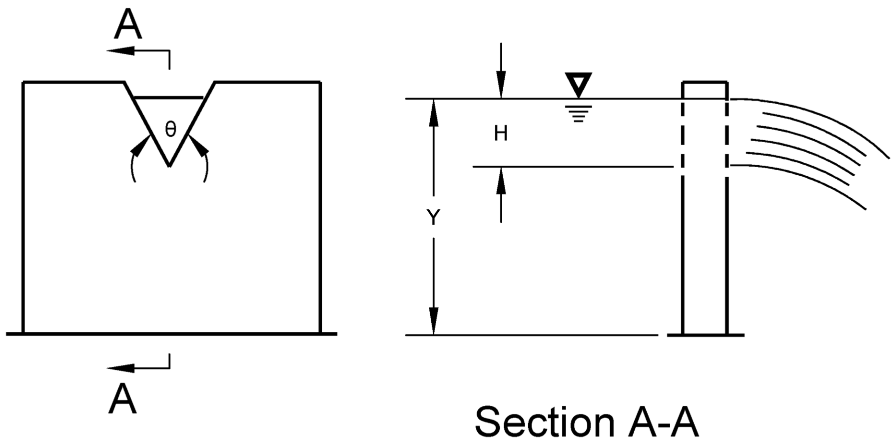
V-Notch Sharp - Crested Weir

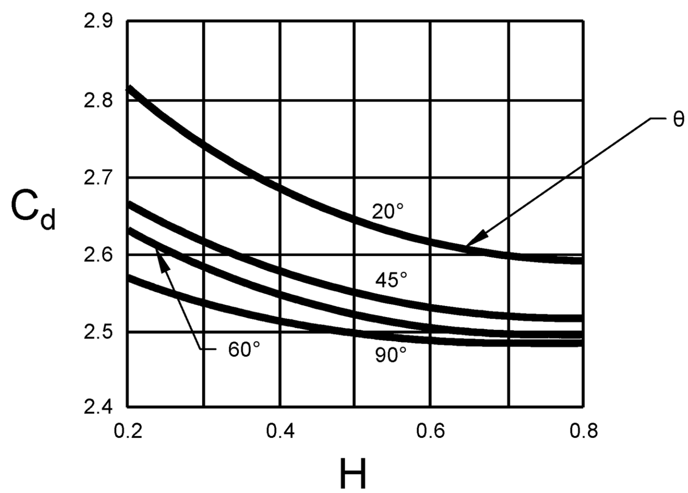
V-notch weirs as shown in Figure V-12.6: V-Notch, Sharp-Crested Weir may be analyzed using standard equations for the fully contracted condition.

Figure V-12.6: V-Notch, Sharp-Crested Weir



$$Q = C_d (\mathrm{Tan}\frac{\theta}{2}) H^{\frac{5}{2}} \text{ in cfs}$$

Where values of C_d may be taken from the following chart :



NOT TO SCALE

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State of Washington

V-Notch, Sharp Crested Weir

Revised June 2016

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 V-12.7: Sutro 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):

$$\frac{x}{b} = 1 - \frac{2}{\pi} Tan^{-1} \sqrt{\frac{Z}{a}}$$

where a, b, x and Z are as shown in Figure V-12.7: Sutro Weir.

The head discharge relationship is:

$$Q = (C_d)(b)\left(\sqrt{2ga}\right)\left(h_1 - \frac{a}{3}\right)$$

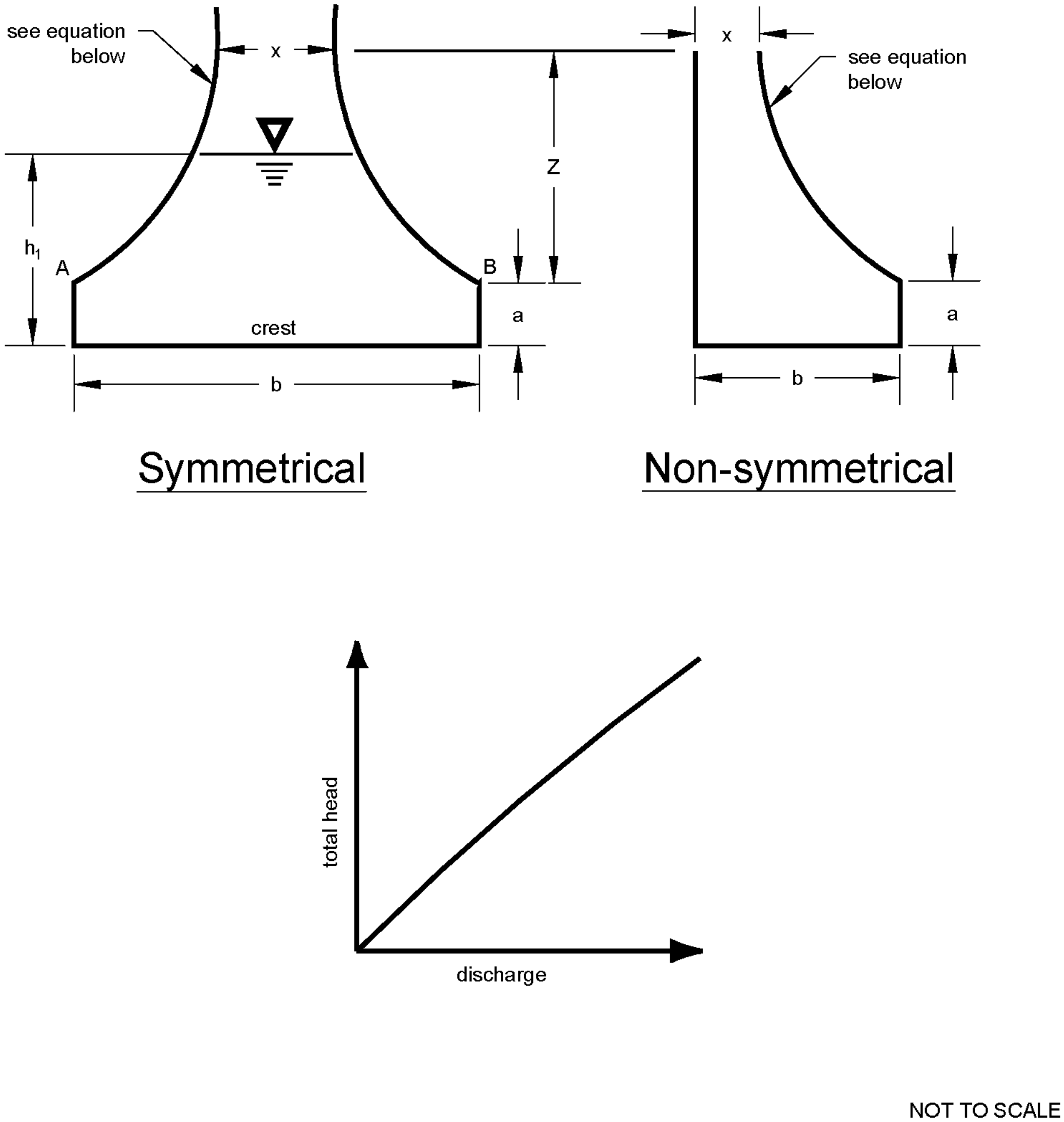
Values of C_d for both symmetrical and non symmetrical sutro weirs are summarized in Table V-12.1: Values of Cd for Sutro Weirs.

Note: When b > 1.50 or a > 0.30, use C_d=0.6.

Table V-12.1: Values of C_d for Sutro Weirs

C_d Values, Symmetrical							C_d Values, Non-Symmetrical					
	b (ft)							b (ft)				
a (ft)	0.50	0.75	1.00	1.25	1.50		a (ft)	0.50	0.75	1.00	1.25	1.50
0.02	0.608	0.613	0.617	0.6185	0.619		0.02	0.614	0.619	0.623	0.6245	0.625
0.05	0.606	0.611	0.615	0.617	0.6175		0.05	0.612	0.617	0.621	0.623	0.6235
0.10	0.603	0.608	0.612	0.6135	0.614		0.10	0.609	0.614	0.618	0.6195	0.620
0.15	0.601	0.6055	0.610	0.6115	0.612		0.15	0.607	0.6115	0.616	0.6175	0.618
0.20	0.599	0.604	0.608	0.6095	0.610		0.20	0.605	0.610	0.614	0.6155	0.616
0.25	0.598	0.6025	0.6065	0.608	0.6085		0.25	0.604	0.6085	0.6125	0.614	0.6145
0.30	0.597	0.602	0.606	0.6075	0.608		0.30	0.603	0.608	0.612	0.6135	0.614

Figure V-12.7: Sutro Weir



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Sutro Weir

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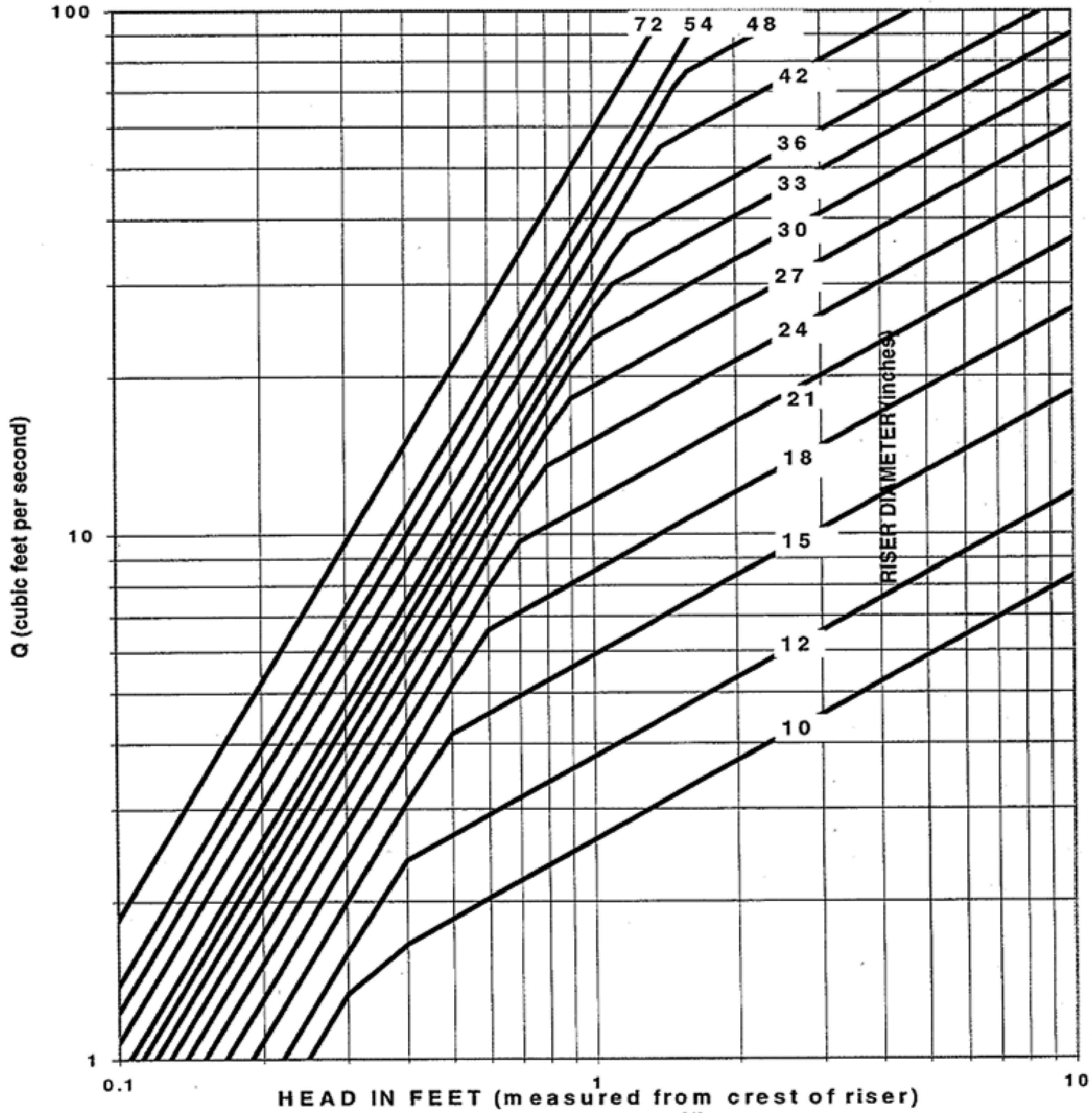
Riser Overflow

The nomograph in Figure V-12.8: 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).

Figure V-12.8: Riser Inflow Curves



$Q_{weir} = 9.739\ DH^{3/2}$

$Q_{orifice} = 3.782\ D^2H^{1/2}$

Q in cfs, D and H in feet

Slope change occurs at weir-orifice transition

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State of Washington

Riser Inflow Curves

Revised June 2016

V-12.3 Other Detention Design Options

This section presents options beyond the BMPs provided in this manual that the designer may want to consider incorporating into the project design for detaining flows to meet Flow Control requirements.

Use of 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:

1. The depth of water detained does not exceed 1 foot at any location in the parking lot for runoff events up to and including the 100 year event.
2. The gradient of the parking lot area subject to ponding is 1 percent or greater.
3. The emergency overflow path is identified and noted on the engineering plan(s). The overflow must not create a significant adverse impact to downhill properties or drainage system(s).
4. Fire lanes used for emergency equipment must be free of ponding water for all runoff events up to and including the 100 year event.

Use of Roofs for Detention

Detention ponding on roofs of structures may be used to meet Flow Control requirements provided all of the following are met:

1. The roof support structure is analyzed by a structural engineer to address the weight of ponded water.
2. The roof area subject to ponding is sufficiently waterproofed to achieve a minimum service life of 30 years.
3. The minimum pitch of the roof area subject to ponding is 1/4 inch per foot.
4. An overflow system is included in the design to safely convey the 100 year peak flow from the roof.
5. 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.

BMP D.1: Detention Ponds

The design criteria in this section are for detention ponds (this BMP). However, many of the criteria also apply to BMP T7.10: Infiltration Basins, BMP T10.10: Wetponds - Basic and Large, and BMP T10.40: Combined Detention and Wetpool Facilities.

Dam Safety for Detention BMPs

Stormwater detention BMPs that can impound 10 acre-feet (435,600 cubic feet; 3.26 million gallons) or more with the water level measured at the embankment crest, or have an embankment height of > 6 feet at the downstream toe, are subject to the state's dam safety requirements, even if water storage is intermittent and infrequent (WAC 173-175-020(1)). The principal safety concern is for the downstream population at risk if the dam should breach and allow an uncontrolled release of the pond contents. Peak flows from dam failures are typically much larger than the 100-year flows which detention BMPs are typically designed to accommodate.

The Dam Safety Office of the Department of Ecology uses consequence dependent design levels for critical project elements. There are eight design levels with storm recurrence intervals ranging from 1 in 500 for design step 1, to 1 in 1,000,000 for design step 8. The specific design step for a particular project depends on the downstream population and other resources that would be at risk from a failure of the dam. Precipitation events more extreme than the 100-year event may be rare at any one location, but have historically occurred somewhere within Washington State every few years on average.

With regard to the engineering design of stormwater detention BMPs, the primary effect of the state's dam safety requirements is in sizing the emergency spillway to accommodate the runoff from the dam safety design storm without overtopping the dam. The hydrologic computation procedures are the same as for the original pond design, except that the computations must use more extreme precipitation values and the appropriate dam safety design storm hyetographs. This information is described in detail within guidance documents developed by and available from Ecology's Dam Safety Office. In addition to the other design requirements for stormwater detention BMPs, dam safety requirements should be an integral part of planning and design for stormwater detention ponds. It is most cost-effective to consider these requirements from the beginning of the project.

In addition to the hydrologic and hydraulic issues related to precipitation and runoff, other dam safety requirements include geotechnical issues, construction inspection and documentation, dam breach analysis, inundation mapping, emergency action planning, and periodic inspections by project owners and by Dam Safety engineers. All of these requirements, plus procedural requirements for plan review and approval and payment of construction permit fees are described in detail in guidance documents developed by and available from the Dam Safety Office.

In addition to the written guidance documents, Dam Safety engineers are available to provide technical assistance to project owners and designers in understanding and addressing the dam safety requirements for their specific project. In the interest of providing a smooth integration of dam safety requirements into the stormwater detention project and streamlining Dam Safety's engineering review and issuance of the construction permit, it is recommended and requested that Dam Safety be contacted early in the project's planning process. The Dam Safety Office is located in the Ecology headquarters building in Lacey.

For more information about dam safety, please refer to Ecology's Dam Safety Office's Website at:

https://www.ecology.wa.gov/Water-Shorelines/Water-supply/Dams

Design Criteria

Standard details for detention ponds are shown in Figure V-12.9: Typical Detention Pond, Figure V-12.10: Typical Detention Pond Sections, and Figure V-12.11: Overflow Structure. Control structure details and design guidance are provided in V-12.2 Control Structure Design.

General

1. Detention ponds must be designed as flow through systems (however, parking lot storage may be utilized through a back up system; see V-12.3 Other Detention Design Options). 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.

2. Detention pond bottoms should be level and be located a minimum of 0.5 foot (preferably 1 foot) below the inlet and outlet to provide sediment storage.

3. Design guidelines for outflow control structures are specified in V-12.2 Control Structure Design.

4. A geotechnical analysis and report must be prepared for slopes over 15%, or if located within 200 feet of the top of a slope steeper than 40%, or landslide hazard area. The scope of the geotechnical report should include the assessment of impoundment seepage on the stability of the natural slope where the pond will be located within the setback limits set forth in this section.

Side Slopes

1. Interior side slopes up to the emergency overflow water surface should not be steeper than 3H:1V unless a fence is provided (see Fencing below).

2. Exterior side slopes must not be steeper than 2H:1V, unless analyzed for stability by a geotechnical engineer.

3. Detention pond walls may be vertical retaining walls, provided:

    - They are constructed of reinforced concrete per BMP D.3: Detention Vaults.
    - A fence is provided along the top of the wall.
    - The entire detention pond perimeter may be retaining walls, however, it is recommended that at least 25 percent of the pond perimeter be a vegetated soil slope not steeper than 3H:1V. If the entire pond perimeter is to be retaining walls, provide ladders on the walls for safety reasons.
    - The design is stamped by a licensed engineer in the state of Washington with structural expertise.

Other retaining walls such as rockeries, concrete, masonry unit walls, and keystone type walls may be used if designed by a geotechnical engineer or a civil engineer with structural expertise.

Embankments

1. Have a licensed engineer in the state of Washington with geotechnical expertise design pond berm embankments higher than 6 feet.
2. For berm embankments 6 feet or less, the minimum top width should be 6 feet, or as recommended by a geotechnical engineer.
3. Construct pond berm embankments on native consolidated soil (or adequately compacted and stable fill soils analyzed by a geotechnical engineer) free of loose surface soil materials, roots, and other organic debris.
4. Construct pond berm embankments greater than 4 feet in height by excavating a key equal to 50 percent of the berm embankment cross sectional height and width, unless specified otherwise by a geotechnical engineer.
5. 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. Place the embankment fill on a stable subgrade and compact 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 referenced compaction standard may have to be increased to comply with local regulations.

   Construct the berm embankment of soils with the following characteristics: 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 specified range can be used, provided the design satisfactorily addresses the engineering concerns posed by these soils. The paramount concerns with these soils are their susceptibility to internal erosion or piping, and to surface erosion from wave action and runoff on the upstream and downstream slopes, respectively. Note: In general, excavated glacial till is well suited for berm embankment material.
6. Place anti seepage filter-drain diaphragms on outflow pipes in berm embankments impounding water with depths greater than 8 feet at the design water surface. See *Dam Safety Guidelines Part IV: Dam Design and Construction*, (Ecology, 1993) Section 3.3.B on pages 3-27 to 3-30.

Primary Overflow

1. Provide a primary overflow (usually a riser pipe within the control structure; see V-12.2 Control Structure Design) in all detention ponds, tanks, and vaults to bypass the 100 year developed peak flow over or around the restrictor system. This assumes the facility will be full due to plugged orifices or high inflows; the primary overflow is intended to protect against breaching of a pond embankment (or overflows of the upstream conveyance system in the case of a detention tank or vault). The design must provide controlled discharge directly into the downstream conveyance system or another acceptable discharge point.

2. Provide a secondary inlet to the control structure in ponds as additional protection against overtopping should the inlet pipe to the control structure become plugged. A grated opening (“jailhouse window”) in the control structure manhole functions as a weir (see Figure V-12.10: Typical Detention Pond Sections) when used as a secondary inlet.

   Note: The maximum circumferential length of this opening must not exceed one half the control structure circumference. The “birdcage” overflow structure as shown in Figure V-12.11: Overflow Structure may also be used as a secondary inlet.

Emergency Overflow Spillway

1. In addition to the primary overflow (described above), ponds must have an emergency overflow spillway. For impoundments of 10 acre-feet or greater, the emergency overflow spillway must meet the state’s dam safety requirements (see Dam Safety for Detention BMPs above). For impoundments under 10 acre-feet, ponds must have an emergency overflow spillway that is sized to pass the 100 year developed peak flow in the event of total control structure failure (e.g., blockage of the control structure outlet pipe) or extreme inflows. Emergency overflow spillways are intended to control the location of pond overtopping and direct overflows back into the downstream conveyance system or other acceptable discharge point.

2. Provide emergency overflow spillways for ponds with constructed berms over 2 feet in height, or for ponds located on grades in excess of 5 percent. As an option for ponds with berms less than 2 feet in height and located at grades less than 5 percent, emergency overflow may be provided by an emergency overflow structure, such as a Type II manhole fitted with a birdcage as shown in Figure V-12.11: Overflow Structure. The emergency overflow structure must be designed to pass the 100 year developed peak flow, with a minimum 6 inches of freeboard, directly to the downstream conveyance system or another acceptable discharge point. Where an emergency overflow spillway would discharge to a slope steeper than 15%, consideration should be given to providing an emergency overflow structure in addition to the spillway.

3. Armour the emergency overflow spillway with riprap in conformance with BMP C209: Outlet Protection. The spillway must be armored full width, beginning at a point midway across the berm embankment and extending downstream to where emergency overflows re enter the conveyance system (see Figure V-12.10: Typical Detention Pond Sections).

4. Emergency overflow spillway designs must be analyzed as broad crested trapezoidal weirs as described in Methods of Analysis (below). Either one of the weir sections shown in Figure V-12.10: Typical Detention Pond Sections may be used.

5. Design the emergency overflow spillway to allow a minimum of 1 foot of freeboard above the maximum design storm (100-year, 24-hour storm) water surface level.

Access

1. Provide maintenance access road(s) to the control structure and other drainage structures associated with the pond (e.g., inlet or bypass structures). It is recommended that manhole and catch basin lids be in or at the edge of the access road and at least 3 feet from a property line.

2. An access ramp is needed for removal of sediment with a trackhoe and truck. Extend the

ramp to the pond bottom if the pond bottom is greater than 1,500 square feet (measured without the ramp). If the pond bottom is less than 1,500 square feet (measured without the ramp), the ramp may end at an elevation 4 feet above the pond bottom.

On large, deep ponds, provide truck access to the pond bottom via an access ramp so loading can be done in the pond bottom. On small deep ponds, the truck can remain on the ramp for loading. On small shallow ponds, a ramp to the bottom may not be required if the trackhoe can load a truck parked at the pond edge or on the internal berm of a wetpond or combined pond (trackhoes can negotiate interior pond side slopes).

3. The internal berm of BMP T10.10: Wetponds - Basic and Large, or BMP T10.40: Combined Detention and Wetpool Facilities, may be used for access if all of the following apply:
   - The internal berm is no more than 4 feet 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, considering the berm is normally submerged and saturated.
4. If a fence is required, access should be limited by a double posted gate or by bollards – two fixed bollards on each side of the access road and two removable bollards equally located between the fixed bollards.
5. The design guidelines for access roads and ramps:
   - A maximum grade of 15%.
   - A minimum of 40 feet outside turning radius.
   - Locate fence gates only on straight sections of road.
   - 15 feet in width on curves and 12 feet on straight sections.
   - Provide a paved apron where access roads connect to paved public roadways.
6. Construct access roads and ramps with permeable pavement, gravel surface, or modular grid pavement. All surfaces must conform to the jurisdictional standards and manufacturer's specifications.

Fencing

1. A fence is needed at the emergency overflow water surface elevation, or higher, where a pond interior side slope is steeper than 3H:1V, or where the impoundment is a wall greater than 24 inches in height. The fence need only be constructed for those slopes steeper than 3H:1V. Other regulations such as the International Building Code or Uniform Building Code may require fencing of vertical walls. If more than 10 percent of slopes are steeper 3H:1V, it is recommended that the entire pond be fenced.

   Fences discourage access to portions of a pond where steep side slopes (steeper than 3:1) increase the potential for slipping into the pond. Fences also serve to guide those who have fallen into a pond to side slopes that are flat enough (flatter than 3:1 and unfenced) to allow for easy escape.

2. It is recommended that fences be 6 feet in height. For example designs, see WSDOT Standard Plan L-2, Type 1 or Type 3 chain link fence. The fence may be a minimum of 4 feet in height if the depth of the impoundment (measured from the lowest elevation in the bottom of the impoundment, directly adjacent to the bottom of the fenced slope, up to the emergency overflow water surface) is 5 feet or less. For example designs, see WSDOT Standard Plan L-2, Type 4 or Type 6 chain link fence.
3. Access road gates may be 16 feet in width consisting of two swinging sections 8 feet in width. Provide additional vehicular access gates as needed to facilitate maintenance access.
4. Pedestrian access gates (if needed) should be 4 feet in width.
5. Vertical metal balusters or 9 gauge galvanized steel fabric with bonded vinyl coating can be used as fence material. For steel fabric fences, consider the following aesthetic features:
    a. Vinyl coating that is compatible with the surrounding environment (e.g., green in open, grassy areas and black or brown in wooded areas). All posts, cross bars, and gates may be painted or coated the same color as the vinyl clad fence fabric.
    b. Fence posts and rails that conform to WSDOT Standard Plan L 2 for Types 1, 3, or 4 chain link fence.
6. For metal baluster fences, Uniform Building Code standards apply.
7. Wood fences may be used in subdivisions where the fence will be maintained by homeowners associations or adjacent lot owners.
8. Wood fences should have pressure treated posts (ground contact rated) either set in 24 inch deep concrete footings or attached to footings by galvanized brackets. Rails and fence boards may be cedar, pressure treated fir, or hemlock.
9. Where only short stretches of the pond perimeter (< 10 percent) have side slopes steeper than 3:1, use split rail fences (3 foot minimum height) or densely planted thorned hedges (e.g., barberry, holly) in place of a standard fence.

Signage

Detention ponds (this BMP), BMP T7.10: Infiltration Basins, BMP T10.10: Wetponds - Basic and Large, and BMP T10.40: Combined Detention and Wetpool Facilities should have a sign placed for maximum visibility from adjacent streets, sidewalks, and paths. An example of sign specifications for a permanent surface water control pond is illustrated in Figure V-12.12: Example of Permanent Surface Water Control Pond Sign.

Right of Way

Right-of-way may be needed for detention pond maintenance. It is recommended that any tract not abutting public right-of-way have 15-20 foot wide extension of the tract to an acceptable location.

Setbacks

It is recommended that detention ponds be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the local government. The detention pond water surface at the pond outlet invert elevation must be set back 100 feet from proposed or existing septic system drainfields. However, the setback requirements are generally specified by the local government, uniform building code, or other statewide regulation and may be different from those mentioned above.

All detention ponds must be a minimum of 50 feet from the top of any steep (greater than 15%) slope. A geotechnical analysis and report must be prepared addressing the potential impact of the pond on a slope steeper than 15%.

Seeps and Springs

Intermittent seeps along cut slopes are typically fed by a shallow ground water source (interflow) flowing along a relatively impermeable soil stratum. These flows are storm driven and should discontinue after a few weeks of dry weather. However, more continuous seeps and springs, which extend through longer dry periods, are likely from a deeper ground water source. When continuous flows are intercepted and directed through detention ponds, adjustments to the pond design may have to be made to account for the additional base flow.

Planting Requirements

Sod or seed exposed earth on the pond bottom and interior side slopes with an appropriate seed mixture. Plant all remaining areas of the tract with grass or landscape and mulch with a 3 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.

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.

Follow these guidelines if landscaping is proposed for facilities:

1. Do not plant trees or shrubs on berms meeting the criteria of dams regulated for safety.
2. Do not plant trees or shrubs within 10 feet of inlet or outlet pipes or manmade drainage structures such as spillways or flow spreaders. Avoid using species with roots that seek water, such as willow or poplar, within 50 feet of pipes or manmade structures.
3. Restrict planting on berms that impound water permanently or temporarily during storms. This restriction does not apply to cut slopes that form pond banks, only to berms.

a. Do not plant trees or shrubs on portions of water impounding berms taller than four feet high. Plant only grasses on berms taller than four feet.

   Grasses allow unobstructed visibility of berm slopes for detecting potential dam safety problems such as animal burrows, slumping, or fractures in the berm.

b. Trees planted on portions of water impounding berms less than 4 feet high must be small, not higher than 20 feet mature height, and have a fibrous root system. Table V-12.2: Small Trees and Shrubs with Fibrous Roots gives some examples of trees with these characteristics developed for the central Puget Sound.

   These trees reduce the likelihood of blow down trees, or the possibility of channeling or piping of water through the root system, which may contribute to dam failure on berms that retain water.

Note: The internal berm in a wetpond is not subject to this planting restriction since the failure of an internal berm would be unlikely to create a safety problem.

4. Plant all landscape material, including grass, in good topsoil. Make native underlying soils suitable for planting by amending with 4 inches of compost tilled into the subgrade. Refer to BMP T5.13: Post-Construction Soil Quality and Depth for soil quality standards.

5. Soil in which trees or shrubs are planted may need additional enrichment or additional compost top dressing. Consult a nursery, landscape professional, or arborist for site specific recommendations.

6. For a naturalistic effect as well as ease of maintenance, plant trees or in clumps to form “landscape islands” rather than spacing evenly.

7. The landscaped islands should 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 six 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.

8. Evergreen or columnar deciduous trees along the west and south sides of ponds are recommended to reduce thermal heating. Evergreen trees or shrubs are preferred to avoid problems associated with leaf drop. Columnar deciduous trees (e.g., hornbeam, Lombardy poplar) typically have fewer leaves than other deciduous trees.

   In addition to shade, trees and shrubs also discourage waterfowl use and the attendant phosphorus enrichment problems they cause. Setback trees so the branches will not extend over the pond.

9. Drought tolerant species are recommended.

Table V-12.2: Small Trees and Shrubs with Fibrous Roots

Small Trees / High Shrubs	Low Shrubs
*Red twig dogwood *(Cornus stolonifera)*	*Snowberry *(symporicarpus albus)*
*Serviceberry *(Amelanchier alnifolia)*	*Salmonberry *(Rubus spectabilis)*
*Filbert (*Corylus cornuta*, others)	Rosa rugosa (avoid spreading varieties)
Highbush cranberry *(Vaccinium opulus)*	Rock rose *(Cistus spp.)*
Blueberry *(Vaccinium spp.)*	Ceanothus spp. (Choose hardier varieties)
Fruit trees on dwarf rootstock	New Zealand flax *(Phormium penax)*
Rhododendron (native and ornamental varieties)	Ornamental grasses (e.g., *Miscanthis*, *Pennisetum*)
*Native species	

Guidelines for Naturalistic Planting

Stormwater BMPs may sometimes be located within open space tracts if "natural appearing." Two generic kinds of naturalistic planting are outlined below, but other options are also possible. Native vegetation is preferred in naturalistic plantings.

- Open Woodland

  In addition to the general landscaping guidelines above, the following are recommended.

  1. Landscaped islands (when mature) should cover a minimum of 30 percent or more of the tract, exclusive of the pond area.
  2. Underplant tree clumps with shade tolerant shrubs and groundcover plants. The goal is to provide a dense understory that need not be weeded or mowed.
  3. Place landscaped islands at several elevations rather than "ring" the pond, and vary the size of clumps from small to large to create variety.
  4. Not all islands need to have trees. Shrub or groundcover clumps are acceptable, but lack of shade should be considered in selecting vegetation.

  Note: Landscaped islands are best combined with the use of wood-based mulch (hog fuel) or chipped on-site vegetation for erosion control (only for slopes above the flow control water surface). It is often difficult to sustain a low maintenance understory if the site was previously hydroseeded. Compost or composted mulch (typically used for constructed wetland soil) can be used below the flow control water surface (materials that are resistant to and preclude flotation). The method of construction of soil landscape systems can also cause natural selection of specific plant species. Consult a soil restoration or wetland soil scientist for site-specific recommendations.

- Northwest Savannah or Meadow

  In addition to the general landscape guidelines above, the following are recommended.

  1. Landscape islands (when mature) should cover 10 percent or more of the site, exclusive of the pond area.
  2. Planting groundcovers and understory shrubs is encouraged to eliminate the need for mowing under the trees when they are young.
  3. Place landscape islands at several elevations rather than “ring” the pond.

Plant the remaining site area with an appropriate grass seed mix, which may include meadow or wildflower species. Native or dwarf grass mixes are preferred. Table V-12.3: Stormwater Tract "Low Grow" Seed Mix below gives an example of dwarf grass mix developed for central Puget Sound. Apply grass seed at 2.5 to 3 pounds per 1,000 square feet. Amended soil or good topsoil is required for all plantings.

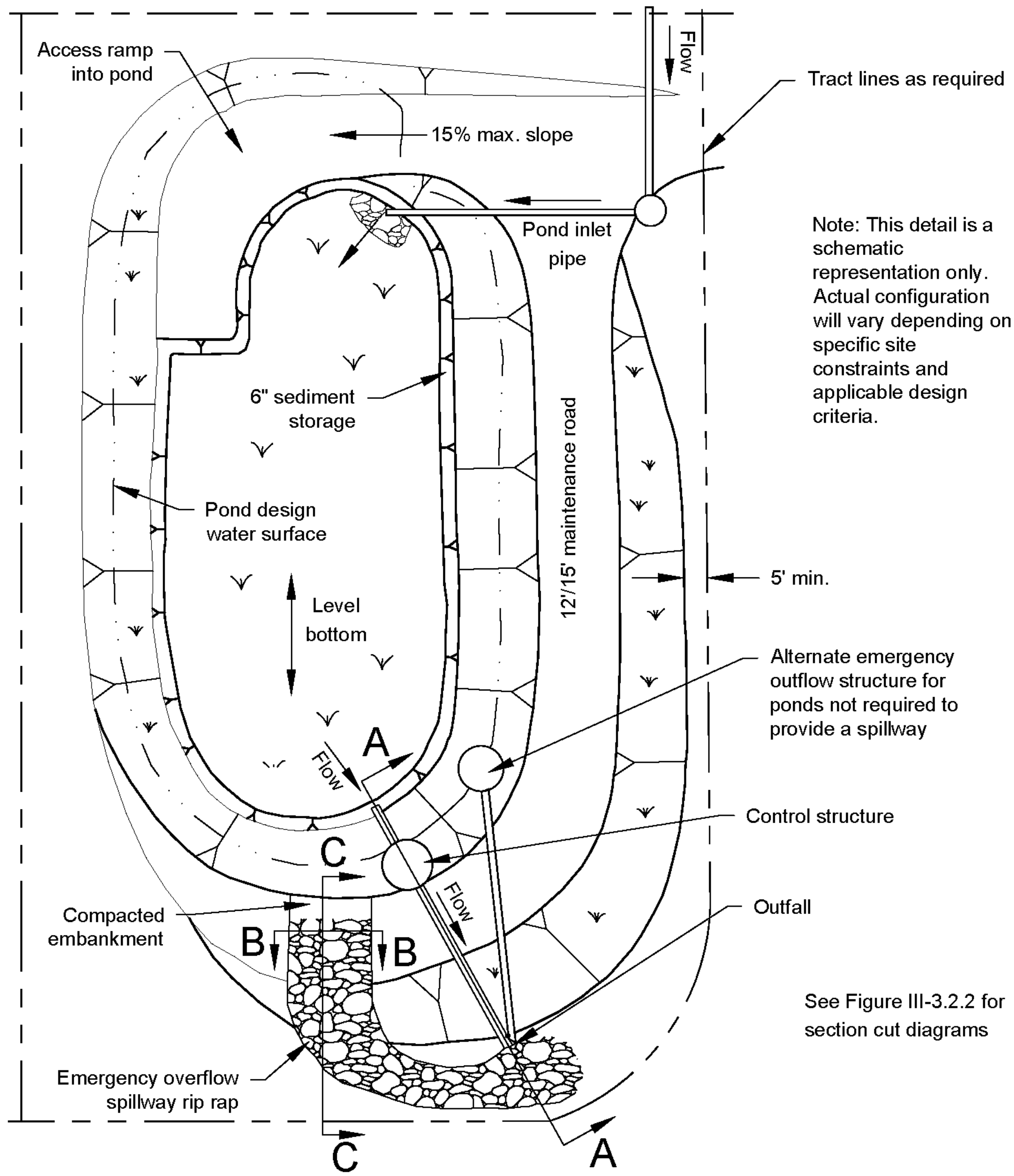
Creation of areas of emergent vegetation in shallow areas of the pond is recommended. Native wetland plants, such as sedges (*Carex sp.*), bulrush (*Scirpus sp.*), water plantain (*Alisma sp.*), and burreed (*Sparganium sp.*) are recommended. If the pond does not hold standing water, a clump of wet tolerant, non invasive shrubs, such as salmonberry or snowberry, is recommended below the detention design water surface.

Note: This landscape style is best combined with the use of grass or sod for site stabilization and erosion control.

Table V-12.3: Stormwater Tract "Low Grow" Seed Mix

Seed Name	Percentage of Mix
Dwarf tall fescue	40%
Dwarf perennial rye "Barclay"*	30%
Red fescue	25%
Colonial bentgrass	5%
* If wildflowers are used and sowing is done before Labor Day, the amount of dwarf perrenial rye can be reduced proportionately to the amount of wildflower seed used.	

Figure V-12.9: Typical Detention Pond



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Typical Detention Pond

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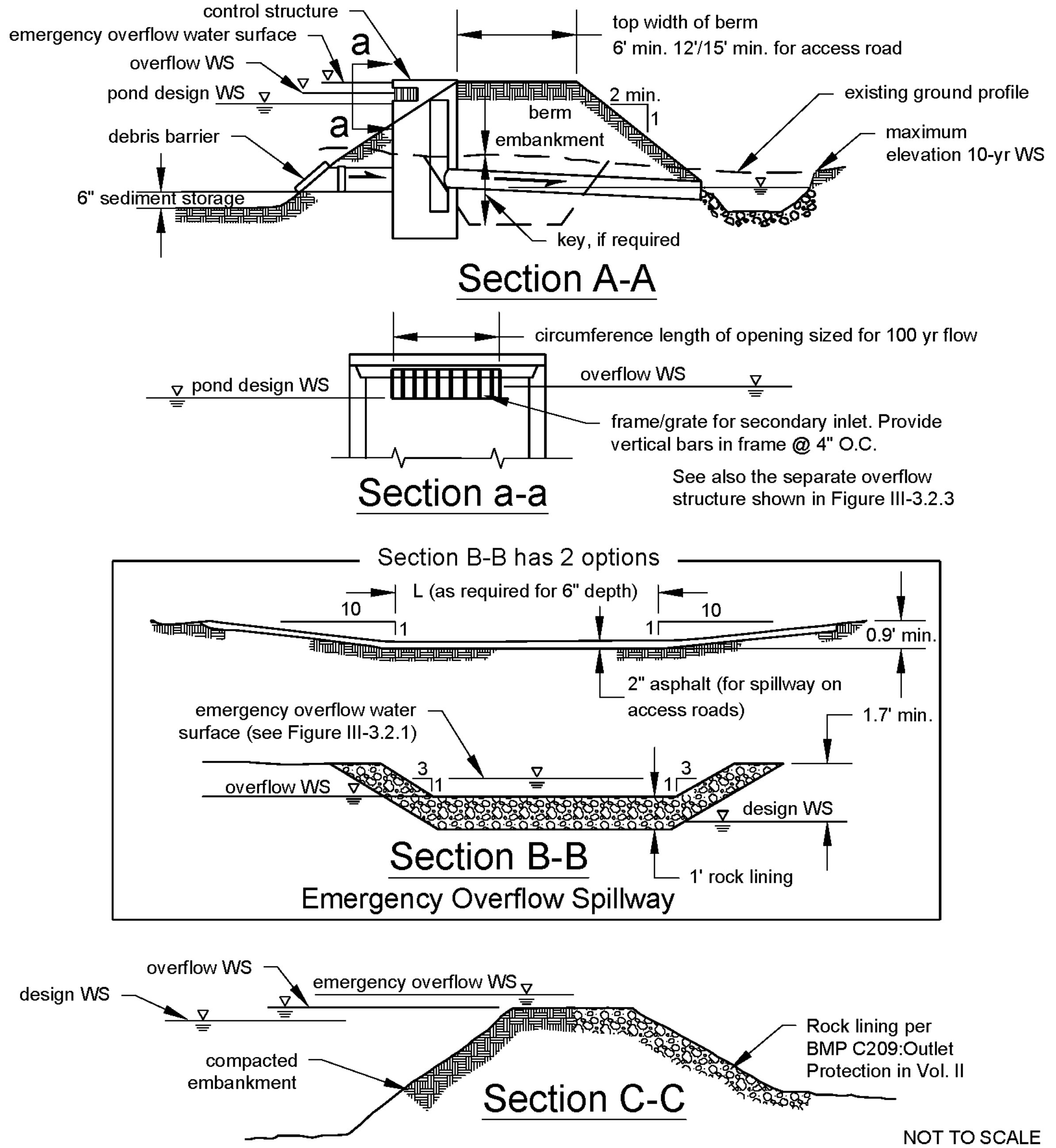
Figure V-12.10: Typical Detention Pond Sections



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Typical Detention Pond Sections

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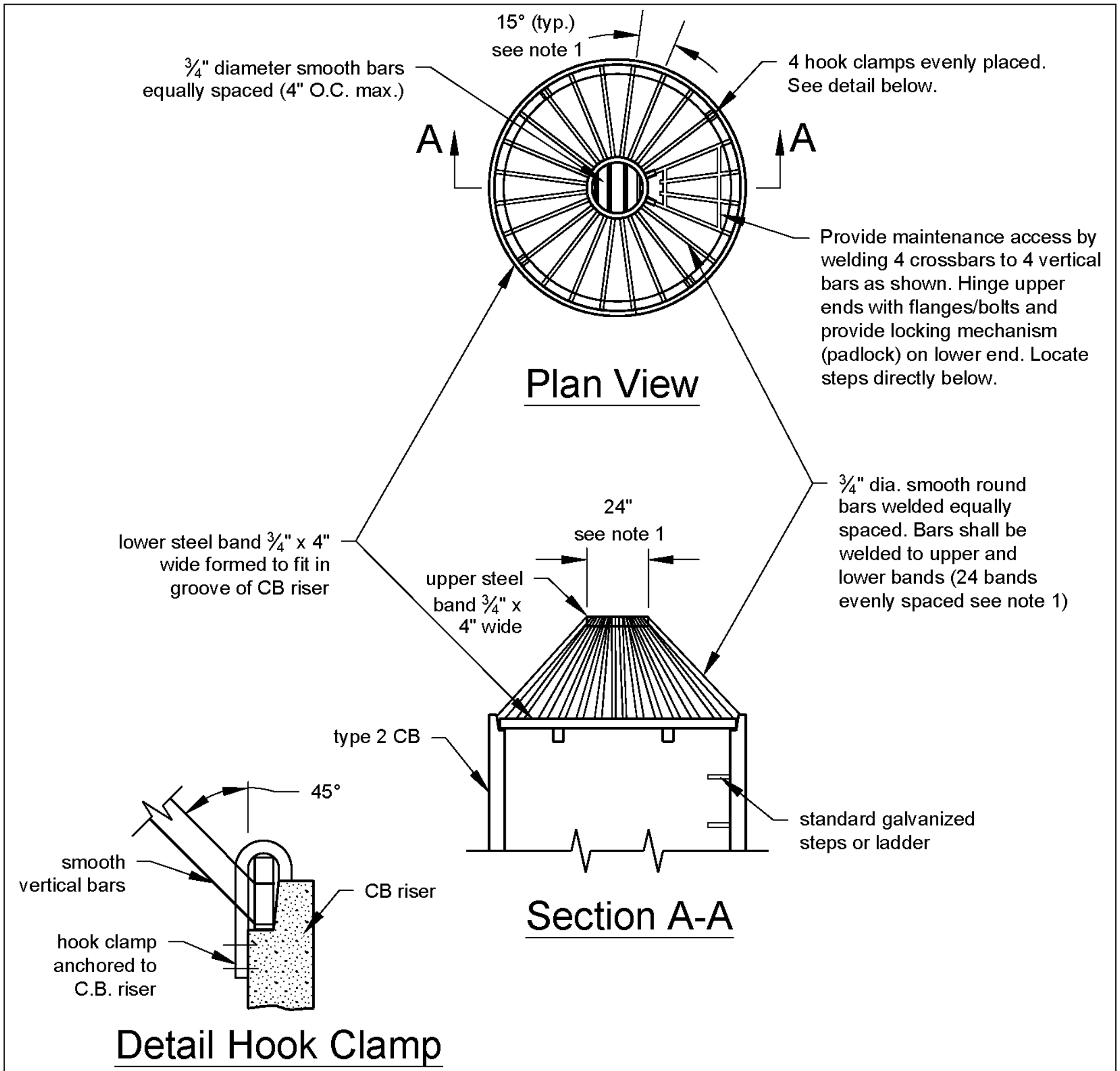
Figure V-12.11: Overflow Structure



Notes:

1. Dimensions are for illustration on 54" diameter CB. For different diameter CB's adjust to maintain 45 degree 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).

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Overflow Structure

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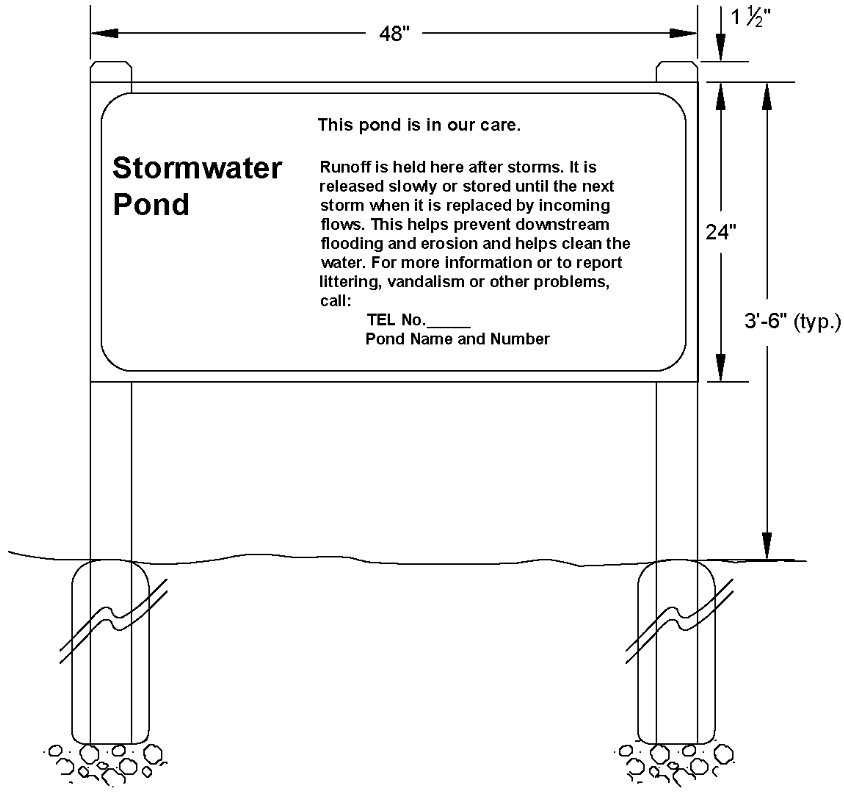
Figure V-12.12: Example of Permanent Surface Water Control Pond Sign



Sample Specifications:

Size:	48 inches by 24 inches
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:	Beige background, teal letters.
Type face:	Helvetica condensed. Title: 3 inch; Sub-Title: 1 ½ inch; Text: 1 inch; Outer Border:; ⅛ inch; Border Distance from Edge: ¼ inch; all text 1 ¾ inch from border.
Posts:	Pressure treated, beveled tops, 1 ½ inch higher than sign.
Installation:	Secure to chain link fence if available. Otherwise install on two 4" x 4" posts, pressure treated, mounted atop gravel bed, installed in 30-inch concrete filled post holes (8-inch minimum diameter). Top of sign no higher than 42 inches from ground surface.
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 facility is lined to protect groundwater (if a liner that restricts infiltration of stormwater exists).

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Example of Permanent Surface Water Control Pond Sign

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Maintenance

General

Maintenance is of primary importance if detention ponds are to continue to function as originally designed. A local government, a designated group such as a homeowners' association, or some individual must accept the responsibility for maintaining the control structures and the impoundment area. Formulate a specific maintenance plan outlining the schedule and scope of maintenance operations. Achieve debris removal in detention ponds by using trash racks or other screening devices.

Design with maintenance in mind. Good maintenance will be crucial to successful use of the detention pond. Hence, build in provisions to facilitate maintenance operations into the project when it is installed. Maintenance must be a basic consideration in design and in determination of first cost. See Appendix V-A: BMP Maintenance Tables for specific maintenance requirements.

Handle any standing water and sediments removed during the maintenance operation in a manner consistent with Appendix IV-B: Management of Street Waste Solids and Liquids.

Vegetation

If a shallow marsh is established, then periodic removal of dead vegetation may be necessary. Since decomposing vegetation can release pollutants captured in the wet pond, especially nutrients, it may be necessary to harvest dead vegetation annually prior to the winter wet season. Otherwise the decaying vegetation can export pollutants out of the pond and also can cause nuisance conditions to occur. If harvesting is to be done in BMP T10.30: Stormwater Treatment Wetlands, have a wetland scientist prepare a written harvesting procedure and submitted it with the drainage design to the local government.

Sediment

Maintenance of sediment forebays and attention to sediment accumulation within the pond is extremely important. Continually monitor sediment deposition in the pond. Owners, operators, and maintenance authorities should be aware that significant concentrations of metals (e.g., lead, zinc, and cadmium) as well as some organics such as pesticides, may be expected to accumulate at the bottom of stormwater ponds. Regularly conduct testing of sediment, especially near points of inflow, to determine the leaching potential and level of accumulation of potentially hazardous material before disposal.

Methods of Analysis

Detention Volume and Outflow

Design volumes and outflows for detention ponds to meet the performance standards as required in I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.7 MR7: Flow Control, and/or I-3.4.8 MR8: Wetlands Protection and the hydrologic analysis and design methods in III-2 Modeling Your BMPs. Design guidelines for control structures are given in V-12.2 Control Structure Design.

Note: The design water surface elevation is the highest elevation which occurs in order to meet the required outflow performance for the pond.

Detention Ponds in Infiltrative Soils

Detention ponds may occasionally be sited on till soils that are sufficiently permeable for a properly functioning infiltration system (see V-5 Infiltration BMPs). These detention ponds have a surface discharge through the control structure, 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 T7.10: Infiltration Basins, including a soils report, testing, ground water protection, pre-settling, and construction techniques.

Emergency Overflow Spillway Capacity

For impoundments under 10-acre-feet, the emergency overflow spillway weir section must be designed to pass the 100 year runoff event for developed conditions assuming a broad crested weir. The **broad crested weir equation** for the spillway section in Figure V-12.13: Weir Section for Emergency Overflow Spillway, for example, would be:

$$Q_{100} = C(2g)^{1/2}\left[\frac{2}{3}LH^{3/2} + \frac{8}{15}\left(Tan\theta\right)H^{5/2}\right]$$

Where:

Q_{100} = peak flow for the 100-year runoff event (cfs)

C = discharge coefficient (0.6)

g = gravity (32.2 ft/sec^2)

L = length of weir (ft)

H = height of water over weir (ft)

θ = angle of side slopes

Q_{100} is either the peak volumetric flow rate calculated using a 10-minute time step from the 100-year, 24-hour storm and a Type 1A distribution, or the 100-year, 15 minute flow rate, indicated by an approved continuous runoff model.

Assuming C = 0.6 and Tanθ = 3 (for 3:1 slopes), the equation becomes:

$$Q_{100} = 3.21[LH^{3/2} + 2.4\ H^{5/2}]$$

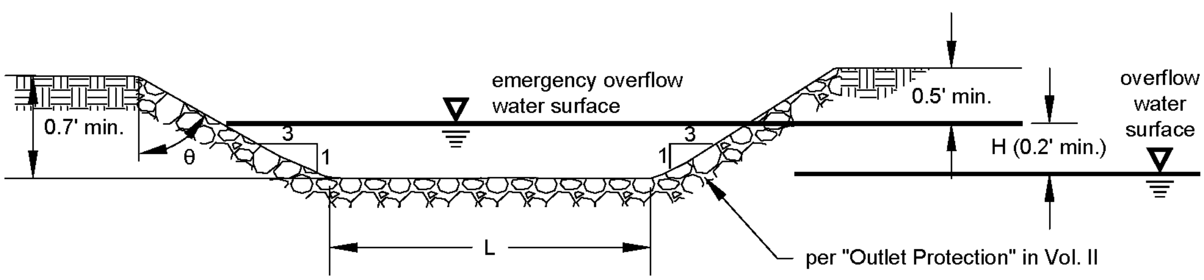
To find width L for the weir section, the equation is rearranged to use the computed Q_{100} and trial values of H (0.2 feet minimum):

$$L = [Q_{100}/(3.21H^{3/2})] - 2.4H$$

or

6 feet minimum

Figure V-12.13: Weir Section for Emergency Overflow Spillway



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Weir Section for Emergency Overflow Spillway

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BMP D.2: Detention Tanks

Detention tanks are underground detention BMPs typically constructed with large diameter corrugated metal pipe. Standard detention tank details are shown in Figure V-12.14: Typical Detention Tank and Figure V-12.15: Detention Tank Access Detail. Control structure details are shown in V-12.2 Control Structure Design.

Design Criteria

General

Typical design guidelines are as follows:

1. Detention tanks may be designed as flow through systems with manholes in line (see Figure V-12.14: Typical Detention Tank) to promote sediment removal and facilitate maintenance. Detention tanks may be designed as back up systems if preceded by Runoff Treatment BMPs, since little sediment should reach the inlet/control structure and low head losses can be expected because of the proximity of the inlet/control structure to the tank.

2. Locate the detention tank bottom 0.5 feet below the inlet and outlet to provide dead storage for sediment.

3. Use a 36-inch minimum pipe diameter.

4. Tanks 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.

5. Refer to the details of outflow control structures in V-12.2 Control Structure Design.

6. Design the emergency overflow to pass the 100 year storm.

Note: Control structures and access manholes should have additional ladder rungs to allow ready access to all detention tank access pipes when the catch basin sump is filled with water (see Figure V-12.1: Flow Restrictor (TEE), plan view).

Materials

Galvanized metals leach zinc into the environment, especially in standing water situations. This can result in zinc concentrations that can be toxic to aquatic life. Therefore, use of galvanized materials in stormwater BMPs and conveyance systems is discouraged. Where other metals, such as aluminum or stainless steel, or plastics are available, they should be used.

Pipe material, joints, and protective treatment for tanks should be in accordance with Section 9.05 of WSDOT's *Standard Specifications for Road, Bridge, and Municipal Construction* (WSDOT, 2016).

Structural Stability

Tanks must meet structural requirements for overburden support and traffic loading if appropriate. Accommodate H20 live loads for tanks lying under parking areas and access roads. Design metal tank end plates for structural stability at maximum hydrostatic loading conditions. Flat end plates generally require thicker gage material than the pipe and/or require reinforcing ribs. Place detention tanks on stable, well consolidated native material with a suitable bedding. Do not place detention tanks in fill slopes, unless analyzed in a geotechnical report for stability and constructability.

Buoyancy

In moderately pervious soils where seasonal ground water may induce flotation, balance buoyancy tendencies by either ballasting with backfill or concrete backfill, providing concrete anchors, or increasing the total weight. Calculations that demonstrate stability must be documented.

Access Openings

The following guidelines for access openings may be used.

1. The maximum depth from finished grade to tank invert should be 20 feet.
2. Position access openings a maximum of 50 feet from any location within the tank.
3. All tank access openings may have round, solid locking lids (usually 1/2 to 5/8-inch diameter Allen-head cap screws).
4. Thirty six inch minimum diameter CMP riser type manholes (Figure V-12.15: Detention Tank Access Detail) of the same gage 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.
5. Make all tank access openings readily accessible by maintenance vehicles.
6. Tanks 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.

Access Roads

Access roads are needed to all detention tank control structures and risers. Design and construct access roads as specified for detention ponds in BMP D.1: Detention Ponds.

Right-of Way

Right-of-way may be needed for detention tank maintenance. It is recommended that any tract not abutting public right of way have a 15 to 20-foot wide extension of the tract to accommodate an access road to the detention tank.

Setbacks

It is recommended that detention tankss be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the local government and from any septic drainfield. However, the setback requirements are generally specified by the local government, uniform building code, or other statewide regulation and may be different from those mentioned above.

All detention tankss must be a minimum of 50 feet from the top of any steep (greater than 15%) slope. A geotechnical analysis and report must be prepared addressing the potential impact of the tank on a slope steeper than 15%.

Maintenance

Build in provisions to facilitate maintenance operations into the project when it is installed. Maintenance must be a basic consideration in design and in determination of first cost. See Appendix V-A: BMP Maintenance Tables for specific maintenance requirements.

Methods of Analysis

Detention Volume and Outflow

Design volumes and outflows for detention tanks to meet the performance standards as required in I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.7 MR7: Flow Control, and/or I-3.4.8 MR8: Wetlands Protection, and the hydrologic analysis and design methods in III-2 Modeling Your BMPs. Design guidelines for control structuresn are given in V-12.2 Control Structure Design.

Figure V-12.14: Typical Detention Tank

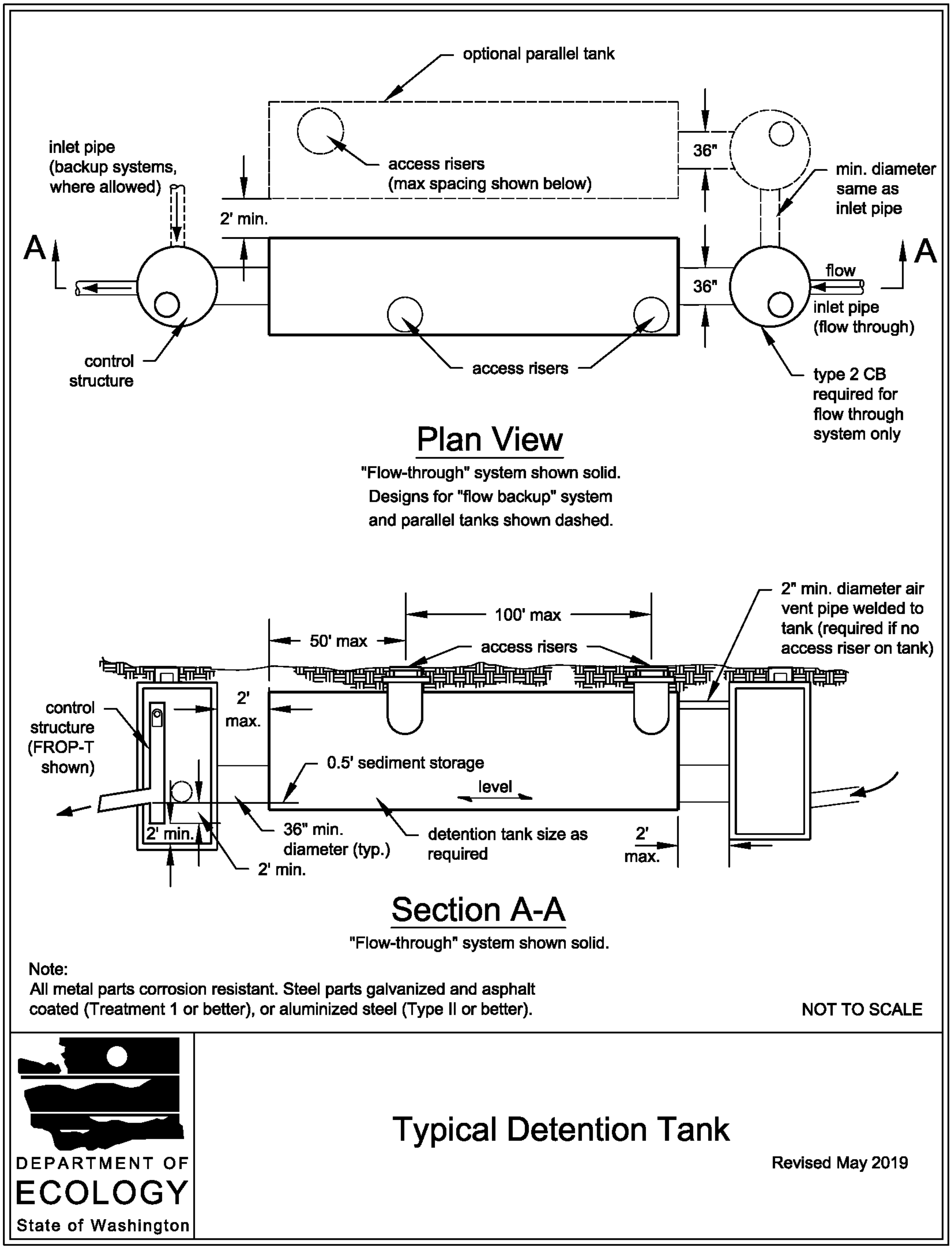
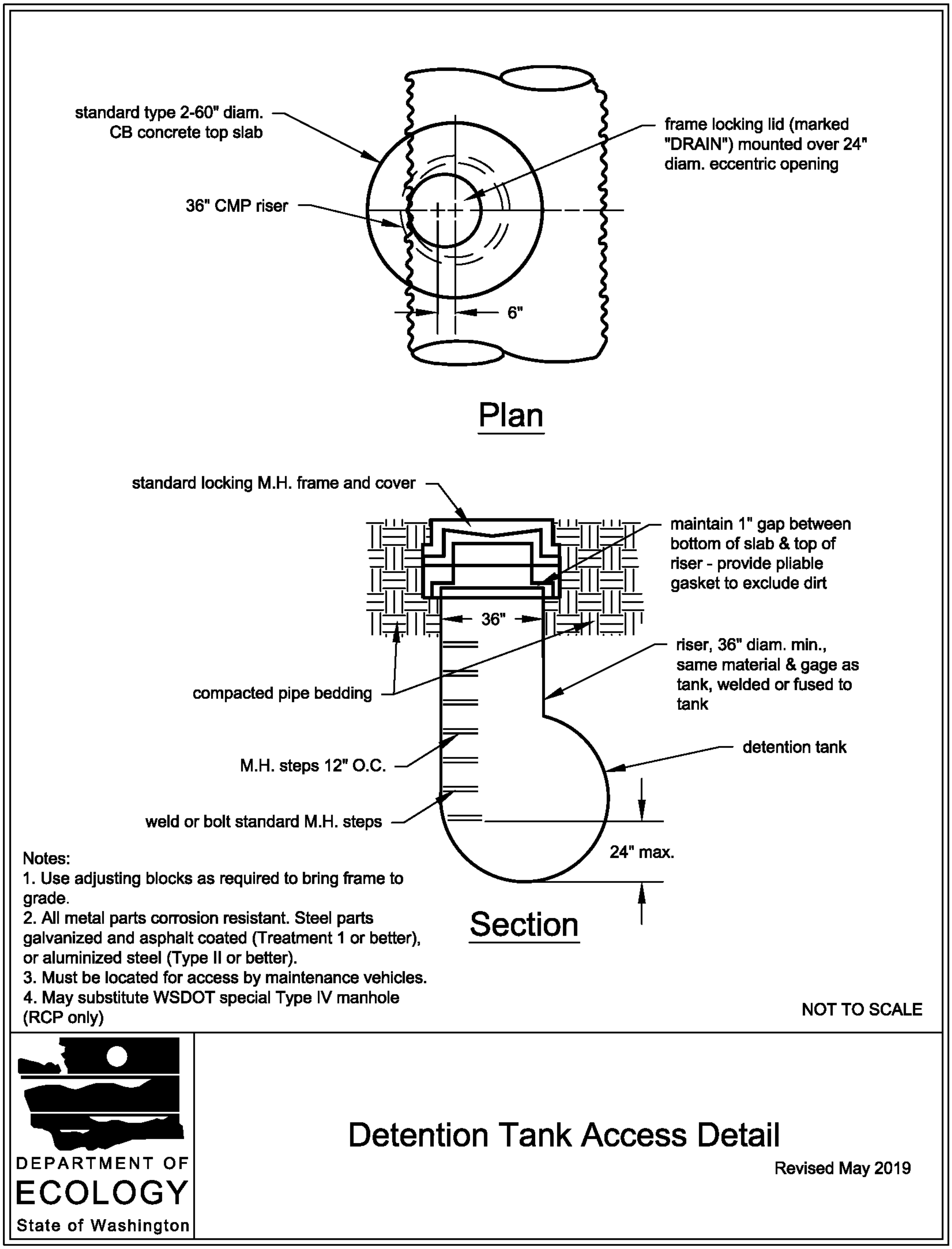


Figure V-12.15: Detention Tank Access Detail



BMP D.3: Detention Vaults

Detention vaults are box shaped underground detention BMPs typically constructed with reinforced concrete. A standard detention vault detail is shown in Figure V-12.16: Typical Detention Vault. Control structure details are shown in V-12.2 Control Structure Design.

Design Criteria

General

Typical design guidelines for detention vaults are as follows:

1. Detention vaults may be designed as flow-through systems with bottoms level (longitudinally), or sloped toward the inlet to facilitate sediment removal. Maximize the distance between the inlet and outlet as feasible.

2. The detention vault bottom may 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. However, 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.

3. Elevate the invert elevation of the outlet above the bottom of the vault to provide an average 6 inches of sediment storage over the entire bottom. Also, elevate the outlet a minimum of 2 feet above the orifice to retain oil within the vault.

4. Details of outflow control structures are given in V-12.2 Control Structure Design.

Materials

Minimum 3,000 psi structural reinforced concrete may be used for detention vaults. Provide all construction joints with water stops.

Structural Stability

All vaults must meet structural requirements for overburden support and H20 traffic loading (See (AASHTO, 2002)). Vaults located under roadways must meet any live load requirements of the local government. Design cast-in place wall sections as retaining walls. Structural designs for cast in place vaults must be stamped by a licensed engineer in the state of Washington with structural expertise. Place vaults on stable, well consolidated native material with suitable bedding. Do not place vaults in fill slopes, unless analyzed in a geotechnical report for stability and constructability.

Access Openings

Provide access openings over the inlet pipe and control structure. Use the following guidelines for access.

1. Position access openings a maximum of 50 feet from any location within the vault. Additional access points may be needed on large vaults. Provide access to each “v” if more than one “v”

is provided in the vault floor.

2. For vaults with greater than 1,250 square feet of floor area, provide a 5' by 10' removable panel over the inlet pipe (instead of a standard frame, grate and solid cover). Or, provide a separate access vault as shown in Figure V-12.16: Typical Detention Vault.
3. For vaults under roadways, locate the removable panel outside the travel lanes. Or, provide multiple standard locking manhole covers. Ladders and hand holds need only be provided at the outlet pipe and inlet pipe, and as needed to meet OSHA confined space requirements.
4. All access openings, except those covered by removable panels, may have round, solid locking lids, or 3 foot square, locking diamond plate covers.
5. Vaults with widths 10 feet or less must have removable lids.
6. The maximum depth from finished grade to the vault invert should be 20 feet.
7. 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.
8. 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. However, 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 requirement may not be needed for any areas covered by removable panels.
9. 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.
10. 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.

Access Roads

Access roads are needed to the access panel (if applicable), the control structure, and at least one access point per cell, and they may be designed and constructed as specified for detention ponds in BMP D.1: Detention Ponds.

Right-of Way

Right-of-way is needed for detention vault maintenance. It is recommended that any tract not abutting public right of way should have a 15 to 20 foot wide extension of the tract to accommodate an access road to the detention vault.

Setbacks

It is recommended that detention vaults be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the local government and from any septic drainfield. However, the setback requirements are generally specified by the local government, uniform building code, or other statewide regulation and may be different from those mentioned above.

All detention vaults must be a minimum of 50 feet from the top of any steep (greater than 15%) slope. A geotechnical analysis and report must be prepared addressing the potential impact of the vault on a slope steeper than 15%.

Maintenance

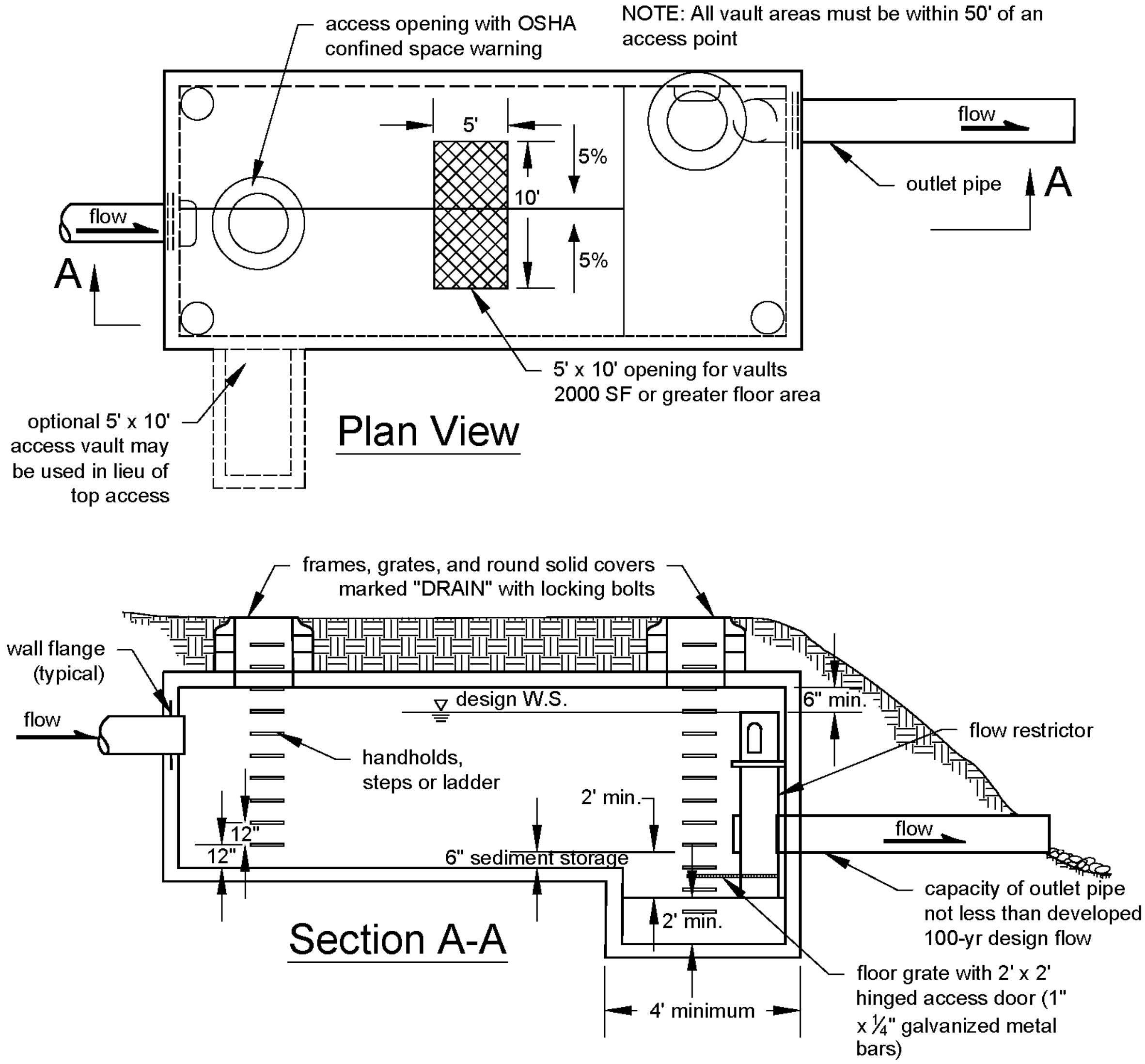
Build in provisions to facilitate maintenance operations into the project when it is installed. Maintenance must be a basic consideration in design and in determination of first cost. See Table V-A.3: Maintenance Standards - Closed Detention Systems (Tanks/Vaults) for specific maintenance requirements.

Methods of Analysis

Detention Volume and Outflow

Design the volumes and outflows for detention vaults to meet the performance standards as required in I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.7 MR7: Flow Control, and/or I-3.4.8 MR8: Wetlands Protection,and the hydrologic analysis and design methods in III-2 Modeling Your BMPs. Design guidelines for control structures are given in V-12.2 Control Structure Design.

Figure V-12.16: Typical Detention Vault



Notes:
1. All metal parts must be corrosion resistant. Steel parts must be galvanized and asphalt coated (Treatment 1 or better).
2. Provide water stop at all cast-in-place construction joints. Precast vaults shall have approved rubber gasket system.
3. Vaults ≤ 10' wide must use removable lids.
4. Prefabricated vault sections may require structural modifications to support 5' x 10' opening over main vault. Alternatively, access can be provided via a side vestibule as shown.

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Typical Detention Vault

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V-13 Oil and Water Separator BMPs

V-13.1 Introduction to Oil and Water Separator BMPs

The purpose of oil and water separator BMPs is to remove oil and other water-insoluble hydrocarbons, and settleable solids from stormwater runoff. Oil and water separator BMPs typically consist of three bays: a forebay, a separator bay, and an afterbay.

There are two general types of oil and water separators:

- the American Petroleum Institute (API) type (also called baffle type) (API, 1990)
  - API separators are composed of three bays separated by baffles. The efficiency of API separators is dependent on detention time in the center bay and on droplet size. API type separators rarely treat stormwater to reduce oil levels below 10 mg/l. The use of API separators should be limited to protection from large oil spills and not for small amounts of oil on the pavement surfaces. See BMP T11.10: API (Baffle type) Separator.
- the coalescing plate (CP) type
  - CP separators use a series of parallel plates in the separator bay, which improve separation efficiency by providing more surface area. CP separators need considerably less space for separation of the floating oil due to the shorter travel distances between parallel plates. See BMP T11.11: Coalescing Plate (CP) Separator.

Both use gravity to remove floating and dispersed oil.

Oil and water separator BMPs must be located off-line from the primary conveyance/detention system, bypassing flows greater than the Water Quality Design Flow Rate.

Oil and water separator BMPs should be placed upstream of other Runoff Treatment BMPs and as close to the source of oil generation as possible.

Other BMPs that may be used for removal of oil include manufactured treatment devices (if approved as an Oil Control BMP, see V-10 Manufactured Treatment Devices as BMPs), and BMP T8.30: Linear Sand Filter.

When designed properly, oil and water separator BMPs shall meet the oil control performance goal as described in III-1.2 Choosing Your Runoff Treatment BMPs.

Applications and Limitations

The following are potential applications of oil and water separator BMPs where free oil is expected to be present at treatable high concentrations and sediment will not overwhelm the separator (Romano, 1990), (Watershed Protection Techniques, 1994), (King County Department of Natural Resources, 1998). For low concentrations of oil, other Runoff Treatment BMPs may be more applicable, such as manufactured treatment devices (if approved as an Oil Control BMP, see V-10 Manufactured Treatment Devices as BMPs) and BMP T8.30: Linear Sand Filter.

- Commercial and industrial areas including petroleum storage yards, vehicle maintenance facilities, manufacturing areas, airports, utility areas (water, electric, gas), and fueling stations. (King County Department of Natural Resources, 1998)
- Facilities that would require Oil Control BMPs per the thresholds described in III-1.2 Choosing Your Runoff Treatment BMPs. These may include parking lots at convenience stores, fast food restaurants, grocery stores, shopping malls, discount warehouse stores, banks, truck fleets, auto and truck dealerships, and delivery services. (King County Department of Natural Resources, 1998)
- Without intense maintenance, oil and water separator BMPs may not be sufficiently effective in achieving oil and TPH removal down to the required levels.
- A pretreatment BMP (see V-9 Pretreatment BMPs) should be considered if the level of TSS in the inlet flow would cause clogging or otherwise impair the long-term efficiency of the oil and water separator BMP.
- For inflows from small drainage areas (such as fueling stations, maintenance shops, etc.) BMP T11.11: Coalescing Plate (CP) Separator is typically considered, due to space limitations. However, if plugging of the plates is likely, then a new design basis for BMP T11.10: API (Baffle type) Separator may be considered on an experimental basis.

Site Suitability

Consider the following site characteristics:

- Sufficient land area
- Adequate TSS control or pretreatment capability
- Compliance with environmental objectives
- Adequate influent flow attenuation and/or bypass capability
- Sufficient access for operation and maintenance (O & M)

General Design Criteria

There is concern that oil and water separator BMPs used for Runoff Treatment have not performed to expectations (Watershed Protection Techniques, 1994), (Schueler et al., 1992). Therefore, emphasis should be given to proper application, design, O & M, (particularly sludge and oil removal) and prevention of CP fouling and plugging (US Army Corps of Engineers, 1994). Other Runoff Treatment BMPs, such as manufactured treatment devices (if approved as an Oil Control BMP, see V-10 Manufactured Treatment Devices as BMPs) and BMP T8.30: Linear Sand Filter, should be considered for the removal of insoluble oil and TPH.

The following are design criteria applicable to both BMP T11.10: API (Baffle type) Separator and BMP T11.11: Coalescing Plate (CP) Separator:

- If practicable, determine oil/grease (or TPH) and TSS concentrations, lowest temperature, pH; and empirical oil rise rates in the runoff, and the viscosity, and specific gravity of the oil. Also determine whether the oil is emulsified or dissolved. Do not use oil and water separator BMPs for the removal of dissolved or emulsified oils such as coolants, soluble lubricants, glycols, and alcohols.
- Locate the oil and water separator BMP off-line, and bypass the incremental portion of flows that exceed the off-line 15-minute, Water Quality Design Flow Rate multiplied by the ratio indicated in Figure V-7.8: Ratio of SBUH Peak/WQ Flow (Offline). If it is necessary to locate the separator on-line, try to minimize the size of the area needing oil control, and use the on-line Water Quality Design Flow Rate multiplied by the ratio indicated in Figure V-7.7: Ratio of SBUH Peak/WQ Flow (Online).
- Use only impervious conveyances for oil contaminated stormwater.
- Specify appropriate performance tests after installation and shakedown, and/or certification by a licensed engineer in the state of Washington that the oil and water separator BMP is functioning in accordance with design objectives. Expeditious corrective actions must be taken if it is determined the oil and water separator BMP is not achieving acceptable performance levels.
- Add a pretreatment BMP (see V-9 Pretreatment BMPs) for TSS that could cause clogging of the CP separator, or otherwise impair the long-term effectiveness of the separator.

Separator Bay Design Criteria

- For an off-line BMP, size the separator bay (the second bay) for the Water Quality Design Flow Rate (as described in III-2.6 Sizing Your Runoff Treatment BMPs) multiplied by the correction factor ratio indicated in Figure V-7.8: Ratio of SBUH Peak/WQ Flow (Offline).
- For an on-line BMP, size the separator bay (the second bay) for the Water Quality Design Flow Rate (as described in III-2.6 Sizing Your Runoff Treatment BMPs multiplied by the correction factor ratio indicated in Figure V-7.7: Ratio of SBUH Peak/WQ Flow (Online).
- To collect floatables and settleable solids, design the surface area of the forebay (the first bay) at ≥ 20 ft^2 per 10,000 ft^2 of area draining to the oil and water separator BMP. The length of the forebay should be 1/3-1/2 of the length of all three bays combined. Include roughing screens for the forebay or upstream of the oil and water separator BMP to remove debris, if needed. Screen openings should be about 3/4 inch.
- Include a submerged inlet pipe with a turned-down elbow in the forebay at least two feet from the bottom. The outlet pipe should be a Tee, sized to pass the Water Quality Design Flow Rate and placed at least 12 inches below the water surface.
- Include a shutoff mechanism at the outlet pipe. (King County Department of Natural Resources, 1998)
- Use absorbents and/or skimmers in the afterbay (the third bay) as needed.

Baffle Design Criteria

- Oil retaining baffles (top baffles) should be located at least at 1/4 of the length of all three bays from the outlet, and should extend down at least 50% of the water depth and at least 1 ft. from the oil and water separator BMP bottom.
- The baffle height to water depth ratios should be 0.85 for top baffles and 0.15 for bottom baffles.

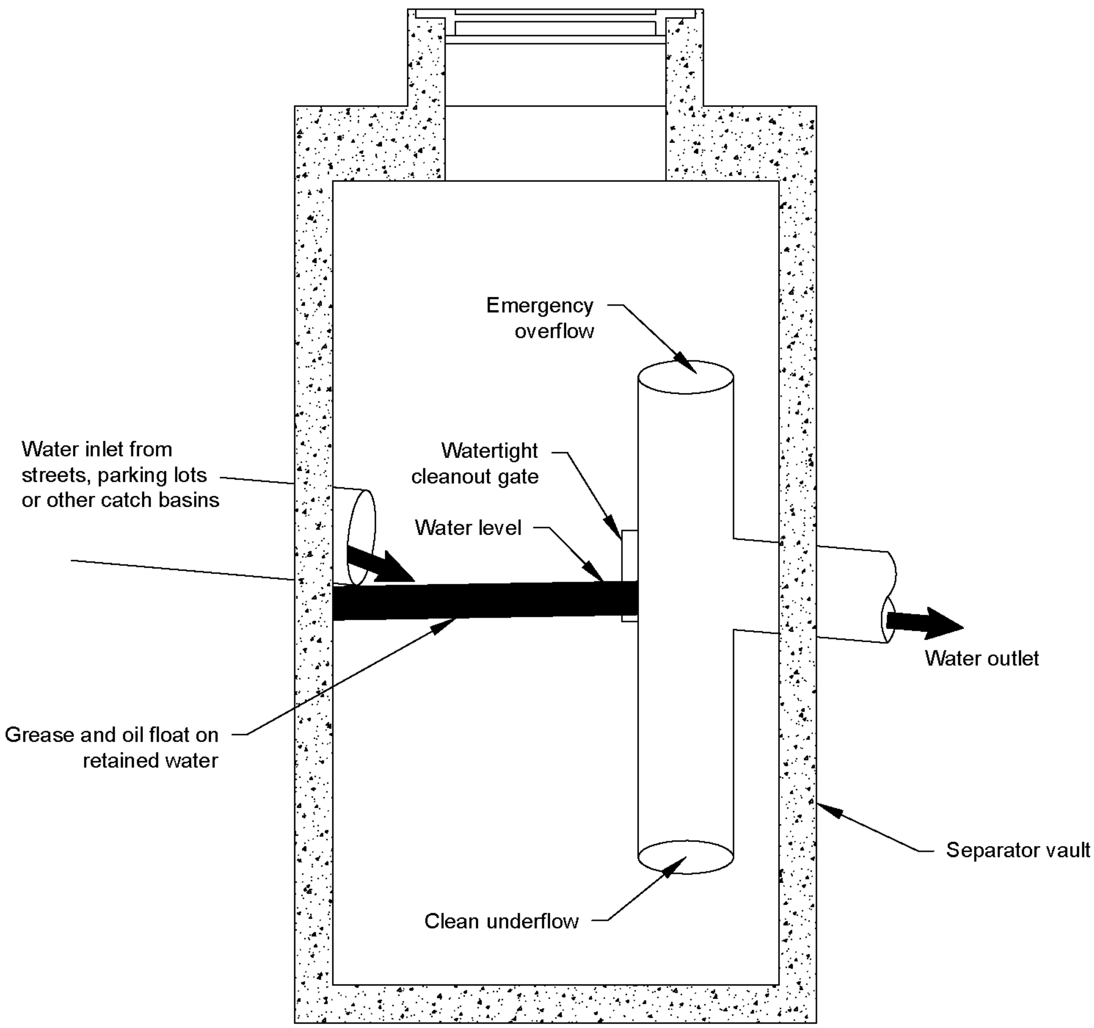
Operation and Maintenance

- Prepare, regularly update, and implement an O & M Manual for the oil and /water separators.
- Inspect oil/water separators monthly during the wet season of October 1-April 30 (WEF and ASCE, 1998), (Woodward-Clyde, n.d.) to ensure proper operation, and, during and immediately after a large storm event of ≥ 1 inch per 24 hours.
- Clean oil/water separators regularly to keep accumulated oil from escaping during storms. They must be cleaned by October 15 to remove material that has accumulated during the dry season (Woodward-Clyde, n.d.), after all spills, and after a significant storm. Coalescing plates may be cleaned in-situ or after removal from the separator. An eductor truck may be used for oil, sludge, and washwater removal. (King County Department of Natural Resources, 1998) Replace wash water in the separator with clean water before returning it to service.
- Remove the accumulated oil when the thickness reaches 1-inch. Also remove sludge deposits when the thickness reaches 6 inches (King County Department of Natural Resources, 1998).
- Replace oil absorbent pads before their sorbed oil content reaches capacity.
- Train designated employees on appropriate separator operation, inspection, record keeping, and maintenance procedures.

Spill Control Separators

A spill control (SC) separator (Figure V-13.1: Spill Control Separator (not for oil treatment)) is a simple catchbasin with a T-inlet for temporarily trapping small volumes of oil. ***The spill control separator is included here for comparison purposes only and is not designed for, or to be used for Runoff Treatment purposes.***

Figure V-13.1: Spill Control Separator (not for oil treatment)



Source: 1992 Ecology Manual

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Spill Control Separator (not for oil treatment)

Revised June 2016

BMP T11.10: API (Baffle type) Separator

Refer to V-13.1 Introduction to Oil and Water Separator BMPs for Applications and Limitations, Site Suitability, General Design Criteria, and Operation and Maintenance guidance for both this BMP and BMP T11.11: Coalescing Plate (CP) Separator. Additional design criteria specific to this BMP is presented below.

Design Criteria

The criteria for small drainages is based on V_h (the horizontal velocity of the bulk fluid), V_t (the rise rate of the oil droplet), residence time, width, depth, and length considerations. As a correction factor API's turbulence criteria is applied to increase the length.

Ecology is modifying the API criteria for treating stormwater runoff from small drainage areas (fueling stations, commercial parking lots, etc.) by using the design hydraulic horizontal velocity, V_h, for the design V_h/V_t ratio rather than the API minimum of $V_h/V_t = 15$. The API criteria are applicable for greater than two acres of impervious drainage area. Performance verification of this design basis must be obtained during at least one wet season using the test protocol referenced in V-10 Manufactured Treatment Devices as BMPs.

The following is the sizing procedure using Ecology's modified API criteria:

1. Determine the oil rise rate, V_t, in cm/sec, using Stokes Law (Water Pollution Control Federation, 1985), or empirical determination, or 0.033 ft./min for 60μ oil. The application of Stokes' Law to site-based oil droplet sizes and densities, or empirical rise rate determinations recognizes the need to consider actual site conditions. In those cases the design basis would not be the 60 micron droplet size and the 0.033 ft/min rise rate.

    - Stokes Law equation for rise rate, V_t (cm/sec):

    $$V_t = [(g)(\rho_w - \rho_o)(d^2)] / [(18^*\mu_w)]$$

    Where:

    V_t = the rise rate of the oil droplet (cm/s or ft/sec)

    g = acceleration due to gravity (cm/s^2 or ft/s^2)

    ρ_w = density of water at the design temperature (g/cm^3 or lbm/ft^3)

    ρ_o = density of oil at the design temperature (g/cm^3 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)]

2. Use the following separator dimension criteria:

    - Separator water depth, $3 \geq d \leq 8$ feet (to minimize turbulence) (API, 1990), (US Army Corps of Engineers, 1994).

- Separator width, 6-20 feet (WEF and ASCE, 1998), (King County Department of Natural Resources, 1998)
- Depth/width (d/w) of 0.3-0.5 (API, 1990)

For Stormwater Inflow from Drainages under 2 Acres

1. Determine V_t and select depth and width of the separator bay based on the above criteria.
2. Calculate the minimum residence time (t_m) of the separator at depth d:

$$t_m = d/V_t$$

3. Calculate the horizontal velocity of the bulk fluid, V_h, vertical cross-sectional area, A_v, and actual design V_h/V_t (API, 1990), (US Army Corps of Engineers, 1994).

   $V_h = Q/dw = Q/A_v$ (V_h maximum at < 2.0 ft/min.) (API, 1990)

   Q = (k) the ratio indicated in Figure V-7.7: Ratio of SBUH Peak/WQ Flow (Online) (for on-line facilities) or Figure V-7.8: Ratio of SBUH Peak/WQ Flow (Offline) (for offline facilities) for the site location multiplied by the Water Quality Design Flow Rate in ft^3/min, at minimum residence time, t_m.

   At V_h/V_t determine F, the turbulence and short-circuiting factor (Figure V-13.3: Recommended Values of F for Various Values of vH/Vt). API F factors range from 1.28-1.74. (API, 1990)

4. Calculate the minimum length of the separator section, l(s), using:

$$l(s) = FQt_m/wd = F(V_h/V_t)d$$

$$l(t) = l(f) + l(s) + l(a)$$

$$l(t) = l(t)/3 + l(s) + l(t)/4$$

   Where:

   l(t) = total length of 3 bays = “L” in Figure 11.2.1

   l(f) = length of forebay

   l(a) = length of afterbay

5. Calculate $V = l(s)wd = FQt_m$, and $A_h = wl(s)$

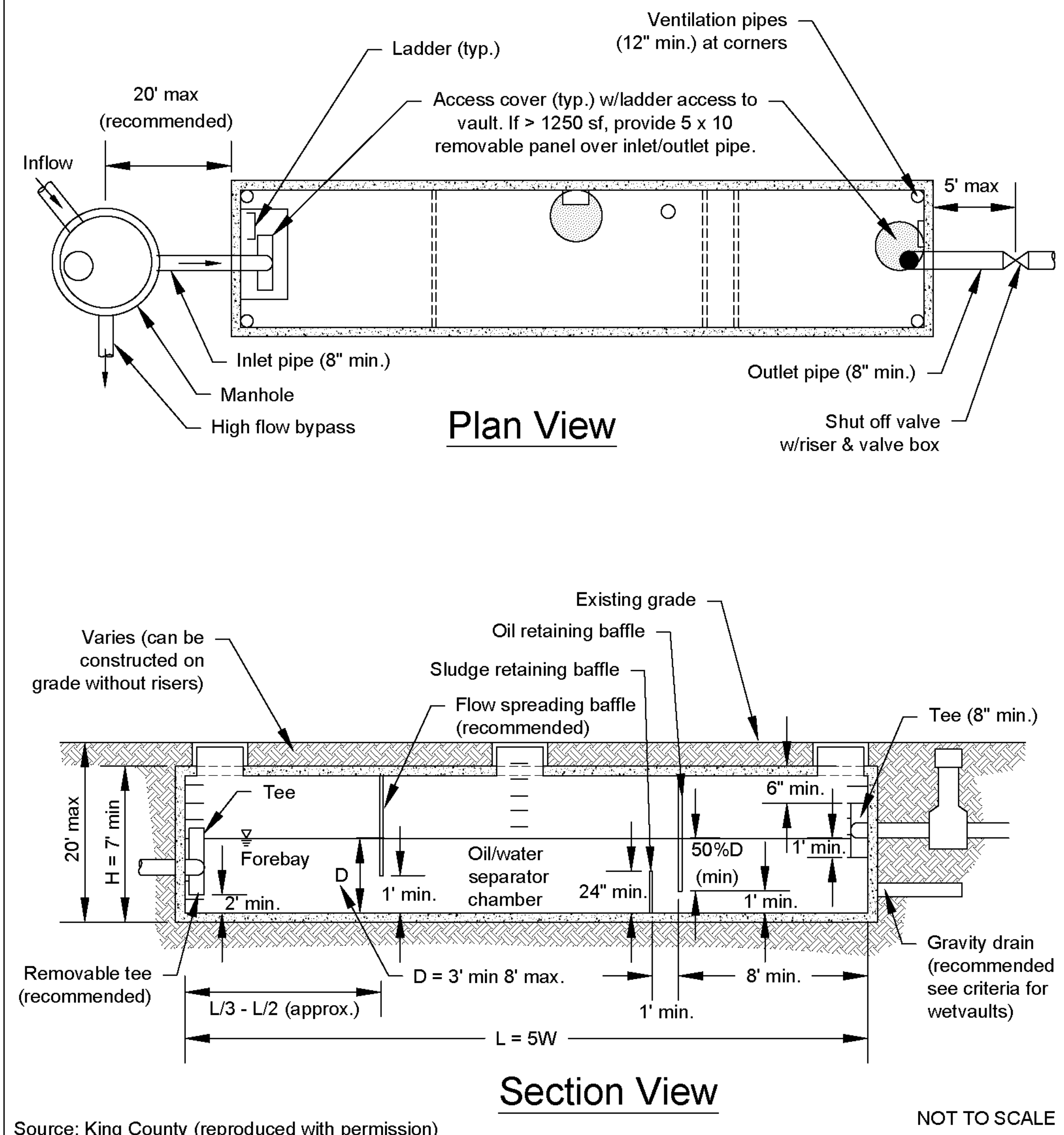
   V = minimum hydraulic design volume

   A_h = minimum horizontal area of the separator

For Stormwater Inflow from Drainages > 2 Acres

Use $V_h = 15\ V_t$ and $d = (Q/2V_h)^{0.5}$ (with d/w = 0.5), and repeat above calculations 3- 5.

Figure V-13.2: API (Baffle Type) Separator

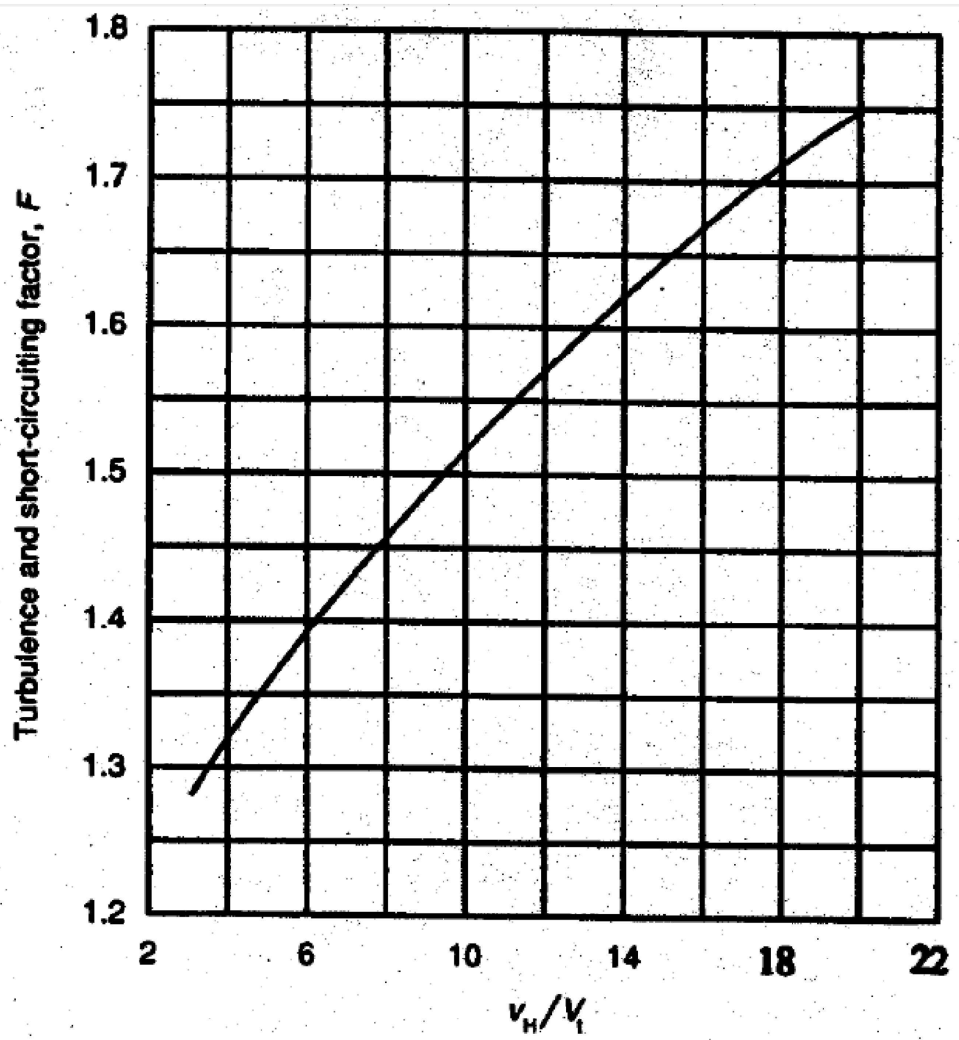


DEPARTMENT OF ECOLOGY
State of Washington

API (Baffle Type) Separator

Revised May 2018

Figure V-13.3: Recommended Values of F for Various Values of v_H/V_t



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

BMP T11.11: Coalescing Plate (CP) Separator

Refer to V-13.1 Introduction to Oil and Water Separator BMPs for Applications and Limitations, Site Suitability, General Design Criteria, and Operation and Maintenance guidance for both this BMP and BMP T11.10: API (Baffle type) Separator. Additional design criteria specific to this BMP is presented below.

Design Criteria

- Calculate the projected (horizontal) surface area of plates needed using the following equation:

  $$A_h = Q/Vt = [Q] / [(.00386) * ((S_w - S_o)/(\mu_w))]$$

  Where

  A_h = horizontal surface area of the plates (ft²)

  Vt = rise rate of the oil droplet (ft/min)

  Q = (k) the ratio indicated in Figure V-7.7: Ratio of SBUH Peak/WQ Flow (Online) (for on-line facilities) or Figure V-7.8: Ratio of SBUH Peak/WQ Flow (Offline) (for offline facilities) for the site location multiplied by the Water Quality Design Flow Rate in ft^3/min, at minimum residence time, t_m

  S_w = specific gravity of water at the design temperature

  S_o = specific gravity of oil at the design temperature

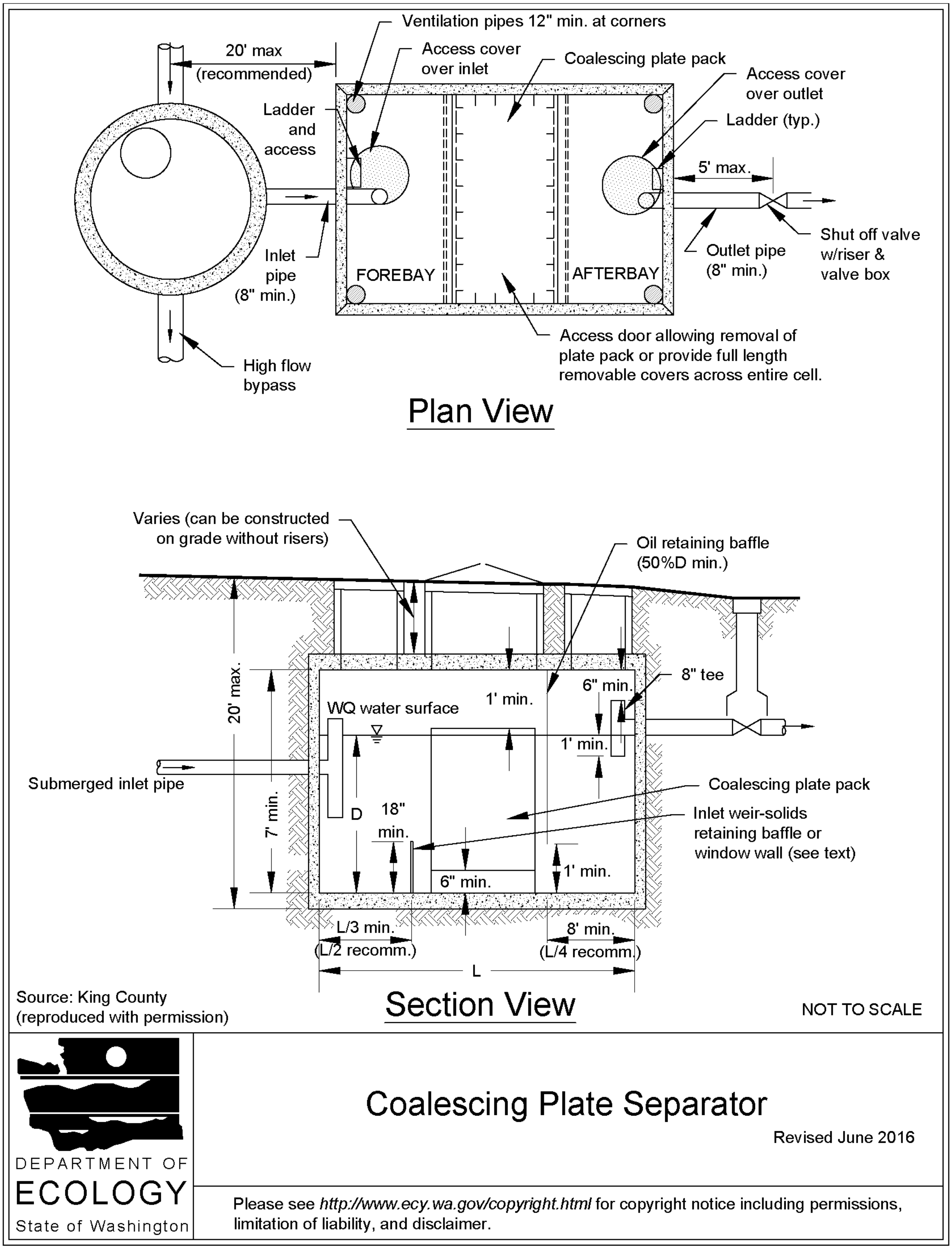
  μ_w = absolute viscosity of the water (poise)

  The above equation is based on an oil droplet diameter of 60 microns.

- The plate spacing should be a minimum of 3/4 in (perpendicular distance between plates), or as determined by the manufacturer. (WEF and ASCE, 1998), (US Army Corps of Engineers, 1994), (Jaisinghani and Sprenger, 1979)
- Select a plate angle between 45° to 60° from the horizontal.
- Locate the plate pack at least 6 inches from the bottom of the separator bay for sediment storage
- Add 12 inches minimum head space from the top of the plate pack and the bottom of the vault cover.
- Design the inlet flow distribution and baffles in the separator bay to minimize turbulence, short-circuiting, and channeling of the inflow especially through and around the plate packs of the CP separator. The Reynolds Number through the separator bay should be <500 (laminar flow).
- Include a forebay for floatables and an afterbay for collection of effluent. (WEF and ASCE, 1998)

- The sediment-retaining baffle must be upstream of the plate pack at a minimum height of 18 in. (King County Department of Natural Resources, 1998).
- Design the coalescing plates for ease of removal, and cleaning with high-pressure rinse or equivalent.

Figure V-13.4: Coalescing Plate Separator



Appendix V-A: BMP Maintenance Tables

Ecology intends the facility-specific maintenance standards contained in this section to be conditions for determining if maintenance actions are required as identified through inspection. Recognizing that Permittees have limited maintenance funds and time, Ecology does not require that a Permittee perform all these maintenance activities on all their stormwater BMPs. We leave the determination of importance of each maintenance activity and its priority within the stormwater program to the Permittee. We do expect, however, that sufficient maintenance will occur to ensure that the BMPs continue to operate as designed to protect ground and surface waters.

Ecology doesn't intend that these measures identify the facility's required condition at all times between inspections. In other words, exceedance of 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 Permittee shall adjust inspection and maintenance schedules to minimize the length of time that a facility is in a condition that requires a maintenance action.

Table V-A.1: Maintenance Standards - Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	Any trash and debris which exceed 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
	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 IPM policies for the use of herbicides).	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with local health department) Complete eradication of noxious weeds may not be possible. Compliance with State or local eradication policies required
	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants (Coordinate removal/cleanup with local water quality response agency).	No contaminants or pollutants present.
	Rodent Holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired. (Coordinate with local health department; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)
	Beaver Dams	Dam results in change or function of the facility.	Facility is returned to design function. (Coordinate trapping of beavers and removal of dams with appropriate permitting agencies)
	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted IPM policies
	Tree Growth and Hazard Trees	Tree growth does not allow maintenance and inspection access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access or maintenance, do not remove If dead, diseased, or dying trees are identified (Use a certified Arborist to determine health of tree or removal requirements)	Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood). Remove hazard Trees
Side Slopes of Pond	Erosion	Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	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 licensed engineer in the state of Washington should be consulted to resolve source of erosion.
Storage Area	Sediment	Accumulated sediment that exceeds 10% of the designed pond depth unless otherwise specified or affects inletting or outletting condition of the facility.	Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion.

Table V-A.1: Maintenance Standards - Detention Ponds (continued)

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
	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.
Ponds 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 licensed engineer in the state of Washington should be consulted to determine the source of the settlement.	Dike is built back to the design elevation.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Goethechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved.
Emergency Overflow/ Spillway and Berms over 4 feet in height	Tree Growth	Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping. 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 licensed engineer in the state of Washington should be consulted for proper berm/spillway restoration.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved.
Emergency Overflow/Spillway	Emergency Overflow/Spillway	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of out flow path of spillway. (Rip-rap on inside slopes need not be replaced.)	Rocks and pad depth are restored to design standards.
	Erosion	See "Side Slopes of Pond"	

Table V-A.2: Maintenance Standards - Infiltration

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	See Table V-A.1: Maintenance Standards - Detention Ponds	See Table V-A.1: Maintenance Standards - Detention Ponds
	Poisonous/Noxious Vegetation	See Table V-A.1: Maintenance Standards - Detention Ponds	See Table V-A.1: Maintenance Standards - Detention Ponds
	Contaminants and Pollution	See Table V-A.1: Maintenance Standards - Detention Ponds	See Table V-A.1: Maintenance Standards - Detention Ponds
	Rodent Holes	See Table V-A.1: Maintenance Standards - Detention Ponds	See Table V-A.1: Maintenance Standards - Detention Ponds
Storage Area	Sediment	Water ponding in infiltration pond after rainfall ceases and appropriate time allowed for infiltration. Treatment basins should infiltrate Water Quality Design Storm Volume within 48 hours, and empty within 24 hours after cessation of most rain events.	Sediment is removed and/or facility is cleaned so that infiltration system works according to design.

Table V-A.2: Maintenance Standards - Infiltration (continued)

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
		(A percolation test pit or test of facility indicates facility is only working at 90% of its designed capabilities. Test every 2 to 5 years. If two inches or more sediment is present, remove).	
Filter Bags (if applicable)	Filled with Sediment and Debris	Sediment and debris fill bag more than 1/2 full.	Filter bag is replaced or system is redesigned.
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.
Side Slopes of Pond	Erosion	See Table V-A.1: Maintenance Standards - Detention Ponds	See Table V-A.1: Maintenance Standards - Detention Ponds
Emergency Overflow Spillway and Berms over 4 feet in height.	Tree Growth	See Table V-A.1: Maintenance Standards - Detention Ponds	See Table V-A.1: Maintenance Standards - Detention Ponds
	Piping	See Table V-A.1: Maintenance Standards - Detention Ponds	See Table V-A.1: Maintenance Standards - Detention Ponds
Emergency Overflow Spillway	Rock Missing	See Table V-A.1: Maintenance Standards - Detention Ponds	See Table V-A.1: Maintenance Standards - Detention Ponds
	Erosion	See Table V-A.1: Maintenance Standards - Detention Ponds	See Table V-A.1: Maintenance Standards - Detention Ponds
Pre-settling Ponds and Vaults	Facility or sump filled with Sediment and/or debris	6" or designed sediment trap depth of sediment.	Sediment is removed.

Table V-A.3: Maintenance Standards - Closed Detention Systems (Tanks/Vaults)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
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.
	Debris and Sediment	Accumulated sediment depth exceeds 10% of the diameter of the storage area for 1/2 length of storage vault or any point depth exceeds 15% of diameter. (Example: 72-inch storage tank would require cleaning when sediment reaches depth of 7 inches for more than 1/2 length of tank.)	All sediment and debris removed from 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 joint between tank/pipe sections are sealed.
	Tank Pipe Bent Out of Shape	Any part of tank/pipe is bent out of shape more than 10% of its design shape. (Review required by engineer to determine structural stability).	Tank/pipe repaired or replaced to design.
	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-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. Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or any evidence of soil particles entering the vault through the walls.	Vault replaced or repaired to design specifications and is structurally sound. No cracks more than 1/4-inch wide at the joint of the inlet/outlet pipe.

Table V-A.3: Maintenance Standards - Closed Detention Systems (Tanks/Vaults) (continued)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Manhole	Cover Not in Place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole is closed.
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread (may not apply to self-locking lids).	Mechanism opens with proper tools.
	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.
	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.
Catch Basins	See Table V-A.5: Maintenance Standards - Catch Basins	See Table V-A.5: Maintenance Standards - Catch Basins	See Table V-A.5: Maintenance Standards - Catch Basins

Table V-A.4: Maintenance Standards - Control Structure/Flow Restrictor

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris (Includes Sediment)	Material exceeds 25% of sump depth or 1 foot below orifice plate.	Control structure orifice is not blocked. All trash and debris removed.
	Structural Damage	Structure is not securely attached to manhole wall. Structure is not in upright position (allow up to 10% from plumb). Connections to outlet pipe are not watertight and show signs of rust. Any holes - other than designed holes - in the structure.	Structure securely attached to wall and outlet pipe. Structure in correct position. Connections to outlet pipe are water tight; structure repaired or replaced and works as designed. Structure has no holes other than designed holes.
Cleanout Gate	Damaged or Missing	Cleanout gate is not watertight or is missing. Gate cannot be moved up and down by one maintenance person. Chain/rod leading to gate is missing or damaged. Gate is rusted over 50% of its surface area.	Gate is watertight and works as designed. Gate moves up and down easily and is watertight. Chain is in place and works as designed. Gate is repaired or replaced to meet design standards.
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.
	Obstructions	Any trash, debris, sediment, or vegetation blocking the plate.	Plate is free of all obstructions and works as designed.
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.
Manhole	See Table V-A.3: Maintenance Standards - Closed Detention Systems (Tanks/Vaults)	See Table V-A.3: Maintenance Standards - Closed Detention Systems (Tanks/Vaults)	See Table V-A.3: Maintenance Standards - Closed Detention Systems (Tanks/Vaults)
Catch Basin	See Table V-A.5: Maintenance Standards - Catch Basins	See Table V-A.5: Maintenance Standards - Catch Basins	See Table V-A.5: Maintenance Standards - Catch Basins

Table V-A.5: Maintenance Standards - Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
General	Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%. 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 six inches clearance from the debris surface to the invert of the lowest pipe. Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height. Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No Trash or debris located immediately in front of catch basin or on grate opening. No trash or debris in the catch basin. Inlet and outlet pipes free of trash or debris. No dead animals or vegetation present within the catch basin.
	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
	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch. (Intent is to make sure no material is running into basin). Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached	Top slab is free of holes and cracks. Frame is sitting flush on the riser rings or top slab and firmly attached.
	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound. Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Basin replaced or repaired to design standards. Pipe is regrouted and secure at basin wall.
	Settlement/ Mis-alignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening. Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation blocking opening to basin. No vegetation or root growth present.
	Contamination and Pollution	See Table V-A.1: Maintenance Standards - Detention Ponds	No pollution present.
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Cover/grate is in place, meets design standards, and is secured
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Mechanism opens with proper tools.
	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.
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.
Metal Grates (If Applicable)	Grate opening Unsafe	Grate with opening wider than 7/8 inch.	Grate opening meets design standards.
	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface inletting capacity.	Grate free of trash and debris.
	Damaged or Missing.	Grate missing or broken member(s) of the grate.	Grate is in place, meets the design standards, and is installed and aligned with the flow path.

Table V-A.6: Maintenance Standards - Debris Barriers (e.g., Trash Racks)

Maintenance Components	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris	Trash or debris that is plugging more than 20% of the openings in the barrier.	Barrier cleared to design flow capacity.
Metal	Damaged/ Missing Bars.	Bars are bent out of shape more than 3 inches. Bars are missing or entire barrier missing. Bars are loose and rust is causing 50% deterioration to any part of barrier.	Bars in place with no bends more than 3/4 inch. Bars in place according to design. Barrier replaced or repaired to design standards.
	Inlet/Outlet Pipe	Debris barrier missing or not attached to pipe	Barrier firmly attached to pipe

Table V-A.7: Maintenance Standards - Energy Dissipators

Maintenance Components	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
External:			
Rock Pad	Missing or Moved Rock	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil.	Rock pad replaced to design standards.
	Erosion	Soil erosion in or adjacent to rock pad.	Rock pad replaced to design standards.
Dispersion Trench	Pipe Plugged with Sediment	Accumulated sediment that exceeds 20% of the design depth.	Pipe cleaned/flushed so that it matches design.
	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.
	Perforations Plugged.	Over 1/2 of perforations in pipe are plugged with debris and sediment.	Perforated pipe cleaned or replaced.
	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 its causing or appears likely to cause damage.	Facility rebuilt or redesigned to standards.
	Receiving Area Over-Saturated	Water in receiving area is causing or has potential of causing landslide problems.	No danger of landslides.
Internal:			
Manhole/Chamber	Worn or Damaged Post, Baffles, Side of Chamber	Structure dissipating flow deteriorates to 1/2 of original size or any concentrated worn spot exceeding one square foot which would make structure unsound.	Structure replaced to design standards.
	Other Defects	See Table V-A.5: Maintenance Standards - Catch Basins	See Table V-A.5: Maintenance Standards - Catch Basins

Table V-A.8: Maintenance Standards - Typical Biofiltration Swale

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits on grass treatment area of the bio-swale. 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.
	Standing Water	When 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.
	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.

Table V-A.8: Maintenance Standards - Typical Biofiltration Swale (continued)

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
	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.
	Poor Vegetation Coverage	When grass is sparse or bare or eroded patches occur in more than 10% 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.
	Vegetation	When the grass becomes excessively tall (greater than 10-inches); when nuisance weeds and other vegetation starts to take over.	Mow vegetation or remove nuisance vegetation so that flow not impeded. Grass should be mowed to a height of 3 to 4 inches. Remove grass clippings.
	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.
	Inlet/Outlet	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.
	Trash and Debris Accumulation	Trash and debris accumulated in the bio-swale.	Remove trash and debris from bioswale.
	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.

Table V-A.9: Maintenance Standards - Wet Biofiltration Swale

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment Accumulation	Sediment depth exceeds 2-inches in 10% of the swale treatment area.	Remove sediment deposits in treatment area.
	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.
	Wetland Vegetation	Vegetation becomes sparse and does not provide adequate filtration, OR vegetation is crowded out by very dense clumps of cattail, which do not allow water to flow through the clumps.	Determine cause of lack of vigor of vegetation and correct. Replant as needed. For excessive cattail growth, cut cattail shoots back and compost off-site. Note: normally wetland vegetation does not need to be harvested unless die-back is causing oxygen depletion in downstream waters.
	Inlet/Outlet	Inlet/outlet area clogged with sediment and/or debris.	Remove clogging or blockage in the inlet and outlet areas.
	Trash and Debris Accumulation	See Table V-A.1: Maintenance Standards - Detention Ponds	Remove trash and debris from wet swale.
	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 dryer areas.

Table V-A.10: Maintenance Standards - Filter Strips

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
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.
	Vegetation	When the grass becomes excessively tall (greater than 10-inches); when nuisance weeds and other vegetation starts to take over.	Mow grass, control nuisance vegetation, such that flow not impeded. Grass should be mowed to a height between 3-4 inches.
	Trash and Debris Accumulation	Trash and debris accumulated on the filter strip.	Remove trash and Debris from filter.
	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.
	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.

Table V-A.11: Maintenance Standards - Wetponds

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
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.
	Trash and Debris	Accumulation that exceeds 1 CF per 1000-SF of pond area.	Trash and debris removed from pond.
	Inlet/Outlet Pipe	Inlet/Outlet pipe clogged with sediment and/or debris material.	No clogging or blockage in the inlet and outlet piping.
	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.	Sediment removed from pond bottom.
	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.
	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.
	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.
	Internal Berm	Berm dividing cells should be level.	Berm surface is leveled so that water flows evenly over entire length of berm.
	Overflow Spillway	Rock is missing and soil is exposed at top of spillway or outside slope.	Rocks replaced to specifications.

Table V-A.12: Maintenance Standards - Wetvaults

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash/Debris Accumulation	Trash and debris accumulated in vault, pipe or inlet/outlet (includes floatables	Remove trash and debris from vault.

Table V-A.12: Maintenance Standards - Wetvaults (continued)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
		and non-floatables).	
	Sediment Accumulation in Vault	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6-inches.	Remove sediment from vault.
	Damaged Pipes	Inlet/outlet piping damaged or broken and in need of repair.	Pipe repaired and/or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened or removed, especially by one person.	Cover repaired or replaced to proper working specifications.
	Ventilation	Ventilation area blocked or plugged.	Blocking material removed or cleared from ventilation area. A specified % of the vault surface area must provide ventilation to the vault interior (see design specifications).
	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. Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound. Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection staff.	Baffles repaired or replaced to specifications.
	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. Ladder and entry notification complies with OSHA standards.

Table V-A.13: Maintenance Standards - Sand Filters (Above Ground/Open)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Above Ground (open sand filter)	Sediment Accumulation on top layer	Sediment depth exceeds 1/2-inch.	No sediment deposit on grass layer of sand filter that would impede permeability of the filter section.
	Trash and Debris Accumulations	Trash and debris accumulated on sand filter bed.	Trash and debris removed from sand filter bed.
	Sediment/ Debris in Clean-Outs	When the clean-outs become full or partially plugged with sediment and/or debris.	Sediment removed from clean-outs.
	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).
	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.	Low, continuous flows are limited to a small portion of the facility by using a low wooden divider or slightly depressed sand surface.
	Short Circuiting	When flows become concentrated over one section of the sand filter rather than dispersed.	Flow and percolation of water through sand filter is uniform and dispersed across the entire filter area.
	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.
	Rock Pad Missing or Out of Place	Soil beneath the rock is visible.	Rock pad replaced or rebuilt to design specifications.

Table V-A.13: Maintenance Standards - Sand Filters (Above Ground/Open) (continued)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
	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.
	Damaged Pipes	Any part of the piping that is crushed or deformed more than 20% or any other failure to the piping.	Pipe repaired or replaced.

Table V-A.14: Maintenance Standards - Sand Filters (Below Ground/Enclosed)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Below Ground Vault.	Sediment Accumulation on Sand Media Section	Sediment depth exceeds 1/2-inch.	No sediment deposits on sand filter section that which would impede permeability of the filter section.
	Sediment Accumulation in Pre-Settling 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.
	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.
	Sediment in Drain Pipes/Cleanouts	When drain pipes, cleanouts become full with sediment and/or debris.	Sediment and debris removed.
	Short Circuiting	When seepage/flow occurs along the vault walls and corners. Sand eroding near inflow area.	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.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and/or replaced.
	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.
	Ventilation	Ventilation area blocked or plugged	Blocking material removed or cleared from ventilation area. A specified % of the vault surface area must provide ventilation to the vault interior (see design specifications).
	Vault Structure Damaged; Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab.	Cracks wider than 1/2-inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound. Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound. Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	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.
	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.

Table V-A.15: Maintenance Standards - Manufactured Media Filters

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Below Ground	Sediment Accumulation on Media.	Sediment depth exceeds 0.25-inches.	No sediment deposits which would impede permeability of the

Table V-A.15: Maintenance Standards - Manufactured Media Filters (continued)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Vault			compost media.
	Sediment Accumulation in Vault	Sediment depth exceeds 6-inches in first chamber.	No sediment deposits in vault bottom of first chamber.
	Trash/Debris Accumulation	Trash and debris accumulated on compost filter bed.	Trash and debris removed from the compost filter bed.
	Sediment in Drain Pipes/Clean-Outs	When drain pipes, clean-outs, become full with sediment and/or debris.	Sediment and debris removed.
	Damaged Pipes	Any part of the pipes that are crushed or damaged due to corrosion and/or settlement.	Pipe repaired and/or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened; one person cannot open the cover using normal lifting pressure, corrosion/deformation of cover.	Cover repaired to proper working specifications or replaced.
	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound. Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound. Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles corroding, cracking warping, and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
	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.
Below Ground Cartridge Type	Media	Drawdown of water through the media takes longer than 1 hour, and/or overflow occurs frequently.	Media cartridges replaced.
	Short Circuiting	Flows do not properly enter filter cartridges.	Filter cartridges replaced.

Table V-A.16: Maintenance Standards - Baffle Oil/Water Separators (API Type)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Monitoring	Inspection of discharge water for obvious signs of poor water quality.	Effluent discharge from vault should be clear with out thick visible sheen.
	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.
	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.
	Oil Accumulation	Oil accumulations that exceed 1-inch, at the surface of the water.	Extract oil from vault by vactoring. Disposal in accordance with state and local rules and regulations.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened, corrosion/deformation of cover.	Cover repaired to proper working specifications or replaced.
	Vault Structure Damage - Includes Cracks in Walls Bottom, Damage to Frame and/or Top Slab	See Table V-A.5: Maintenance Standards - Catch Basins Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound. Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
	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.

Table V-A.17: Maintenance Standards - Coalescing Plate Oil/Water Separators

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Monitoring	Inspection of discharge water for obvious signs of poor water quality.	Effluent discharge from vault should be clear with no thick visible sheen.
	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.
	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.
	Oil Accumulation	Oil accumulation that exceeds 1-inch at the water surface.	Oil is extracted from vault using vactoring methods. Coalescing plates are cleaned by thoroughly rinsing and flushing. Should be no visible oil depth on water.
	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.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and or replaced.
	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
	Vault Structure Damage - Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound. Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound. Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	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.

Table V-A.18: Maintenance Standards - Catch Basin Inserts

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment Accumulation	When sediment forms a cap over the insert media of the insert and/or unit.	No sediment cap on the insert media and its unit.
	Trash and Debris Accumulation	Trash and debris accumulates on insert unit creating a blockage/restriction.	Trash and debris removed from insert unit. Runoff freely flows into catch basin.
	Media Insert Not Removing Oil	Effluent water from media insert has a visible sheen.	Effluent water from media insert is free of oils and has no visible sheen.
	Media Insert Water Saturated	Catch basin insert is saturated with water and no longer has the capacity to absorb.	Remove and replace media insert
	Media Insert-Oil Saturated	Media oil saturated due to petroleum spill that drains into catch basin.	Remove and replace media insert.
	Media Insert Use Beyond Product Life	Media has been used beyond the typical average life of media insert product.	Remove and replace media at regular intervals, depending on insert product.

Table V-A.19: Maintenance Standards - Media Filter Drain (MFD)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
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.
	No-vegetation	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.

Table V-A.19: Maintenance Standards - Media Filter Drain (MFD) (continued)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
	zone/flow spreader		
	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.
	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.
	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.
	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.
	Trash and debris	Trash and debris have accumulated on embankment.	Remove trash and debris from embankment.
	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.

Table V-A.20: Maintenance Standards - Compost Amended Vegetated Filter Strip (CAVFS)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment accumulation on grass	Sediment depth exceeds 2 inches.	Remove sediment deposits. Relevel so slope is even and flows pass evenly through strip.
	Vegetation	Grass becomes excessively tall (greater than 10 inches); nuisance weeds and other vegetation start to take over.	Mow grass and control nuisance vegetation so that flow is not impeded. Grass should be mowed to a height of 6 inches.
	Trash and debris	Trash and debris have accumulated on the vegetated filter strip.	Remove trash and debris from filter.
	Erosion/scouring	Areas have eroded or scoured due to flow channelization or high flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with a 50/50 mixture of crushed gravel and compost. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the vegetated filter strip should be regraded and reseeded. For smaller bare areas, overseed when bare spots are evident.
	Flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed over entire filter width.	Level the spreader and clean so that flows are spread evenly over entire filter width

Table V-A.21: Maintenance Standards - Bioretention Facilities

Maintenance Component	Recommended Frequency [a] Inspection	Recommended Frequency [a] Routine Maintenance	Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
Facility Footprint				
Earthen side slopes and berms	B, S		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.
	A		Erosion of sides causes slope to become a hazard	Take actions to eliminate the hazard and stabilize slopes
	A, S		Settlement greater than 3 inches (relative to undisturbed sections of berm)	Restore to design height
	A, S		Downstream face of berm wet, seeps or leaks evident	Plug any holes and compact berm (may require consultation with engineer, particularly for larger berms)
	A		Any evidence of rodent holes or water piping in berm	• Eradicate rodents (see "Pest control") • Fill holes and compact (may require consultation with engineer, particularly for larger berms)
Concrete sidewalls	A		Cracks or failure of concrete sidewalls	• Repair/ seal cracks • Replace if repair is insufficient
Rockery sidewalls	A		Rockery side walls are insecure	Stabilize rockery sidewalls (may require consultation with engineer, particularly for walls 4 feet or greater in height)
Facility area		All maintenance visits (at least biannually)	Trash and debris present	Clean out trash and debris
Facility bottom area	A, S		Accumulated sediment to 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
		During/after fall leaf drop	Accumulated leaves in facility	Remove leaves if there is a risk to clogging outlet structure or water flow is impeded
Low permeability check dams and weirs	A, S		Sediment, vegetation, or debris accumulated at or blocking (or having the potential to block) check dam, flow control weir or orifice	Clear the blockage
	A, S		Erosion and/or undercutting present	Repair and take preventative measures to prevent future erosion and/or undercutting
	A		Grade board or top of weir damaged or not level	Restore to level position

Table V-A.21: Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Ponded water	B, S		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 an engineer is recommended.
Bioretention soil mix	As needed		Bioretention soil mix 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.
Inlets/Outlets/Pipes				
Splash block inlet	A		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
Curb cut inlet/outlet	M during the wet season and before severe storm is forecasted	Weekly during fall leaf drop	Accumulated leaves at curb cuts	Clear leaves (particularly important for key inlets and low points along long, linear facilities)
Pipe inlet/outlet	A		Pipe is damaged	Repair/ replace
	W		Pipe is clogged	Remove roots or debris
	A, S		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	Accumulated leaves at inlets/outlets	Clear leaves (particularly important for key inlets and low points along long, linear facilities)
		A	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

Table V-A.21: Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency [a] Inspection	Recommended Frequency [a] Routine Maintenance	Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
Erosion control at inlet	A		Concentrated flows are causing erosion	Maintain a cover of rock or cobbles or other erosion protection measure (e.g., matting) to protect the ground where concentrated water enters the facility (e.g., a pipe, curb cut or swale)
Trash rack	S		Trash or other debris present on trash rack	Remove/dispose
	A		Bar screen damaged or missing	Repair/replace
Overflow	A, S		Capacity reduced by sediment or debris	Remove sediment or debris/dispose
Underdrain pipe	Clean pipe as needed	Clean orifice at least biannually (may need more frequent cleaning during wet season)	• Plant roots, sediment or debris reducing capacity of underdrain • Prolonged surface ponding (see "Ponded water"	• 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.
Vegetation				
Facility bottom area and upland slope vegetation	Fall and Spring		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*, (Hinman and Wulkan, 2012)). • Confirm that plant selection is appropriate for site growing conditions • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
Vegetation (general)	As needed		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 the *Pacific Northwest Plant Disease Management Handbook* (Pscheidt and Ocamb, 2016) for information on disease recognition and for additional resources • Replant as necessary according to recommendations provided for "facility bottom area and upland slope vegetation".
Trees and shrubs		All pruning seasons (timing varies by species)	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
	A		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.
	Fall and Spring		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

Table V-A.21: Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				• If specific plants have a high mortality rate, assess the cause and replace with appropriate species. Consultation with a landscape architect is recommended.
	Fall and Spring		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.
	Fall and Spring		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.
Trees and shrubs adjacent to vehicle travel areas (or areas where visibility needs to be maintained)	A		Vegetation causes some visibility (line of sight) or driver safety issues	• Maintain appropriate height for sight clearance • When continued, 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
Flowering plants		A	Dead or spent flowers present	Remove spent flowers (deadhead)
Perennials		Fall	Spent plants	Cut back dying or dead and fallen foliage and stems
Emergent vegetation		Spring	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)
Ornamental grasses (perennial)		Winter and Spring	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
Ornamental grasses (evergreen)		Fall and Spring	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
Noxious weeds		M (March - October, preceding seed dispersal)	Listed noxious vegetation is present (refer to current county 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")
Weeds		M (March - October,	Weeds are present	• Remove weeds with their roots manually with pincer-type weeding tools, flame weeders, or hot water weeders as

Table V-A.21: Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
		preceding seed dispersal)		appropriate • Follow IPM protocols for weed management (see "Additional Maintenance Resources" section for more information on IPM protocols)
Excessive vegetation		Once in early to mid- May and once in early- to mid-September	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
	As needed		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 planting 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 blocking curb cuts, causing excessive sediment buildup and flow bypass	Remove vegetation and sediment buildup
Mulch				
Mulch		Following weeding	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
Watering				
Irrigation system (if any)		Based on manufacturer's instructions	Irrigation system present	Follow manufacturer's instructions for O&M
	A		Sprinklers or drip irrigation not directed/located to properly water plants	Redirect sprinklers or move drip irrigation to desired areas
Summer watering (first year)		Once every 1-2 weeks or as needed during prolonged dry periods	Trees, shrubs and groundcovers in 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

Table V-A.21: Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				◦ 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
Summer watering (second and third years)		Once every 2-4 weeks or as needed during prolonged dry periods	Trees, shrubs and groundcovers in 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
Summer watering (after establishment)		As needed	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
Pest Control				
Mosquitoes	B, S		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 storm drainage system (if runoff is from non pollution-generating surfaces) or sanitary sewer system (if runoff is from pollution-generating surfaces) after getting approval from sanitary sewer authority. • Use of pesticides or *Bacillus thuringiensis israelensis* (Bti) may be considered only as a temporary measure while addressing the standing water cause. If overflow to a surface water will occur within 2 weeks after pesticide use, apply for coverage under the Aquatic Mosquito Control NPDES General Permit.
Nuisance animals	As needed		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 (see "Additional Maintenance Resources" section for more information on IPM protocols) • Remove pet waste regularly • For public and right-of-way sites consider adding garbage cans with dog bags for picking up pet waste.
Insect pests	Every site visit associated with		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 (see "Additional Maintenance Resources" section for more information on IPM

Table V-A.21: Maintenance Standards - Bioretention Facilities (continued)

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
	vegetation management			protocols)
Note that the inspection and routine maintenance frequencies listed above are recommended by Ecology. They do not supersede or replace the municipal stormwater permit requirements for inspection frequency required of municipal stormwater permittees for "stormwater treatment and flow control BMPs/facilities". [a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least one visit should occur during the wet season (for debris/clog related maintenance, this inspection/maintenance visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval). IPM - Integrated Pest Management ISA - International Society of Arboriculture				

Table V-A.22: Maintenance Standards - Permeable Pavement

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Surface/Wearing Course				
Permeable Pavements, all	A, S		Runoff from adjacent pervious areas deposits soil, mulch or sediment on paving	• Clean deposited soil or other materials from permeable pavement or other adjacent surfacing • Check if surface elevation of 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
Porous asphalt or pervious concrete		A or B	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 when equipment is most effective for cleaning permeable pavement. Dry weather is more effective for some equipment.
	A[b]		Surface is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)	• 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:

Table V-A.22: Maintenance Standards - Permeable Pavement (continued)

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				◦ 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 Note: If the annual/biannual routine maintenance standard to clean the pavement surface is conducted using equipment from the list above, corrective maintenance may not be needed.
	A		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).
	Summer		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.
	A		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
Interlocking concrete paver blocks and aggregate pavers		A or B	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.
	A[b]		Surface is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)	• 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.

Table V-A.22: Maintenance Standards - Permeable Pavement (continued)

Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				• 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
	A		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).
	Summer		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
	A		Paver block missing or damaged	Remove individual damaged paver blocks by hand and replace or repair per manufacturer's recommendations
	A		Loss of aggregate material between paver blocks	Refill per manufacturer's recommendations for interlocking paver sections
	A		Settlement of surface	May require resetting
Open-celled paving grid with gravel		A or B	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.
	A_b		Aggregate is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)	• Use vacuum truck to remove and replace top course aggregate • Replace aggregate in paving grid per manufacturer's recommendations
	A		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.
	A		Settlement of surface	May require resetting
	A		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.
		A	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)
Open-celled paving grid with grass		A or B	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.

Table V-A.22: Maintenance Standards - Permeable Pavement (continued)

Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
	A b		Aggregate is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)	Rehabilitate per manufacturer's recommendations.
	A		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.
	A		Settlement of surface	May require resetting
	A		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	None (routine maintenance)	Use a mulch mower to mow grass
		A	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
		A	Weeds present	• Manually remove weeds • Mow, torch, or inoculate and replace with preferred vegetation
Inlets/Outlets/Pipes				
Inlet/outlet pipe	A		Pipe is damaged	Repair/replace
	A		Pipe is clogged	Remove roots or debris
Underdrain pipe	Clean pipe as needed	Clean orifice at least biannually (may need more frequent cleaning during wet season)	Plant roots, sediment or debris 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
Raised subsurface overflow pipe	Clean pipe as needed	Clean orifice at least biannually (may need more frequent cleaning during wet season)	Plant roots, sediment or debris 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
Outlet structure	A, S		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
Overflow	B		Native soil is exposed or other signs of erosion damage are present at discharge point	Repair erosion and stabilize surface
Aggregate Storage Reservoir				
Observation port	A, S		Water remains in the storage aggregate longer than anticipated by design after the end of a storm	If immediate cause of extended ponding is not identified, schedule investigation of subsurface materials or other potential causes of system failure.

Table V-A.22: Maintenance Standards - Permeable Pavement (continued)

Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Vegetation				
Adjacent large shrubs or trees		As needed	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
		Once in May and Once in September	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.
Leaves, needles, and organic debris		In fall (October to December) after leaf drop (1-3 times, depending on canopy cover)	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

Note that the inspection and routine maintenance frequencies listed above are recommended by Ecology. They do not supersede or replace the municipal stormwater permit requirements for inspection frequency required of municipal stormwater permittees for "stormwater treatment and flow control BMPs/facilities".

a Frequency: A= Annually; B= Biannually (twice per year); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

b Inspection should occur during storm event.

Table V-A.23: Maintenance Standards - Vegetated Roofs

Activity	Objective	Schedule	Notes
Structural and Drainage Components			
Clear inlet pipes: Remove soil substrate, vegetation or other debris.	Maintain free drainage of inlet pipes.	Twice annually.	
Inspect drain pipe: Check for cracks settling and proper alignment, and correct and re-compact soils or fill material surrounding pipe, if necessary.	Maintain free drainage of inlet pipes.	Twice annually.	
Inspect fire ventilation points for proper operation	Fire and safety.	Twice annually.	
Maintain egress and ingress: Clear routes of obstructions and maintained to design standards.	Fire and safety.	Twice annually.	
Insects: (see note)			Roof garden design should provide drainage rates that do not allow pooling of water for periods that promote insect larvae development. If standing water is present for extended periods correct drainage problem. Chemical sprays should not be used.
Prevent release of contaminants: Identify activities (mechanical systems maintenance, pet access, etc.) that can potentially release pollutants to the roof garden and establish agreements to prevent release.	Water quality protection.	During construction of roof and then as determined by inspection.	Any cause of pollutant release should be corrected as soon as identified and the pollutant removed.
Vegetation and Growth Medium			
Invasive or nuisance plants: Remove manually and without herbicide applications.	Promote selected plant growth and survival, maintain aesthetics.	Twice annually.	At a minimum, schedule weeding with inspections to coincide with important horticultural cycles (e.g., prior to major weed varieties dispersing seeds).

Table V-A.23: Maintenance Standards - Vegetated Roofs (continued)

Activity	Objective	Schedule	Notes
Removing and replacing dead material: (see note)	See note.	Once annually.	Normally, dead plant material will be recycled on the roof; however specific plants or aesthetic considerations may warrant removing and replacing dead material (see manufacturer's recommendations).
Fertilization: If necessary apply by hand (see note)	Plant growth and survival.	Determined by inspection.	Extensive roof gardens should be designed to not require fertilization after plant establishment. If fertilization is necessary during plant establishment or for plant health and survivability after establishment, use an encapsulated, slow release fertilizer (excessive fertilization can contribute to increased nutrient loads in the stormwater system and receiving waters).
Mulching: (see note)			Avoid application of mulch on extensive roof gardens. Mulch should be used only in unusual situations and according to the roof garden provider guidelines. In conventional landscaping mulch enhances moisture retention; however, moisture control on a vegetated roof should be through proper soil/growth media design. Mulch will also increase establishment of weeds.
Irrigate: Use subsurface or drip irrigation.		Determined by inspection and only when absolutely necessary for plant survival.	Surface irrigation systems on extensive roof gardens can promote weed establishment, root development near the drier surface layer of the soil substrate, and increase plant dependence on irrigation. Accordingly, subsurface irrigation methods are preferred. If surface irrigation is the only method available, use drip irrigation to deliver water to the base of the plant.
Source: Eastern Washington LID Guidance Manual (June 2013)			

Glossary

The following terms are provided for reference and use with this manual. They may be superseded by any other definitions for these terms adopted by local ordinance, unless the terms match the definitions provided by a Washington State WAC or RCW.

- A -- B -- C -- D -- E -- F -- G -- H -- I -- J -- K -- L -- M -- N -- O -- P -- Q -- R -- S -- T -- U -- V -- W -- X -- Y -- Z -

- A -

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 the dissolving of a soluble gas in a liquid.

Adjacent steep slope

A slope with a gradient of 15 percent or steeper within five hundred feet of the site.

Adjustment

A variation in the application of a Minimum Requirement to a particular project. Adjustments provide substantially equivalent environmental protection.

Administrator

The local government official(s) authorized to make decisions in regard to Adjustments and Exceptions/Variances.

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.

Aggressive plant species

Opportunistic species of inferior biological value that tend to out compete more desirable forms and become dominant; applied to native species in this manual.

AKART

All known, available, and reasonable methods of prevention, control, and treatment.

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.

Annual flood

The highest peak discharge on average which can be expected in any given year.

Antecedent moisture conditions

The degree of wetness of a watershed or within the soil at the beginning of a storm.

Anti-seep collar

A device constructed around a pipe or other conduit and placed through a dam, levee, or dike for the purpose of reducing seepage losses and piping failures.

Anti-vortex device

A facility placed at the entrance to a pipe conduit structure such as a drop inlet spillway or hood inlet spillway to prevent air from entering the structure when the pipe is flowing full.

Applicable BMPs

As used in Volume IV, applicable BMPs are those source control BMPs that are expected to be required by local governments at new development and redevelopment sites. Applicable BMPs will also be required if they are incorporated into NPDES permits, or they are included by local governments in a stormwater program for existing facilities.

Applicant

The person who has applied for a development permit or approval.

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.

Aquifer

A geologic stratum containing ground water that can be withdrawn and used for human purposes.

Arterial

A road or street primarily for through traffic. The term generally includes roads or streets considered collectors. It does not include local access roads which are generally limited to providing access to abutting property. See also RCW 35.78.010, RCW 36.86.070, and RCW 47.05.021.

As-built drawings

Engineering plans which have been revised to reflect all changes to the plans which occurred during construction.

As-graded

The extent of surface conditions on completion of grading.

ATB

Asphalt Treated Base

- B -

Background

A description of pollutant levels arising from natural sources, and not because of man's immediate 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.

Bankfull discharge

A flow condition where streamflow completely fills the stream channel up to the top of the bank. In undisturbed watersheds, the discharge conditions occur on average every 1.5 to 2 years and controls the shape and form of natural channels.

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 1983 (NGVD).

Baseline sample

A sample collected during dry-weather flow (i.e., it does not consist of runoff from a specific precipitation event).

Basin plan

A plan that assesses, evaluates, and proposes solutions to existing and potential future impacts to the beneficial uses of, and the physical, chemical, and biological properties of waters of the state within a basin. Basins typically range in size from 1 to 50 square miles. A plan should include but not be limited to recommendations for:

- Stormwater requirements for new development and redevelopment;
- Capital improvement projects;
- Land Use management through identification and protection of critical areas, comprehensive land use and transportation plans, zoning regulations, site development standards, and conservation areas;
- Source control activities including public education and involvement, and business programs;
- Other targeted stormwater programs and activities, such as maintenance, inspections and enforcement;
- Monitoring; and
- An implementation schedule and funding strategy.

A plan that is “adopted and implemented” must have the following characteristics:

- It must be adopted by legislative or regulatory action of jurisdictions with responsibilities under the plan;

- Ordinances, regulations, programs, and procedures recommended by the plan should be in effect or on schedule to be in effect; and,
- An implementation schedule and funding strategy that are in progress.

Bearing capacity

The maximum load that a material can support before failing.

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.

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 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.

BFM

Bonded Fiber Matrix

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.

Biological magnification

The increasing concentration of a substance along succeeding steps in a food chain. Also called biomagnification.

Bioretention BMPs

Engineered facilities that treat stormwater by passing it through a specified soil profile, and either retain or detain the treated stormwater for flow attenuation. Refer to BMP T7.30: Bioretention for Bioretention BMP types and design specifications.

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 includes a material derived from biosolids, and septic tank sludge, also known as septage, that can be beneficially recycled and meets all applicable requirements under Chaper 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.

BMPs

Best Management Practices

Bollard

A post (may or may not be removable) used to prevent vehicular access.

Bond

A surety bond, cash deposit or escrow account, assignment of savings, irrevocable letter of credit or other means acceptable to or required by the manager to guarantee that work is completed in compliance with the project's drainage plan and in compliance with all local government requirements.

Borrow area

A source of earth fill material used in the construction of embankments or other earth fill structures.

BSBL

Building Setback Line

Buffer

The zone contiguous with a sensitive area that is required for the continued maintenance, function, and structural stability of the sensitive area. The critical functions of a riparian buffer (those associated with an aquatic system) include shading, input of organic debris and coarse sediments, uptake of nutrients, stabilization of banks, interception of fine sediments, overflow during high water events, protection from disturbance by humans and domestic animals, maintenance of wildlife habitat, and room for variation of aquatic system boundaries over time due to hydrologic or climatic effects. The critical functions of terrestrial buffers include protection of slope stability, attenuation of surface water flows from stormwater runoff and precipitation, and erosion control.

Building setback line (BSBL)

A line measured parallel to a property, easement, drainage 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.

- C -

Capital Improvement Project or Program (CIP)

A project prioritized and scheduled as a part of an overall construction program or, the actual construction program.

Catch basin

A chamber or well, usually built at the curb line of a street, for the admission of surface water to a sewer or subdrain, having at its base a sediment sump designed to retain grit and detritus below the point of overflow.

Catchline

The point where a severe slope intercepts a different, more gentle slope.

Catchment

Surface drainage area.

Cation Exchange Capacity (CEC)

The amount of exchangeable cations that a soil can absorb. Units are milli-equivalents per 100 g of soil, typically abbreviated simply as meq. 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 has 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). A CESCL is knowledgeable in the principles and practices of erosion and sediment control. The CESCL must have the skills to assess site conditions and construction activities that could impact the quality of stormwater and, the effectiveness of erosion and sediment control measures used to control the quality of stormwater discharges. Certification is obtained through an Ecology approved erosion and sediment control course. Course listings are provided online at Ecology's website.

CESCL

Certified Erosion and Sediment Control Lead

CESCP

Contractor's Erosion and Sediment Control Plan

CFR

Code of Federal Regulations

Channel

A feature that conveys surface water and is open to the air.

Channel stabilization

Erosion prevention and stabilization of velocity distribution in a channel using vegetation, jetties, drops, revetments, and/or other measures.

Channel storage

Water temporarily stored in channels while enroute to an outlet.

Channel, constructed

Channels or ditches constructed (or reconstructed natural channels) to convey surface water.

Channel, natural

Streams, creeks, or swales that convey surface/ground water and have existed long enough to establish a stable route and/or biological community.

Channelization

Alteration of a stream channel by widening, deepening, straightening, cleaning, or paving certain areas to change flow characteristics.

Check dam

Small dam constructed in a gully 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.

CIP

Capital Improvement Project

Civil engineer

A professional engineer licensed in the State of Washington in Civil Engineering.

Civil engineering

The application of the knowledge of the forces of nature, principles of mechanics and the properties of materials to the evaluation, design and construction of civil works for the beneficial uses of mankind.

Clay lens

A naturally occurring, localized area of clay which acts as an impermeable layer to runoff infiltration.

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, surface water 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 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 drainage ditches related to an existing and ongoing agricultural activity.

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) phase 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 development 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) projects in a contiguous area 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; and 4) 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 in determining permit requirements.

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.

Compensatory storage

New excavated storage volume equivalent to the flood storage capacity eliminated by filling or grading within the flood fringe. Equivalent shall mean that the storage removed shall be replaced by equal volume between corresponding one-foot contour intervals that are hydraulically connected to the floodway through their entire depth.

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.)

Comprehensive planning

Planning that takes into account all aspects of water, air, and land resources and their uses and limits.

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

Those wetlands intentionally created on sites that are not wetlands for the primary purpose of wastewater or stormwater treatment and managed as such. Constructed wetlands are normally considered as part of the stormwater collection and treatment system.

Construction Stormwater Pollution Prevention Plan

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.

Converted vegetation (areas)

The surfaces on a project site where native vegetation, pasture, scrub/shrub, or unmaintained non-native vegetation (e.g., Himalayan blackberry, 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 drainage facilities, both natural and man-made, which collect, contain, and provide for the flow of surface and stormwater from the highest points on the land down to a receiving water. The natural elements of the conveyance system include swales and small drainage courses, streams, rivers, lakes, and wetlands. The human-made elements of the conveyance system include gutters, ditches, pipes, channels, and most retention/detention facilities.

Cover crop

A close-growing crop grown primarily for the purpose of protecting and improving soil between periods of permanent vegetation.

CPESC

Certified Professional in Erosion and Sediment Control

Created wetland

Means those wetlands intentionally created from nonwetland sites to produce or replace natural wetland habitat (e.g., compensatory mitigation projects).

Critical Areas

At a minimum, areas which include wetlands, 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 Drainage Area

An area with such severe flooding, drainage and/or erosion/sedimentation conditions that the area has been formally adopted as a Critical Drainage Area by rule under the procedures specified in an ordinance.

Critical reach

The point in a receiving stream below a discharge point at which the lowest dissolved oxygen level is reached and stream recovery begins.

CSWGP

Construction Stormwater General Permit

Culvert

Pipe or concrete box structure that drains open channels, swales or ditches under a roadway or embankment. Typically with no catch-basins 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.

- D -

Dead storage

The volume available in a depression in the ground below any conveyance system, or surface drainage pathway, or outlet invert elevation that could allow the discharge of surface and stormwater runoff.

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 (disturbed) wetland (community)

A wetland (community) 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.

Denitrification

The biochemical reduction of nitrates or nitrites in the soil or organic deposits to ammonia or free nitrogen.

Depression storage

The amount of precipitation that is trapped in depressions on the surface of the ground.

Designer

The professional civil engineer licensed in the State of Washington who prepares the analysis, design, and engineering plans for an applicant's permit or approval submittal.

Design storm

A prescribed hyetograph and 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 drainage, designing new drainage facilities or assessing other impacts of a proposed project on the flow of surface water. (A hyetograph is a graph of percentages of total precipitation for a series of time steps representing the total time during which the precipitation occurs.)

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 facility

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.

Discharge

Runoff leaving a new development or redevelopment 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 point

The location where a discharge leaves the Permittee’s MS4 through the Permittee’s MS4 facilities/BMPs designed to infiltrate.

Dispersion

Release of surface and stormwater runoff such that the flow spreads over a wide area and is located so as not to allow flow to concentrate anywhere upstream of a drainage channel with erodible underlying granular soils.

Ditch

A long narrow excavation dug in the earth for drainage with its top width less than 10 feet at design flow.

Divide, Drainage

The boundary between one drainage basin and another.

DNS

See Determination of Nonsignificance.

Drain

A buried pipe or other conduit (closed drain). A ditch (open drain) for carrying off surplus surface water or ground water.

(To) Drain

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

Refers to the collection, conveyance, containment, and/or discharge of surface and stormwater runoff.

Drainage basin

A geographic and hydrologic subunit of a watershed.

Drainage channel

A drainage pathway with a well-defined bed and banks indicating frequent conveyance of surface and stormwater runoff.

Drainage course

A pathway for watershed drainage characterized by wet soil vegetation; often intermittent in flow.

Drainage easement

A legal encumbrance that is placed against a property's title to reserve specified privileges for the users and beneficiaries of the drainage facilities contained within the boundaries of the easement.

Drainage pathway

The route that surface and stormwater runoff follows downslope as it leaves any part of the site.

Drainage review

An evaluation by Plan Approving Authority staff of a proposed project's compliance with the drainage requirements in this manual or its technical equivalent.

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 ground water flow) resulting from a withdrawal of water.

Drop-inlet spillway

Overall structure in which the water drops through a vertical riser connected to a discharge conduit.

Drop spillway

Overall structure in which the water drops over a vertical wall onto an apron at a lower elevation.

Drop structure

A structure for dropping water to a lower level and dissipating its surplus energy; a fall. A drop may be vertical or inclined.

Dry weather flow

The combination of ground water seepage and allowed non-stormwater flows found in storm sewers during dry weather. Also that flow in streams during the dry season.

- E -

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 D5268 specifications. Engineered soil/landscape systems are also defined independently.

Easement

The legal right to use a parcel of land for a particular purpose. It does not include fee ownership, but may restrict the owners use of the land.

Ecology

Washington State Department of Ecology

Effective impervious surface

Those impervious surfaces that are connected via sheet flow or discrete conveyance to a drainage system. Impervious surfaces are considered ineffective if:

1. the runoff is dispersed through at least one hundred feet of native vegetation in accordance with BMP T5.30: Full Dispersion;
2. residential roof runoff is infiltrated in accordance with BMP T5.10A: Downspout Full Infiltration; or
3. approved continuous runoff modeling methods indicate that the entire runoff file is infiltrated.

EIS

See Environmental Impact Statement.

Embankment

A structure of earth, gravel, or similar material raised to form a pond bank or foundation for a road.

Emergency spillway

A vegetated earth channel used to safely convey flood discharges in excess of the capacity of the principal spillway.

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.

Emerging technology

Treatment technologies that have not been evaluated with approved protocols, but for which preliminary data indicate that they may provide a necessary function(s) in a stormwater treatment system. Emerging technologies need additional evaluation to define design criteria to achieve, or to contribute to achieving, state performance goals, and to define the limits of their use.

Energy dissipator

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).

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.

The engineered soil/plant system shall have the following characteristics:

a. Be protected from compaction and erosion.

b. Have a plant system to support a sustained soil quality.

c. 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 D3385). D is less than 0.6 inches/hour.

d. 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 D2974).

Engineering geology

The application of geologic knowledge and principles in the investigation and evaluation of naturally occurring rock and soil for use in the design of civil works.

Engineering plan

A plan prepared and stamped by a professional civil engineer.

Enhancement

To raise value, desirability, or attractiveness of an environment associated with surface water.

Environmental Impact Statement (EIS)

A document that discusses the likely significant adverse impacts of a proposal, ways to lessen the impacts, and alternatives to the proposal. They are required by the national and state environmental policy acts when projects are determined to have significant environmental impact.

EPA

U.S. Environmental Protection Agency

Erodible granular soils

Soil materials that are easily eroded and transported by running water, typically fine or medium grained sand with minor gravel, silt, or clay content. Such soils are commonly described as Everett or Indianola series soil types in the SCS classification. Also included are any soils showing examples of existing severe stream channel incision as indicated by unvegetated streambanks standing over two feet high above the base of the channel.

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 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., 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.

- Normal erosion - The gradual erosion of land used by man which does not greatly exceed natural 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 run-off.
- 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 facility

A type of drainage facility 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.

Erosion and sedimentation 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 classes (soil survey)

A grouping of erosion conditions based on the degree of erosion or on characteristic patterns. Applied to accelerated erosion, not to normal, natural, or geological erosion. Four erosion classes are recognized for water erosion and three for wind erosion.

ESA

The Federal Endangered Species Act

ESC

Erosion and Sediment Control (Plan).

Escarpment

A steep face or a ridge of high land.

Estuarine wetland

Generally, an eelgrass bed; salt marsh; or rocky, sandflat, or mudflat intertidal area where fresh and salt water mix. (Specifically, a tidal wetland with salinity greater than 0.5 parts per thousand, usually semi-enclosed by land but with partially obstructed or sporadic access to the open ocean).

Estuary

An area where fresh water meets salt water, or where the tide meets the river current (e.g., bays, mouths of rivers, salt marshes, and lagoons). Estuaries serve as nurseries and spawning and feeding grounds for large groups of marine life and provide shelter and food for birds and wildlife.

Eutrophication

Refers to the process where nutrient over-enrichment of water leads to excessive growth of aquatic plants, especially algae.

Evapotranspiration

The collective term for the processes of evaporation and plant transpiration by which water is returned to the atmosphere.

Excavation

The mechanical removal of earth material.

Exception

Relief from the application of a Minimum Requirement to a project.

Exfiltration

The downward movement of runoff through the bottom of an infiltration BMP into the soil layer or the downward movement of water through soil.

- F -

FCWA

Federal Clean Water Act

FEMA

Federal Emergency Management Agency

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 nonwoven, 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 fabric fence

A temporary sediment barrier consisting of a filter fabric stretched across and attached to supporting posts and entrenched. The filter fence is constructed of stakes and synthetic filter fabric with a rigid wire fence backing where necessary for support. Also commonly referred to in the Washington Department of Transportation standard specifications as "construction geotextile for temporary silt fences."

Filter strip

A grassy area with gentle slopes that treats stormwater runoff from adjacent paved areas before it concentrates into a discrete channel.

FIRM

See Flood Insurance Rate Map.

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, storm drains, or excess rainfall. Any relatively high stream flow overtopping the natural or artificial banks in any reach of a stream.

Flood-proofing

Adaptations that ensure a structure is substantially impermeable to the passage of water below the flood protection elevation that resists hydrostatic and hydrodynamic loads and effects of buoyancy.

Flood control

Methods or facilities for reducing flood flows and the extent of flooding.

Flood control project

A structural system installed to protect land and improvements from floods by the construction of dikes, river embankments, channels, or dams.

Flood frequency

The frequency with which the flood of interest may be expected to occur at a site in any average interval of years. Frequency analysis defines the "n-year flood" as being the flood that will, over a long period of time, be equaled or exceeded on the average once every "n" years.

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.

Flood Insurance Rate Map (FIRM)

The official map on which the Federal Emergency Management Agency has delineated many areas of flood hazard, floodway, and the risk premium zones.

Flood Insurance Study

The official report provided by the Federal Emergency Management Agency that includes flood profiles and the FIRM.

Flood peak

The highest value of the stage or discharge attained by a flood; thus, peak stage or peak discharge.

Flood protection elevation

The base flood elevation or higher as defined by the local government.

Flood protection facility

Any levee, berm, wall, enclosure, raise bank, revetment, constructed bank stabilization, or armoring, that is commonly recognized by the community as providing significant protection to a property from inundation by flood waters.

Flood routing

An analytical technique used to compute the effects of system storage dynamics on the shape and movement of flow represented by a hydrograph.

Flood stage

The stage at which overflow of the natural banks of a stream begins.

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 BMP (or facility)

A drainage facility designed to mitigate the impacts of increased surface and stormwater runoff flow rates 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 flow rate of interest. For example, the amount of time that peak flows are at or above 50% of the 2-year peak flow rate 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.

Flow path

The route that stormwater runoff follows between two points of interest.

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:

a. Road and trail construction.

b. Harvesting, final and intermediate.

c. Precommercial thinning.

d. Reforestation.

e. Fertilization.

f. Prevention and suppression of diseases and insects.

g. Salvage of trees.

h. Brush control.

Forested communities (wetlands)

In general terms, communities (wetlands) characterized by woody vegetation that is greater than or equal to 6 meters in height; in this manual the term applies to such communities (wetlands) that represent a significant amount of tree cover consisting of species that offer wildlife habitat and other values and advance the performance of wetland functions overall.

Freeboard

The vertical distance between the highest designed water surface elevation and the elevation of the crest of the facility. For example, in pond design, freeboard is the vertical distance between the emergency overflow water surface and the top of the pond embankment.

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. Sewers designed to handle flows that occur under such storm conditions would be expected to be surcharged by any storms of greater amount or intensity.

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.

Frost-heave

The upward movement of soil surface due to the expansion of water stored between particles in the first few feet of the soil profile as it freezes. May cause surface fracturing of asphalt or concrete.

Fully controlled limited access highway

A highway where the right of owner or occupants of abutting land or other persons to access, light, air, or view in connection with the highway is controlled to give preference to through traffic by providing access connections with selected public roads only, and by prohibiting crossings or direct private driveway connections at grade. (See WAC 468-58-010)

Function(s)

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, ground water recharge and discharge, water quality improvement, and soil stabilization.

- G -

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

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.

Gaging station

A selected section of a stream channel equipped with a gage, recorder, or other facilities for determining stream discharge.

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.

Geologist

A person who has earned a degree in geology from an accredited college or university or who has equivalent educational training and has at least five years of experience as a practicing geologist or four years of experience and at least two years post-graduate study, research or teaching. The practical experience shall include at least three years work in applied geology and landslide evaluation, in close association with qualified practicing geologists or geotechnical professional/civil engineers.

Geometrics

The mathematical relationships between points, lines, angles, and surfaces used to measure and identify areas of land.

Geotechnical professional civil engineer

A practicing, geotechnical/civil engineer licensed as a professional Civil Engineer with the State of Washington who has at least four years of professional employment as a geotechnical engineer in responsible charge, including experience with landslide evaluation.

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.

(To) Grade

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 flow rate. See also biofilter.

Ground water

Water in a saturated zone or stratum beneath the land surface or a surface waterbody.

Ground water protection area

The area surrounding a drinking water source evaluated as part of SSC-2 Ground Water Protection Areas that includes the wellhead protection area and may also include aquifer sensitive areas, sole source aquifers, ground water management areas, or critical aquifer recharge areas.

Ground water recharge

Inflow to a ground water reservoir.

Ground water table

The free surface of the ground water, 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.

- H -

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.

Hard surface

An impervious surface, a permeable pavement, or a vegetated roof.

Hardpan

A cemented or compacted and often clay-like layer of soil that is impenetrable by roots. Also known as glacial till.

Harmful pollutant

A substance that has adverse effects to an organism including immediate death, chronic poisoning, impaired reproduction, cancer or other effects.

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-use site

High-use sites are those that typically generate high concentrations of oil due to high traffic turnover or the frequent transfer of oil. 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;
- 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 improvements.

Highway

A main public road connecting towns and cities.

Hog fuel

Wood-based mulch.

HSPF

Hydrological Simulation Program-Fortran. A continuous simulation hydrologic model that transforms an uninterrupted rainfall record into a concurrent series of runoff or flow data by means of a set of mathematical algorithms which represent the rainfall-runoff process at some conceptual level.

Humus

Organic matter in or on a soil, composed of partly or fully decomposed bits of plant tissue or from animal manure.

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

Means the dynamic energy, force, or motion of fluids as affected by the physical forces acting upon those fluids.

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.

(Novotny and Olem, 1994)

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.

- I -

IECA

International Erosion Control Association

Illicit discharge

All non-stormwater discharges to stormwater drainage systems that cause or contribute to a violation of state water quality, sediment quality or ground water quality standards, including but not limited to sanitary sewer connections, industrial process water, interior floor drains, car washing, and greywater systems.

Impact basin

A device used to dissipate the energy of flowing water. Generally constructed of concrete in the form of a partially depressed or partially submerged vessel, it may utilize baffles to dissipate velocities.

Impervious

A surface which cannot be easily penetrated. For instance, rain does not readily penetrate paved surfaces.

Impervious surface

A non-vegetated surface area which either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development. A non-vegetated 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, roof tops, 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.

Impoundment

A natural or man-made containment for surface water.

Improvement

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.

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.

Infiltration

Means the downward movement of water from the surface to the subsoil.

Infiltration facility (or system)

A drainage 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 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.

Ingress/egress

The points of access to and from a property.

Inlet

A form of connection between surface of the ground and a drain or sewer for the admission of surface and stormwater runoff.

Insecticide

A substance, usually chemical, that is used to kill insects.

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 weedy plant species

Opportunistic species of inferior biological value that tend to out compete more desirable forms and become dominant; applied to non native species in this manual.

Invert

The lowest point on the inside of a sewer or other conduit.

Invert elevation

The vertical elevation of a pipe or orifice in a pond that defines the water level.

Isopluvial map

A map with lines representing constant depth of total precipitation for a given return frequency.

- J -

- K -

- L -

Lag time

The interval between the center of mass of the storm precipitation and the peak flow of the resultant runoff.

Lake

An 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.

Land disturbing activity

Any activity that results in a change in the existing soil cover (both vegetative and non-vegetative) and/or the 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. Stormwater facility maintenance is not considered land disturbing activity if conducted according to established standards and procedures.

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.

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 garbage dumpster leakage.

Leachate

Liquid that has percolated through soil and contains substances in solution or suspension.

Leaching

Removal of the more soluble materials from the soil 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 pool routing

The basic technique of storage routing used for sizing and analyzing detention storage and determining water levels for ponding water bodies. The level pool routing technique is based on the continuity equation: Inflow – Outflow = Change in storage.

Level spreader

A temporary ESC 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.

LID

See Low Impact Development

Local government

Any county, city, town, or special purpose district having its own incorporated government for local affairs.

Low flow channel

An incised or paved channel from inlet to outlet in a dry basin which is designed to carry low runoff flows and/or baseflow, directly to the outlet without detention.

Low Impact Development (LID)

A stormwater and land use management strategy that strives to mimic pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration by emphasizing conservation, use of on-site 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 pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration. LID BMPs include, but are not limited to:

- BMP T7.30: Bioretention,
- BMP T5.14: Rain Gardens,
- BMP T5.15: Permeable Pavements,
- BMP T5.10A: Downspout Full Infiltration,
- BMP T5.10B: Downspout Dispersion Systems,

- BMP T5.10C: Perforated Stub-out Connections
- BMP T5.30: Full Dispersion,
- BMP T5.13: Post-Construction Soil Quality and Depth,
- BMP T5.19: Minimal Excavation Foundations,
- BMP T5.17: Vegetated Roofs, and
- BMP T5.20: Rainwater Harvesting.

Low Impact Development (LID) Principles

Land use management strategies that emphasize conservation, use of on-site natural features, and site planning to minimize impervious surfaces, native vegetation loss, and stormwater runoff.

Low permeability liner

A layer of compacted till, compacted clay, concrete, or a geomembrane.

Lowest floor

The lowest enclosed area (including basement) of a structure. An area used solely for parking of vehicles, building access, or storage, in an area other than a basement area, is not considered a building's lowest floor, provided that the enclosed area meets all of the structural requirements of the flood hazard standards.

- M -

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. Those usual activities may include replacement of dysfunctional 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. One example is the replacement of a collapsed, fish blocking, round culvert with a new box culvert under the same span, or width, of roadway. In regard to 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 defects as identified in the BMP design guidance. See also Pavement Maintenance exemptions in I-3.2 Exemptions.

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.

Mass wasting

The movement of large volumes of earth material downslope.

Master drainage plan

A comprehensive drainage control plan intended to prevent significant adverse impacts to the natural and manmade drainage system, both on and off-site.

MBFM

Mechanically Bonded Fiber Matrix

MDNS

A Mitigated Determination of Nonsignificance (See DNS and Mitigation).

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.

Measuring weir

A shaped notch through which water flows are measured. Common shapes are rectangular, trapezoidal, and triangular.

Mechanical analysis

The analytical procedure by which soil particles are separated to determine the particle size distribution.

Mechanical practices

Soil and water conservation practices that primarily change the surface of the land or that store, convey, regulate, or dispose of runoff water without excessive erosion.

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.

Min.

Minimum

Mitigation

Means, in the following order of preference:

a. Avoiding the impact altogether by not taking a certain action or part of an action;

b. 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;

c. Rectifying the impact by repairing, rehabilitating or restoring the affected environment;

d. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and

e. Compensating for the impact by replacing, enhancing, or providing substitute resources or environments.

Modification, 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 the visual appeal of the area.

Types of mulches used in this manual include: Chipped site vegetation, compost, hydromulch, wood-based or wood straw, wood strand, straw, and aggregate.

Multifamily property

A parcel that contains four or more residential dwelling units.

- N -

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 Records Division.

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 location

Means the location of those channels, swales, and other non-manmade 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. In the case of outwash soils with relatively flat terrain, no natural location of surface discharge may exist.

New development

Land disturbing activities, including Class IV-general forest practices that are conversions from timberland to other uses; structural development, including construction or installation of a building or other structure; creation of hard surfaces; and subdivision, short subdivision and binding site plans, as defined and applied in Chapter 58.17 RCW. Projects meeting the definition of redevelopment shall not be considered new development.

New impervious surface

A surface that is:

- changed from a pervious surface to an impervious surface (e.g. resurfacing by upgrading from dirt to gravel, a bituminous surface treatment ("chip seal"), asphalt, concrete, or an impervious structure); or
- upgraded from gravel to chip seal, asphalt, concrete, or an impervious structure; or
- upgraded from chip seal to asphalt, concrete, or an impervious structure.

Note that if asphalt or concrete has been overlaid by a chip seal, the existing condition should be considered as asphalt or concrete.

NGPE

See Native Growth Protection Easement.

NGVD

National Geodetic Vertical Datum.

Nitrate (NO_3)

A form of nitrogen which is an essential nutrient to plants. It can cause algal blooms in water if all other nutrients are present in sufficient quantities. It is a product of bacterial oxidation of other forms of nitrogen, from the atmosphere during electrical storms and from fertilizer manufacturing.

Nitrification

The biochemical oxidation process by which ammonia is changed first to nitrites and then to nitrates by bacterial action, consuming oxygen in the water.

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.

NOEC

No observed effects concentration

NOI

Notice of Intent

Nonpoint source pollution

Pollution that enters a waterbody from diffuse origins on the watershed and does not result from discernible, confined, or discrete conveyances.

Normal depth

The depth of uniform flow. This is a unique depth of flow for any combination of channel characteristics and flow conditions. Normal depth is calculated using Manning's Equation.

NPDES

The National Pollutant Discharge Elimination System as established by the Federal Clean Water Act.

NRCS Method

A single-event hydrologic analysis technique for estimating runoff based on the Curve Number method. The Curve Numbers are published by NRCS in *Technical Release No. 55: Urban Hydrology for Small Watersheds* (USDA et al., 1986). With the change in name to the Natural Resource Conservation Service, the method may be referred to as the NRCS Method.

Nutrients

Essential chemicals needed by plants or 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.

- O -

Off-line facilities

Water quality treatment facilities to which stormwater runoff is restricted to some maximum flow rate or volume by a flow-splitter.

Off-site

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.

Off-system storage

Facilities for holding or retaining excess flows over and above the carrying capacity of the drainage system, in chambers, tanks, lagoons, ponds, or other basins that are not a part of the subsurface sewer system.

Oil/water separator

A vault, usually underground, designed to provide a quiescent environment to separate oil from water.

On-line facilities

Water quality treatment facilities which receive all of the stormwater runoff from a drainage area. Flows above the water quality design flow rate or volume are passed through at a lower percent removal efficiency.

On-site

The entire property that includes the proposed development.

On-site stormwater management BMPs

As used in this manual, a synonym for Low Impact Development BMPs.

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 D2974. 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 drainage, 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 drain.

Outlet channel

A waterway constructed or altered primarily to carry water from man-made structures, such as terraces, tile lines, and diversions.

Outwash soils

Soils formed from highly permeable sands and gravels.

Overflow

A pipeline or conduit device, together with an outlet pipe, that provides for the discharge of portions of combined sewer flows into receiving waters or other points of disposal, after a regular device has allowed the portion of the flow which can be handled by interceptor sewer lines and pumping and treatment facilities to be carried by and to such water pollution control structures.

Overflow rate

Detention basin release rate divided by the surface area of the basin. It can be thought of as an average flow rate through the basin.

Overtopping

To flow over the limits of a containment or conveyance element.

- P -

PAM

Polyacrylamide

Partially controlled limited access highway

A highway where the right of owner or occupants of abutting land or other persons to access, light, air, or view in connection with the highway is controlled to give preference to through traffic to a degree that, in addition to access connections with selected public roads, there may be some crossings and some private driveway connections at grade. (See WAC 468-58-010)

Particle Size

The effective diameter of a particle as measured by sedimentation, sieving, or micrometric methods.

Peak-shaving

Controlling post-development peak discharge rates to pre-development levels by providing temporary detention in a BMP.

Peak discharge

The maximum instantaneous rate of flow during a storm, usually in reference to a specific design storm event.

Percolation

The movement of water through soil.

Percolation rate

The rate, often expressed in minutes/inch, at which clear water, maintained at a relatively constant depth, will seep out of a standardized test hole that has been previously saturated. The term percolation rate is often used synonymously with infiltration rate (short-term infiltration rate).

Permanent Stormwater Control (PSC) Plan

A plan which includes permanent BMPs for the control of pollution from stormwater runoff after construction and/or land disturbing activity has been completed

Permeable pavement

Pervious concrete, porous asphalt, permeable pavers, 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, corporation, association, organization, cooperative, public or municipal corporation, agency of the state, or local government unit, however designated.

Pervious Surface

Any surface material that allows stormwater to infiltrate into the ground. Examples include lawn, landscape, pasture, native vegetation areas, and permeable pavements.

Perviousness

Related to the size and continuity of void spaces in soils; related to a soil's infiltration rate.

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

A measure of the alkalinity or acidity of a substance which is conducted by measuring the concentration of hydrogen ions in the substance. A pH of 7.0 indicates neutral water. A 6.5 reading is slightly acid.

Physiographic

Characteristics of the natural physical environment (including hills).

Plan Approval Authority

The Plan Approval Authority is defined as that department within a local government that has been delegated authority to approve stormwater site plans.

Planned unit development (PUD)

A special classification authorized in some zoning ordinances, where a unit of land under control of a single project proponent may be used for a variety of uses and densities, subject to review and approval by the local governing body. The locations of the zones are usually decided on a case-by-case basis.

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.

Plunge pool

A device used to dissipate the energy of flowing water that may be constructed or made by the action of flowing. These facilities may be protected by various lining materials.

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.

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. See the listing of surfaces under pollution-generating impervious surface.

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 any of the following:

- vehicular use;
- industrial activities (as further defined in this glossary);
- 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 (e.g., baked-on enamel coating);
- roofs that are subject to venting significant amounts of dusts, mists, or fumes from manufacturing, commercial, or other indoor activities.

Pollution-generating pervious surface (PGPS)

Any pervious surface subject to any of the following:

- vehicular use,
- industrial activities (as further defined in this glossary);
- storage of erodible or leachable materials, wastes or chemicals, and that receive direct rainfall or run-on or blow-in of rainfall,
- use of pesticides and fertilizers, or
- loss of soil.

Typical PGPS include permeable pavement subject to vehicular use, lawns and landscaped areas including: golf courses, parks, cemeteries, and sports fields (natural and artificial turf).

Pre-developed condition

The native vegetation and soils that existed at a site prior to the influence of Euro-American settlement. The pre-developed condition shall be assumed to be forested land cover unless reasonable, historic information is provided that indicates the site was prairie prior to settlement.

Prediction

For the purposes of this document an expected outcome based on the results of hydrologic modeling and/or the judgment of a trained professional civil engineer or geologist.

Pretreatment

A BMP that removes at least 50% solids. Typically installed upstream of a UIC well or a Runoff Treatment BMP.

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.

Professional civil engineer

A person registered with the state of Washington as a professional engineer in civil engineering.

Project

Any proposed action to alter or develop a site.

Project site

That portion of a property, properties, or right of way subject to land disturbing activities, new hard surfaces, or replaced hard surfaces.

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.

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.

- Q -

- R -

R/D

See Retention/detention facility.

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. See BMP T5.14: Rain Gardens.

Rare, threatened, or endangered species

Plant or animal species that are regional relatively uncommon, are nearing endangered status, or whose existence is in immediate jeopardy and is usually restricted to highly specific habitats.

Threatened and endangered 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 storm drainage flow rates (Q) by use of the formula Q = CIA, where C is a coefficient describing the physical drainage area, I is the rainfall intensity and A is the area. This method is no longer used in the technical manual.

Reach

A length of channel with uniform characteristics.

Receiving waterbody or receiving waters

Naturally and/or reconstructed naturally occurring surface water bodies, such as creeks, streams, rivers, lakes, wetlands, estuaries, and marine waters, or groundwater, to which a MS4 discharges.

Recharge

The addition of water to the zone of saturation (i.e., an aquifer).

Recommended BMPs

As used in Volume IV, recommended 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 (i.e., has 35% or more of existing hard surface coverage), 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 detention facility

A stormwater quantity control structure designed to correct existing surface water runoff problems of a basin or subbasin. The area downstream has been previously identified as having existing or predicted significant and regional flooding and/or erosion problems.

This term is also used when a detention facility is sited to detain stormwater runoff from a number of new developments or areas within a catchment.

Release rate

The computed peak rate of surface and stormwater runoff from a site.

Replaced hard surface

For structures, the removal and replacement of hard surfaces down to the foundation. For other hard surfaces, the removal down to bare soil or base course and replacement.

Replaced impervious surface

For structures, the removal and replacement of impervious surfaces down to the foundation. For other impervious surfaces, the removal down to bare soil or base course and replacement.

Residential density

The number of dwelling units per unit of surface area. Net density includes only occupied land. Gross density includes unoccupied portions of residential areas, such as roads and open space.

Restoration

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.

Retention

The process of collecting and holding surface and stormwater runoff with no surface outflow.

Retention/detention facility (R/D)

A type of drainage 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

A statistical term for the average time of expected interval that an event of some kind will equal or exceed given conditions (e.g., a stormwater flow that occurs every 2 years).

Rhizome

A modified plant stem that grows horizontally underground.

Riffles

Fast sections of a stream where shallow water races over stones and gravel. Riffles usually support a wider variety of bottom organisms than other stream sections.

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.

Riparian

Pertaining to the banks of streams, wetlands, lakes, or tidewater.

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.

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.

Rodenticide

A substance used to destroy rodents.

Runoff

Water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, springs, seeps, ponds, lakes and wetlands as well as shallow ground water. As applied in this manual, it also means the portion of rainfall or other precipitation that becomes surface flow and interflow.

RUSLE

Revised Universal Soil Loss Equation

- S -

Salmonid

A member of the fish family Salmonidae. Chinook, Coho, chum, sockeye and pink salmon; cut-throat, brook, brown, rainbow, and steelhead trout; Dolly Varden, kokanee, and char are examples of salmonid species.

Sand filter

A man-made depression or basin with a layer of sand that treats stormwater as it percolates through the sand and is discharged via a central collector pipe.

Sanitary control area

The inner circle of a wellhead protection area maintained around a drinking water source to minimize direct contamination at the wellhead and reduce the possibility of surface flows reaching the wellhead and traveling down the casing (WAC 246-290-135).

Saturation point

In soils, the point at which a soil or an aquifer will no longer absorb any amount of water without losing an equal amount.

Scour

Erosion of channel banks due to excessive velocity of the flow of surface and stormwater runoff.

SCS

Soil Conservation Service (now the Natural Resources Conservation Service), U.S. Department of Agriculture

SCS method

See NRCS Method.

SDS

Safety Data Sheet

Seasonal high ground water

Seasonal high groundwater is the highest annual groundwater elevation as determined by a qualified soil scientist, geohydrologist, or licensed engineer in the state of Washington based on monitoring wells or other recognized methods.

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.

Sensitive emergent vegetation communities

Assemblages of erect, rooted, herbaceous vegetation, excluding mosses and lichens, at least some of whose members have relatively narrow ranges of environmental requirements, such as hydroperiod, nutrition, temperature, and light. Examples include fen species such as sundew and, as well as a number of species of Carex (sedges).

Sensitive life stages

Stages during which organisms have limited mobility or alternatives in securing the necessities of life, especially including reproduction, rearing, and migration periods.

Sensitive scrub shrub vegetation communities

Assemblages of woody vegetation less than 6 meters in height, at least some of whose members have relatively narrow ranges of environmental requirements, such as hydroperiod, nutrition, temperature, and light. Examples include fen species such as Labrador tea, bog laurel, and cranberry.

SEPA

State Environmental Policy Act

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.

Site suitability criteria

Eight criteria that must be considered for siting infiltration BMPs for Flow Control and Runoff Treatment. See V-5.6 Site Suitability Criteria (SSC).

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.

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 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 permeability

The ease with which gases, liquids, or plant roots penetrate or pass through a layer of soil.

Soil profile

A vertical section of the soil from the surface through all horizons, including C horizons.

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 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 Texture Class

The relative proportion, by weight, of particle sizes, based on the USDA system, of individual soil grains less than 2 mm equivalent diameter in a mass of soil. The basic texture classes in the approximate order of increasing proportions of fine particles include: sand, loamy sand, sandy loam, loam, silt loam, silt, clay loam, sandy clay, silty clay, and clay.

Sorption

The physical or chemical binding of pollutants to sediment or organic particles.

Source control BMP

A structure or operation 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 Source Control BMPs* are non-structural practices that prevent or reduce pollutants from entering stormwater. See Volume IV for details.

SPCC

Spill Prevention Control and Countermeasures

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 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.

State Environmental Policy Act (SEPA) RCW 43.21C

The Washington State law intended to minimize environmental damage. SEPA requires that state agencies and local governments consider environmental factors when making decisions on activities, such as development proposals over a certain size and comprehensive plans. As part of this process, environmental documents are prepared and opportunities for public comment are provided.

Steep slope

Slopes of 40 percent gradient or steeper within a vertical elevation change of at least ten feet. A slope is delineated by establishing its toe and top, and is measured by averaging the inclination over at least ten feet of vertical relief. For the purpose of this definition:

The toe of a slope is a distinct topographic break in slope that separates slopes inclined at less than 40% from slopes 40% or steeper. Where no distinct break exists, the toe of a steep slope is the lower-most limit of the area where the ground surface drops ten feet or more vertically within a horizontal distance of 25 feet; AND

The top of a slope is a distinct topographic break in slope that separates slopes inclined at less than 40% from slopes 40% or steeper. Where no distinct break exists, the top of a steep slope is the upper-most limit of the area where the ground surface drops ten feet or more vertically within a horizontal distance of 25 feet.

Storage routing

A method to account for the attenuation of peak flows passing through a detention facility or other storage feature.

Storm drains

The enclosed conduits that transport surface and stormwater runoff toward points of discharge (sometimes called storm sewers).

Storm frequency

The time interval between major storms of predetermined intensity and volumes of runoff for which storm sewers 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.

Storm sewer

A sewer that carries stormwater and surface water, street wash and other wash waters or drainage, but excludes sewage and industrial wastes. Also called a storm drain.

Stormwater

That portion of precipitation that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, pipes and other features of a stormwater drainage system into a defined surface waterbody, or a constructed infiltration facility.

Stormwater drainage 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.

Stormwater facility

A constructed component of a stormwater drainage system, designed or constructed to perform a particular function, or multiple functions. Stormwater facilities include, but are not limited to, pipes, swales, ditches, culverts, street gutters, detention ponds, retention ponds, constructed wetlands, infiltration devices, catch basins, oil/water separators, and biofiltration swales.

Stormwater Management Manual for Western Washington (SWMMWW)

This manual, as prepared by Ecology, contains BMPs to prevent, control or treat pollution in stormwater and reduce other stormwater-related impacts to waters of the State. The SWMMWW 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.

Stormwater Program

Either the Basic Stormwater Program or the Comprehensive Stormwater Program (as appropriate to the context of the reference) called for under the *Puget Sound Water Quality Management Plan* (PSWQA, 1987 et seq.).

Stormwater Site Plan

The comprehensive report containing all of the technical information and analysis necessary for regulatory agencies to evaluate a proposed new development or redevelopment project for compliance with stormwater requirements. Contents of the Stormwater Site Plan will vary with the type and size of the project, and individual site characteristics. It includes a Construction Stormwater Pollution Prevention Plan (Construction SWPPP) and a Permanent Stormwater Control Plan (PSC Plan). Guidance on preparing a Stormwater Site Plan is contained in III-3 Stormwater Site Plans.

Stream gaging

The quantitative determination of stream flow using gages, current meters, weirs, or other measuring instruments at selected locations. See Gaging station.

Streambanks

The usual boundaries, not the flood boundaries, of a stream channel. Right and left banks are named facing downstream.

Streams

Those areas where surface waters flow sufficiently to produce a defined channel or bed. A defined channel or bed is an area that demonstrates clear evidence of the passage of water and includes, but is not limited to, indicated by hydraulically sorted sediments or the removal of vegetative litter or loosely rooted vegetation by the action of moving water. 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.

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.

Structure

A catchbasin or manhole in reference to a drainage system.

Stub-out

A short length of pipe provided for future connection to a drainage 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.

Subcatchment

A subdivision of a drainage basin (generally determined by topography and pipe network configuration).

Subdrain

A pervious backfilled trench containing stone or a pipe for intercepting ground water or seepage.

Subgrade

A layer soil used as the underlying base for a BMP.

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 sewer.

Surface and stormwater

Water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, springs, seeps, ponds, lakes, and wetlands as well as shallow ground water.

Surface and stormwater management system

Drainage facilities and any other natural features that collect, store, control, treat and/or convey surface and stormwater.

Susceptibility

The ease with which contaminants can move from the land surface to the aquifer, based solely on the types of surface and subsurface materials in the area. Susceptibility usually defines the rate at which a contaminant will reach an aquifer unimpeded by chemical interactions with the vadose zone media.

Susceptible drinking water source

Sources rated highly susceptible by DOH and any drinking water source where a deep injection well will be placed within a ground water protection area.

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 drainage conveyance with relatively gentle side slopes, generally with flow depths less than one foot.

SWPPP

Stormwater Pollution Prevention Plan

- T -

TDA

Threshold Discharge Area

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.

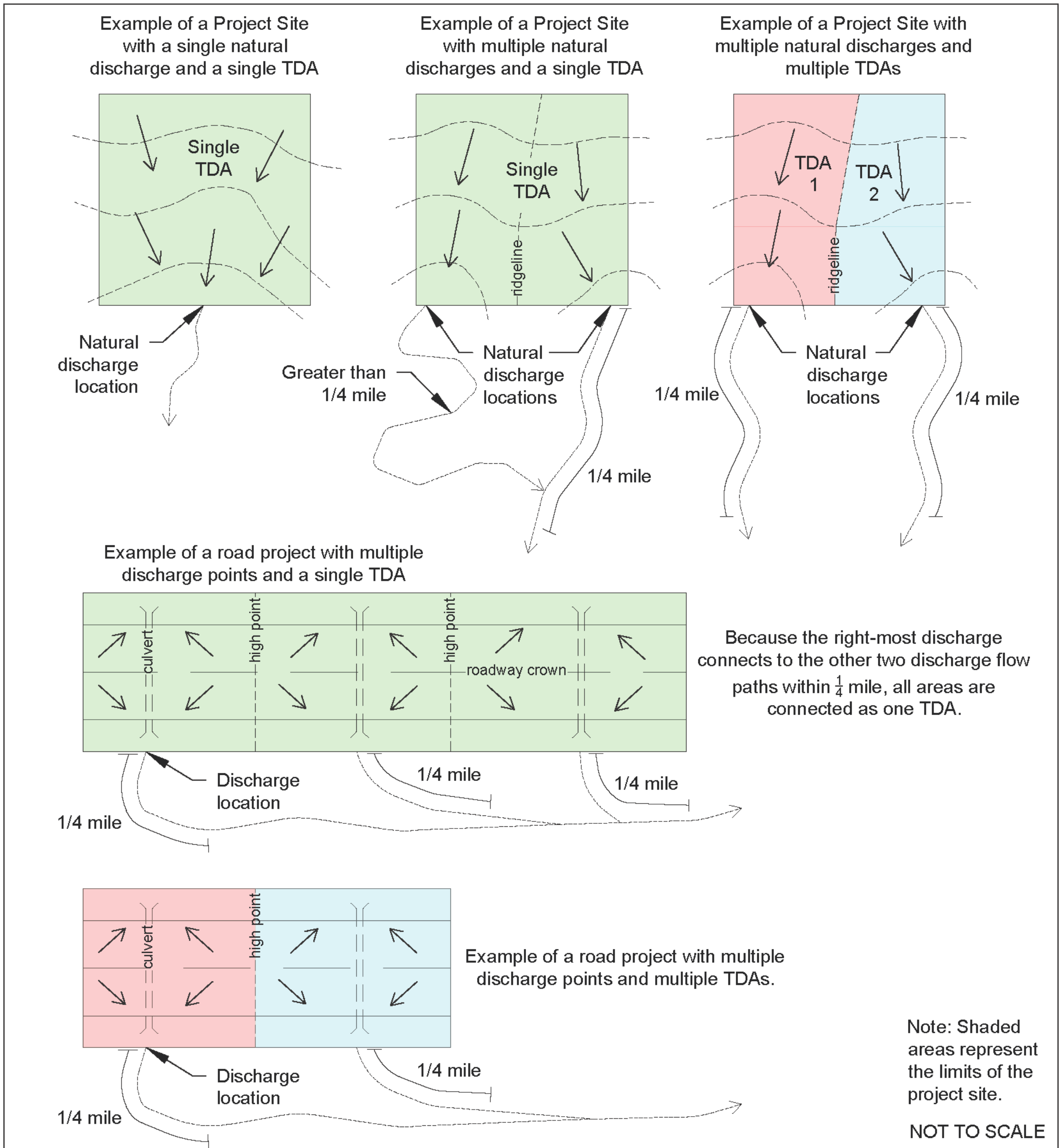
TESC

Temporary Erosion and Sediment Control

Threshold Discharge Area

An area within a project site draining to a single natural discharge location or multiple natural discharge locations that combine within one-quarter mile downstream (as determined by the shortest flowpath). The examples in Figure V-B.1: Example TDA Delineations below 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 points.

Figure V-B.1: Example TDA Delineations



DEPARTMENT OF
ECOLOGY
State of Washington

Example TDA Delineations

Revised March 2018

Tightline

A continuous length of pipe that conveys water from one point to another (typically down a steep slope) with no inlets or collection points in between.

Tile drainage

Land drainage by means of a series of tile lines laid at a specified depth and grade.

Tile, Drain

Pipe made of burned clay, concrete, or similar material, in short lengths, usually laid with open joints to collect and carry excess water from the soil.

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 tributary drainage area.

TMDL

Total Maximum Daily Load

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 Maximum Daily Load (TMDL) – Water Cleanup Plan

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 like support (fishing), and the scientific criteria to support that use. The Clean Water Act, section 303, establishes the water quality standards and TMDL programs.

Total Petroleum Hydrocarbons (TPH)

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.

Toxic

Poisonous, carcinogenic, or otherwise directly harmful to life.

Tract

A legally created parcel of property designated for special nonresidential and noncommercial uses.

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 or Facility

A BMP that is intended to remove pollutants from stormwater. A few examples of treatment BMPs are Wetponds, oil/water separators, biofiltration swales, and constructed wetlands.

Treatment liner

A layer of soil that is designed to slow the rate of infiltration and provide sufficient pollutant removal so as to protect ground water quality.

Treatment train

A combination of two or more treatment facilities connected in series.

TSS

Total Suspended Solids

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.

- U -

U.S. EPA

The United States Environmental Protection Agency.

Underdrain

Plastic pipes with holes drilled through the top, installed on the bottom of an infiltration BMP, which are used to collect and remove excess runoff.

Underground Injection Control (UIC) Program

A federal regulatory program established to protect underground sources of drinking water from UIC well discharges. In Washington, the U.S. EPA has granted Ecology authority to regulate UIC wells, except for UIC wells on tribal land.

Underground Injection Control (UIC) Well

A UIC well is defined as a structure built to discharge fluids from the ground surface into the subsurface; a bored, drilled, or driven shaft whose depth is greater than the largest surface dimension; or a dug hole whose depth is greater than the largest surface dimension; or an improved sinkhole, which is a natural crevice that has been modified; or a subsurface fluid distribution system that includes an assemblage of perforated pipes, drain tiles, or other similar mechanisms intended to distribute fluids below the surface of the ground. Examples of UIC wells or subsurface infiltration systems include drywells, drain fields, infiltration trenches with perforated pipe, storm chamber systems with the intent to infiltrate, french drains, bioretention systems intended to distribute water to the subsurface by means of perforated pipe installed below the treatment soil, and other similar devices that discharge to the ground.

Undisturbed buffer

A zone where development activity shall not occur, including logging, and/or the construction of utility trenches, roads, and/or surface and stormwater facilities.

Undisturbed low gradient uplands

Forested land, sufficiently large and flat to infiltrate surface and storm runoff without allowing the concentration of water on the surface of the ground.

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.

Unusual biological community types

Assemblages of interacting organisms that are relatively uncommon regionally.

Urbanized area

Areas designated and identified by the U.S. Bureau of Census according to the following criteria: an incorporated place and densely settled surrounding area that together have a maximum population of 50,000.

USDA

United States Department of Agriculture

- V -

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.

Variance

See Exception.

Vegetated flow path

A vegetated flow path consists of well-established lawn or pasture, landscaping with well-established groundcover, native vegetation with natural groundcover, or an area that meets BMP T5.13: Post-Construction Soil Quality and Depth. The groundcover shall be dense enough to help disperse and infiltrate flows and to prevent erosion..

Vegetation

All organic plant life growing on the surface of the earth.

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 storage yards, and
- airport runways.

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.

Vulnerability

Vulnerability is a water source's potential for contamination. Two factors influence vulnerability:

- Physical susceptibility to contaminant infiltration. Susceptibility depends on conditions that affect the movement of contaminants from the land surface into a water supply. This includes the depth of the well, its construction, the geology of the area, the pumping rate, the source(s) of ground water recharge, and the aquifer material.
- The source's risk of exposure to contaminants. The risk of exposure is measured by determining whether contaminants were used in the water supply area. However, each type of contaminant may behave differently in the environment, making it difficult to predict ground water pollution from surface exposure accurately. For this reason, susceptibility is the key factor used in determining vulnerability. See Washington *State Wellhead Protection Program Guidance Document* (WSDOH, 2010).

- W -

Water Cleanup Plan

See Total Maximum Daily Load

Water quality

A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.

Water quality design storm

The 24-hour rainfall amount with a 6-month return frequency. Commonly referred to as the 6-month, 24-hour storm.

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.

Water table

The upper surface or top of the saturated portion of the soil or bedrock layer, indicates the uppermost extent of ground water.

Waterbody

Surface waters including rivers, streams, lakes, marine waters, estuaries, and wetlands.

Watershed

A geographic region within which water drains into a particular river, stream, or body of water. Watersheds can be as large as those identified and numbered by the State of Washington Water Resource Inventory Areas (WRIAs) as defined in Chapter 173-500 WAC.

Waters of the state

Lakes, rivers, ponds, streams, inland waters, underground waters, salt waters, and all other surface waters and watercourses within the jurisdiction of the state of Washington.

Weir

Device for measuring or regulating the flow of water.

Weir notch

The opening in a weir for the passage of water.

Wellhead protection area

The area surrounding a drinking water source that is focused on protection from potential contamination that typically includes four or five zones: a sanitary control area, Zone 1 (1-year travel time), Zone 2 (5-year travel time), Zone 3 (10-year travel time), and an additional buffer zone (if warranted) (WAC 246-290-130 and WAC 246-290-135).

Wetland edge

Delineation of the wetland edge shall be based on the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory, 1987)

Wetlands

Those areas that are inundated or saturated by surface or ground water 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 non-wetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, 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 non-wetland areas to mitigate the conversion of wetlands.

Wetponds and wetvaults

Drainage facilities for water quality 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.

Wetpool

A pond or constructed wetland that stores runoff temporarily and whose normal discharge location is elevated so as to maintain a permanent pool of water between storm events.

WSDOT

Washington State Department of Transportation

- X -

- Y -

- Z -

Zoning ordinance

An ordinance based on the police power of government to protect the public health, safety, and general welfare. It may regulate the type of use and intensity of development of land and structures to the extent necessary for a public purpose. Requirements may vary among various geographically defined areas called zones. Regulations generally cover such items as height and bulk of buildings, density of dwelling units, off-street parking, control of signs, and use of land for residential, commercial, industrial, or agricultural purposes. A zoning ordinance is one of the major methods for implementation of a comprehensive plan.

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